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Carboniferous and Lower Permian Fusulines of the Atetsu Limestone in West Japan

By

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with 23 Tables and 8 Plates

ABSTRACT: This paper includes descriptions of the Pennsylvanian and Lower Permian fusulines from the Atetsu Limestone in Okayama Prefecture of West Japan. Fusulines described and illustrated herein are two species of *Millerella*, four species of *Eostaffella* and one species of *Pseudostaffella* from the *Millerella bigemmicula-Eostaffella kanmerai* zone; four species of *Fusulinella* from the *Fusulinella imamurai* zone; one species of *Rugosofusulina*, five species of *Triticites*, two species of *Chusenella*, one species of *Pseudofusulina* and four species of *Pseudoschwagerina* from the *Pseudoschwagerina* zone.

CONTENTS

I. INTRODUCTION

The stratigraphical and paleontological knowledge of the Carboniferous and Permian Limestones in the Atetsu district of Okayama Prefecture has been gained by several workers such as IMAMURA (1959), OKIMURA (1958), SADA (1960, 1961(a), 1961(b), 1963), NOGAMI (1961, 1962), MINATO and NAKAZAWA (1957), YAMAGIWA (1962), etc., since MOCHIZUKI (1938) described the outline of the stratigraphy of the Atetsu Limestone and reported the presence of the prolific fusuline faunas in it. However, many fusuline species important for the purpose of correlation have been left undescribed and many stratigraphical problems have remained unsolved. From the standpoint of the study of fusulines, the Carboniferous deposits in this district may be defined as follows in descending order:

	Iwamoto formation	*Pseudoschwagerina* zone	Low. Permian
	~~ Unconf. ~~~~~~		
Mitsudo group	Kodani formation	*Fusulinella imamurai* zone *Profusulinella toriyamai* zone	Mid. Pennsylvanian
		Millerella bigemmicula-Eostaffella kanmerai zone	Low. Pennsylvanian
	Nagoe formation	*Endothyra-Plectogyra* zone	Mississipian

Concerning the stratigraphy of the Permian of this limestone, the readers are requested to refer to my preceding paper (1961(b)).

This paper includes descriptions of the fusulines obtained from the *Millerella bigemmicula-Eostaffella kanmerai* zone, the *Fusulinella imamurai* zone and the *Pseudoschwagerina* zone. The stratigraphical descriptions of the Atetsu Limestone and the full accounts of the significance of the fusuline faunas will be completed in my paper will be published in near future.

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II. DESCRIPTIONS OF SPECIES

Subfamily Ozawainellinae THOMPSON and FOSTER, 1937

Genus *Millerella* THOMPSON, 1942

Type-species.—*Millerella marblensis* THOMPSON, 1942.

Millerella inflecta THOMPSON
Pl. XXI, figs. 1–4

1954. *Millerella inflecta* THOMPSON. Kansas Geol. Survey, Bull. 60, pp. 44–46, pl. 1, figs. 1–7; pl. 5, figs. 2, 3, text-fig. 11.

1948. *Millerella inflecta* THOMPSON. Univ. Kansas, Paleont. Cont. Protozoa, Art. 1, pp. 76–77, pl. 24, figs. 10–15.

Description.—The shell of the species is large for the genus, discoidal in shape commonly with a broadly rounded periphery and umbilicated poles. The specimens of five volutions are 151 to 170 microns long and 472 to 491 microns wide, giving form ratios of 0.3 to 0.4. The inner four volutions are involute and the last one may be slightly evolute in the umbilical regions.

The proloculus is spherical and its outside diameter is about 25 microns. The inner two volutions are tightly coiled but beyond the third volution the shell expands rapidly. The radius vectors of the first to the fifth volution of two specimens are 37, 56–75, 94–113, 170–188 and 264 microns, respectively.

The spirotheca is composed of a tectum and inner and outer tectoria, and its thickness of the first to the fifth volution of two specimens is 8, 9–14, 12–15, 19–20 and 19 micons, respectively.

The septa are thin and loosely spaced. The exact septal counts cannot be known, but there are 9 to 10 septa in outer volution of one specimen.

The chomata seem to be discontinuous, small and low, and are usually asymmetrical. The tunnel is low and fairly broad, and its path is irregular.

Comparison.—In the outline of the shell, the number of volutions, the spirothecal thickness and the septal arrangement, the Atetsu specimens are most agreeable with the types of *Millerella inflecta* THOMPSON from the Belden formation of Colorado and eastern Utah (THOMPSON, 1945), and the hypotypes from the lower part of the Pennsylvanian in Powwow Canyon, Hueco Mountains, Texas (THOMPSON, 1948). Minor differences are seen in that the former has a slightly thinner discoidal with a larger form ratio, and less heavy chomata than the latter. However, it seems to me that such differences are within a specific variation. The present species somewhat resemble *Millerella designata* ZELLER (1953, p. 194, pl. 26, figs. 2, 4) from the Clore Limestone of Randolph County, Illinois. However, the latter species has a much distinctly evolute outer volution.

The present species have a similarity to *Millerella tortula* ZELLER (1953, p. 129, pl. 26, figs. 7–10, 12–21, 23–26) from the Glen Dean Limestone of Breckinridge County in Kentucky, but the former species has larger shell and rapider expansion of the shell.

TABLE 1. TABLE OF MEASUREMENTS OF *Millerella inflecta* THOMPSON. (in millimeters)

	Volution	Specimen 1	Specimen 2
Length		.151	.170
Width		.491	.472
Ratio		.3	.4
Radius vector	1	.037	
	2	.075	.056
	3	.113	.094
	4	.188	.170
	5	.264	.264
Thickness of spirotheca	1	.008	
	2	.014	.009
	3	.015	.012
	4	.020	.019
	5	.019	.019

Specimen 1, IGSH-TN-SA 4-35. 2, IGSH-TN-SA 4-9.

Occurrence.—Common in the *Millerella bigemmicula-Eostaffella kanmerai* zone of the Atetsu Limestone. Associated species are *Millerella bigemmicula*, *Eostaffella kanmerai*, *E.* sp. A, *E.* sp. B, *E.* sp. C, *E.* sp. D and *Pseudostaffella* cf. *kanumai.*

Millerella bigemmicula IGO
Pl. XXI, figs. 5–6, 10–13

1957. *Millerella bigemmicula* IGO. Sci. Rept. Tokyo Kyoiku Daigaku, Sec. C, Vol. 5, Nos. 47-48, pp. 172-174, pl. 1, figs. 1-9, 15-17, 27.

Description.—The shell of *Millerella bigemmicula* IGO is discoidal in shape with a broadly rounded periphery and umbilicated poles. The shells of four volutions are 104 to 133 microns long and 336 to 370 microns wide, possessing form ratios of 0.3 to 0.4. The inner two volutions are involute but the outer two are partially evolute.

The proloculus is small and spherical and its outside diameter ranges from 26 to 32 microns. The radius vectors of the first to the fourth volution of three specimens are 32–47, 64–76, 104–123 and 180–199 microns, respectively. The shell expands rapidly. The spirotheca consists of a tectum and inner and outer tectoria in all volutions. The thickness of the spirotheca of the first to the fourth volution of three specimens is 9–13, 9–12, 12–13 and 14–19 microns, respectively. The chomata are small and asymmetrical.

TABLE 2. TABLE OF MEASUREMENTS OF *Millerella bigemmicula* IGO. (in millimeters)

		Specimen			
		1	2	3	4
Length		.104	.133	.121	.076
Width		.370	.346	.336	.355
Ratio		.3	.4	.3	.2
Proloculus		.026		.032	.042
	Volution				
Radius vector	1	.038	.047	.032	.037
	2	.072	.076	.064	.094
	3	.120	.123	.104	.151
	4	.199	.190	.180	.188
Thickness of spirotheca	1	.013	.009	.009	.012
	2	.011	.009	.012	.012
	3	.012	.013	.013	.010
	4	.014	.019	.019	.010

Specimen 1, IGSH-TN-SA 4-27. 2, IGSH-TN-SA 4-32. 3, IGSH-TN-SA 4-15. 4, IGSH-M-SA 6-24

Remarks and Comparison.—As is understood from the original descriptions and illustrations by IGO (1957, p. 172, pl. 1, figs. 1-9, 15-17, 27), *Millerella bigemmicula* from the Ichinotani formation of the Hida Massif, shows a fairly wide range of variation in its shell-shape, especially in the shape of the periphery. The holotype has a moderately narrow periphery, but some of the paratypes have a broadly pointed ones. This variation can be seen even in a single specimen (see IGO's pl. 1, figs. 7, 8). In many specimens, however, the periphery is broadly rounded in the inner three to three and a half volutions and become narrowly rounded in the last volution. In the shell-shape, the number of volutions, the size of the shell, the diameter of the proloculus, the spirothecal thickness and developement of the chomata, the Atetsu specimens are closer to the holotype of *Millerella bigemmicula* than to those of any other known species of the genus. They may be referable to this species, although they have a periphery of more uniform shape throughout the growth.

In the shell-shape, the size and the number of volutions, the present specimens closely resembles the types of *Millerella tortula* ZELLER (1953, pp. 192-194, pl. 26, figs. 7-10, 12-21, 23-26) from the Glen Dean Limestone in Breckinridge County, Kentucky, but further material of good preservation is needed for the precise identification. With regard to the shell-shape, the number of volutions and the radius vectors of the shell, the specimens illustrated herein resemble closely that of *Millerella* sp. of ZELLER (1953, pl. 26, fig. 11) from the Menard Limestone, type Chesterian, in Illinois. However, the principal distinctions are in that the former has a thicker spirotheca for corresponding volutions and less distinct chomata.

Occurrence.—Common in the *Millerella bigemmicula-Eostaffella kanmerai* zone of the Atetsu Limestone. Associated fusulinids are the same as those of *M. inflecta* THOMPSON.

Genus *Eostaffella* RAUSER, 1948

Type-species.—*Eostaffella parastruvei* RAUSER, 1948.

Eostaffella kanmerai (IGO)
Pl. XXI, figs. 8, 16, 17

1957. *Millerella kanmerai* IGO. Sci. Rept. Tokyo Kyoiku Daigaku Sec. C, Vol. 5, Nos. 47-48, pp. 175-177, pl. 1, figs. 20-26; pl. 2, fig. 14.

Description.—The shell of *Eostaffella kanmerai* (IGO) is fairly large for the genus and discoidal in shape, having a broadly rounded periphery and distinctly convex lateral slopes. One (Pl. XXI, fig. 8) of the illustrated specimens has five volutions and is 218 microns long and 570 microns wide, giving a form ratio of 0.4. The inner four volutions are evolute, and the last one may become slightly evolute.

The proloculus is small and its outside diameter measures 23 microns in the specimen mentioned above. The radius vectors of the first to the fifth volution are 38, 73, 123, 194 and 347 microns, respectively.

The spirotheca is fairly thick and is composed of a distinct tectum and inner and outer dense layers. The thickness of the spirotheca of the first to the fifth volution of the specimen stated above is 13, 11, 14, 28 and 26 microns, respectively.

The chomata are poorly developed, and the tunnel is low and rather broad.

Comparison.—In the shell-shape, the number of volutions, the size, the form ratio and the spirothecal thickness, the specimens described above agree closely with *Eostaffella kanmerai* (IGO) (1957, pp. 175-177, pl. 1, figs. 20-26; pl. 2, fig. 14) from the Ichinotani formation of the Hida Massif in Central Japan. They can be referred to *E. kanmerai.*

This species shows some resemblances to *Millerella gigantea* described by KANMERA (1952, pp. 172-173, pl. 12, fig. 4) from the Kakisako formation of Kyushu, but it is easily distinguished by its smaller shell and its lower chambers for corresponding volutions.

The present species somewhat resembles *Eostaffella circuli* described by THOMPSOM (1945, 1951) from the Belden formation of Utah and also by THOMPSON (1948) from Powwow Canyon of Texas, but it has a smaller proloculus, smaller and more indistinct chomata, higher chambers for corresponding volutions and thinner spirotheca.

The present form is easily distinguishable from *Parastaffella holmensis* ROSS and DUNBAR (1962, pp. 18-20, pl. 3, figs. 1-6) from the basal part of the Lower Marine

TABLE 3. TABLE OF MEASUREMENTS OF *Eostaffella kanmerai* (IGO) (in millimeters)

		Specimen		
		1	2	3
Length		.218	.142	.163
Width		.570	.294	.420
Ratio		.4	.5	.4
	Volution			
Radius vector	1	.038		
	2	.073	.042	.060
	3	.123	.085	.118
	4	.194	.153	.213
	5	.347		
Thickness of spirotheca	0	.012		
	1	.013		
	2	.011	.013	.019
	3	.014	.012	.028
	4	.028	.009	.022
	5	.026		

Specimen 1, IGSH-TN-SA 4-35. 2, IGSH-TN-SA 4-11. 3, IGSH-TN-SA 4-28.

group in Holm Land, for the former has smaller shell, fewer volutions, more broadly rounded periphery, smaller and more indistinct chomata and thinner spirotheca consisting of a distinct tectum and inner and outer dense layers.

Occurrence.—Common in the *Millerella bigemmicula-Eostaffella kanmerai* zone of the Atetsu Limestone. Associated fusulinids are the same as those of *M. inflecta* THOMPSON.

Eostaffella sp. A
Pl. XXII, figs. 1–2

Description.—The shell of *Eostaffella* sp. A is large for the genus and subdiscoidal, having a rounded periphery, a straight axis of coiling and slightly umbilicated poles. The specimen of four volutions illustrated as fig. 1 on Pl. XXII (IGSH-TN-SA 4-11 (a)) is 377 microns long and 604 microns wide, giving a form ratio of 0.6. The shell is completely involute.

The proloculus is small and its outside diameter is 18 microns. The first two volutions are tightly coiled, but beyond the second the shell expands rapidly. The radius vectors of the first to the fourth volution of a specimen are 75, 132, 207 and 321 microns, respectively.

The spirotheca is thin and it is composed of a tectum and inner and outer dense layers. The thickness of the spirotheca of the first to the fourth volution measured at the center of the shell is 19, 20, 29 and 28 microns, respectively.

The chomata are massive and distinctly asymmetrical. The tunnel sides of the chomata are steep and their poleward slopes are very gentle and low. The tunnel is broad.

TABLE 4. TABLE OF MEASUREMENTS OF *Eostaffella* sp. A (in millimeters)

		Volution	Radius vector	Thickness of spirotheca
Length	.377	0		.023
Width	.604	1	.075	.019
Ratio	.6	2	.132	.020
Proloculus	.018	3	.207	.029
		4	.321	.028

Specimen, IGSH-TN-SA 4-11(a)

Remarks.—*Eostaffella* sp. A described above somewhat resembles *Eostaffella circuli* (THOMPSON) (1945, 1948) from the Carboniferous rocks of Utah, Colorado and Texas, but it can be distinguished by its larger shell and its longer axial length. *Eostaffella* sp. A also resembles *Eostaffella* sp. described by IGO (1957, pp. 180–181, pl. 2, figs. 6–7) from the Ichinotani formation of the Hida Massif in Central Japan. The former, however, differs from the latter in having a comparatively thicker shell and fewer volutions.

No accurate determination is made here due to the poor preservation of the shell.

Occurrence.—Rare in the *Millerella bigemmicula-Eostaffella kanmerai* zone of the Atetsu Limestone. Associated fusulinids are the same as those of *Millerella inflecta* THOMPSON.

Eostaffella sp. B
Pl. XXI, figs. 18–20; Pl. XXII, figs. 5, 6(?), 7(?)

Descriptive remarks.—The shell of *Eostaffella* sp. A is moderate for the genus and thick discoidal in shape with broadly rounded periphery and slightly umbilicated poles. The shells of four volutions are 184 to 210 microns long and 367 to 462 microns wide, having form ratios of 0.4 to 0.6. The shell is involute but may rarely be evolute only in the last volution.

The proloculus has been obliterated because of the secondary mineralization. The radius vectors of the first to the fourth volution of two typical specimens are 26–37, 66–70, 122–127 and 191–224 microns, respectively.

The spirotheca is composed of a tectum and inner and outer tectoria. The thickness of the spirotheca of the first to the fourth volution of two specimens is 10–13, 9–16, 11–15 and 9–13 microns, respectively. The chomata are indistinct and, if present, they may be discontinuous.

TABLE 5. TABLE OF MEASUREMENTS OF *Eostaffella* sp. B (in millimeters)

		Specimen		
		1	2	3
Length		.210	.184	.245
Width		.367	.462	.453
Ratio		.6	.4	.5
	Volution			
Radius vector	1	.026	.037	.056
	2	.066	.070	.094
	3	.122	.127	.132
	4	.191	.224	.226
Thickness of spirotheca	1	.010	.013	.011
	2	.009	.016	.009
	3	.011	.015	.009
	4	.013	.009	.020

Specimen, 1, IGSH-TN-SA 4-8. 2, IGSH-TN-SA 4-43. 3, IGSH-TN-SA 4-29.

The present specimens have a similarity to the types of *Millerella chesterensis* COOPER (1947, pp. 85–86, pl. 19, figs. 1–5) from the Kinkaid formation of Johnson County, Illinois, but they can be distinguished by their slightly larger shell, their larger radius vectors for corresponding volutions, its larger form ratio, and their thicker spirotheca. For accurate determination more complete specimens are needed.

