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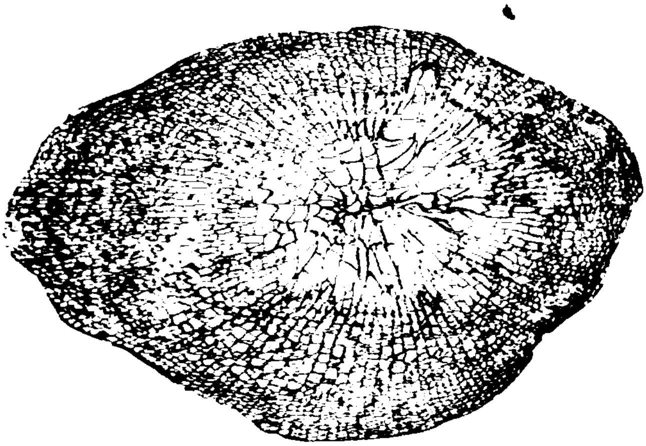

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529. *PSEUDOFUSULINELLA*, A GENUS OF FUSULINACEA*

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「フズリナ超科の一属・*Pseudofusulinella*」: *Pseudofusulinella* 属の多くの種が最近アメリカおよびカナダの西海岸，北極海周辺地域，ウラル山地から報告されている。しかし本属の分類上の特性，種または種群間の系統的関係およびそれらの地質学的価値はまだ十分吟味されていない。筆者は南部関東山地の下部ペルム系より本属に同定すべき新種を得たのを契機として，本属の古生物学的検討を行った。従来 *Pseudofusulinella* 属とされた種には，模式種 *P. occidentalis* および *P. utahensis* で代表される二つの大きなグループがあり，それらは分類上区別されるべきであるという結論に達し，後者に対し新亜属，*Kanmeraia* を提唱した。*Kanmeraia* に属するものとして関東山地産の一新種を記載しその個体発生について検討した。さらに既報告種を文献ならびに，北米西海岸産の標本により検討し殻の特性から5種群に分け，相互の系統進化および，それらの地理的分布，移動について考察した。上部石炭—下部ペルム紀に於ける北部大平洋よりウラル地域にかけての，生層序学，対比，生物地理区等の考察上，*Pseudofusulinella* の重要性が高まった。

小 沢 智 生

Introduction

Pseudofusulinella is one of the latest genera of the Fusulinidae. Since THOMPSON (1951) established *Pseudofusulinella*, a number of species have been described under the genus form various localities in the Pacific Northwest by SKINNER and WILDE (1965, 1966), THOMPSON *et al.* (1956, 1958) and some other American authors. *Pseudofusulinella* also occurs in the Upper Carboniferous and Lower Permian rocks of the Ural Mountains and the Arctic region, but it has been treated as a junior synonym of *Fusulinella* MÖLLER by ROZOVSKAYA (1958) or a subgenus of the latter by RAUSER-CHERNOUSOVA (1965). In the Japanese Islands, little has been known of the genus except for a species reported by KANUMA (1958). In the course of the biostratigraphic study of the Upper Carboniferous and Lower Permian of the Tamagawa area, southeastern Kwanto massif, I have found among others a new species of *Pseudofusulinella*.

Before going into the description of this new species, I think it necessary to revise *Pseudofusulinella* and to establish a new subgenus. In this note I attempt to give a new idea on the classification and phylogeny of *Pseudofusulinella* on morphologic, ontogenetic, stratigraphic and biogeographic grounds. A description of the new species is added to the note.

Achnowledgements:—I express here my heartfelt thanks to Professor Tatsuro MATSUMOTO of Kyushu University for his supervision of the present study and his critical reading of the typescript. I am also deeply indebted to Professor Ryuzo TORIYAMA and Assoc. Professor Kametoshi KANMERA of the same university for their intructive suggestion and valuable information in the Paleozoic

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stratigraphy and fusulinacean paleontology. I express my sincere thanks to Professor Rokuro MORIKAWA of Saitama University who gave me an opportunity of examining his collection of several Americans species of *Pseudofusulinella*. Thanks are also extended to Professor Mosaburo KANUMA, Mr. Atsushi ISHII, Tokyo University of Liveral Arts, Dr. Hisayoshi IGO of Mejirogakuen Women's Junior College, Drs. Itaru HAYAMI and Hakuyu OKADA of Kyushu University, and Dr. Toshio KOIKE of Tokyo University of Education for their kind help in many ways.

Classification of *Pseudofusulinella*

Genus *Pseudofusulinella* THOMPSON, 1951

Type-species:—*Neofusulinella occidentalis* THOMPSON and WHEELER, 1946, from the Middle Wolfcampian part of the McCloud Limestone, northern California.

Generic diagnosis:—The shell is elongate to thickly fusiform with a small proloculus. The spirotheca is composed of a tectum and a diaphanotheca. The dense deposits composed of the same element as the chomata cover the inner and outer surfaces of the primary layers of the spirotheca. Occasionally the mural pores can be seen penetrating the wall and the chomata. The septa are fluted in the polar regions. The chomata are prominent, often extending to the polar regions in a few inner volutions.

Remarks:—*Pseudofusulinella* is one of the latest members of the Fusulinidae. Fifty-five species of the genus have so far been described from the Pacific Northwest region of North America, the Arctic region, the northern Ural and the Japanese Islands. The described species show a wide range in the shell structure which reasonably requires the subdivision of the genus. No attempt of the taxonomic grouping of the species of *Pseudofusulinella* has so far been made. I examined in detail shell structure of several American species collected from the Pacific Northwest and a new species from Japan. I also surveyed through available literature other known species of *Pseudofusulinella*.

As a result of this study, I have arrived at the conclusion that *Pseudofusulinella* consists of several species groups, as shown in Fig. 4, which can be sorted into two subgenera. The diagnoses of the two subgenera, the principal criteria for the classification and the synoptic list of species are presented below.

Subgenus *Pseudofusulinella* THOMPSON, 1951

Type-species:—*Neofusulinella occidentalis* THOMPSON and WHEELER, 1946, from the Middle Walfcampian of the McCloud Limestone, Shasta Lake area, northern California.

Diagnosis:—The shell is small and inflated fusiform to subglobular, having nearly straight to concave lateral slopes, sharply to bluntly pointed poles and almost straight axis of coiling. Mature specimens of seven to twelve volutions measure 3 to 7.5 mm. in length and 1.6 to 4 mm. in width. The form ratio ranges from 1.1 to 2.2, on the average 1.78, for all the known species of this subgenus.

The shell is tightly coiled throughout the growth, especially so in second to third inner volutions. The form ratio increases from the first volution to the third or forth one, where it attains the maximum value. Beyond the forth volution it gradually decreases to the minimum in the last volution, as shown in the form ratio-volution diagram (Fig. 1).

The proloculus is very minute and spherical. The spirotheca is thin and composed of a tectum and a diaphanotheca, having sometimes very minute pores.

The deposits of the same material as the chomata usually cover the floor of the wall. The chomata are massive. Its tunnel sides are steep but gradually decrease the height toward the polar sides, sometimes giving a false appearance of axial fillings. The tunnel is very narrow and its angle varies from 11 to 22 degrees, averaging 16 degrees, for all the known species of this subgenus. Its path is almost straight.

List of species:—The following species are included in the subgenus *Pseudofusulinella*.

Pseudofusulinella alta SKINNER and WILDE, 1965 (=*P. sera* SKINNER and WILDE, 1965).
P. biconica SKINNER and WILDE, 1965 (=*P. bellura* SKINNER and WILDE, 1965).
P. dunbari SKINNER and WILDE, 1965.
P. dunneri SKINNER and WILDE, 1966.
P. formosa SKINNER and WILDE, 1965.
P. jeffordsi SKINNER and WILDE, 1966.
P. montis (THOMPSON and WHEELER), 1946 (=*P. retusa* SKINNER and WILDE, 1965).
P. munda SKINNER and WILDE, 1965 (=*P. decora* SKINNER and WILDE, 1965., *P. pulchella* SKINNER and WILDE, 1965).
P. nitida SKINNER and WILDE, 1965.
P. occidentalis (THOMPSON and WHEELER), 1946.
P. opima SKINNER and WILDE, 1965 (=*P. acureata* SKINNER and WILDE, 1965., *P. obusta* SKINNER and WILDE, 1965).
P. pinguis SKINNER and WILDE, 1965 (=*P. venusta* SKINNER and WILDE, 1965).
P. pusilla SKINNER and WILDE, 1966.
P. rotunda SKINNER and WILDE, 1965.
P. solida SKINNER and WILDE, 1965.
P. solita SKINNER and WILDE, 1965 (=*P. moorei* SKINNER and WILDE, 1965).
P. steevensi MILLS and DAVIS, 1962 (=*P. mucronata* SKINNER and WILDE, 1966).
P. tumida SKINNER and WILDE, 1965.
P. wheeleri SKINNER and WILDE, 1965.

Geologic occurrence:—Restricted to the Wolfcampian and the early Leonardian in the Pacific Northwest region of North America.

Subgenus *Kanmeraia* nov.

Etymology:—The subgeneric name is dedicated to Dr. Kametoshi KANMERA of Kyushu University who has made a great contribution to our knowledge of Upper Paleozoic biostratigraphy and paleontology.

Type-species:—*Pseudofusulinella utahensis* THOMPSON and BISSEL, 1954, from the Lower Wolfcampian of the Oquirrh Formation, Wasatch Mountains, Utah.

Diagnosis:—The shell is small and more or less elongate fusiform, possessing straight to concave lateral slopes, a straight to slightly arched axis of coiling and bluntly to sharply pointed poles. Mature specimens with six to nine volutions are 2.5 to 7 mm. long and 1 to 3 mm. wide, giving the form ratio of 2.0 to 3.5, usually 2.5 or so.

The shell form changes with growth from ellipsoidal in the early stage to an elongate fusiform in the late stage. The form ratio gradually increases from the first volution to the late growth-stage and attains the maximum usually in the sixth or seventh volution, and then it scarcely increases or rather decreases in the final stage (Fig. 1).

The coiling is tight in the inner few volutions and then the chamber increases in height. The proloculus is minute and spherical. In microscopic specimens, the first volution is coiled at high angles to the subsequent ones.

The spirotheca is composed of a tectum and a diaphanotheca, and its upper and lower surfaces are discontinuously covered with dense deposits which are related to the chomata. The diaphanotheca is not so clear as in *Fusulinella*. The mural perforation of the wall is recognized in some species from stratigraphically higher horizons. The comata are narrow and high. The tunnel is relatively broad and its angles measure 20 to 40 averaging 27 degrees for the twenty four species of this subgenus. The tunnel path is almost straight. The septa are nearly plane in the middle part of the shell but gently or sometimes strongly fluted in axial and polar regions.

List of species :—The following species are to be referable to this subgenus.

Pseudofusulinella acuminata SKINNER and WILDE, 1965.
P. acuta SKINNER and WILDE, 1965.
P. antiqua SKINNER and WILDE, 1965.
P. delicata SKINNER and WILDE, 1965.
P. fragilis SKINNER and WILDE, 1965.
P. fusiformis SKINNER and WILDE, 1965.
P. haubaughi SKINNER and WILDB, 1965.
P. logandalensis CASSITY and LANGENHEIM, 1966.
P. meeki SKINNER and WILDE, 1965.
P. parvulla SKINNER and WILDE, 1965.
P. prima SKINNER and WILDE, 1965.
P. proba SKINNER and WILDE, 1965.
P. simplex SKINNER and WILDE, 1965.
P. spicata SKINNER and WILDE, 1965.
P. splendens SKINNER and WILDE, 1965.
P. templensis ROSS, 1965.
P. thompsoni SKINNER and WILDER, 1965.
P. utahensis THOMPSON and BISSEL, 1954.
P. ventricosa SKINNER and WILDE, 1965.
P. sp. A (RICH, 1961).
P. sp. B (RICH, 1961).
P. sp. (THOMPSON and VERVILLE, 1950).
P. spp. (BOSTWICK, 1955)
P. spp. (THOMPSON, DODGE and YOUNGQUIST, 1958).

P. japonica sp. nov. described in this paper also belongs to this subgenus. The following three species may be included in this subgenus: *Fusulinella alta* VERVILLE, THOMPSON and LOKKE, 1956 (=*F. navadensis* VERVILLE, THOMPSON and LOKKE, 1956)., "*Fusulinella*" *usvae* DUTKEVITCH, 1934, and "*Wedekindellina*" *ardomorensis* THOMPSON, VERVILLE and LOOKE, 1956.

Geologic occurrence :—Lower Upper Pennsylvanian (at least Lower Missourian) to lower Lower Permian (Lower Wolfchampian) of the Pacific Northwest region of North America, Japan, the Arctic region and the Ural Mountains.

Discussion :—*Pseudofusulinella* (*s. str.*) is considered to be derived from *Pseudofusulinella* (*Kanmeraia*) from the shell characters and the occurrence. The subgenus *Kanmeraia* is closely similar to the species-group of *Fusulinella alta* which includes *Fusulinella devexa* THOMPSON and *F. juncea* THOMPSON, but is distinguished from it by less developed tectoria of the wall and a more larger shell with much concave lateral slopes. *Pseudofusulinella* (*Kanmeraia*) is probably a descendant of the group of *Fusulinella alta*.

Affinity and distinction

1) Distinction between *Pseudofusulinella* (*Kanmeraia*) and *Pseudofusulinella* (*s. str.*)

The proposed new subgenus *Kanmeraia* is closely allied to the subgenus *Pseudofusulinella* in many respects, but is distinguished by a more elongate shell, less developed and different shaped chomata which are narrow and high, a broader tunnel and less numerous volutions. The explanation in detail may be given as follows:

shell shape :—The shell of the species belonging to *P.* (*Kanmeraia*) is more or less elongate fusiform, having a form ratio of 3.5 to 2.0, that of *P.* (*Pseudofusulinella*) is usually inflated fusiform or subglobular with smaller form ratios of 1.1-2.2. The maximum form ratio is attained in the late growth stage, usually in the sixth or seventh volutions in the former, but in earlier stage, that is, in the third or fourth in the latter.

The situation is shown in Fig. 1 and Table 1.

number of volution :—As shown in Fig. 1 and Table 1, the mature shell of *P.* (*Kanmeraia*) has 6 to 8, at most 9 volutions, but that of *Pseudofusulinella* (*s. str.*) has more numerous volutions ranging from 7 to 12, usually 9 to 10.

chomata :—The chomata of *P.* (*Kanmeraia*) are narrow and high, but those of *P.* (*Pseudofusulinella*) are broader and more massive, although there may be exceptions.

tunnel angle :—The species of the subgenus *Kanmeraia* have a relatively broad tunnel angle varying from 20 to 35 degrees, while those of *Pseudofusulinella* (*s. str.*) have a narrower one measuring only 11 to 22 degrees. Whether or not the tunnel angle is proportionate to the elongation of the shell shape is a question to be examined.