Occurrence.—Rarely found in the *Millerella bigemmicula-Eostaffella kanmerai* zone of the Atetsu Limestone. Associated fusulinids are the same as those of *Millerella inflecta* THOMPSON.

Eostaffella? sp. C
Pl. XXI, figs. 9

Descriptive remarks.—The shell of *Eostaffella*? sp. C is minute and subdiscoidal in shape, having a broadly rounded but somewhat irregular periphery and slightly depressed axial regions. The illustrated specimen of five volutions is 132 microns long and 741 microns wide, possessing a form ratio of 0.3. The shell is involute but the last volution is partially evolute.

The proloculus diameter is uncertain owing to the secondary mineralization. The radius vectors of the second to the fifth volutions are 77, 142, 237 and 402 microns, respectively.

The spirotheca is composed of a tectum and inner and outer dense layers. The spirotheca is moderately thick and its thickness of the second to the fifth volution is 21, 13, 28 and 30 microns, respectively.

TABLE 6. TABLE OF MEASUREMENTS OF *Eostaffella*? sp. C (in millimeters)

		Volution	Radius vector	Thickness of spirotheca
Length	.132	0		
Width	.741	1		
Ratio	.3	2	.077	.021
		3	.142	.013
		4	.237	.028
		5	.403	.030

Specimen, IGSH-TN-SA 4-1.

The chomata are poorly developed and somewhat irregular in the third to the fourth volution.

This species is incompletely known owing to the scantiness of the material and its generic assignment is doubtful. So the specific comparison is postponed until more information is obtained.

Occurrence.—Rare in the *Millerella bigemmicula-Eostaffella kanmerai* zone of the Atetsu Limestone. Associated fusulinids are the same as those of *M. inflecta* THOMPSON.

Subfamily Fusulininae RHUMBLER, 1895

Genus *Pseudostaffella* THOMPSON, 1942

Type-species.—*Pseudostaffella needhami* THOMPSON, 1942.

Pseudostaffella cf. *kanumai* IGO
Pl. XXII, figs. 4, 8-9

1957. *Pseudostaffella kanumai* IGO. Sci. Rept. Tokyo Kyoiku Daigaku, Sec. C, Nos. 47-48, pp. 194-196, pl. 4, fig. 26; pl. 5, figs. 1-5.

Descriptive remarks.—The shell of the specimens under the heading is small and is spherical to subspherical in shape. The mature specimen of five volutions (Pl. XXII, fig. 9) (IGSH-TN-SA 4-23) is 566 microns long and 660 microns wide, giving a form ratio of 0.9.

The proloculus is minute. The first one and a half volutions have an axis of coiling like an endothyroid. The inner two volutions are tightly coiled, but beyond the third volution the expansion of the shell becomes rapid. The radius vectors of the first to the fifth volution of the specimen mentioned above are 37, 94, 151, 226 and 358 microns, respectively.

The spirotheca is thin and it consists of a tectum and inner and outer tectoria. The spirothecal thickness of the first to the fifth volution of the above mentioned specimen is 15, 14, 20, 32 and 38 microns, respectively.

TABLE 7. TABLE OF MEASUREMENTS OF *Pseudostaffella* cf. *kanumai* IGO (in millimeters)

		Volution	Radius vector	Thickness of spirotheca
Length	.566			
Width	.660	1	.037	.015
Ratio	.9	2	.094	.014
Proloculus	.018	3	.151	.020
		4	.226	.032
		5	.358	.038

Specimen, IGSH-TN-SA 4-23.

The chomata are massive and asymmetrical. The tunnel sides of the chomata are steep but their poleward slopes are gentle. The tunnel angles of the second to the fourth volution are about 40, 39 and 41 degrees, respectively.

The present specimens have been poorly preserved. They show the closest resemblance to the types of *Pseudostaffella kanumai* IGO in the shell shape, the size and the internal characters, but their chomata are not so heavy as those of the latter.

Occurrence.—Rare in the *Millerella bigemmicula-Eostaffella kanmerai* zone of the Atetsu Limestone. Associated fusulinids are the same as those of *Millerella inflecta* THOMPSON.

Genus *Fusulinella* MÖLLER, 1877

Type-species.—Fusulinella bocki MÖLLER, 1878.

Fusulinella imamurai, sp. nov.
Pl. XXIII, figs. 8–11

Description.—The shell of *Fusulinella imamurai*, sp. nov. is large for the genus and elongate fusiform, having a straight axis of coiling and acute polar ends. The lateral slopes are straight to slightly concave, especially near the poles. Mature shells of six volutions are 3.50 to 3.60 mm. long and 0.85 to 1.05 mm. wide. The form ratio ranges from 3.3 to 4.1. The holotype specimen has a length of 3.06 mm. and a width of 1.00 mm., attaining a form ratio of 3.6. The first volution is subspherical, the second one is ellipsoidal, and beyond the third volution the shell attains its mature shape. The ratios of the half length to the radius vector in the first to the sixth volution of four specimens are 1.4–2.0, 2.4–3.4, 2.9–3.6, 3.3–3.5, 3.3–3.7 and 3.0–4.0, respectively.

The proloculus is large and its outside diameter varies from 170 to 207 microns, commonly 170 to 180 microns. The shell is tightly coiled in the inner three volutions, and expands rapidly and uniformly in the outer volutions. The radius vectors of the first to the sixth volution of four specimens are 94–132, 132–170, 188–226, 283, 377–415 and 472–566 microns, respectively. The height of the chambers is almost the same throughout the length of the shell, except in the extreme polar ends where the chambers slightly increase in height.

The spirotheca is thin, and consists of a tectum, a diaphanotheca and thin inner and outer tectoria. The diaphanotheca is distinct in all volutions. The thickness of all layers of the spirotheca of the first to the sixth volution of four specimens is 18–27, 18–32, 18–29, 25–27, 23–36 and 23–36 microns, respectively.

The septa are almost plane and rather closely spaced. Only in the extreme polar regions the septa are very weakly fluted. The septal counts of the first to the fifth volution of a specimen are 6, 10, 12, 15 and 18, respectively.

The chomata are well developed throughout the growth of the shell. The tunnel sides of the chomata are very steep, but the poleward slopes are very gentle. The tunnel path is about straight. The tunnel angles of the first to the fifth volution of the holotype specimen are about 25, 23, 24, 35 and 31 degrees, respectively. It increases in width rapidly from the fourth volution.

TABLE 8. TABLE OF MEASUREMENTS OF *Fusulinella imamurai*, sp. nov. (in millimters)

Speci-men	Rg.	No.	Pl.	fig.	L.	W.	R.	Prol.	Radius vector					
									1	2	3	4	5	6
1	IGSH-AZ-SA	4-5	23	8	3.60	1.00	3.6	.207	.132	.170	.226	.283	.415	.547
2	IGSH-AZ-SA	4-49	23	10	3.50	1.05	3.3	.170	.094	.151	.207	.283	.415	.566
3	IGSH-AZ-SA	4-24	23	9	3.50	1.05	3.6	.180	.094	.132	.188	.283	.396	.528
4	IGSH-AZ-SA	4-48	23	11	3.50	.85	4.1	.170	.094	.132	.188	.283	.377	.472

Speci-men	Half length						Ratio of Hl. to Rv.						Thickness of spirotheca						
	1	2	3	4	5	6	1	2	3	4	5	6	0	1	2	3	4	5	6
1	.188	.415	.698	.944	1.284	1.624	1.4	2.4	3.1	3.3	3.3	3.0	.023	.027	.023	.025	.025	.034	.034
2	.188	.377	.603	.944	1.511	2.077	2.0	2.5	2.9	3.3	3.6	3.6	.013	.018	.032	.018	.025	.032	.036
3	.188	.453	.679	.981	1.303	1.889	2.0	3.4	3.6	3.5	3.3	3.6	.025	.018	.023	.029	.027	.023	.023
4	.188	.453	.622	.981	1.416	1.889	2.0	3.4	3.3	3.5	3.7	4.0	.023	.021	.018	.025	.027	.036	.027

Remarks and Comparison.—The specimens of the present new species have been slightly deformed, but they are characterized by the large biconical shell with very acute polar ends throughout the growth, fairly large proloculus and unfluted septa. In these characteristics the present species is very similar to *Fusulinella subpulchra subpulchra* PUTRJA (1937, pp. 59–61, pl. 1, fig. 11; 1951, pp. 234–253, pl. 35, figs. 3, 4; 1956, pp. 426–427, pl. 10, figs. 1–4) and *F. subpulchra submesopachis* PUTRJA (1956, pp. 427–428, pl. 10, figs. 5), but it has a larger shell and more weakly concave lateral slopes, and its chomata are smaller and are not extended towards the poles so long as in the latter.

The present species is also similar to *Fusulinella usvae* DOUTKEVITCH (1932, pp. 15–16, 19, 88–89, pl. 6, figs. 1–11) from the western slope of the Middle Ural, but its septa are almost plane and its chomata are smaller and shorter.

The present species closely resembles *Wedekindellina ultima* NEWELL and KEROHER (1937, pp. 700–705, pl. 93, figs. 1–9; THOMPSON, VERVILLE and LOKKE, 1956, pp. 801–803, pl. 90, figs. 1–11; pl. 91, figs. 1–15) and *W. ardmorensis* THOMPSON, VERVILLE and LOKKE (1956, pp. 803–805, pl. 92, figs. 1–12) in the general shell structures, but can be distinguished by less tightly coiled shell in inner volutions and in having no axial deposits.

Fusulinella imamurai, sp. nov. is somewhat similar to *F. juncea* THOMPSON (1948, pp. 93–94, pl. 1, fig. 3; pl. 32, fig. 1; pl. 37, figs. 1–18) from Mud Springs group in New Mexico. However, the major differences between these two species are in that *F. imamurai*, sp. nov. has a larger proloculus, smaller chomata, weaker septal fluting especially in the polar regions. *Fusulinella imamurai*, sp. nov. can be distinguished from *F. searighti* THOMPSON (1953, pp. 323–325, pl. 42, figs. 1–7) by its larger shell and larger proloculus. *Fusulinella imamurai*, sp. nov. bears a close resemblance to *F. dakotensis* THOMPSON (1936, pp. 99–100, pl. 13, figs. 8–10) from Loring Siding of South Dakota, but they are easily distinguished by fewer volutions of *F. imamurai*, sp. nov., larger proloculus, rapid expansion of the shell, and weaker septal fluting in the extreme polar regions. *Fusulinella imamurai*, sp. nov. is nearly allied to *F. velmae protensa* THOMPSON (1936, pp. 103–104, pl. 14, figs. 1–3) from the Hartville formation of Wyoming. *F. imamurai*, sp. nov. is, however, elongate fusiform, and has larger proloculus and a larger form ratio. In the shell-shape *Fusulinella imamurai*, sp. nov. resembles somewhat *Wedekindellina lata* THOMPSON (1961, p. 1134, pl. 136, figs. 1–7) from the Ward Hunt Island in Arctic Ocean. However, the axial filling, larger tunnel angles, and smaller form ratio of *W. lata* serve to distinguish it from *F. imamurai*, sp. nov.

Occurrence.—The present species occurs abundantly in the upper part of the Kodani formation, the *Fusulinella imamurai* zone, of the Atetsu Limestone, in association with *Fusulinella* sp. nov. (?) *F. subrhomboides* (LEE and CHEN), *F. hirokoae*, *F.* sp. A, *F.* spp. and *Fusulina* sp.

Fusulinella sp. nov. (?) cf. *F. subrhomboides* LEE and CHEN
Pl. XXIII, figs. 1–4, 6

Description.—The shell of the present species is thick biconical to nearly rhombic in shape with concave lateral slopes, a straight axis of coiling and bluntly pointed poles. Mature shells of six volutions is 1.55 to 2.10 mm. long and 1.55 to 1.70 mm. wide. The form ratio varies from 1.0 to 1.2, being mostly 1.2. The shell of the holotype is 1.90 mm. long and 1.60 mm. wide, giving a form ratio of 1.2. The inner two volutions are tightly coiled and subspherical usually with convex lateral slopes, beyond the third volution the shell expands rapidly and assumes its mature shape. The ratios of the half length to the radius vector in the first to the sixth volution of four specimens are 0.5–1.0, 0.6–1.1, 0.9–1.2, 1.0–1.4, 1.0–1.2 and 1.0–1.2, respectively.

The proloculus is small and spherical. Its outside diameter ranges from 94 to 151 microns, being mostly 151 microns. The radius vectors of the first to the sixth volution of four specimens are 113–151, 188–226, 283–340, 396–472, 566–623 and 774–944 microns, respectively. The chambers are almost the same in height throughout the length of the shell.

The spirotheca is moderately thick. The spirotheca of the first to the penultimate volution consists of a tectum, a diaphanotheca, and thin inner and outer tectoria. The thickness of the spirotheca of the first to the sixth volution are 21–34, 27–50, 25–55, 27–36, 23–62 and 32–50 microns, respectively.

The septa are weakly fluted only in the extreme polar regions. They are closely spaced, but their exact counts are cannot be given due to the lack of well-oriented sagittal sections.

The chomata are distinct in all but the last volution. The tunnel sides of the chomata are nearly vertical but the poleward slopes are gentle. The tunnel is narrow and relatively high, and its path is straight. The tunnel angles of the first to the fifth volution of the holotype specimen are about 21, 12, 12, 14, and 17 degrees, respectively.

TABLE 9. TABLE OF MEASUREMENTS OF *Fusulinella* sp. nov. (?) cf. *F. subrhomboides* (LEE & CHEN)

Specimen	Rg. No.	Pl.	fig.	L.	W.	R.	Prol.	Radius vector 1	2	3	4	5	6
1	IGSH-AZ-SA 4-47	23	1	1.90	1.60	1.2	.113	.132	.207	.340	.472	.661	.944
2	IGSH-AZ-SA 4-43	23	6	1.75	1.45	1.2	(.132 .093)	.113	.188	.283	.396	.566	.774
3	IGSH-AZ-SA 4-23	23	2	2.10	1.70	1.2	.151	.151	.207	.302	.415	.661	.887
4	IGSH-AZ-SA 4-21	23	4	1.55	1.55	1.0	.151	.151	.226	.321	.453	.623	.812

Specimen	Half length						Ratio of Hl. to Rv.						Thickness of spirotheca						
	1	2	3	4	5	6	1	2	3	4	5	6	0	1	2	3	4	5	6
1	.113	.188	.321	.491	.698	.963	.9	.9	.9	1.0	1.0	1.0	.032	.034	.050	.055	.036	.034	
2	.056	.113	.283	.472	.623	.906	.5	.6	1.0	1.2	1.1	1.2	.025	.021	.029	.025	.027	.023	.043
3	.151	.226	.377	.566	.755	1.038	1.0	1.1	1.2	1.4	1.1	1.1	.041	.029	.029	.052	.036	.062	.050
4	.132	.988	.321	.472	.755	.944	.9	.8	1.0	1.0	1.2	1.2	.029	.032	.027	.029	.036	.041	.032

Remarks and Comparison.—Owing to the strong deformation of the shell, adequate comparison of this species with the known species cannot be made. However, this species seems to have originally had a rhomboidal shell-shape with a concave lateral slopes, and rather closely coiled in the inner volutions and sudden expansion of the shell in the last two volutions. The chomata of the inner volutions are often extended to the polar ends, but those of the outer volutions become much narrower. In these characteristics this species resembles *Fusulinella subrhomboides* (LEE and CHEN) (1930, pp. 125–126, pl. 11, figs. 3) more closely than any of the known species, but the latter has a larger proloculus. *F. subrhomboides* is originally monotypy and its illustrated figure is not appreciated probably due to poor preservation. Therefore it is desirable that anyone who are accessible to the holotype and the topotypes should redescribe on this species.

Fusulinella sp. nov. (?) cf. *F. subrhomboides* (LEE and CHEN) resembles *F. itoi* OZAWA (1925, p. 19, pl. 3, figs. 6, 8; TORIYAMA, 1958, p. 48–52, pl. 4, figs. 3–6) more closely than any other Japanese species. However, *F. itoi* has much heavier chomata which are extended to the poles, and lower chambers for corresponding volutions *Fusulinella* sp. nov. (?) cf. *F. subrhomboides* (LEE and CHEN) is similar to *F. biconica* (HAYASAKA) originally described from the Omi Limestone in Niigata Prefecture, but it differs in having a smaller shell, the concave lateral slopes, smaller proloculus, thinner spirotheca, smaller chomata, narrower tunnel and slower expansion of the shell. *Fusulinella* sp. nov. (?) cf. *F. subrhomboides* is distinguished from *F. eopulchra* RAUSER-CERNOUSSOVA (1951, p. 235, pl. 35, figs. 5–8; ROSS and DUNBAR, 1962, pp. 26–28, pl. 4, figs. 1–5) by less heavier chomata and weaker septal fluting.

Occurrence.—Abundant in the *Fusulinella imamurai* zone of the Atetsu Limestone; associated with *Fusulinella imamurai*, *F. hirokoae*, *F.* sp. A, *F.* spp. and *Fusulina* sp.

Fusulinella hirokoae SUYARI
Pl. XXIII, figs. 12–15

1962. *Fusulinella hirokoae* SUYARI. Jour. Gakugei, Tokushima Univ., Nat. Sci., Vol. 12, pp. 13–14, pl. 3, figs. 9–13.