I have precisely investigated all the known species of *Pseudofusulinella* through the published measurements and/or the data obtained by direct measurements from the illustrated specimens (Table 2). Fig. 2 shows a summarized results of the study which

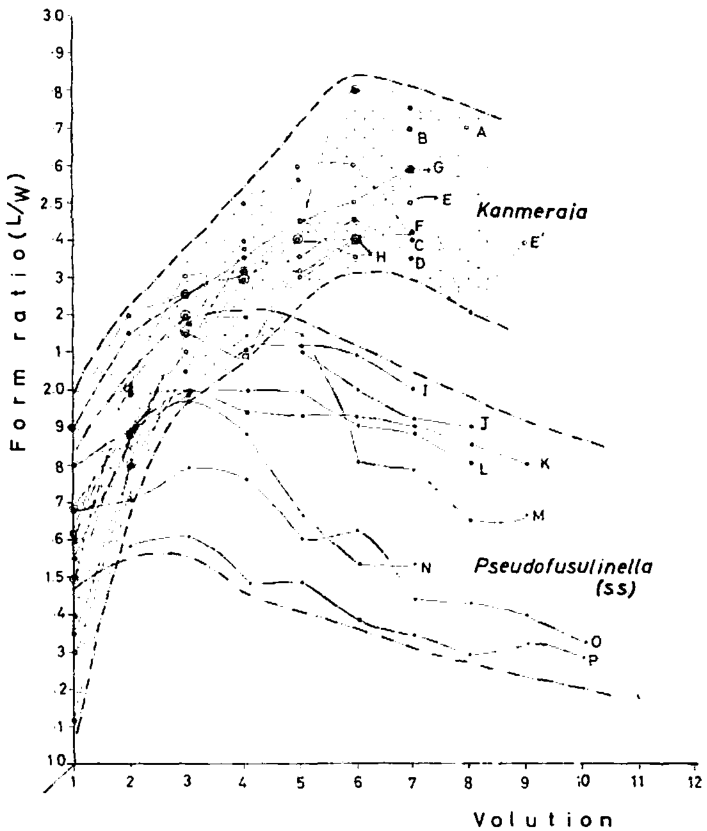


Fig. 1. Volution-form ratio diagram of the main species of *Pseudofusulinella* (*s. l.*). ○: *P.* (*Kanmeraia*), ●: *Pseudofusulinella* (*s. s.*)

Table 1. Comparison of form ratios of the main species of *Pseudofusulinella* which are diagrammatically represented in Fig. 1.

Symbols in Fig. 1	Specific name	Form ratio of volutions									
		1	2	3	4	5	6	7	8	9	10
	Subgenus *Kanmeraia*										
A	*K. ? alta*	1.35	1.8	2.05	2.3	2.4	2.8	2.75	2.7	—	—
B	*K. ? ardomorensis*	1.10	1.65+	2.1+	2.35+	2.55+	2.80	2.7−	—	—	—
C	*K. logandalensis*	1.3	1.8	2.2	2.5	2.6	2.6	2.4	—	—	—
D	*K.* sp.	1.55	1.85	2.15	2.05	2.35	2.45	2.35	—	—	—
E	*K. utahensis*, (Utah)	1.9	2.2	2.25	2.35	2.45	2.3	2.5	—	—	—
E′	———, (Idaho)	1.6	2.0	2.3	2.3	2.3	2.4	2.6	2.2	2.4	—
F	*K. japonica* sp. nov.	1.5	2.0−	2.2	2.2	2.3	2.4	2.4	2.4	—	—
G	*K. meeki*	1.9	2.15	2.25	2.35	2.45	2.5	2.6	—	—	—
H	*K. thompsoni*	1.7	1.9	2.1	2.4−	2.3	2.4	—	—	—	—
	Subgenus *Pseudofusulinella*										
I	*P. nitida*	1.8	1.9	2.0−	2.1	2.1+	2.1	2.0	—	—	—
J	*P. occidentalis*	1.6	2.0	2.2	2.2	2.1	2.0	1.9	1.9	—	—
K	*P. alta*	1.7−	1.9	2.0	1.95−	1.9+	1.9+	1.9	1.85	1.8	—
L	*P. biconica*	1.8+	2.0−	2.0	2.0	2.0	1.9+	1.9	1.8	—	—
M	*P. tumida*	1.4	1.9	2.0	2.2	2.2	1.8	1.8−	1.65	1.65+	—
N	*P. solita*	1.5	1.9	2.0−	1.9−	1.65+	1.5+	1.55−	—	—	—
O	*P. pinguis*	1.7−	1.7+	1.8	1.8−	1.6	1.6+	1.45−	1.4+	1.4	1.4−
P	*P. montis*	1.5	1.6−	1.6+	1.5−	1.5−	1.4−	1.35	1.3−	1.3+	1.3−

(Notes: 1.5+....1.51-1.53; 1.5−....1.49-1.47; 1.55+....1.56; 1.55−....1.54)

A: *P.* (*Kanmeraia*) ? *alta*, average form ratio of six specimens from the Pennsylvanian (Middle Desmoinesian) of eastern Nevada (after VERVILLE, THOMPSON and LOKKE, 1956).

B: *P.* (*Kanmeraia*) ? *ardomorensis*, average form ratio of five specimens from the Pennsylvanian of the Confederate Limestone, Ardomore Basin, Oklahoma (after THOMPSON, VERVILLE and LOKKE, 1956).

C : P. (*Kanmeraia*) *logandalensis*, average form ratio of four specimens from the Pennsylvanian (Missourian) of the Bird Spring Group, Arrow Canyon, Clark Country, Nevada (after CASSITY and LANGENHEIM, 1966).

D : P. (*K.*) sp. average form ratio of two specimens from the Pennsylvanian (Virgilian) of the Sublett Range, Idaho (after THOMPSON, DODGE and YOUNGQUIST, 1958, pl. 18, fig. 9, pl. 20, fig. 1).

E : P. (*K.*) *utahensis*, average form ratio of two specimens from the Permian (Lower Wolfcampian) Oquirrh Formation, Wasatch Mountains, Utah (after THOMPSON and BISSELL in THOMPSON, 1954).

E' : P. (*K.*) *utahensis*, average form ratio of eight specimens from the Permian (Lower Wolfcampian) of the Sublett Range, Idaho (after THOMPSON, DODGE and YOUNGQUIST, 1958).

F : P. (*K.*) *japonica* sp. nov., average form ratio of seventeen specimens from the Wolfcampian of the Raidenyama Formation, southeastern Kwanto massif, Central Japan (This species is described in this paper).

G : P. (*K.*) *meeki*, form ratio of a paratype from the Lower Wolfcampian of the McCloud Limestone, northern California (SKINNER and WILDE, 1965, pl. 8, fig. 15).

H : P. (*K.*) *thompsoni*, form ratio of a paratype from the Lower Wolfcampian of the McCloud Limestone (SKINNER and WILDE, 1965, pl. 19, fig. 20).

I : P. (*Pseudofusulinella*) *nitida*, form ratio of the holotype from the Lower Wolfcampian of the McCloud Limestone (SKINNER and WILDE, 1965, pl. 9, fig. 22).

J : P. (*Pseudofusulinella*) *occidentalis*, form ratio of a paratype from the middle part of Wolfcampian of the McCloud Limestone. (SKINNER and WILDE, 1965, pl. 27, fig. 18).

K : P. (*P.*) *alta*, form ratio of the holotype of *P. sera* which should be referred to a synonym of *P. alta*, from the Lower Leonardian of the McCloud Limestone (SKINNER and WILDE, 1965, pl. 59, fig. 6).

L : P. (*P.*) *biconica*, form ratio of a paratype from the Wolfcampian of the McCloud Limestone (SKINNER and WILDE, 1965, pl. 14, fig. 8).

M : P. (*P.*) *tumida*, form ratio of a paratype specimen from the Wolfcampian of the McCloud Limestone (SKINNER and WILDE, 1965, pl. 22, fig. 13).

N : P. (*P.*) *solita*, form ratio of the holotype of *P. moorei* which should be referred to a synonym of *P. solita*, from the Middle Wolfcampian of the McCloud Limestone (SKINNER and WILDE, 1965, pl. 28, fig. 6).

O : P. (*P.*) *pinguis*, form ratio of the holotype from the Upper Wolfcampian of theM cClound Limestone (SKINNER and WILDE, 1965, pl. 53, fig. 6).

P : P. (*P.*) *montis*, form ratio of a topotype specimen from the Upper Wolfcampian of the McCloud Limestone (SKINNER and WILDE, 1965, pl. 36, fig. 25).

Form ratio of D and G–P are calculated from the measurements on the magnified photos of the specimens cited in the parenthesis in the respective species.

demonstrates that there is a considerable correlation between the two characters (r, coefficient of correlation, =0.79). In other words the two subgenera significantly differ in the relative form-ratio of the shell and the tunnel angle.

2) Affinity to other genera

Certain species of *Fusulinella* MÖLLER are closely allied to earlier representatives *Pseudofusulinella* (*Kanmeraia*) such as *P.* (*K.*) *logandarensis* CASSITY and LANGENHEIM and *P.* (*K.*) sp. (THOMPSON, DODGE and YOUNGQUIST, 1958, pl. 18, fig. 9, pl. 20, fig. 1). They comprise *Fusulinella devexa*, *F. juncea*, *F. alta* (=*F. nevadensis*) and "*Wedekindellina*" *ardomorensis* from the Pennsylvanian of U.S.A., *Fusulinella eopulchra*, *F. pulchra*, *F. subpulchra* and "*Fusulinella*" *usvae* from the Upper Carboniferous of U.S.S.R., and *F. elegantula* and "*Wedekindellina*" *prolifica* from the *Fusulinella*-

Table 2. Relationship between form ratios (shell form) and tunnel angles of all the known species of *Pseudofusulinella*.

Number in Fig. 2	Specific name	Tunnel angle (X)	deviation (x)	Form ratio (Y)	deviation (y)
	P. (*Kanmeraia*)				
1	? *alta*	30	9	2.75	0.65
2	? *nevadensis*	27	6	2.23	0.13
3	? *ardomorensis*	39	18	2.68	0.58
4	*logandalensis*	29	8	2.60	0.50
5	sp. (Idaho)	30	9	2.45	0.35
6	*usvae*, (Spits.)	28	7	2.60	0.50
7	*templensis*, (〃)	20	−1	2.20	0.10
8	*utahensis*, (Utah)	30	9	2.50	0.40
9	*utahensis*, (Idaho)	26	5	2.40	0.30
10	*japonica*	29	8	2.40	0.30
11	*antiqua*	26	5	2.63	0.53
12	*prima*	23	2	2.36	0.26
13	*meeki*	22	1	2.40	0.30
14	*ventricosa*	20	−1	2.21	0.11
15	*delicata*	40	19	3.46	1.36
16	*haubaughi*	30	9	2.58	0.48
17	*fusiformis*	25	4	2.23	0.13
18	*proba*	32	11	3.05	0.95
19	*splendens*	21	0	2.02	−0.08
20	*acuminata*	20	−1	2.60	0.50
21	*parvulla*	21	0	1.99	−0.11
22	*acuta*	26	5	2.78	0.68
23	*fragilis*	30	9	2.69	0.59
24	*simplex*	21	0	2.04	−0.06
25	*thompsoni*	26	5	2.42	0.32
	aver. (1–25)	27		2.49	

(Continued from Table 2)

Number in Fig. 2	Specific name	Tunnel angle (X)	deviation (x)	Form ratio (Y)	deviation (y)
	Pseudofusulinella (*s. s.*)				
26	*wheeleri*	17	−4	1.56	−0.54
27	*nitida*	18	−3	1.91	−0.19
28	*biconica*	18	−3	1.72	−0.38
29	*tumida*	17	−4	1.86	−0.24
30	*solida*	16	−5	2.60	0.50
31	*occidentalis*	16	−5	1.84	−0.26
32	*spicata*	19	−2	2.44	0·34
33	*soiita*	21	0	1.97	−0.13
34	*moorei*	15	−6	1.58	−0.52
35	*rotunda*	17	−4	1.71	−0.39
36	*formosa*	20	−1	1.71	−0.39
37	*retusa*	15	−6	1.26	−0.84
38	*dunbari*	14	−7	1.63	−0.47
39	*montis*	11	−10	1.23	−0.87
40	*opima*	20	−1	1.84	−0.26
41	*pinguis*	12	−9	1.46	−0.64
42	*munda*	17	−4	1.62	−0.48
43	*venusta*	13	−8	1.55	−0.55
44	*decora*	18	−3	1.96	−0.14
45	*pulchella*	13	−8	1.68	−0.42
46	*alta*	16	−5	2.05	−0.05
47	*sera*	12	−9	2.02	−0.08
48	*bellura*	17	−4	1.83	−0.27
49	*pusilla*	19	−2	1.85	−0.25
50	*steevensi*	10	−11	1.89	−0.21
51	*dunneri*	22	1	1.95	−0.15
52	*rotunda*, (Nevada)	15	−6	1.56	−0.54
53	*jeffordsi*	15	−6	2.03	−0.07
54	*pinguis*, (Oregon)	15	−6	1.50	−0.60
55	*pulchella*, (Oregon)	17	−4	1.59	−0.51
	aver. (26-55)	16		1.78	
	Aver. (1-55)	21		2.10	

The mean value of X, $\overline{X}=21$ degrees; The mean of Y, $\overline{Y}=2.10$: x, deviation of X from the mean value; y, deviation of Y from the mean value; r, coefficient of correlation between X and Y ($r=Sxy/\sqrt{(Sx^2)(Sy^2)}$). 0.79 for the value of r, was obtained. This result means that there is a considerable correlation between the shell form (form ratio) and the tunnel angle.

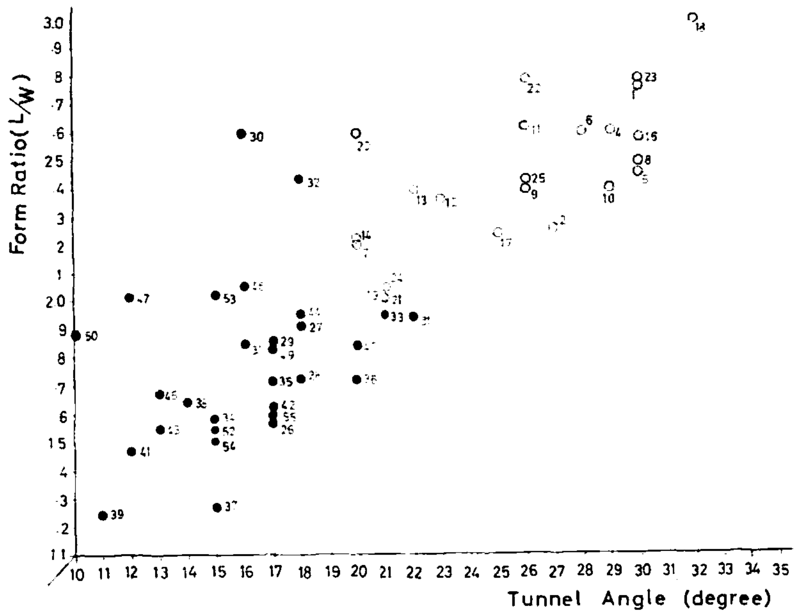


Fig. 2. Graph showing the relationships between the form ratio (shell form and the tunnel angles of all the species of *Pseudofusulinella* (s. l.).
○: *P.* (*Kanmeraia*), ●: *Pseudofusulinella* (*s. s.*)

Fusulina zone of Japan. They have commonly elongate and slender shell with concave lateral slopes, prominent and highly asymmetrical chomata, tightly coiled inner volutions and relatively minute proloculus. They are considerably different from the typical species of *Fusulinella*, represented by the type-species, *F. bocki*, since the latter possess usually an inflated fusiform, or a biconical, to typical fusiform shell with convex lateral slopes, high but narrow chomata and a small number of rather loosely coiled whorls.