Description.—The shell of *Fusulinella hirokoae* SUYARI is elongate fusiform in shape, with a straight axis of coiling and narrowly rounded poles. The lateral slopes are straight to convex. The shell of five volutions is 3.75 mm. long and 1.20 mm. wide, giving a form ratio of about 3.1. The inner two volutions are subspherical to ellipsoidal, beyond the third volution the shell becomes of its mature shape. The ratios of the half length to the radius vector of the specimen illustrated as fig. 13 on Pl. XXIII are 94, 132, 226, 340 and 528 microns, respectively, for the first to the fifth volution.

The proloculus is small and spherical, and measures 151 microns in its outside diameter. The shell expands rapidly. The radius vectors of the first to the fifth volution of a specimen are 94, 132, 226, 340 and 528 microns, respectively. The chambers slightly increase in height towards the polar regions.

The spirotheca is relatively thin and is composed of a tectum, a diaphanotheca, and thin inner and outer tectoria. The diaphanotheca is clearly visible from the third volution to the last one. The thickness of the spirotheca of the first to the fifth volution of a specimen is 23, 27, 23, 39 and 50 microns, respectively.

The septa are weakly fluted in the extreme polar regions. The septal counts cannot be determined because of the absence of the well-oriented sagittal section.

The chomata are asymmetrical. Their tunnel sides are almost vertical and their poleward slopes are low. The tunnel path is about straight. The tunnel angles of the second to the fourth volution of a specimen are about 42, 46 and 57 degrees, respectively.

TABLE 10. TABLE OF MEASUREMENTS OF *Fusulinella hirokoae* SUYARI (in millimeters)

Specimen	Rg. No.	Pl.	fig.	L.	W.	R.	Prol.	Radius vector 1	2	3	4	5	6
1	IGSH-AZ-SA 4-27	23	13	3.75	1.20	3.10	.151	.094	.132	.226	.340	.528	
2	IGSH-AZ-SA 4-25	23	14	3.95	.95	4.20			.132	.188	.340	.528	
3	IGSH-AZ-SA 4-14	23	15	2.60	.85	3.10	.094	.075	.094	.151	.245	.358	.491

Specimen	Half length 1	2	3	4	5	6	Ratio of Hl. to Rv. 1	2	3	4	5	6	Thickness of spirotheca 0	1	2	3	4	5	6
1	.132	.283	.491	1.038	1.567	2.077	1.4	2.1	2.2	3.1	3.0		.034	.023	.027	.023	.039	.050	
2		.377	.566	1.081	1.605	2.266		2.9	3.0	2.9	3.0				.029	.036	.046	.050	
3	.113	.245	.340	.585	1.001	1.360	1.5	2.6	2.3	2.4	2.8	2.8	.025	.011	.021	.027	.032	.042	.042

Remarks.—*Fusulinella hirokoae*, described by SUYARI (1962) from the upper part of the Daigo group in Anan City, Shikoku, is characterized by its elongate fusiform shape, rapid expansion of the shell, massive but short chomata, and wide tunnel angles. In these features and the statistical data the present specimens well agree with the types of *F. hirokoae*, although they show fairly larger form ratios due to deformation.

F. hirokoae is distinguished from *F. hanzawai* IGO (pp. 209–210, pl. 7, figs, 10–21) from the Ichinotani formation of the Hida Massif only in that the first volution of the latter is coiled with a large angle to the axis of outer volutions and slightly more numerous septa in outer volutions. It is highly probable that these two species may be identical, but they should be examined on a number of well-oriented topotypes.

The outline of the shell of *Fusulinella velmae protensa* THOMPSON (1936, pp. 103–104, pl. 14, figs. 1–4) which came from Guernsey, Wyoming, is similar to that of *F. hirokoae*. However, *F. velmae protensa* is more inflated fusiform with six volutions in maturity, and has bluntly rounded poles and strongly fluted septa in the axial region.

Occurrence.—Common in the *Fusulinella imamurai* zone of the Atetsu Limestone; associated with *Fusulinella imamurai*, *F.* sp. nov. (?) cf. *F. subrhomboides*, *F.* sp. A. *F.* spp. and *Fusulina* sp.

Fusulinella sp. A
Pl. XXIII, fig. 5–7

Descriptive remarks.—The shell of *Fusulinella* sp. A has a highly tumid form with a straight axis of coiling and rounded poles. The lateral slopes are almost straight to slightly concave. The shell of six volutions is 1.85 mm. long and 1.85 mm. wide, assuming a form ratio of 1.0. The inner three volutions are tightly coiled and ellipsoidal with a short axis of coiling, but beyond the fourth volution the shell expands rapidly and assumes its mature shape. The ratios of the half length to the radius vector in the illustrated specimens (Pl. XXIII, figs. 5 and 7) are 0.6, 0.7, 0.8, 0.8, 0.9 and 1.0, respectively, for the first to the sixth volution.

The proloculus is minute and spherical, and its outside diameter is measured 37 microns. The radius vectors of the first to the sixth volution of a specimen are 94, 151, 226, 415, 698 and 963 microns, respectively. The heights of the chambers are almost the same throughout the length of the shell except for the extreme polar ends where the chambers slightly increase in height.

TABLE 11. TABLE OF MEASUREMENTS OF *Fusulinella* sp. A (in millimeters)

Specimen	Rg.	No.	Pl.	fig.	L.	W.	R.	Prol.	Radius vector					
									1	2	3	4	5	6
1	IGSH-AZ-SA	4-15	23	7	1.85	1.85	1.0	.037	.094	.151	.226	.415	.698	.963

Specimen	Half length						Ratio of Hl. to Rv.						Thickness of spirotheca						
	1	2	3	4	5	6	1	2	3	4	5	6	0	1	2	3	4	5	6
1	.056	.094	.170	.304	.604	.944	.6	.7	.8	.8	.9	1.0	.018	.029	.021	.025	.039	.039	.055

The spirotheca is thick, consisting of a tectum, a diaphanotheca, and thin inner and outer tectoria. The thickness of the spirotheca of the first to the sixth volution is 29, 21, 25, 39, 39 and 55 microns, respectively.

The septa are weakly fluted only in the polar regions. The septal counts can not be given.

The chomata are well developed in the outer volutions, and are nearly symmetrical. They are about a half to one-third as high as the chambers. The tunnel is narrow and its path is almost straight. The tunnel angles of the third to the fifth volution are 19, 21 and 22 degrees, respectively.

This species is somewhat unique in some respects. The shell-shape of this species is like that of *Fusulinella* sp. nov. (?) cf. *F. subrhomboides*. However, *Fusulinella* sp. A differs from *F.* sp. nov. (?) cf. *F. subrhomboides* in having a smaller proloculus, tighter coiling of the inner volutions, and more rapid expansion of the outer ones. This species is probably a new species, but more numerous specimens are needed to erect it.

Occurrence.—Rare in the *Fusulinella imamurai* zone of the Atetsu Limestone; the associated species are *Fusulinella imamurai*, *F.* sp. nov. (?) cf. *F. subrhomboides*, *F. hirokoae*, etc.

Subfamily Schwagerininae DUNBAR & HENBEST, 1930

Genus *Rugosofusulina* RAUSER-CERNOUSSOVA, 1937

Type-species.—*Fusulina prisca* (EHRENBERG) emend. MÖLLER, 1878.

Rugosofusulina arctica (SCHELLWIEN)
Pl. XXIV, figs. 1-17, 20(?); Pl. XXVI, figs. 19-29

1908. *Fusulina arctica* SCHELLWIEN, Paleontographica, Vol. 55, p. 173, pl. 16, figs. 3-9.
1938. *Triticites arcticus*, RAUSER-CERNOUSSOVA, U.S.S.R. Akad. Nauk., Geol Inst. Trudy, Vol. 7, p. 115, pl. 4, figs. 5, 6.
1958. *Triticites arcticus*, ROZOVSKAYA, *Ibid.*, Vol. 13, p. 90, pl. 4, figs. 10, 11.
?1958. *Triticites arctica*, TORIYAMA, Mem. Fac. Sci., Kyushu Univ., Ser. D, Vol. 7, pp. 110-112, pl. 11, figs. 14-25.
1962. *Pseudofusulina (Rugosofusulina) arctica*, ROSS and DUNBAR, Meddel. om Greenland, Bd. 167, No. 5, pp. 41-43, pl. 6, figs. 1-7.

Description.—The shell of *Rugosofusulina arctica* (SCHELLWIEN) is of a medium size for the genus and is elongate fusiform in shape, with convex to slightly irregular lateral slopes, a straight axis of coiling, and narrowly rounded poles. Mature shells of five to six volutions are 3.00 to 5.25 mm. long and 1.00 to 1.50 mm. wide, giving the form ratios of 2.4 to 3.8. The ratios of the half length to the radius vector of nineteen specimens are 1.0–2.5, 1.0–2.7, 1.4–3.1, 1.8–3.1, 1.7–3.2 and 1.9–3.5, respectively, for the first to the sixth volution.

The proloculus is minute and spherical to subspherical. Its outside diameter ranges from 100 to 250 microns, commonly from 100 to 200 microns. In many specimens the shell expands slowly in the inner two volutions, but somewhat rapidly in the succeeding outer ones. The radius vectors of the first to the sixth volution are 75–188, 132–283, 188–472, 321–642, 472–831 and 642–793 microns, respectively. The chamber is about the same in height in the central two-thirds of the shell and becomes slightly higher in the polar regions.

The spirotheca is thin, but increases in thickness rapidly in outer volutions. The spirotheca is composed of a tectum and a keriotheca. Its thickness of the first to the sixth volution is 18–37, 18–37, 18–56, 37–75, 56–75 and 56–75 microns, respectively.

The septa are thin and rather widely spaced. Average septal counts of the third to the sixth volution of five specimens are 8, 15, 19 and 23, respectively. The septa are strongly fluted in the polar regions and are slightly developed in the central part of the shell.

The chomata are low and narrow, but they are easily observed in the inner five volutions. The tunnel is broad. Its angles are about 45 degrees in the outer volutions.

Remarks and Comparison.—A number of sectioned specimens are referable to the present species. They show a wide range of variation in the size of proloculus and the height of the chambers in the inner one or two volutions. Therefore the shape of the shell in the young stage varies greatly in individuals, assuming a thick fusiform to an elongate fusiform.

A similar wide range of variation in the proloculus size and in the shape of inner

Table 12. Table of Measurements of *Rugosofusulina arctica* (Schellwien) (in millimeters)

Specimen		Pl.	fig.	L.	W.	R.	Prol.	Radius vector					
								1	2	3	4	5	6
1	IGSH-KU-SA 2-53			5.15	1.50	3.5	.25	.170	.245	.396	.604	.793	
2	IGSH-KU-SA 2-45(a)	24	2	5.25	1.40	3.8	.15	.132	.188	.283	.434	.661	
3	IGSH-KU-SA 2-45(b)			3.25	1.00	3.3	.15	.094	.151	.377	.566	.793	
4	IGSH-KU-SA 2-21	24	4	5.10	1.45	3.5	.25	.170	.283	.434	.642		
5	IGSH-KU-SA 2-42(a)			3.35	1.10	3.1	.20	.151	.245	.377	.434		
6	IGSH-KU-SA 2-42(b)			3.75	1.05	3.6	.20	.151	.226	.377	.472		
7	IGSH-KU-SA 2-14(b)			4.00	1.50	2.7	.10	.132	.207	.377	.566	.831	
8	IGSH-KU-SA 2-14(a)	24	13	4.00	1.50	2.7	.15	.132	.188	.321	.528	.831	
9	IGSH-KU-SA 2-8			3.50	0.90	3.9	.20	.132	.188	.321	.491		
10	IGSH-KU-SA 2-9(a)	24	10	4.50	1.30	3.5	.20	.113	.151	.226	.340	.491	.680
11	IGSH-KU-SA 2-35	24	8	3.50	1.00	3.5	.10	.075	.132	.188	.340	.472	
12	IGSH-KU-SA 2-52			4.10	1.25	3.2	.10	.113	.188	.302	.472	.717	
13	IGSH-KU-SA 2-59(b)	24	20	4.75	1.60	3.0	.10	.132	.226	.340	.566	.812	
14	IGSH-KU-SA 2-59(a)			4.00	1.35	3.0	.20	.188	.283	.472	.604		
15	IGSH-KU-SA 2-70	24	17	3.00	1.25	2.4	.15	.094	.151	.245	.377	.566	
16	IGSH-KU-SA 2-92			4.25	1.40	3.4	.20	.113	.151	.264	.377	.623	.793
17	IGSH-KU-SA 2-94			4.75	1.50	3.2	.25	.151	.226	.358	.377	.566	.755
18	IGSH-KU-SA 2-5(b)	24	9	4.50	1.40	3.2	.10	.094	.151	.188	.321	.528	.642
19	IGSH-KU-SA 2-19			3.00	1.25	2.4	.15	.094	.151	.264	.396	.566	

Specimen	Half length							Ratio of Hl. to Rv.						Thickness of spirotheca						
	1	2	3	4	5	6	7	1	2	3	4	5	6	0	1	2	3	4	5	6
1	.359	.661	1.227	1.889	2.455			2.1	2.7	3.1	3.1	3.1		.018	.018	.037	.056	.056	.056	
2	.188	.377	.717	1.133	1.983			1.4	2.0	2.5	2.0	3.0		.018	.018	.037	.037	.037	.056	
3	.226	.377	.661	1.133	1.983			2.4	2.5	1.8	2.0	2.5		.018	.018	.018	.037	.056	.056	
4	.283	.604	1.076	1.794	2.739			1.7	2.1	2.5	2.8			.018	.018	.037	.037	.056	.056	
5	.283	.472	.944	1.605				1.9	1.9	2.5	3.7			.018	.018	.018	.037	.056		
6	.377	.775	1.227	1.889				2.5	3.3	3.3	4.0			.018	.018	.037	.056	.075		
7	.132	.264	.566	1.095	1.889			1.0	1.3	1.5	1.9	2.3		.018	.018	.018	.056	.056	.056	
8	.151	.377	.566	1.038	1.794			1.1	2.0	1.8	2.0	2.2		.018	.018	.018	.037	.056	.056	
9	.226	.472	.889	1.133	1.794			1.7	2.5	2.8	2.3			.018	.018	.018	.037	.037		
10	.113	.302	.472	.850	1.511	2.172		1.0	2.0	2.1	2.5	3.1	3.2	.018	.018	.018	.018	.037	.056	
11	.113	.118	.377	.755	.944	1.567		1.5	1.4	2.0	2.2	2.0		.018	.018	.018	.037	.037	.056	
12	.133	.188	.566	1.038	1.700	2.266		1.0	1.0	2.0	2.5	2.4		.018	.018	.018	.018	.037	.056	
13	.207	.566	.944	1.730	2.266			1.6	2.5	2.8	3.0	2.8		.018	.018	.037	.037	.075	.075	
14	.283	.566	1.133	1.730				1.5	2.0	2.4	2.8			.018	.037	.018	.056	.037		
15	.188	.226	.431	.755	1.133	1.794		2.0	1.5	1.8	2.0	2.0		.018	.018	.018	.037	.075	.056	
16	.113	.188	.377	.661	1.038	1.511	1.983	1.0	1.2	1.4	1.8	1.7	1.9	.018	.018	.018	.037	.075	.075	.075
17	.207	.377	.661	1.133	1.794	2.550		1.4	1.7	1.8	3.0	3.2	3.4	.018	.018	.037	.037	.075	.075	
18	.188	.377	.566	.850	1.416	2.266		2.0	2.5	3.0	2.7	2.7	3.5	.018	.018	.018	.018	.037	.056	.056
19	.151	.302	.396	1.038	1.643			1.6	2.0	1.5	2.6	2.9		.018	.018	.018	.037	.056	.056	

volutions can be seen in the original types* of the present species from Spitzbergen (SCHELLWIEN, 1908) and the hypotypes from Greenland (ROSS and DUNBAR, 1962).

Many of the specimens at hand are smaller than the types, but not a few specimens show that a part of the outermost volution or even one volution must have been broken at the time of deposition. Moreover, they have been more or less deformed.

Rugosofusulina arctica (SCHELLWIEN) is characterized by its biconical inner volutions which possess massive chomata, rather thin and rugose spirotheca, and considerable difference in the height of chambers through the length of the shell. The difference between the types and the present specimens is only in that the latter has slightly smaller chomata. In other respects they can not be distinguished from the types.

The present specimens are similar to the types of *Rugosofusulina serrata* RAUSER-CERNOUSSOVA (1937, pl. 2, fig. 4–6) and the variant forms (pl. 1, figs. 8, 9; pl. 2, figs. 1, 2) of the species, but differs in having more weakly fluted septa and smaller shells.

The specimens identified by TORIYAMA (1958, p. 110, pl. 11, figs. 14–25) from the Akiyoshi Limestone have concave lateral slopes, and they may be differentiated from this species.

Occurrence.—Abundant in the *Rugosofusulina arctica* subzone, the lower part of the *Pseudoschwagerina* zone; the associated fossils are *Quasifusulina longissima ultima*, *Triticites ozawai*, *T. montiparus*, *T. obai*, *T. haydeni*, *T. kawanoboriensis*, *T.* sp. cf. *T. pseudosimplex*, *T.* sp. aff. *T. subventricosus*, *Chusenella* sp. aff. *C. schwagerinaeformis*, *C.*? *atetsuensis*, etc.