THOMPSON (1951, 1954, 1964) stated that *Pseudofusulinella* has axil fiillings, which *Fusulinella* has not. The axial fillings of *Pseudofusulinella*, if present, very slight and narrow, but there are heavy deposits which are related to the massive chomata and the linings on the inner surfaces of the chambers. These very dense secondary deposits in the central part of the shell are one of the most diagnostic features of the genus. In the wall structure *Pseudofusulinella* is very similar to *Fusulinella* but is distinguished by a thinner spirotheca which has discontinuous tectoria (i. e. the above mentioned secondary deposits) and minute pores.

Subgenus *Pseudofusulinella* resembles *Leptotriticites* SKINNER and WILDE, 1965, a subgenus of *Triticites* GIRTY, in the nature of the spirotheca and chomata, and shell shape. Judging from the shell characters and the stratigraphic occurrence, it is possible that *Leptotriticites* was derived from the early representatives of *Pseudofusulinella* (*s. str.*). *Waeringella* THOMPSON resembles *Pseudofusulinella*, but has a much smaller shell,

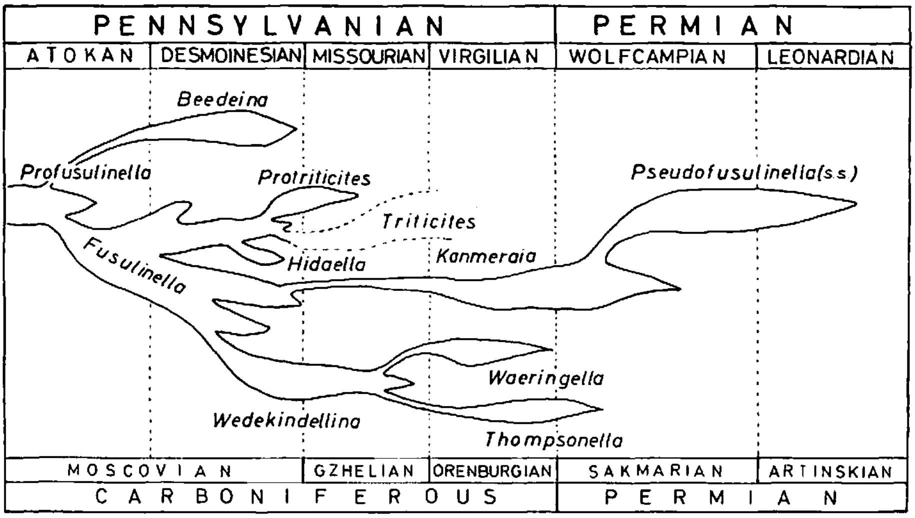


Fig. 3. Phylogenetic position of *Pseudofusulinella* (*Kanmeraia*) and *Pseudofusulinella* (*s. s.*) in Fusulinidae.

different structure of spirotheca and unmistakable axial fillings. As ROSS and DUNBAR (1962, p. 26) suggested, *Waeringella* is probably a specialized descendant of *Wedekindellina* DUNBAR and HENBEST. Although *Pseudofusulinella* resembles *Wadekindellina* and *Thompsonella* SKINNER and WILDE, the latter two genera have heavier axial fillings and a more elegante and somewhat different shaped of the shell. Incidentally HOARE (1963) described *Pseudofusulinella asymmetrica* HOARE, *P. nevadensis* HOARE and *Bartramella* ? sp. from the Sunflower Reservoir area of northern Nevada, but these species are to be referred to *Thompsonella* from the shell characters. *Thompsonella* is considered to be a descendant of *Wedekindellina* from the shell characters and the stratigraphic occurrence.

The phylogenetic position of the two subgenera of *Pseudofusulinella* in the family Fusulinidae is shown in Fig. 3.

Evolutionary trends and phylogeny within *Pseudofusulinella*

As I listed in the foregoing chapter, more than fifty species have been recognized from the Upper Pennsylvanian to Middle Permian rocks in the Pacific Northwest of North America, the Japanese Islands, and the Arctic and Ural regions of the U. S. S. R. Most of them occur successively in stratigraphic sequence, and accordingly it is possible to observe details in evolutional change of shell characters and to follow lines of descent at specific level.

(A) Evolutionary trends Main evolutionary trends recognized in the shell characters of *Pseudofusulinella* on the basis of the stratigraphic facts are summarized as follows:

(1) As a rule, the shell becomes larger and the number of volutions increases. Primitive species from the stratigraphically lower horizons are actually small. For example *P.* (*Kanmeraia*) *logandalensis*

CASSITY and LANGENHEIM, from the basal part of the Missourian, measures 3.3 mm. in average length and has six and a half volutions. On the other hand, the highly evolved ones from the upper part of the Wolfcampian and the Leonardian excess 7 mm. and have more than ten volutions. Several exceptional species are, however, extraordinary small, in spite of high stratigraphic positions. For example, *P.* (*Kanmeraia*) *pulvulla* SKINNER and WILDE measures only 2.7 mm. in maximum length. These species are interpreted as specialized and degenerated forms.

(2) The shell changes in shape from an elongate fusiform to a thick fusiform or biconical. In other words the form ratio gradually decreases. Most of species from the Upper Pennsylvanian (Virgilian) and Lower Permian (Lower Wolfcampian) belong to *Kanmeraia* have an elongate fusiform to typical fusiform shell and the average form ratio is about 2.5. As the stratigraphic position becomes higher, the shell becomes thicker. The Upper Wolfcampian species belonging to the subgenus *Pseudofusulinella* are typically thick fusiform to biconical in shape and the form ratio is usually less than 1.9 (Fig. 1).

(3) The chomata gradually become more prominent. They are narrow and high in most of the Virgilian and Lower Wolfcampian species of *Kanmeraia*. Whereas in the Upper Wolfcampian and Leonardian species belonging to subgenus *Pseudofusulinella*, the chomata become as high as the chamber and broader, and the same dense deposits as the chomata spread almost completely on the spirothecal surfaces, and give the false appearance of the axial fillings.

(4) The tunnel becomes narrower. As shown in Fig. 3, this tendency is recognized in the genus *Pseudofusulinella*. In most of species of *Kanmeraia*, the tunnel is relatively broad and its angles measure 40 to at least 20 degrees. In most species of *Pseudofusulinella* (*s. s.*) which occur from higher stratigraphic levels than *Kanmeraia*, the tunnel is narrow and its angles ranges from 10 to 20, at most 21 degrees.

(5) The septal fluting becomes stronger. In the primitive species of *Pseudofusulinella* either of subgenus *Pseudofusulinella* (*s. s.*) or *P.* (*Kanmeraia*), the septa are fluted only in the axial and polar regions. Whereas in the evolved species, such as *P.* (*K.*) *thompsoni*, *P.* (*K.*) *splendens*, *P.* (*K.*) *acuminata*, *P.* (*P.*) *tumida* and *P.* (*P.*) *alta*, they are strongly and irregularly fluted in the axial and polar regions, sometimes throughout the length of the shell. The same trend is recognized not only in this genus but also in other genera of the family Fusulinidae.