Genus *Triticites* GIRTY, 1904

Type-species.—*Miliolites secalicus* SAY, 1823

Triticites obai TORIYAMA
Pl. XXV, figs. 1-9, 11–18, 30(?)

1925. *Schellwienia subobsoleta* OZAWA. Jour. Coll. Sci. Imp. Univ. Tokyo, Vol. 45, Art. 6, pp. 41-42, pl. 5, figs. 2; pl. 9, figs. 2, 4, 6(?), 7 (right); non pl. 9, figs. 5, 7.
1934. *Triticites subobsoletus*, CHEN. Paleontologia Sinica, Ser. B, Vol. 4, fasc. 2, pp. 33-34, pl. 4, fig. 18.
1958. *Triticites (Rauserites) subobsoletus*, ROSOVSKAYA. Akad. Nauk. S.S.S.R., Trudy Geol. Inst., B. 13, Ser. 98, Tab. 8, fig. 11-13.
1958. *Triticites obai*, TORIYAMA. Mem. Fac. Sci. Kyushu Univ., Ser. D, Vol. 7, pp. 105-107, pl. 11, figs. 1-7.
1961. *Triticites obai*, NOGAMI. Mem. Coll. Sci. Univ. Kyoto, Ser. B, Vol. 27, No. 3, pp. 168-169, pl. 2, figs. 8-11.

* SCHELLWIEN (1908) distinguished two forms in this species, megalospheric and microspheric. As already pointed out by TORIYAMA (1958), however, they are only showing variation among individuals.

Diagnosis.—The shell of *Triticites obai* TORIYAMA is fusiform, having a straight axis of coiling and bluntly pointed poles. The lateral slopes are convex to nearly straight. The mature shells of the five to six volutions are about 3.50 mm. long and 1.50 to 1.70 mm. wide, giving form ratios of 1.8 to 2.1. The ratios of the half length to the radius vector of the first to the sixth volution of the specimen illustrated as fig. 18 of Pl. XXV (AZ-SA 6-79) are 2.0, 1.5, 1.7, 1.7, 2.0 and 2.1, respectively.

The proloculus is small and spherical. Its outside diameter varies from 100 to 250 microns in ten specimens. The shell expands slowly in the first three volutions but beyond the third the expansion of the shell becomes rapid. The radius vectors of the first to the sixth volution in ten specimens are 94–188, 150–283, 250–528, 377–661, 650–950 and 950–1.000 microns, respectively. The height of chambers is uniform in the central two-thirds of the shell, but increases towards the extreme polar areas.

The spirotheca is thin and finely alveolar. The thickness of the spirotheca in ten specimens of the first to the sixth volution is 18–27, 18–37, 18–37, 27–41, 37–69 and 69–93 microns, respectively. The septa are closely spaced and strongly fluted. The chomata are asymmetrical. The tunnel is low and narrow in the inner volutions but widens in the outer one. The tunnel angles of the first to the fifth volution of the specimen illustrated as figs. 18 of Pl. XXV (AZ-SA 6-79) are 28, 25, 33, 40 and 46, respectively.

TABLE 13. TABLE OF MEASUREMENTS OF *Triticites obai* TORIYAMA (in millimeters)

Specimen	Rg. No.	Pl.	fig.	L.	W.	R.	Prol.	Radius vector 1	2	3	4	5	6
1	IGSH-AZ-SA 6-39	25	14	3.50	1.70	2.1	.15	.10	.20	.35	.60	.90	
2	IGSH-AZ-SA 6-79	25	18	3.50(+)	1.80	2.0	.15	.10	.20	.30	.45	.65	.95
3	IGSH-AZ-SA 6-74	25	16	3.00(+)	1.70	1.8	.10	.10	.15	.25	.45	.70	1.00
4	IGSH-AZ-SA 6-70(a)	25	12	2.50	1.21	2.3	.20	.10	.15	.25	.40	.60	
5	IGSH-AZ-SA 6-70(b)	25	11	2.25	1.30	1.7	.15	.10	.20	.30	.45	.65	
6	IGSH-AZ-SA 6-24			6.00	2.25	2.7	.20	.15	.25	.40	.65	1.00	1.25

Specimen	Half length 1	2	3	4	5	6	Ratio of Hl. to Rv. 1	2	3	4	5	6	Thickness of spirotheca 0	1	2	3	4	5	6
1	.15	.30	.70	1.40	2.10		1.5	1.5	2.0	2.3	2.3		.027	.027	.029	.041	.050	.069	
2	.20	.30	.50	.85	1.30	2.00	2.0	1.5	1.7	1.7	2.0	2.1	.023	.023	.029	.034	.057	.041	.069
3	.10	.20	.40	.75	1.10	1.60	1.0	1.3	1.6	1.7	1.6	1.6(+)	.013	.018	.023	.027	.041	.048	.093
4	.10	.20	.40	.85	1.30		1.0	1.3	1.6	2.1	2.1		.011	.018	.023	.034	.046	.057	
5	.10	.25	.35	.55	1.05		1.0	1.3	1.2	1.2	1.7		.023	.027	.034	.041	.034	.052	
6	.20	.50	.80	1.60	2.25	3.25	1.3	2.0	2.0	2.1	2.3		.032	.023	.034	.039	.062	.085	.115

Remarks.—The specimens are quite identical with the types of *Triticites obai* TORIYAMA described from the Akiyoshi Limestone in the shell-shape, the size, the proloculus diameter, the radius vectors, the spirothecal thickness, the septal fluting, and the tunnel angles.

OZAWA's *Schellwienia subobsoleta* (1925, pp. 41–42, pl. 5, fig. 2; pl. 9, figs. 2, 4, 5, 6, 7) from the Akiyoshi Limestone, which was transferred by CHEN (1934) to the genus *Triticites* includes two forms as pointed out by TORIYAMA (1958) and NOGAMI (1961). One is represented by the specimen of fig. 2 of pl. 5 and is safely referable to *Triticites obai* in the shape, the measured values, and the internal characters of the shell, although it was once referred by Hujimoto (1936) to *Pseudofusulina parvula*, and the other by that of the left side of fig. 7 of pl. 9, which should be designated as the lectotype of *T. subobsoletus*. The former can be easily distinguished from the latter in having a strongly fluted septa and more massive and asymmetrical chomata.

Occurrence.—Common in the *Rugosofusulina arctica* subzone, the lower part of the *Pseudoschwagerina* zone; the associated fusulinids are the same as those of *Rugosofusulina arctica* (SCHELLWIEN).

Triticites kawanoboriensis HUZIMOTO
Pl. XXVI, figs. 1–6

1937. *Triticites kawanoboriensis* HUZIMOTO. Japan. Jour. Geol. Geogr. Vol. 27, Nos. 3-4, pp. 118-119, pl. 7, figs. 1-7.
1957. *Triticites kawanoboriensis*, SAKAGAMI and OMATA. Ibid., Vol. 28, No. 4, pp. 255-256, pl. 20, figs. 7, 8.
1958. *Triticites kawanoboriensis*, TORIYAMA. Mem. Fac. Sci. Kyushu. Univ. Ser. D, Vol. 7, pp. 107-108, pl. 11, figs. 8-13.

Description.—The shell of the present species is small and inflated fusiform, having a straight axis of coiling, convex lateral slopes and bluntly pointed poles. The specimens of five volutions are 2.95 to 4.75 mm. long and 1.25 to 2.00 mm. wide, giving form ratios of 2.1 to 2.7. The ratios of the half length to the radius vector for the first to the fifth volution in six specimens are 1.0–2.2, 1.3–2.3, 1.5–2.5, 1.8–2.8 and 2.0–2.8, respectively.

The proloculus is small and spherical. Its outside diameter ranges from 100 to 200 microns, mostly 150 to 200 microns. The shell tightly coiled in the inner two volutions and expands rapidly in the outer volutions. The radius vectors of six specimens are 113–188, 188–283, 321–434, 434–642 and 642–868 microns, respectively, for the first to the fifth volution. The chamber increases gradually in height toward the polar regions.

The spirotheca is moderately thick. In the outer three volutions it is composed of a tectum and a keriotheca with fine alveori. In the first to the second volution, however, the spirotheca consists of a tectum and the upper and lower tectoria. The thickness of the spirotheca in six specimens is 18, 18–56, 37–56, 37–56 and 56 microns, respectively, for the first to the fifth volution. The proloculus wall is thin and seems to be composed of a single dense layer, having the thickness of 18 microns.

The septa are thin and the septal counts in the inner three volutions are 7 to 16, in the outer two 15 to 20. The septal fluting is weak in the central part of the shell and is complicated in the polar regions.

The chomata are somewhat small. They are asymmetrical in the inner two volutions but become symmetrical in the outer volutions. The tunnel is low and narrow in the inner two volutions and becomes wider in the outer volutions. The tunnel angles are about 25 degrees in the inner volutions and about 32 degrees in the outer ones.

TABLE 14. TABLE OF MEASUREMENTS OF *Triticites kawanoboriensis* HUZIMOTO (in millimete)

Speci-men	Rg. No.	Pl.	fig.	L.	W.	R.	Prol.	Radius vector				
								1	2	3	4	5
1	IGSH-KU-SA 2-1	26	2	3.75	1.85	2.1	.20	.188	.283	.434	.642	.868
2	IGSH-KU-SA 2-10	26	1	4.75	2.00	2.4	.20	.151	.245	.377	.566	.850
3	IGSH-KU-SA 2-64			3.50	1.35	2.6	.15	.132	.188	.283	.434	.642
4	IGSH-KU-SA 2-9(b)			4.00	1.50	2.7	.20	.132	.226	.377	.566	.831
5	IGSH-KU-SA 2-27			2.95	1.25	2.4	.10	.188	.245	.340	.491	.698
6	IGSH-KU-SA 2-4(a)			3.75	1.65	2.3	.15	.113	.188	.321	.528	.755

Speci-men	Half length					Ratio of Hl. to Rv.					Thickness of Spirotheca					
	1	2	3	4	5	1	2	3	4	5	0	1	2	3	4	5
1	.188	.472	.661	1.133	1.794	1.0	1.9	1.5	1.8	2.1	.018	.018	.018	.037	.037	.056
2	.283	.566	.944	1.605	2.361	1.9	2.3	2.5	2.8	2.8	.018	.018	.018	.037	.056	.056
3	.188	.377	.661	1.038	1.512	1.4	2.0	2.3	2.4	2.4	.018	.018	.018	.056	.037	
4	.283	.472	.755	1.227	1.889	2.2	2.1	2.0	2.2	2.3	.018	.018	.056	.056	.056	.056
5	.188	.321	.566	.944	1.416	1.0	1.3	1.7	1.9	2.0	.018	.018	.037	.056	.056	.056
6	.113	.340	.566	.944	1.511	1.0	1.8	1.8	1.8	2.0	.018	.018	.037	.037	.037	.056

Remarks.—The present species quite agrees with *Triticites kawanoboriensis* HUZIMOTO described from Kyushu in the shell-shape, the radius vectors, the septal fluting, the spirothecal thickness, the proloculus diameter and the other internal modes. Thus the present species may be referable to *T. kawanoboriensis.*

Triticites kawanoboriensis HUZIMOTO resembles *Triticites isaensis* TORIYAMA from the *Triticites simplex* subzone (Pl. α) and the *Pseudofusulina vulgaris* subzone (Pl. β) of the Akiyoshi Limestone in having small size of the shell and considerably intense septal fluting. The spirotheca of the holotype of TORIYAMA (GK, D 822) is three layered wall which is composed of a tectum and the inner and the outer tectorium in the first volution, beyond the second it consists of the tectum and the keriotheca with alveoli. In this point, my specimens quite resemble the holotype. However, *Triticites kawanoboriensis* HUZIMOTO can be distinguished from *T. isaensis* by its slightly larger shell, larger from ratio and more massive chomata.

In the general shell-shape, *Triticites kawanoboriensis* HUJIMOTO somewhat resembles

Triticites kuroiwaensis TORIYAMA (1958, pp. 113-115, pl. 12, figs. 1–12) from the Akiyoshi Limestone. The principal distinguishing features between them are that the former has a slightly larger shell, rapider expansion of the shell, a slightly smaller proloculus and a slightly thicker spirotheca.

Triticites kawanoboriensis is somewhat allied to *T. simplex* (SCHELLWIEN) in some respects. However, *T. kawanoboriensis* can be distinguished by its slower expansion, stronger septal fluting, smaller chomata and smaller proloculus.

The present species resembles *Triticites obai* TORIYAMA (1958, pp. 105–107, pl. 11, figs. 1–7) from Pl. α of *Triticites simplex* subzone in the Akiyoshi Limestone. The former, however, differs from the latter in having more inflated fusiform, smaller proloculus, thinner spirotheca, more rapid rate of expansion, and more tightly coiling in the inner volutions.

Triticites arctica (SCHELLWIEN) of TORIYAMA (1958, pp. 110–112) from the Akiyoshi Limestone is somewhat allied to the present specimens in some respects. They are, however, distinguishable in that *T. arctica* has larger shell, more elongate fusiform, larger proloculus, and thicker spirotheca.

In the outline of the shell and its size, the species under consideration is slightly similar to *Triticites confertus* THOMPSON (1954, pp. 38–39, pl. 8, figs. 11–22) from the Waldrip beds, southwest of Rockwood, Texas and the Five Point Limestone of Kansas, but *T. confertus* has more number of volutions, considerably thicker spirotheca, less strongly fluted septa and more massive and distinct chomata than those of my specimens.

Occurrence.—The species was collected from the following localities; loc. KU-SA2, TA-SA338, NA-SA107 and others. The associated fusulinids are the same as those of *Rugosofusulina arctica* SCHELLWIEN: the *Rugosofusulina arctica* subzone, the lower part of the *Pseudoschwagerina* zone.

Triticites sp. cf. *T. pseudosimplex* CHEN
Pl. XXIV, fig. 20

1934. *Triticites pseudosimplex* CHEN. Acad. Sinica, Monogr. National Research Institute of Geol. Ser. A, Vol. 5, pp. 25-26, pl. 1, figs. 19-20.
1956. *Triticites pseudosimplex*, KOCHANSKY-DEVIDÉ. Extrait de Rad de l'Académie Yougoslave, Tome 305, pp .18-19, Taf. 3, figs. 3-6.

Descriptive remarks.—The shell of the present species is cylindrical fusiform, having a straight axis of coiling, rounded poles, and straight to slightly convex lateral slopes. A mature shell of six volutions illustrated as fig. 20 on Pl. XXIV is 4.75 mm. long and 1.65 mm. wide, giving a form ratio of 2.8. The ratios of the half length to the radius vector of the first to the sixth volution in the same specimen are 1.4, 1.9, 2.0, 2.1, 2.6 and 2.8, respectively.

The proloculus is small and its outside diameter measures 151 microns. The inner volutions are tightly coiled, but outer ones are rather loosely coiled. The radius

TABLE 15. TABLE OF MEASUREMENTS OF *Triticites* sp. cf. *T. pseudosimplex* CHEN (in millimeters)

Specimen	Rg. No.	Pl.	fig.	L.	W.	R.	Prol.	Radius vector 1	2	3	4	5	6
1	IGSH-KU-SA 2-59(b)	24	20	4.75	1.65	2.8	.151	.094	.151	.226	.358	.582	.849

Specimen	Half length 1	2	3	4	5	6	Ratio of Hl. to Rv. 1	2	3	4	5	6	Thickness of spirotheca 0	1	2	3	4	5	6
1	.132	.283	.472	.755	1.511	2.361	1.4	1.9	2.0	2.1	2.6	2.8	.023	.025	.034	.041	.043	.055	.078

vectors of the first to the sixth volution in the above mentioned specimen are 94, 151, 226, 358, 582 and 849 microns, respectively. The chamber is nearly uniform in height to near the extreme polar ends, where they become slightly higher.

The spirotheca is rather thick. The thickness of the spirotheca in the first to the sixth volution of the specimen is 25, 34, 41, 43, 55 and 78 microns, respectively. The proloculus wall is thin and its thickness is 23 microns.

The septa are strongly folded in the lateral regions. The septal counts are unknown because of the lack of the well-oriented sagittal sections.

The chomata are small and asymmetrical. The tunnel has a more or less irregular path and is about a half as high as the chambers. The tunnel angles of the second to the fourth volution in the specimen are 28, 31 and 42 degrees, respectively.

Triticites pseudosimplex was originally described by CHEN (1934) from the Swine Limestone of South China based on two parallel sections, and recently KOCHANSKY-DEVIDÉ identified the same species from the Permian rocks of Lika in Jugoslavia. The present specimen illustrated here well agrees with the types of the species and with the specimens of KOCHANSKY-DEVIDÉ in the shell structure.

Triticites sp. cf. *T. pseudosimplex* somewhat resembles *Rugosofusulina arctica* (SHELLWIEN) in general shell-shape. However, the former species can be distinguished by its closely coiled inner volutions, smaller proloculus and stronger septal fluting.

Occurrence.—Rare in the *Rugosofusulina arctica* subzone, the lower part of the *Pseudoschwagerina* zone; the associated fusulinids are the same as those of *Rugosofusulina arctica* (SCHELLWIEN).