(6) The diaphanotheca becomes obscure and the mural pores penetrate it. In the primitive species from the stratigraphically lower horizon, a relatively clear diaphanotheca is recognized in the spirotheca as observed in the species of *Fusulinella*. But in the evolved species from the stratigraphically higher horizon a diaphanotheca is no more so clear as recognized in *Fusulinella* and gives an appearance of fibrous layer (example, *P.* (*Kanmeraia*) *meeki*. In one of the most evolved species from the Leonardian, *P.* (*Pseuofusulinella*) *danneri*, alveoli-like dark pillars which are very similar to the alveoli in Schwagerinidae, are recognized in the spirotheca. These features of the wall well conincide with that of the last genera of the family Fusulinidae such as *Quasifusulina*,, *Fusulina* and *Thompsonella*.

(B) **Phylogeny** From a combined view of the serial development in the shell characters and the successive stratigraphic occurrence, the previously described species are classified into at least five species groups. The phylogenetic relation among these groups is discussed below in some detail.

(a) *Pseudofusulinella* (*Kanmeraia*) *logandalensis* group.

As mentioned in page 152, this group is probably derived from a group of *Fusulinella* which comprises *Fusulinella devexa* THOMPSON and *F. juncea* THOMPSON. It is considered to be one of the main ancestral stocks of the Permian *Pseudofusulinella*. *P.* (*K.*) ? *alta* VERVILLE, THOMPSON and LOKKE and *P.* (*K.*) ? *ardomorensis* THOMPSON, VERVILLE and LOKKE can also be included in this group.

This group has an elongate fusiform shell with straight or slightly concave lateral slopes, an almost straight axis of coiling and blunt pointed or rounded poles. The septa are plane in the middle part of the shell and gently folded in the axial and polar regions. The chomata are developed throughout the growth of the shell, narrow and high. The spirotheca is composed of a tectum, a diaphanotheca and discontinuous or continuous tectoria. This group is stratigraphically restricted to the Upper Pennsylvanian (Upper Desmoinesian to Missourian) in the Pacific Northwest of North America.

(b) *Pseudofusulinella* (*Kanmeraia*) *utahensis* group.

This group is morphologically very similar to and considered as a direct descendant of the *P.* (*K.*) *logandalensis* group. It includes a large number of species, such as *P.* (*K.*) *antiqua* SKINNER and WILDE, *P.* (*K.*) *acuminata* SKINNER and WILDE, *P.* (*K.*) *fragilis* SKINNER and WILDE, *P.* (*K.*) *fusiformis* SKINNER and WILDE, *P.* (*K.*) *haubaughi* SKINNER and WILDE, *P.* (*K.*) *meeki* SKINNER and WILDE, *P.* (*K.*) *prima* SKINNER and WILDE, *P.* (*K.*) *proba* SKINNER and WILDE, *P.* (*K.*) *splendens* SKINNER and WILDE, *P.* (*K.*) *thompsoni* SKINNER and WILDE, *P.* (*K.*) *uavae* (DUTKEVITCH), *P.* (*K.*) *ventricosa* SKINNER and WILDE, *P.* (*K.*) sp. A, *P.* (*K.*) sp. B, *P.* (*K.*) sp. (BOSTWICK, 1955), *P.* (*K.*) sp. *P.* (*K.*) sp. B (RICH, 1961), *P.* (*K.*) sp. (THOMPSON, DODGE and YOUNGQUIST, 1958, pl. 18, fig. 9, pl. 20, fig. 1). *P.* (*K.*) *japonica* sp. nov. described in this paper also belongs to this group.

The species of this group have an elongate fusiform to typical fusiform shell with more or less concave lateral slopes, a straight or slightly arched axis of coilings, and narrow and high chomata. The septa are nearly plane or slightly folded in the middle part of the shell but are strongly and rather irregularly folded in the axial and polar regions. The spirotheca is composed of a tectum, a diaphanotheca and discontinuous tectoria. The shell is rather loosely coiled except for the juvenile volutions and is much larger than that of the *P.* (*K.*) *logandalensis* group.

This group has been known from the latest Pennsylvanian (Virgilian) and the earliest Permian (Lower Wolfcampian) rocks in the Pacific Northwest of North America, the Japanese Islands, Spitsbergen and the Ural Mountains.

(c) *P.* (*K.*) *parvulla* group. This group consists of *P.* (*K.*) *acuta* SKINNER and WILDE, *P.* (*K.*) *delicata* SKINNER and WILDE, *P.* (*K.*) *parvulla* SKINNER and WILDE and *P.* (*K.*) *spicata* SKINNER and WILDE. They are characterized by an extraordinarily small, elongate fusiform shell which has a very thin spirotheca, small number of volutions and rather small chomata. This group is similar to the *P.* (*K.*) *utahensis* group in general characters except for the minute size and may be a specialized offshoot of the *P.*

(*K.*) *utahensis* group. It is, however, not so easy for us to substantiate whether these small species are dwarfed forms under unfavorable ecological conditions or degenerated species, but the limestone lithology may give us some clues on this problem. According to SKINNER and WILDE (1965, p. 12), who established the detailed stratigraphy of the McCloud Limestone, the limestone from which these species occurred is remarkably uniform in lithology. Therefore I am inclined to consider that these small species are degenerated species. This group is known in the lower half of the Wolfcampian in the Pacific Northwest of North America.

(d) *P.* (*Pseudofusulinella*) *tumida* group. This is an intermediate group between the *P.* (*K.*) *utahensis* group and the *P.* (*P.*) *occidentalis*-*P.* (*P.*) *montis* group mentioned below. This group was probably derived from species of the *P.* (*K.*) *utahensis* group and includes *P.* (*P.*) *biconica* SKINNER and WILDE, *P.* (*P.*) *formosa* SKINNER and WILDE, *P.* (*P.*) *nitida* SKINNER and WILDE, *P.* (*P.*) *pusilla* SKINNER and WILDE, *P.* (*P.*) *wheeleri* SKINNER and WILDE. The species of this group have an inflated fusiform or a biconical shell with concave lateral slopes, narrow and high chomata, thightly coiled inner volutions and a very minute proloculus. The septa are weakly fluted in the middle part of the test and strongly and irregularly fluted in the axial and polar regions. The distribution of this group is, as far as is known, restricted to the middle part of the Wolfcampian in the Pacific Northwest of North America.

(e) *P.* (*Pseudofusulinella*) *occidentalis*-*P.* (*P.*) *montis* group. This group includes the type-species and also *P.* (*P.*) *danneri* SKINNER and WILDE, *P.* (*P.*) *jeffordsi* SKINNER and WILDE, *P.* (*P.*) *montis* (THOMPSON and WHEELER), *P.* (*P.*) *opima* SKINNER and WILDE, *P.* (*P.*) *pinguis* SKINNER and WILDE, *P.* (*P.*) *rotunda* SKINNER and WILDE, *P.* (*P.*) *solida* SKINNER and WILDE, *P.* (*P.*) *steevensi* MILLS and DAVIS and *P.* (*P.*) *venusta* SKINNER and WILDE. It occurs at the highest level, namely in the Upper Wolfcampian and the lowest Leonardian rocks in the Pacific Northwest of North America. They have an inflated fusiform to subsperical shell with heavy chomata, almost straight lateral slopes, bluntly to sharply pointed poles and a minute proloculus. The shell is tightly coiled throughout the growth and consists of ten or eleven volutions in maximum. The septa are strongly fluted in the axial and polar regions. The chomata are highly asymmetrical and often extended to the polar areas covering the upper surface of the spirotheca and giving the false appearance of axial fillings. The tunnel is narrow and high, and its path almost straight. The septa are numerous. This group is very similar to the *P.* (*P.*) *tumida* group. Its immediate ancestor may be such as *P.* (*P.*) *nitida* SKINNER and WILDE, *P.* (*P.*) *wheeleri* SKINNER and WILDE which are in this paper included in the *P.* (*P.*) *tumida* group.