Triticites sp. aff. *T. subventricosus* DUNBAR and SKINNER
Pl. XXV, figs. 31-32

1937. *Triticites subventricosus* DUNBAR and SKINNER. Univ. Texas, Bull. No. 3701, Geol. Texas, Vol. 3, Pt. 2, pp. 619-620, pl. 49, figs. 15-23.
1958. *Triticites subventricosus*, Kanuma. Bull. Tokyo Gakugei Univ., Vol. 9, p. 47, pl. 3, figs. 16-17.

Descriptive remarks.—The shell of the species under the above heading *Triticites subventricosus* DUNBAR and SKINNER is thickly elongate fusiform with a straight axis of coiling and bluntly pointed poles. The lateral slopes are straight to slightly convex. A typical form of seven volutions illustrated as fig. 31 on Pl. XXV (KU-SA 2-20) is 5.55 mm. long and 2.30 mm. wide, attaining a form ratio of 2.4. The inner three volutions are subspherical, but beyond the fourth volution the shell becomes of its mature shape. The ratios of the half length to the radius vector of the first to the seventh volution of a specimen are 1.0, 1.7, 2.4, 2.4, 2.5, 2.6 and 2.2, respectively.

The proloculus is small and spherical, with outside diameter of 100 to 150 microns. The shell expands slowly in the inner four volutions but in the succeeding ones the rate of expansion becomes rapid and almost uniform. The radius vectors of the first to the seventh volution in a specimen are 100, 150, 250, 400, 600, 850 and 1.150 microns, respectively. The chamber is of about uniform height throughout their length except the polar areas.

The spirotheca is rather thick. The thickness of the spirotheca of the first to the seventh volution in a specimen is 20, 23, 23, 39, 46, 92 and 80 microns, respectively. The proloculus wall is thin and its thickness is measured as 18 microns.

The septa are fluted across the lateral portion of the shell, becoming rather strongly but irregularly near the poles. Since no well oriented sagittal section has been obtained, the septal counts cannot be known.

The chomata are small and asymmetrical. The tunnel is low and narrow in the inner volutions and becomes gradually wider in the outer ones. Its path is almost straight. The tunnel angles in the second to the sixth volution of a specimen are 29, 33, 32, 43 and 46 degrees, respectively.

The specimen here illustrated from *Pseudoschwagerina* zone of the Atetsu Limestone agrees in the measurable details and the general internal characters of the shell with the types of *Triticites subventricosus* Dunbar and Skinner from the lower part of the Wolfcamp formation of Glass Mountains, Texas, but it has more compact inner volutions, more strongly fluted septa, and less massive chomata.

In Japan Kanuma (1958) identified the same species from the Okumyōgata formation of the southern part of the Hida Plateau. His specimens are similar to the lectotype in some internal characters, but the septal fluting of his species is fairly stronger than that of the types.

Triticites sp. aff. *T. subventricosus* resembles *Rugosofusulina arctica* (Schellwien) somewhat closely. However, the former species is elongate fusiform, and has a number of volutions, smaller proloculus, and thicker spirotheca. *Triticites* sp. aff. *T. subventricosus* also resembles *T. pseudosimplex* Chen (1934, pp. 25-26, pl. 1, figs. 19-20) somewhat closely. Major differences between these forms are in that *T.* sp. aff. *T. subventricosus* is larger at maturity and elongate fusiform, and has slightly larger tunnel angles. The general shell-shape of *T. subventricosus* is similar to that of *T. pusillus* (Schellwien) (1898, pp. 253-255, pl. 20, figs. 8-14). These forms may be distinguished easily, however, by the thicker spirotheca of *T.* sp. aff. *T. subventricosus*, its higher chambers for corresponding volutions, its more massive chomata, and its absence of the secondary deposits. *Triticites* sp. aff. *T. subventricosus* is like *T. uddeni*

TABLE 16. TABLE OF MEASUREMENTS OF *Triticites* sp. aff. *T. subventricosus* DUNBAR and SKINNER (in millimeters)

Specimen	Rg. No.	Pl.	fig.	L.	W.	R.	Prol.	Radius vector 1	2	3	4	5	6	7
1	IGSH-KU-SA 2-20	25	31	5.55	2.30	2.4	.10	.10	.15	.25	.40	.60	.85	1.15
2	IGSH-KU-SA 2-40	25	32	5.00(+)	2.15	2.3	.15	.10	.20	.35	.60	.90	1.20	

Specimen	Half length 1	2	3	4	5	6	7	Ratio of Hl. to Rv. 1	2	3	4	5	6	7	Thickness of spirotheca 0	1	2	3	4	5	6	7
1	.10	.25	.60	.95	1.50	2.25	2.50	1.0	1.7	2.4	2.4	2.5	2.6	2.2	.011	.020	.023	.023	.039	.046	.092	.080
2	.25	.50	.75	1.45	2.30			2.5	2.5	2.2	2.4	2.5			.018	.020	.023	.027	.029	.055	.057	

TABLE 17. TABLE OF MEASUREMENTS OF *Chusenella* sp. aff. *C. schwagerinaeformis* SHENG (in millimeters)

Specimen	Rg. No.	Pl.	fig.	L.	W.	R.	Prol.	Radius vector 1	2	3	4	5	6	7	8
1	IGSH-AZ-SA 6-48	27	12	4.40	2.45	1.8	.15	.10	.20	.30	.40	.50	.75	1.00	1.35
2	IGSH-AZ-SH 6-51	27	13	4.25	2.55	1.7	.15	.10	.20	.25	.40	.50	.80	1.10	1.35
3	IGSH-KU-SA 2-20			5.50	2.25	2.5	.10	.09	.15	.23	.34	.50	.77	1.13	
4	IGSH-KU-SA 2-47	24	18	4.00	1.40	2.9	.10	.09	.15	.23	.34	.51	.70		
5	IGSH-KU-SA 2-4	24	19	5.25	1.50	3.5	.15	.09	.13	.19	.28	.42	.59	.81	

Specimen	Half length 1	2	3	4	5	6	7	8	Ratio of Hl. to Rv. 1	2	3	4	5	6	7	8	Thickness of spirotheca 0	1	2	3	4	5	6	7	8
1	.10	.25	.50	.85	1.10	1.50	1.85	2.40	1.0	1.2	1.7	2.1	2.2	2.0	1.9	1.8	.027	.016	.013	.021	.032	.050	.059	.069	.085
2	.15	.35	.55	.75	1.10	1.60	2.00	2.60	1.5	1.8	2.2	1.9	2.2	2.0	1.8	1.9	.029	.023	.025	.029	.036	.041	.087	.085	.087
3	.11	.21	.42	.85	1.42	1.89	2.83		1.2	1.4	1.8	2.8	2.9	2.5	2.5		.018	.018	.018	.037	.056	.056			
4	.28	.51	.85	1.32	1.51	1.98			3.0	3.3	3.8	3.9	3.0	2.9			.009	.018	.018	.056	.037	.056	.056		
5	.19	.38	.57	.94	1.42	1.98	2.55		2.0	2.5	3.0	3.3	3.4	3.4	3.2		.018	.018	.018	.018	.037	.018	.037	.094	

DUNBAR and SKINNER (1937, pp. 616-617, pl. 47, figs. 1-11) in the general shell-shape but the former can be distinguished from the latter by its thinner spirotheca, its slower expansion of the shell, its narrower tunnel angles, and its weaker septal fluting.

Occurrence.—Rare in the *Rugosofusulina arctica* subzone, the lower part of the *Pseudoschwagerina* zone; the associated fusulinids are the same as those of *Rugosofusulina arctica* (SCHELLWIEN).

Genus *Chusenella* HSU, 1942

Type-species.—*Chusenella ishanensis* HSU, 1942.

Chusenella sp. aff. *C. schwagerinaeformis* SHENG
Pl. XXVII, figs. 11-13; Pl. XXIV, figs. 18?, 19?

Synonymy.—

1958. *Dunbarinella* sp. TORIYAMA. Mem. Fac. Sci. Kyushu Univ., Ser. D, Vol. 7, p. 125, pl. 13, figs. 21, 22.

Compare.—

1963. *Chusenella schwagerinaeformis* SHENG. Palaeontologia Sinica, N.S. B, No. 10, pp. 81, 211, pl. 23, figs. 1-6.

Description.—The shell of the species under the name of the heading is short fusiform, having a straight axis of coiling, bluntly pointed poles, and convex lateral slopes. Mature shells of eight volutions of the typical specimens (Pl. XXIII, figs. 11 -13) are 4.25 to 4.40 mm. long and 2.45 to 2.55 mm. wide, giving form ratios of 1.7 to 1.8. The ratios of the half lenght to the radius vector of two specimens (Pl. XXIII, figs. 11, 13) are 1.0, 1.2, 1.7, 2.1, 2.2, 2.0, 1.9 and 1.8, respectively, for the first to the eighth volution.

The proloculus is small and spherical, showing a small range of variation with the outside diameter mostly of 150 microns. The proloculus wall is thin, measuring about 28 microns. The shell is tightly coiled, especially in the inner five volutions. The radius vectors of the first to the eighth volution of one of the illustrated specimens (AZ-SA 6-51, Pl. XXIII, fig. 13) are 100, 200, 250, 400, 500, 800, 1.100 and 1.350 microns, respectively. The chamber is nearly the same in height throughout the length of the shell.

The spirotheca is thin and composed of a tectum and a finely alveolar keriotheca. The thickness of the spirotheca measured at the tunnel of the first to the eighth volution of a specimen (Pl. XXIII, fig. 13) is 23, 25, 29, 36, 41, 87, 85 and 87 microns, respectively.

The septa are thin and strongly fluted throughout the length of the shell. The number of the septa cannot be known because of the absence of the well oriented sagittal section. The rudimentary chomata are observed only in the inner volutions. The tunnel is low but considerably broad. Its path is somewhat irregular, with the tunnel angles of 30, 29, 25, 34 and 31 degrees, respectively, for the second to the sixth volution. The heavy fillings occur in the axial and lateral regions commonly of the third to the sixth volutions.

Comparison and Remarks.—Two of the five specimens referred to this species have narrower, less dense axial fillings and seem to be somewhat more slender than the other three which, although slightly obliquely sectioned, were described above as typical for this species. They agree, however, quite well with the latter in the proloculus size, the very tight coiling of inner volutions, the thickness of the spirotheca, the mode of septal fluting, etc.

In having the minute proloculus, the tightly coiled inner volutions with very thin spirotheca and almost unfluted septa, the rather rapidly expanded outer volutions, and the dense and commonly wide axial fillings, this species is most safely referable to *Chusenella* Hsu than to any of the known genera of the Schwagerininae.

This species cannot be distinguished from the species described by TORIYAMA (1958, p. 125) as *Dunbarinella* sp. A (pl. 13, figs. 21, 22) from the Pl. β zone of the Akiyoshi Limestone Group.

This species is close to *Chusenella schwagerinaeformis* SHENG (1963, p. 211, pl. 23, figs. 1–6) from the Maokou Limestone Near Pingding Village of Desheng, Yishan of Kwangsi in the shell size, the proloculus size, the tightly coiled inner volutions, the thickness of the spirotheca, the mode of septal fluting and the other internal characters of the shell. Thus the Atetsu specimens may be referable to *C. schwagerinaeformis*, but as they are not well oriented, the precise comparison cannot be made.

This species somewhat resembles *Dunbarinella alpina* KOCHANSKY (pp. 410–412, pl. 1, figs. 9–10; pl. 2, figs. 1–6) from Straža bei Bled, Julische Alpen, but it can be distinguished by its smaller shell, its slightly thinner spirotheca and its slightly weaker septal fluting in the outer volutions and its smaller chomata.

Occurrence.—Rarely found in the *Pseudoschwagerina kanmerai* subzone, the upper part of the *Pseudoschwagerina* zone; the associated fusulinids are *Pseudofusulina regularis*, *P. vulgaris*, *Schwagerina okafujii*, *S.* sp., *Pseudoschwagerina saigusai*, *P. pavlovi*, *P. muongthensis*, and *P. kanmerai*.

Chusenella? atetsuensis, sp. nov.
Pl. XXVI, figs. 12–18

Description.—The shell of *Chusenella? atetsuensis* sp. nov. is small and slender, elongate-fusiform to subcylindrical, with a straight axis of coiling, slightly convex lateral slopes, and bluntly pointed poles. The shell of six to seven volutions is 2.75 to 4.50 mm. long and 0.75 mm. wide, giving the form ratios of 3.6 to 4.5. The ratios of the half length to the radius vector in the first to the seventh volution are 2.5–3.3, 2.5–

4.0, 2.5–4.4, 2.5–3.8, 2.5–3.5 and 3.0, respectively.

The proloculus is very minute and its outside diameter varies from 37 to 94 microns, mostly from 56 to 75 microns. The shell is slender, closely coiled and tapered to acute poles in the inner three to four volutions, and beyond the fifth volution it is not only highly elongated but also rather rapidly expanded assuming a subcylindrical to elongate triangular shape. The radius vectors of the first to the seventh volution are 37–75, 75–113, 113–217, 151–284, 226–415, 377–585 and 755 microns, respectively. The chamber is almost the same in height in the central two-thirds of the shell and becomes slightly higher in the polar regions.

The spirotheca is very thin and increases gradually as the shell grows. In the inner volutions it consists of a tectum and a extremely thin, less dense structureless lower layer in the inner volutions, but in the outer volutions it is composed of a tectum and a rather coarse alveolar keriotheca. The thickness of the spirotheca of the first to the seventh volution is 9–18, 18–75, 18–37, 18–37, 27–56, 37–75 and 75 microns, respectively. The axial sections show a distinct rugosity of the spirotheca. The proloculus wall is composed of a single structureless dense material. Its thickness is 9 to 18 microns, mostly 18 microns.

The septa are thin and widely spaced. The septal counts of the first to the fifth volution in a specimen are 5, 10, 10, 14 and 16, respectively. The septa are plane in the inner three to three and a half volutions, and are weakly fluted in the polar ends of the succeeding one or two volutions. In the outer volutions the septal fluting reaches nearly tops of the chambers in the polar regions, but is low in the central area, where the septa are fluted along their lower parts and almost plane in their upper parts.

The chomata are present in all but the last volution, but they are quite small and low, especially in the inner volutions. The tunnel is wide and nearly straight. The tunnel angles in the third to the fifth volution are 30, 35–50 and 40–50 degrees, respectively.

Remarks and Comparison.—This species is referred to the genus *Chusenella* with a query. It is characterized by a minute proloculus, very tightly coiled inner volutions with acute polar ends and low and straight lateral slopes, very thin spirotheca and questionable chomata in the inner volutions, and axial filling. These features of the proloculus and juvenaria of the species agree quite well with those of the early volutions of the type-species of *Chusenella*, *C. ishanensis* Hsu, on one hand, and with those of "*Boultonia*" *rawi* Lee (*Wedekindellina*? of authors) on the other. The distinctions among these are clear and are needless to mention here. However, the close resemblance of the morphological features in the juvenaria including proloculus suggest that they are probably phylogenetically related, and the present species may be an ancestor of such a species-group of *Chusenella* as *C. ciboloensis* Stewart, *C. alpina pristina* (Kochansky-Devidé) and *C. tieni* (Chen).

The present species cannot be referred to the genera *Triticites* and *Kansanella*,

TABLE 18. TABLE OF MEASUREMENTS OF *Chusenella? atetsuensis*, sp. nov. (in millimters)

Specimen	Rg. No.	Pl.	fig.	L.	W.	R.	Prol.	Radius vector						
								1	2	3	4	5	6	7
1	IGSH-KU-SA 2-17	26	1	4.50	1.10	4.1	.037	.075	.113	.188	.245	.415	.585	
2	IGSH-KU-SA 2-9(a)	26	12	3.75	1.00	3.7	.075	.075	.113	.171	.283	.415	.585	
3	IGSH-KU-SA 2-26(b)			2.25 (H)	1.00	4.5	.075	.056	.094	.188	.264	.377	.566	
4	IGSH-KU-SA 2-41			2.75	0.75	3.7	.056	.037	.075	.113	.151	.226	.377	
5	IGSH-KU-SA 2-50	26	17	2.25 (H)	1.30	3.6	.094	.056	.094	.151	.226	.340	.566	.755

Specimen	Half length							Ratio of Hl. to Rv.							Thickness of spirotheca							
	1	2	3	4	5	6	7	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7
1	.188	.377	.665	.850	1.322	1.889		2.5	3.4	3.5	3.5	3.2	3.0		.018	.018	.018	.018	.018	.027	.037	
2	.188	.377	.661	.944	1.322	1.700		2.5	3.4	4.4	3.3	3.2	3.0		.018	.018	.075	.035	.037	.056	.075	
3	.188	.377	.661	.850	1.416	1.983		3.3	4.0	3.5	3.2	3.8	3.5		.009	.009	.018	.027	.018	.037		
4	.094	.188	.377	.566	.850	1.227		2.5	2.5	3.4	3.8	3.8	3.3		.018	.009	.018	.018	.018	.037	.056	
5	.188	.283	.377	.566	.793	1.416	2.266	3.3	3.0	2.5	2.5	2.3	2.5	3.0	.018	.018	.018	.037	.037	.056	.075	.075

although it shows nearly the same stage of development as the species of those genera in the schwagerininae. Because it has no appreciable chomata in the early volutions.