To sum up the above description, the phylogeny and stratigraphic distribution of these species-groups in the genus *Pseudofusulinella* are diagramatically shown in Fig. 4.

Distribution of *Pseudofusulinella*

The migration of fusulinacean foraminifera is very interesting and significant for the study of the phylogeny and classification of the fusulinaceans. Little has been done on this problem. ROSS (1962) who discussed the migration of the Permian genera *Pseudoschwagerina*

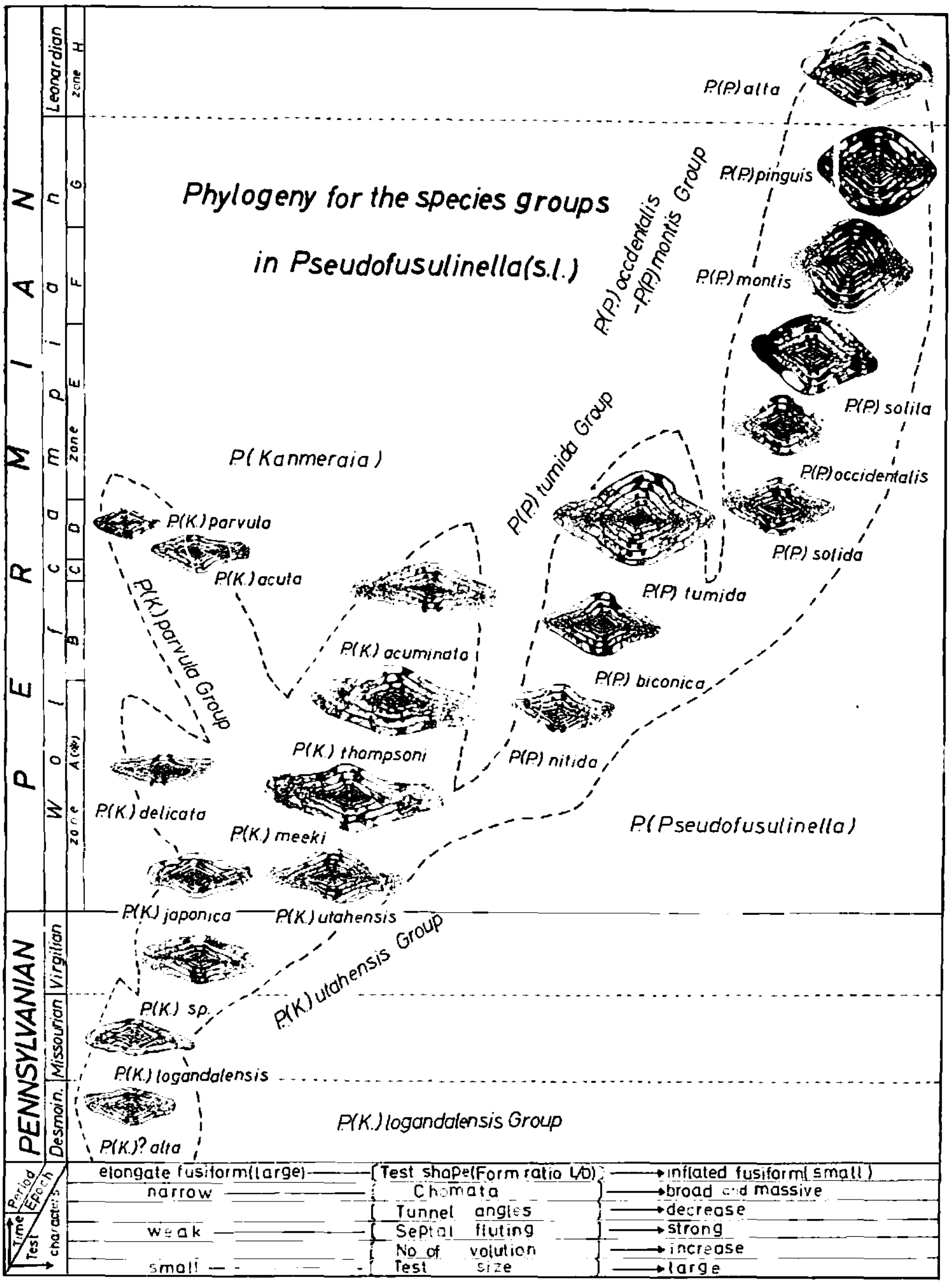


Fig. 4. Phylogeny of the species groups in *Pseudofusulinella* (s. l.).
(* Fusulinacean zones of the Wolfcampian and Leonardian of the McCloud Limestone by SKINNER and WILDE, 1965)

and *Paraschwagerina* is probably the first student who tried to study the problems concerning the migration of fusulinaceans in some detail, even if some problems still remained unsolved. I discuss herein the migration of *Pseudofusulinella* on the basis of the available data.

In the preceding chapter, I have classified the previously described species of *Pseudofusulinella* into five species-groups from a combined view of their shell characters and their stratigraphic ocurrence. Their ascending sequence is: (1) the *P.* (*Kanmeraia*) *logandalensis*, (2) the *P.* (*K.*) *utahensis*, (3) the *P.* (*K.*) *parvulla*, (4) the *P.* (*Pseudofusulinella*) *tumida* and (5) the *P.* (*P.*) *occidentalis*-*P.* (*P.*) *montis* group. The *P.* (*K.*) *logandalensis* group, which is considered to be ancestral to the other four Permian groups, is restricted to the Pacific Northwest of North America and has never been reported outside this regions. *Fusulinella pulchra*, *F. subpulchra* from the Upper Crrboniferous of Ural, *F. elegantura* and "*Wedekindellina*" *prolifica* from *Fusulinella*-*Fusulina* zone of Japan are very similar to this group, but these species have dissimilar and stronger chomata as compared with *Pseudofusulinella* and seem to form another taxonomic group which are parallel to the *Wedekindellina euthysepta* group and the *P.* (*Kanmeraia*) *logandalensis* group. Therefore the group of *Fusulinella pulchra* cannot be the direct ancestor of the Permian *Pseudofusulinella*. On the other hand *P.* (*K.*) *utahensis* group, which is interpreted to be a direct decendant of *P.* (*K.*) *logandalensis* group, is widely distributed in the Pacific Northwest of North America, the Japanese Islands, Spitsbergen and also the Ural Mountains. These marine realms are probably intimately connected at that time, and are considered to have been more or less similar also in sedimentary condition. The geographic distribution of the other three Permian groups, the *P.* (*K.*) *parvulla*, the *P.* (*P.*) *tumida* and the *P.* (*P.*) *occidentalis*-*P.* (*P.*) *montis* groups, are restricted to the Pacific Northwest of North America.