The species most closely similar to the present species are "*Pseudofusulina paragregaria paragregaria* RAUSER-CERNOUSSOVA (1940, pp. 81–82, pl. 2, figs. 5–7; 1958, RAUSER-CERNOUSSOVA and SCHERBOVICH, pp. 35–36, pl. 2, figs. 13–14) and *P. paragregaria tumida* SCHERBOVICH (1958, RAUSER-CERNOUSSOVA and SCHERBOVICH, p. 36, pl. 2, fig. 15), but the present species has a less dense and narrower axial filling.

The present species is similar to *Pseudofusulina iwaizakiensis* MORIKAWA (1960, p. 290, pl. 48, figs. 1–9) and *Pseudofusulina gregaria* (Lee) by MORIKAWA (1960, p. 281, pl. 47, figs. 10–12; probably conspecific with *P. iwaizakiensis*) from the *Yabeina shiraiwensis* zone of the Iwaizaki Limestone of the Kitakami Massif. It differs, however, from the latter two species in its smaller shell and weaker septal fluting.

The present species has a similar appearance in the general shell structures to *Kwantoella fujimotoi* SAKAGAMI and OMATA (1957, p. 252, pl. 19, figs. 5–7), but it is clearly distinguishable in its different spirothecal structure and stronger septal fluting and much larger shell.

Occurrence.—Rarely found in the *Rugosofusulina arctica* subzone, the lower part of the *Pseudoschwagerina* zone; the associated fusulinids are the same as those of *Rugosofusulina arctica* (SCHELLWIEN).

Genus *Pseudofusulina* DUNBAR & SKINNER, 1931

Type-species.—*Pseudofusulina huecoensis* DUNBAR & SKINNER, 1931.

Pseudofusulina regularis (SCHELLWIEN)
Pl. XXVI, figs. 8–11; Pl. XXVII, figs. 9–10

1898. *Fusulinella regularis* SCHELLWIEN. Palaeontographica, Vol. 44, pp. 250-251, pl. 19, figs. 1-6.
1930. *Pseudofusulina regularis*, HUZIMOTO. Sci. Rept., Tokyo Bunrika Daigaku, Sec. C, Vol. 1, No. 2, pp. 94-95, pl. 10, figs. 9-11; pl. 18, fig. 1.
1912. ?*Fusulina regularis*, DEPRAT. Mém. Service Géol. Indochine, Vol. 1, fasc. 3, pp. 28-29, pl. 7, figs. 14-15.
1927. ?*Schellwienia regularis*, LEE. Palaeontologia Sinica, Ser. B, Vol. 4, fasc. 1, pp. 50-52, pl. 7, figs. 8-10.
1958. *Pseudofusulina regularis*, KANMERA. Mem. Fac. Sci. Kyushu Univ., Vol. 6, No. 3, pp. 194-196, pl. 33, figs. 1-10.

Descriptive remarks.—The shell of the present species is moderate and inflated fusiform, with a straight axis of coiling and bluntly pointed poles. The lateral slopes are straight to slightly convex. The number of volution is generally five, but sometimes six. The specimens of five to six volutions are 3.50 to 5.00 mm. long and 1.35 to 3.60 mm. wide, giving form ratios of 2.1 to 2.6. The inner two volutions are subspherical, and beyond the third volution the shell assumes its mature shape. The

TABLE 19. TABLE OF MEASUREMENTS OF *Pseudofusulina regularis* (SCHELLWIEN) (in millimeters)

Specimen	Rg. No.	Pl.	fig.	L.	W.	R.	Prol.	Radius vector 1	2	3	4	5	6
1	IGSH-KU-SA 2-23	26	10	4.00	1.90	2.1	.05	.188	.302	.396	.755	1.057	
2	IGSH-KU-SA 2-36	26	8	5.00	2.10	2.4	.25	.188	.377	.623	.963	1.227	
3	IGSH-KU-SA 2-60	26	11	4.00	3.60	2.5	.15	.132	.226	.377	.566	.755	
4	IGSH-KU-SA 2-31			4.00	1.65	2.4	.25	.188	.283	.434	.604	.850	
5	IGSH-KU-SA 2-11 (a)			1.75(H)	1.35	2.6	.10	.113	.188	.283	.472	.661	
6	IGSH-KU-SA 2-11 (b)			4.00	1.75	2.3	.15	.113	.188	.302	.472	.717	.963
7	IGSH-KU-SA 2-55			3.50	1.50	2.3	.10	.113	.188	.283	.415	.623	.887
8	IGSH-KU-SA 2-68	26	9	4.50	1.90	2.4	.15	.113	.226	.415	.604	1.001	
9	IGSH-KU-SA 2-30			3.50	1.40	2.5	.10	.113	.207	.340	.547		
10	IGSH-KU-SA 2-2			3.50	1.50	2.3	.15	.132	.283	.415	.604	.831	

Specimen	Half length 1	2	3	4	5	6	Ratio of Hl. to Rv. 1	2	3	4	5	6	Thickness of spirotheca 0	1	2	3	4	5	6
1	.283	.472	.850	1.511	2.077		1.5	1.6	2.2	2.0	2.0		.018	.018	.037	.056	.094		
2	.283	.604	1.038	1.511	2.266		1.5	1.6	1.7	1.6	1.8		.037	.037	.037	.056	.094	.056	
3	.188	.377	.604	1.038	1.548		1.4	1.7	1.6	1.8	2.0		.018	.037	.037	.056	.075	.056	
4	.321	.566	.963	1.511	2.266		1.7	2.0	2.2	2.5	2.7		.018	.018	.037	.037	.075	.056	
5	.188	.377	.566	.944	1.700		1.6	2.0	2.0	2.0	2.6		.018	.018	.018	.018	.037	.056	
6	.188	.472	.661	1.038	1.322		1.6	2.5	2.2	2.2	1.8	2.0	.018	.018	.018	.037	.056	.056	.056
7	.188	.340	.566	1.038	1.511		1.6	1.8	2.0	2.0	2.4	2.4	.018	.018	.018	.037	.056	.075	.056
8	.188	.377	.755	1.322	2,077		1.6	1.7	1.8	2.2	2.2		.018	.018	.037	.056	.094	.056	
9	.188	.377	.661	1.038	1.700		1.6	1.3	1.9	1.9			.018	.018	.018	.037	.037		
10	.283	.566	.944	1.322	1.889		2.2	2.0	2.3	2.2	2.3		.018	.037	.037	.037	.037	.056	

ratios of the half length to the radius vectors of ten specimens are 1.4–2.2, 1.6–2.5, 1.6–2.3, 1.6–2.5, 1.8–2.7 and 2.0–2.4, respectively, for the first to the sixth volution.

The proloculus is small and spherical. Its outside diameter ranges from 50 to 250 microns, mostly 100 to 150 microns. The shell expands rather rapidly. The radius vectors of the first to the fifth volution of ten specimens are 113–188, 188–377, 283–623, 415–963 and 623–1.227 microns, respectively. The chamber increases in height toward the polar ends of the shell.

The spirotheca is thick and composed of a tectum and a keriotheca. The thickness of the spirotheca of the first to the fifth volution of ten specimens is 18–37, 18–37, 18–56, 37–94 and 56–75 microns, respectively. The proloculus wall is thick and its thickness is 18–37 microns, mostly 18 microns.

The septa are thick and closely spaced. They consist of the downward deflection of the tectum and a distinct pyconotheca. The septa are fluted throughout the shell, but in the central part the fluting is confined to their lower part. The average septal counts in the first to the fifth volution of five specimens are 7, 12, 16, 20 and 21, respectively.

The chomata are well developed and asymmetrical, being about as half as the height of chambers. The tunnel is narrow and its path is straight. The tunnel angle is about 30 degrees in the inner volutions and about 40 degrees in the outer ones.

Pseudofusulina regularis was originally described by SCHELLWIEN from the Carnic Alps. In Japan this species was identified and fully discussed by FUJIMOTO (HUZIMOTO, 1936) from the Kwanto Massif and by KANMERA (1958) from the Yayamadake Limestone in Kyushu. The Atetsu specimens well agree with the types and KANMERA's specimens in many essential characters such as the shell-shape, the expansion of the shell, the spirothecal thickness, and the septal fluting. They may be a conspecific.

Occurrence.—This species was obtained from loc. KU-SA2, TN-SA338, NA-SA107 and some other localities. They belong to the *Pseudoschwagerina kanmerai* subzone, the upper part of the *Pseudoschwagerina* zone; the associated fusulinids are the same as those of *Chusenella* sp. aff. *C. schwagerinaeformis*.

Genus *Pseudoschwagerina* DUNBAR and SKINNER, 1936

Type-species.—*Schwagerina uddeni* BEEDE and KNIKER, 1924.

Pseudoschwagerina saigusai NOGAMI
Pl. XXVII, figs. 1–5

Description.—The shell of *Pseudoschwagerina saigusai* is large and highly inflated fusiform, having a straight axis of coiling and bluntly pointed poles. The lateral slopes are convex. A mature specimen of seven volutions attains a length of 5.25 mm. and a width of 4.10 mm., giving a form ratio of 1.3. The ratios of the half length to the radius vector in the specimen illustrated as fig. 2 of Pl. XXVII (AZ-SA 6–76) are 1.0, 1.3, 1.7, 2.3, 1.9, 1.5 and 1.2, respectively, for the first to the seventh volution.

The proloculus is small and spherical, and its outside diameter measures 150 microns. The shell is very tightly coiled in the inner four volutions with sharply pointed poles, but beyond the fourth volution the shell expands rapidly. The radius vectors of the first to the seventh volution in a specimen (Pl. XXVII, fig. 2) are 100, 200, 300, 450, 950, 1.650 and 2.250 microns, respectively. The chamber is almost the same in height throughout the length of the shell except the extreme polar regions.

The spirotheca is thin in the inner three volutions but moderately thick in the outer volutions where it consists of a tectum and a coarsely alveolar keriotheca. The thickness of the spirotheca measured above the tunnel in the first to the seventh volution is 9, 29, 36, 46, 46, 80 and 80 microns, respectively. The proloculus wall is thin, measuring 27 microns in the specimen illustrated as fig. 1 of Pl. XXVII (AZ-SA 6–84).

The septa are numerous. They are almost plane in the inner volutions except in the polar areas and are rather intensely fluted in the outer volutions, especially in the lower part. The chomata are massive in the inner volutions, and is small and indistinct in the outer volutions. The tunnel is moderately broad and low.

Remarks and Comparison.—In many important characters the specimens at hand well agree with the types of *Pseudoschwagerina saigusai* NOGAMI (1961, pp. 179–181, pl. 2, figs. 12–15) from the Atetsu Limestone. They are slightly smaller than the types, but this is due probably to the incompleteness of one or two outermost volutions which have been apparently missing.

In the shape of the shell the present species resembles *Pseudoschwagerina minatoi* KANMERA (1958, pp. 179–181, pl. 28, figs. 1–8) from the Yayamadake Limestone. However, it can be distinguished by its smaller height of the chambers in outer volutions, more strongly fluted septa, and larger proloculus.

The present species is also similar to *Pseudoschwagerina morikawai*, which was described by IGO (1957) from the Hida Massif and by KANMERA (1958) from the Yayamadake Limestone in Kyushu in the general shell-shape throughout the growth. It is, however, distinguished in its smaller proloculus, thinner spirotheca for the corresponding volutions, and different types of septal fluting.

Occurrence.—Common in the *Pseudoschwagerina kanmerai* subzone, the upper part of the *Pseudoschwagerina* zone; the associated fusulinids are the same as those of *Pseudoschwagerina kanmerai*.

Pseudoschwagerina pavlovi (RAUSER-CERNOUSSOVA)
Pl. XXVIII, figs. 5–10

1938. *Schwagerina pavlovi* RAUSER-CERNOUSSOVA. Akada. Nauk., U.S.S.R. Paleont. Inst. Trudy, V. 7, pp. 127, 158, pl. 6, figs. 6, 7.
1959. *Schwagerina pavlovi*, RAUSER-CERNOUSSOVA. Akad. Nauk., U.S.S.R. Paleont. Inst. Trudy, V. 13, pl. 46, pl. 5, figs. 4, 5.
1962. *Pseudoschwagerina pavlovi*, ROSS and DUNBAR. Meddelelser om Greenland, Udgivne Af Kommissionen for Videnskabelige Undersegelser I Greenland, Bd. 167, Nr. 5, pp. 51-53, pl. 7, figs. 5-11.

Description.—The shell of *Pseudoschwagerina pavlovi* (RAUSER-CERNOUSSOVA) are large and spherical to subspherical, with a straight axis of coiling, broadly rounded poles and exclusively convex lateral slopes. The mature shell of seven volutions illustrated as fig. 5 of Pl. XXVIII (AZ-SA 6-3) is 4.40 mm. in length and 4.30 mm. in width, giving a form ratio of 1.0. The average ratios of the half length to the radius vector in some specimens are 1.0, 1.2, 1.7, 1.6, 1.4, 1.3 and 1.1, respectively for the first to the seventh volution.

The proloculus is minute and spherical, having an outside diameter of 50 microns in a specimen. The shell expands slowly during the first three volutions, but beyond the third volution the chambers increase in height rapidly. The radius vectors of the first to the seventh volution in a specimen are 50, 100, 200, 400, 850, 1.500 and

TABLE 20. TABLE OF MEASUREMENTS OF *Pseudoschwagerina saigusai* NOGAMI (in millimeters)

Specimen	Rg. No.	Pl.	fig.	L.	W.	R.	Prol.	Radius vector 1	2	3	4	5	6	7
1	IGSH-AZ-SA 6-76	27	2	5.25	4.10	1.3		.10	.20	.30	.45	.95	1.65	2.25
2	IGSH-AZ-SA 6-84	27	1	5.50	3.25	1.5	.15	.10	.20	.30	.45	.75	1.30	1.75

Specimen	Half length 1	2	3	4	5	6	7	Ratio of Hl. to Rv. 1	2	3	4	5	6	7	Thickness of spirotheca 0	1	2	3	4	5	6	7
1	.10	.25	.50	1.05	1.80	2.50	2.75	1.0	1.3	1.7	2.3	1.9	1.5	1.2		.009	.029	.036	.046	.046	.080	.080
2	.10	.25	.50	.75	1.25	1.95	2.60	1.0	1.3	1.7	1.7	1.7	1.5	1.5	.027	.023	.023	.032	.034	.041	.046	.092

TABLE 21. TABLE OF MEASUREMENTS OF *Pseudoschwagerina pavlovi* (RAUSER-CERNOUSSOVA) (in millimeters)

Specimen	Rg. No.	Pl.	fig.	L.	W.	R.	Prol.	Radius vector 1	2	3	4	5	6	7
1	IGSH-AZ-SA 6-3	28	5	4.40	4.30	1.0			.10	.20	.40	.85	1.50	2.10
2	IGSH-AZ-SA 6-50	28	8	4.10	3.05	1.3	.05	.05	.10	.20	.50	.95	1.60	

Specimen	Half length 1	2	3	4	5	6	7	Ratio of Hl. to Rv. 1	2	3	4	5	6	7	Thickness of spirotheca 0	1	2	3	4	5	6	7
1		.15	.35	.70	1.30	2.00	2.35		1.5	1.7	1.7	1.5	1.3	1.1		.021	.023	.034	.023	.059	.057	.073
2	.05	.10	.35	.70	1.25	2.10		1.0	1.0	1.7	1.4	1.3	1.3		.011	.013	.023	.025	.034	.039	.073	

2.500 microns, respectively. The height of the chambers is the same throughout the length of the shell except in the polar regions where it is slightly higher.

The spirotheca is very thin in the inner volutions but moderately thick in the outer volutions, where it consists of a tectum and a finely alveolar keriotheca. The thickness of the spirotheca measured above the tunnel in the first to the seventh volution is 21, 23, 34, 23, 59, 57 and 73 microns, respectively. The proloculus wall is thin and its thickness is 11 microns in a specimen.

The septa are thin and nearly plane throughout the length of the shell. The chomata are very small in the inner volutions, but they are commonly indistinct in the outer two or three volutions. The tunnel is low and narrow with a regular path, and the tunnel angles in the third to the sixth volution are 29, 27, 23 and 25 degrees, respectively, in a typical specimen (Pl. XXVIII, fig. 5).

Remarks.—*Pseudoschwagerina pavlovi* (RAUSER-CERNOUSSOVA) (1938) was described from the early Permian (Sakmarian) of Petschoraland on the west flank of the northern Urals and was recently identified by ROSS and DUNBAR (1962) from northeast Greenland. The size and the internal characters of the specimens here dealt with from the Atetsu Limestone agree with the original types and hypotypes of *Schwagerina pavlovi.*

Pseudoschwagerina pavlovi is similar to *P. minatoi* KANMERA (1958, pp. 179–181, pl. 28, figs. 1–8), but it can be distinguished by its smaller shell, smaller chomata and thinner spirotheca. *Pseudoschwagerina pavlovi* also resembles *P. saigusai* NOGAMI (1961, pp. 179–181, pl. 2, figs. 12–15) in the general shell-shape, but it can be distinguished by its smaller shell, thinner spirotheca, weaker septal fluting, and smaller proloculus.

Occurrence.—Abundant in the *Pseudoschwagerina kanmerai* subzone, the upper part of the *Pseudoschwagerina* zone; the associated fusulinids are the same as those of *Pseudoschwagerina kanmerai.*

Pseudoschwagerina muongthensis (DEPRAT)
Pl. XXVII, figs. 6–8

1915. *Fusulina muongthensis* DEPRAT. Mem. Service Géol. l'Indochine, Vol. 4, fasc. 1, pp. 5-7, pl. 2, figs. 1-6.
1925. *Schwagerina muongthensis*, OZAWA. Jour. Coll. Sci., Imp. Univ. Tokyo. Vol. 45, Art. 6, pp. 47-48, pl. 8, figs. 1-2.
1927. *Schwagerina muongthensis*, LEE. Palaeontologia Sinica, Ser. B, Vol. 4, fasc. 1, p. 120, pl. 23, figs. 3, 4.
1938. *Schwagerina muongthensis*, RAUSER-CERNOUSSOVA. Travaux l'Institut géol. Acad. Sci. U.S.S.R., Tome 7, pp. 131, 132, pl. 7, fig. 4.
1958. *Pseudoschwagerina muongthensis*, TORIYAMA. Mem. Fac. Sci., Kyushu Univ., Ser. D, Geology. Vol. 7, pp. 158-161, pl. 18, figs. 15-18; pl. 19, figs. 1-9.

Description.—The shell of *Pseudoschwagerina muongthensis* (DEPRAT) is moderately large and globular in shape, having a straight axis of coiling, convex lateral slopes, and rounded to bluntly pointed poles.

A mature specimen of six volutions is 5.05 mm. long and 4.25 mm. wide, giving a form ratio of 1.2. The first volution is spherical and the second to the third volutions attain a fusiform shape. Beyond the fourth volution the shell assumes its mature shape. The ratios of the half length to the radius vector in the specimen illustrated as fig. 8 of Pl. XXVII (AZ-SA 6-6) are 1.7, 1.3, 1.5, 1.4, 1.3 and 1.3, respectively, for the first to the sixth volution.

The proloculus is moderately large and spherical, having an outside diameter of 283 microns. The shell is very tightly coiled in the inner three volutions with more or less sharply pointed poles, but beyond the third volution the shell expands rapidly and the poles become rounded to bluntly pointed. The radius vectors of the first to the sixth volution in a specimen (Pl. XXVII, fig. 8) are 150, 300, 500, 900, 1.500 and 2.100 microns, respectively. The chambers are almost the same in height throughout the shell except in the extreme polar regions.

The spirotheca is thin in the inner volutions but moderately thick in the outer volutions where it consists of a tectum and a relatively coarse alveolar keriotheca. The thickness of the spirotheca of the first to the sixth volution is 41, 46, 46, 75, 98 and 80 microns, respectively. The proloculus wall is relatively thin and its thickness is 41 microns in the specimen illustrated as fig. 8 of Pl. XXVII (AZ-SA 6-6).

The septa are thin and are almost plane throughout the length of the shell in the inner volutions and slightly fluted in the outer volutions. The chomata are very small in the inner five volutions, but they are absent in the outer one or two volutions. The tunnel is low and narrow with a regular path, and its angles in the first to the fifth volution of a specimen (Pl. XXVII, fig. 8) are 24, 29, 30, 24 and 32 degrees, respectively.

Remarks.—This species was originally described by DEPART (1915) from the coal field of Muongthé, Van-yén, Tonkin, and in Japan it was identified by OZAWA (1925) and TORIYAMA (1958) from the Akiyoshi Limestone. The Atetsu specimens described above are quite identical with the lectotype of the species and the hypotypes from Akiyoshi in the shell-shape, the size, the expansion of the shell, the spirothecal thickness, and the proloculus diameter, although they show a slightly stronger septal fluting.

Occurrence.—Common in the *Pseudoschwagerina kanmerai* subzone, the upper part of the *Pseudoschwagerina* zone; the associated fusulinids are the same as those of *Pseudoschwagerina saigusai.*

Pseudoschwagerina kanmerai, sp. nov.
Pl. XXVIII, figs. 1–4

Description.—The shell of *Pseudoschwagerina kanmerai*, sp. nov. is large and oval, with

TABLE 22. TABLE OF MEASUREMENTS OF *Pseudoschwagerina muongthensis* (DEPRAT) (in millimeters)

Specimen	Rg. No.	Pl.	fig.	L.	W.	R.	Prol.	Radius vector						
								1	2	3	4	5	6	7
1	IGSH-AZ-SA 6-61	27	6	4.50	2.40	1.9	.321	.15	.25	.35	.85	1.25		
2	IGSH-AZ-SA 6-6	27	8	5.05	4.25	1.2	.283	.15	.30	.50	.90	1.50	2.10	

Specimen	Half length						Ratio of Hl. to Rv.						Thickness of spirotheca							
	1	2	3	4	5	6	1	2	3	4	5	6	0	1	2	3	4	5	6	7
1	.30	.70	.90	1.40	2.40		2.0	2.8	2.6	1.7	1.9		.050	.034	.034	.052	.057	.057		
2	.25	.40	.75	1.25	2.00	2.65	1.7	1.3	1.5	1.4	1.3	1.3	.041	.029	.041	.046	.046	.075	.098	.080

TABLE 23. TABLE OF MEASUREMENTS OF *Pseudoschwagerina kanmerai*, sp. nov. (in millimeters)

Specimen	Rg. No.	Pl.	fig.	L.	W.	R.	Prol.	Radius vector						
								1	2	3	4	5	6	7
1	IGSH-AZ-SA 6-98	28	3	6.65	4.00	1.7	.10	.10	.15	.25	.50	1.00	1.50	2.00
2	IGSH-AZ-SA 6-19	28	1	6.10	3.05	2.0	.07	.10	.20	.35	.60	1.00	1.50	
3	IGSH-AZ-SA 6-72	28	2	5.50(+)	3.50	1.6	.10	.10	.15	.20	.45	.95	1.25	1.75

Specimen	Half length							Ratio of Hl. to Rv.							Thickness of spirotheca							
	1	2	3	4	5	6	7	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7
1	.10	.25	.60	1.10	2.25	3.40		1.0	1.7	2.4	2.2	2.3	2.3		.023	.018	.025	.027	.041	.041	.108	
2	.20	.35	.75	1.25	2.10	3.15		1.0	1.8	2.1	2.1	2.1	2.1		.018	.021	.023	.029	.057	.092	.121	
3	.10	.30	.65	1.10	1.60	2.50	3.75	1.0	2.0	3.2	2.4	1.7	2.0	2.1	.016	.013	.016	.023	.023	.046	.046	.117

a straight axis of coiling and bluntly pointed poles. The lateral slopes are convex. The holotype specimen of seven volutions (Pl. XXVIII, fig. 3) is 6.65 mm. in length and 4.00 mm. in width, giving a form ratio of 1.7. The ratios of the half length to the radius vector of the same specimen are 1.0, 1.7, 2.4, 2.2, 2.3 and 2.3, respectively, for the first to the sixth volution.

The proloculus is small and its outside diameter is 100 microns in the holotype. The average outside diameter is 90 microns in some specimens. The shell is tightly coiled in the inner three volutions and beyond the third volution it expands rapidly. The radius vectors of the first to the seventh volution in the holotype are 100, 150, 250, 500, 1.000, 1.500 and 2.000 microns, respectively.

The spirotheca is thin in the inner three or four volutions, but beyond the fourth volution the spirotheca gradually increases in thickness. The thickness of the spirotheca measured above the tunnel in the first to the seventh volution of the holotype is 18, 25, 27, 41, 41, 108 and 133 microns, respectively, and that of the six volutions of some other specimens are 17, 21, 26, 40, 59 and 125 microns, respectively.

The septa are closely spaced in the inner three volutions and more widely spaced in the following four volutions. They are nearly plane except in their lower part and also in the end zone where they are narrowly and weakly fluted. The septa are thin. The septal counts of the first to the seventh volution of the figured sagittal section are 5, 10, 9, 11, 14, 18 and 11 in a half volution, respectively. The chomata are very small and low, and they seem to occur only in the area adjacent to the septa. The absence of the distinct chomata in the central part of the chambers makes it difficult to measure the tunnel angle in many of the specimens. The tunnel angles of the first to the sixth volution of the holotype are about 18, 34, 35, 42, 49 and 52? degrees, respectively.

Remarks.—Pseudoschwagerina kanmerai, sp. nov. somewhat closely resembles *P. minatoi* Kanmera (1958, pp. 179–181, pl. 28, figs. 1–8) from the Yayamadake Limestone of Kyushu, but it can be distinguished by its smaller shell, smaller chomata in the inner volutions, and the slower expansion of the shell. This species differs from *P. morikawai* Igo by its more slender shell, smaller proloculus, weaker septal fluting, and much smaller chomata. It is also clearly distinguishable from *P. miharanoensis* Akagi from the Taishaku Limestone in Hiroshima Prefecture. Major differences between these two species are seen in that *P. kanmerai*, sp. nov. has more numerous volutions, smaller proloculus, more tightly coiled inner volutions, and the slower expansion of the shell.

Pseudoschwagerina kanmerai, sp. nov. shows a fairly close resemblance to some North American species such as *P. texana* Dunbar and Skinner (1937, pp. 662–665, pl. 52, figs. 1–8; pl. 53, fig. 9) *P. convexa* Thompson (1954, pp. 75–76, pl. 44, figs. 1–4; pl. 51, figs. 1–8), and *P. rhodesi* Thompson (1954, pp. 73–74, pl. 50, figs. 1–2; pl. 51, figs. 9–11; pl. 52, figs. 1–6). Of these, *P. rhodesi* is most close but its shell is larger and more loosely coiled, its proloculus is larger, its septa are strongly fluted, and its chomata are larger.

Occurrence.—Common in the *Pseudoschwagerina kanmerai* subzone, the upper part of *Pseudoschwagerina* zone; the associated fusulinids are the same as those of *Pseudoschwagerina pavlovi.*

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Explanation of Plate XXI

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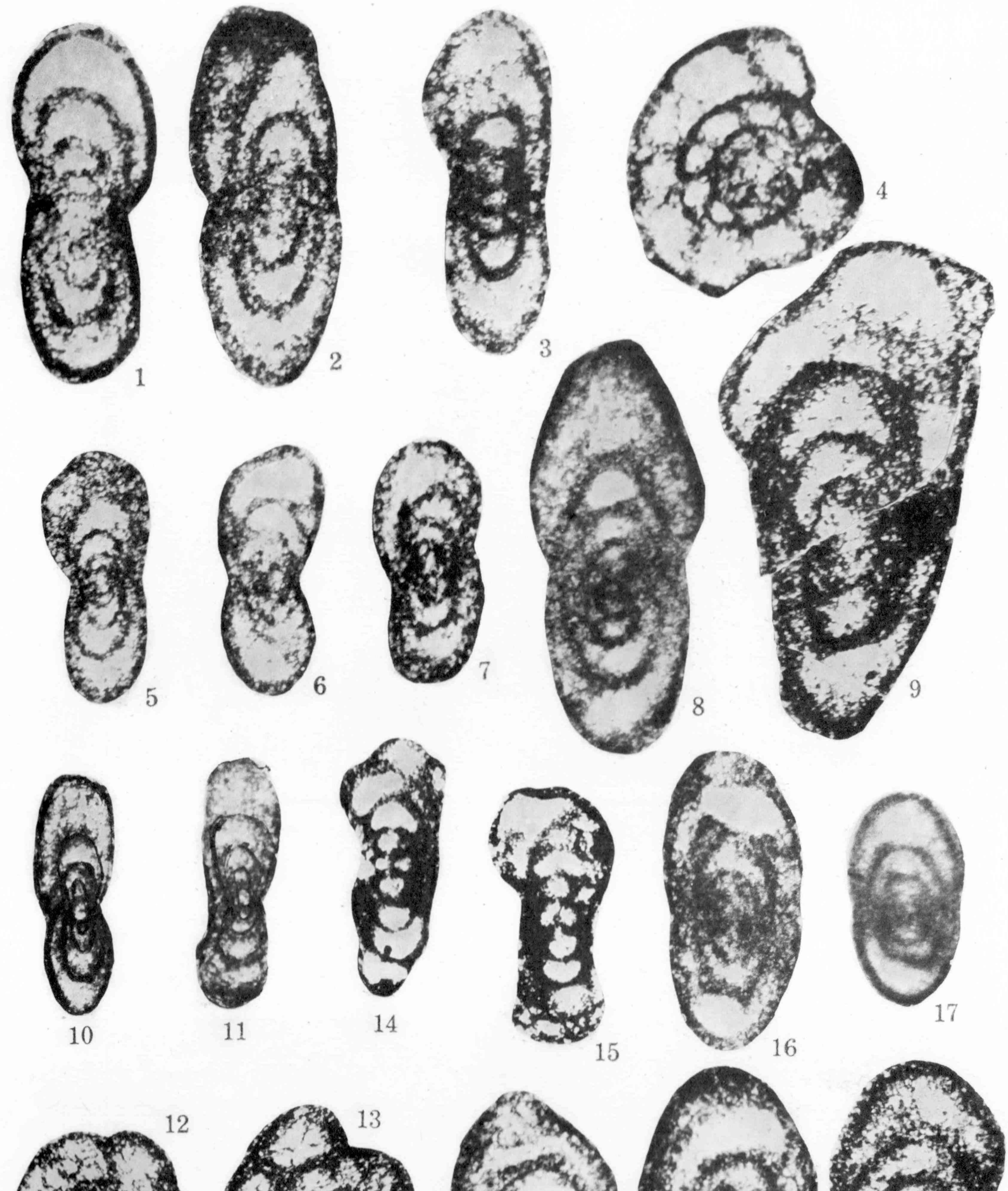
All from the *Millerella bigemmicula-Eostaffella kanmerai* Zone of the Atetsu Limestone.



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Explanation of Plate XXII

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All from the *Millerella bigemmicula-Eostaffella kanmerai* Zone of the Atetsu Limestone.

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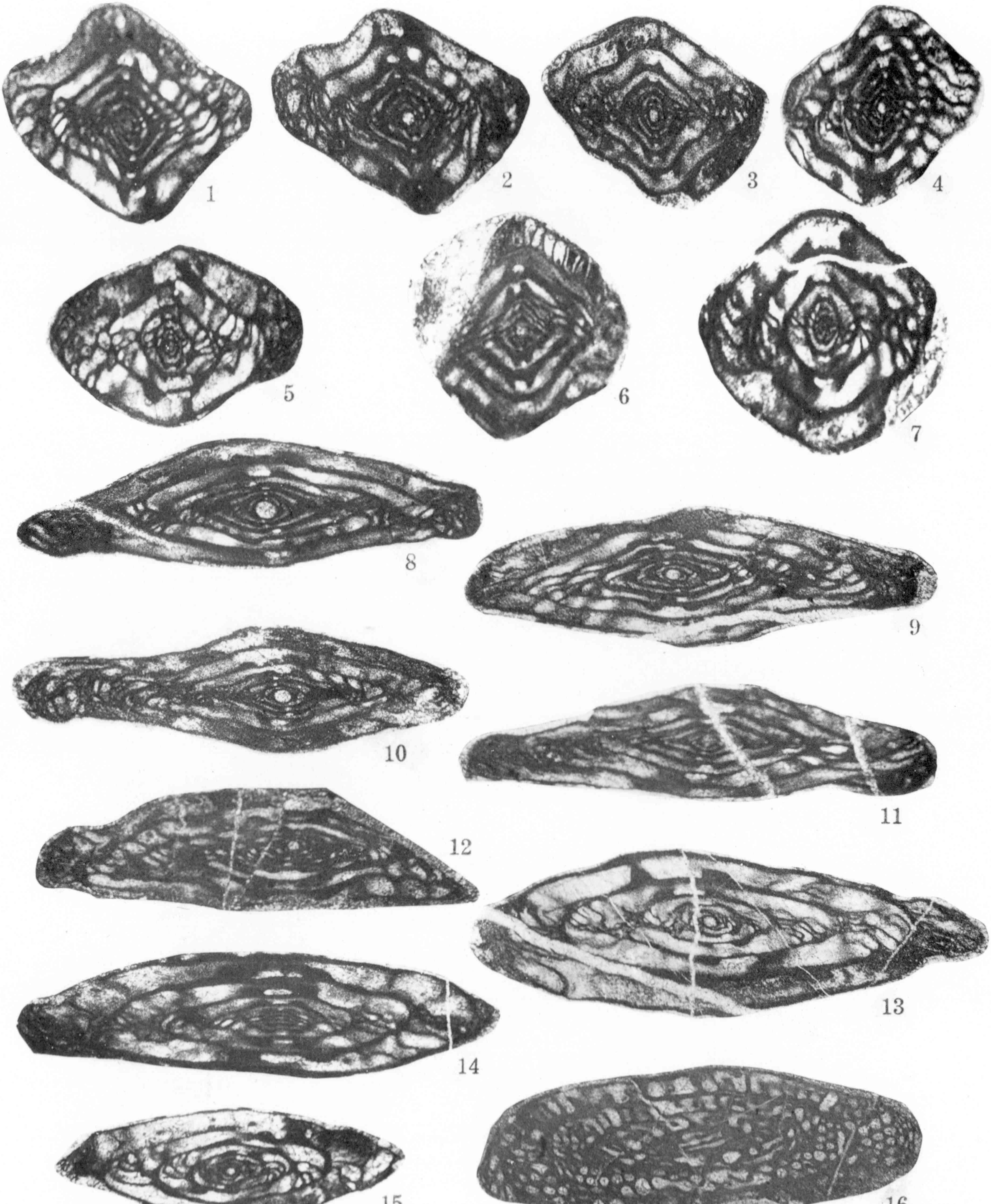
All from the *Fusulinella imamurai* Zone of the Atetsu Limestone.



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EXPLANATION OF PLATE XXIV

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All from the *Pseudoschwagerina* Zone of the Atetsu Limestone.

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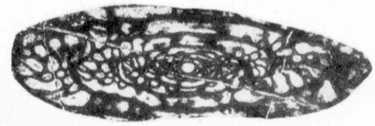

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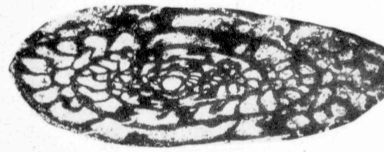

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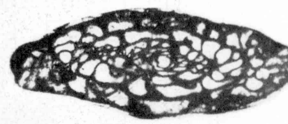

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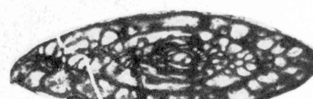

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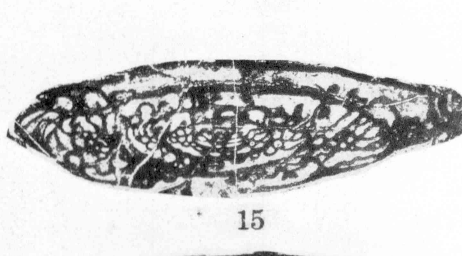

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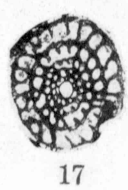

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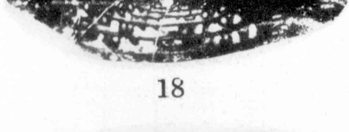

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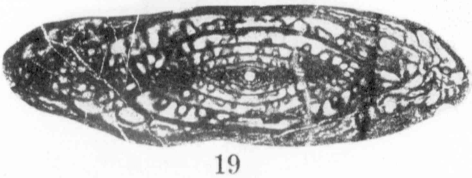

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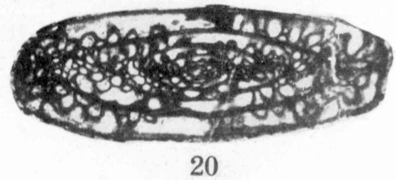

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Explanation of Plate XXV

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1-9, 11-12. Axial sections of the immature specimen: Rg. No. IGSH-KU-SA 2-25, 2-69, 2-6(b), 2-43, 2-75, 2-20, 2-6(a), 2-29, 2-77, AZ-SA 6-70(b) and 6-70(a), respectively.

13-18, 30(?). Axial sections of the mature specimen: Rg. No. IGSH-AZ-SA 6-32, 6-39, 6-78, 6-74, 6-85, 6-79 and 6-56, respectively.

FIG. **10.** *Pseudofusulina* sp.

10. Axial section: Rg. No. IGSH-KU-SA 2-3.

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19-28. Axial sections of the immature specimen: Rg. No. IGSH-KU-SA 2-42(a), 2-51, 2-19, 2-76, 2-20, 2-15, 2-52(b), 2-43, 2-13 and 2-86, respectively.

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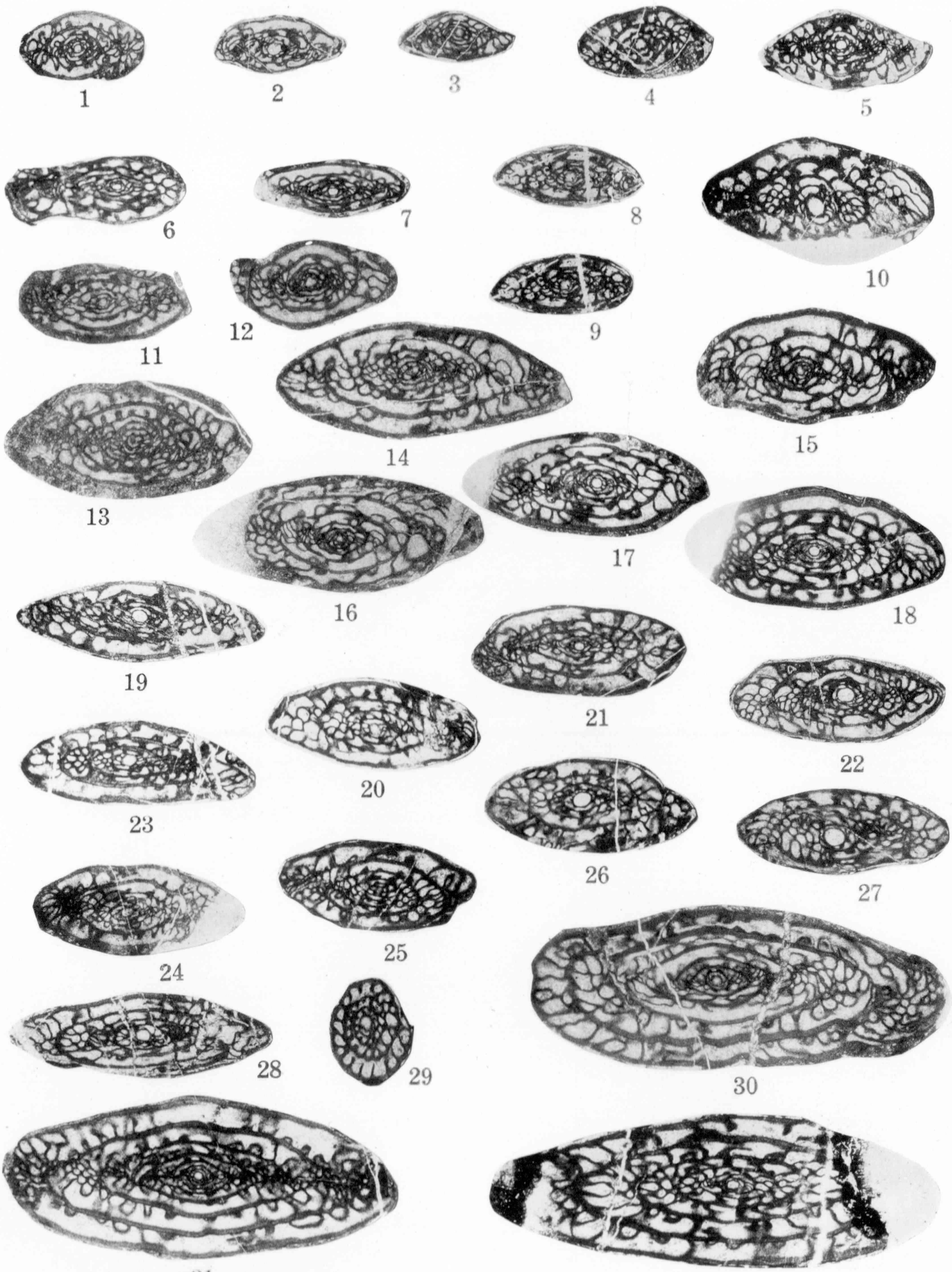
31-32. Axial sections: Rg. No. IGSH-KU-SA 2-20 and 2-40, respectively.

All from the *Pseudoschwagerina* Zone of the Atetsu Limestone.



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Explanation of Plate XXVI

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1–6, 7(?). Axial sections: Rg. No. IGSH-KU-SA 2-10, 2-1, 2-26(a), 2-9, 2-62, 2-38 and 2-74, respectively.

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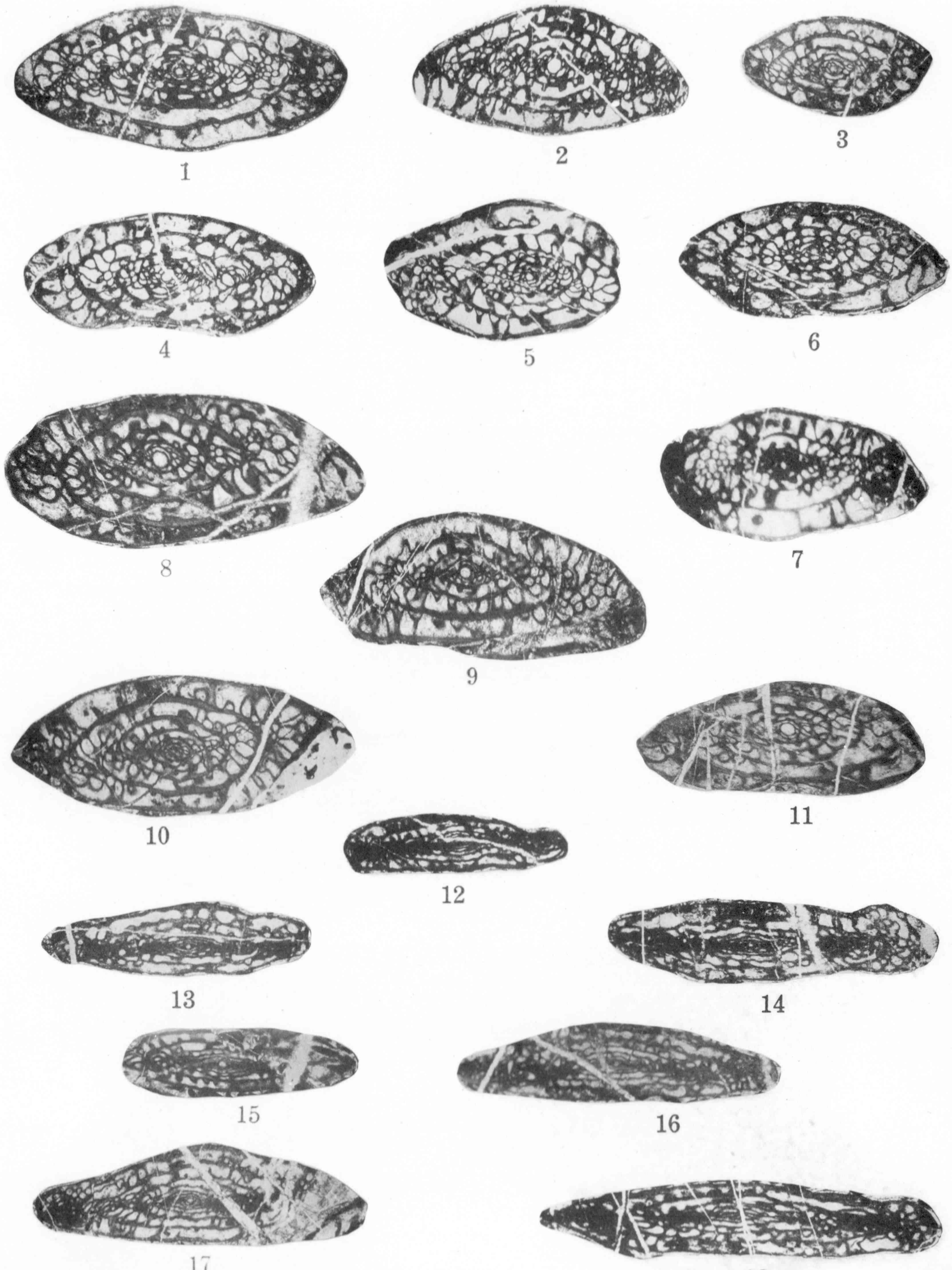
14. Axial section of the holotype: Rg. No. IGSH-KU-SA 2-17.

12–13, 15–18. Axial sections of the paratype: Rg. No. IGSH-KU-SA 2-9(a), 2-9(b), 2-46, 2-26, 2-50 and 2-58, respectively.

All from the *Pseudoschwagerina* Zone of the Atetsu Limestone.



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EXPLANATION OF PLATE XXVII

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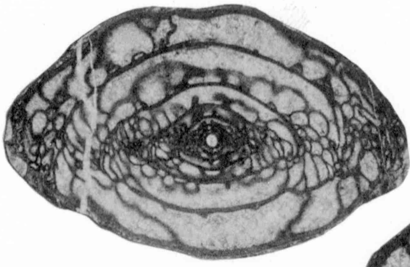
All from the *Pseudoschwagerina* Zone of the Atetsu Limestone.



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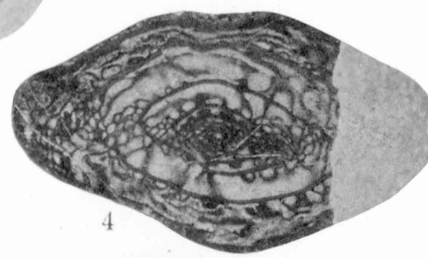

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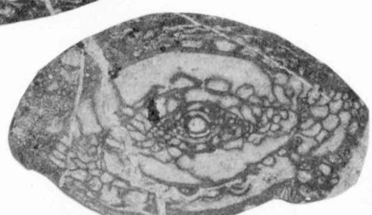

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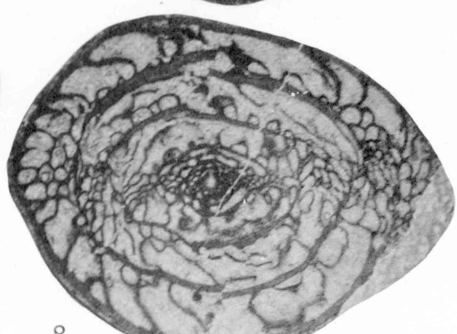

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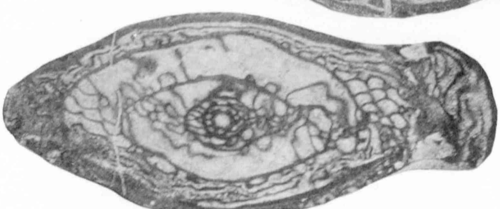

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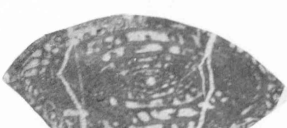

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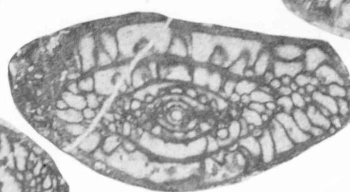

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Explanation of Plate XXVIII

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Figs. **1–4.** *Pseudoschwagerina kanmerai*, sp. nov. 263

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1–2, 4. Axial sections of the paratype: Rg. No. IGSH-AZ-SA 6-19, 6-72 and 6-68, respectively.

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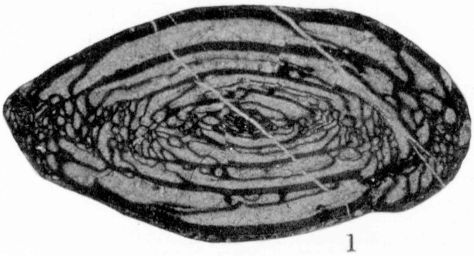
All from the *Pseudoschwagerina* Zone of the Atetsu Limestone.



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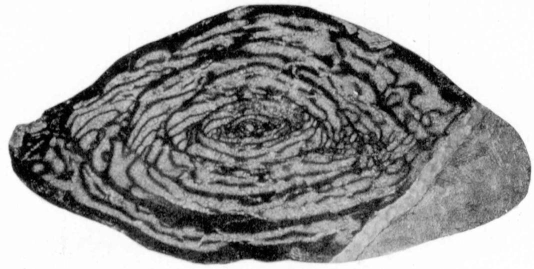

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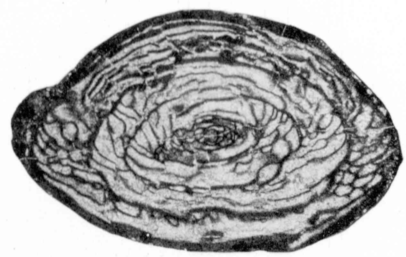

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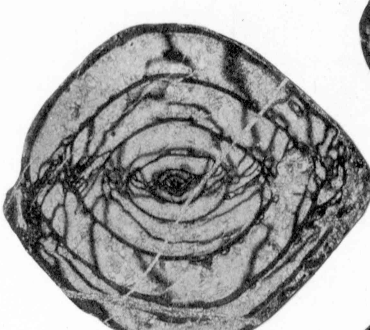

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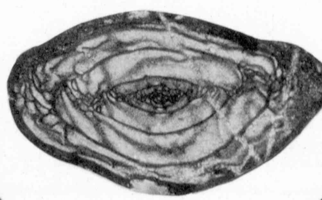

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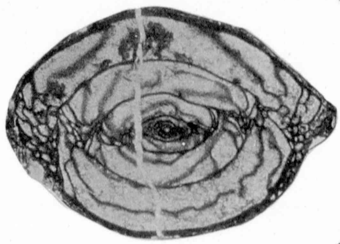

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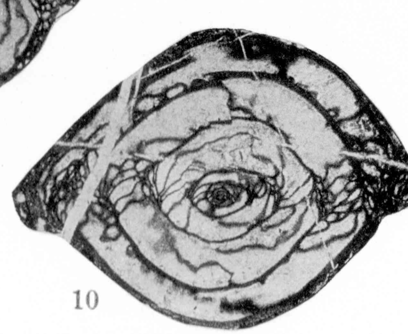

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