On the basis of the stratigraphic occurrence and the geographic distribution of these species-groups, I have lead the following idea. In the western North America, the ancestral species of *Pseudofusulinella*, the *P.* (*K.*) *logandarensis* group, may have arisen in the late Desmoinesian to early Missourian age. Later, in a Virgilian or Uppermost Carboniferous age, the *P.* (*K.*) *utahensis* group was derived from the *P.* (*K.*) *logandalensis* group and may have been migrated into the Uralian seaways and the far east end of the Tethyan seaways including the Japanese Islands through the Arctic region. On the other hand, the *P.* (*Kanmeraia*) *parvulla* and *P.* (*Pseudofusulinella*) *tumida* group are considered to have evolved from the *P.* (*Kanmeraia*) *utahensis* group in early Wolfcampian age and later the *P.* (*Pseudofusulinella*) *occidentalis*-*P.* (*P.*) *montis* group have evolved from the primitive species of the *P.* (*Pseudofusulinella*) *utahensis* group. The last three groups are restricted to to the Cordilleran seaways.

The distribution and migration of the genus *Pseudofusulinella* is shown in Fig. 5.

Notes on a new species of *Pseudofusulinella* (*Kanmeraia*) from Japan

In this chapter a new species of *Pseudofusulinella* (*Kanmeraia*) is established and its ontogeny is described.

Pseudofusulinella has been abundantly recorded from the Pacific Northwest region of North America, but in the eastern Asiatic region including the Japanese Islands, which has an intimate connection with the Pacific Northwest region in the general fusulinacean faunal assemblage, only one species of the genus has so far been recorded. It is *Pseudofusulinella utahensis* described by KANUMA (1958)

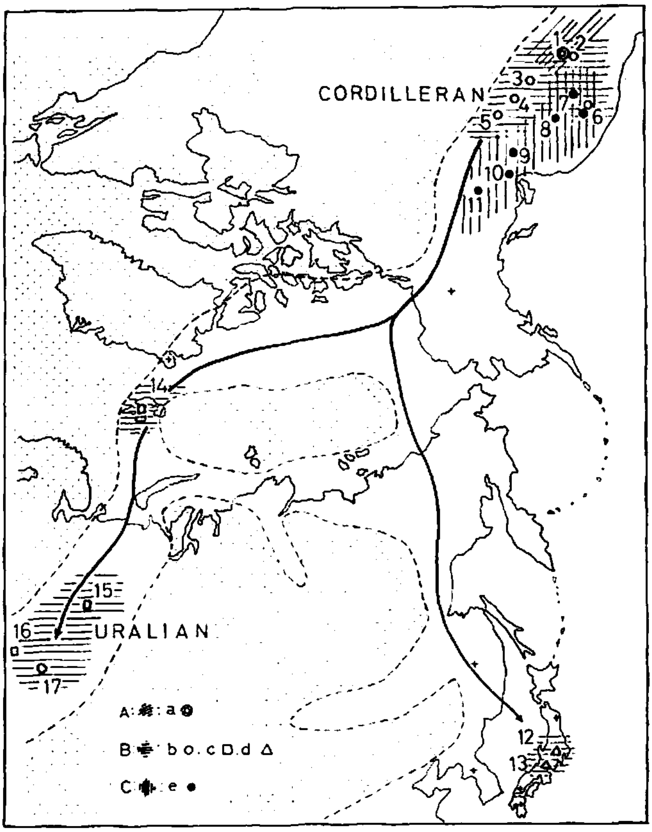


Fig. 5. Distribution and migration of *Pseudofusulinella*. The heavy dashed lines give an outline of sea ways in early Permian age (Wolfcampian).

A : *P.* (*K.*) ***logandalensis*** group; a, *P.* (*K.*) ***logandalensis***, etc; Missourian-Virgilian.

B : *P.* (*K.*) ***utahensis*** group and *P.* (*K.*) ***parvulla*** group; b, *P.* (*K.*) ***utahensis***, etc: c, *P.* (*K.*) *usvae*, d, *P.* (*K.*) *japonica*; Virgilian-Lower Wolfcampian.

C : *P.* (*P.*) *occidentalis-P.* (*P.*) *montis* group; e, *P.* (*P.*) *occidentalis*, *P.* (*P.*) *montis*, *P.* (*P.*) ***pinguis***, etc; Lower Wolfcampian-Lower Leonardian.

1, 2, Southern Nevada, 3, Utah, 4, Idaho, 5, Central Idaho, 6, Northern California, 7, Northwestern Nevada, 8, East-central Oregon, 9, Northeastern Washington, 10, Northwestern Washington, 11, Kamloop, British Columbia, 12, Kwanto massif, Central Japan, 13, Hida massif, Central Japan, 14, Vestspitsbergen, 15, Chusovaya river area, 16, Sakmara river area, 17. Samara area.

from the northern Mino mountains of Central Japan. The report of *Pseudofusulinella* from Japan throws light on the distribution of this important fusulinacean genus.

While I was engaged in the biostratigraphical study of the Upper Paleozoic formations of the Raidenyama area in southeastern part of the Kwanto massif, I collected numerous well preserved specimens of *Pseudofusulinella* from a limestone at the summit of Mt. Raidenyama. They are ascribed to a new species as described below. By courtesy of Prof. KANUMA, I have also examined the specimens which were identified with *P. utahensis*. In my opinion, they are also referable to the same new species.

The Upper Paleozoic strata of the Raidenyama area are divided into the following stratigraphic units:

Nariki Formaiion....*Neoschwagerina* zone to *Yabeina* zone
Raidenyama Formation....mainly *Psudoschwagerina* zone and probably lower part of *Neoschwagerina* zone in the uppermost part
Kitaosaki Formation....*Fusulinella-Beedeina* zone to *Triticites* zone

A new species of *Pseudofusulinella* (*Kanmeraia*) came from a limestone in Paidenyama Formation. It is accompanied by *Schubertella* sp. and *Nankinella* sp. cf. *N. kawadai*, the latter of which is associated with species of *Pseudoschwagerina* in some other area. Above and below the *Pseudofusulinella* Limestone there are several lenses of limestone which contain many Lower Permian fusulinaceans such as *Quasifusulina*, *Triticites*, *Schwagerina*, *Pseudoschwagerina*, *Paraschwagerina* and *Pseudofusulina*. Accordingly the new species of *Pseudofusulinella* is undoubtedly of Lower Permian (Wolfcampian) age.

Description of a species

Pseudofusulinella (*Kanmeraia*) *japonica* sp. nov.

Pl. 14, Fig. 7; Pl. 15, Figs. 1-21

1958, *Pseudofusulinella utahensis*, KANUMA, *Bull. Tokyo Gakugei Univ.*, vol. 9, pl. 2, figs. 1-5. (non THOMPSON and BIESSELL)

Material:—Holotype-GK. D15001; paratypes-GK. D15002-15015, 15020 and 15021. In addition to these, ten axial sections, three sagittal sections and more than twenty oblique and tangential sections were examined. They came from loc. RA. 151 in the lower part of the Raidenyama Formation.

Description:—The shell is small, elongate fusiform and inflated in the central region, with an almost straight to broadly curving axis of coiling, straight to concave lateral slopes, and bluntly pointed poles. Mature specimens with six to eight volutions measure 2.5 to 4.2 mm. in length and 1.2 to 1.8 mm. in width. The form ratio of the first to eighth volution averages 1.5, 2.0(−), 2.2, 2.2, 2.3, 2.4, 2.4 and 2.4, respectively for thirteen well oriented axial sections. The holotype (GK. D15001) is 4.02 mm. long and 1.68 mm. wide, giving a form ratio of 2.4 for seventh volution. In the megalospheric specimens, the first volution is almost subspherical in shape and is coiled planispirally, but the microspheric specimens have an endothyroid or a pseudostaffelloid juvenarium which is coiled at high angles to the outer volutions. (GK. G15011, Pl. 15, Figs. 16, 17, etc.) The shell is tightly coiled in the inner two or three volutions and increase uniformly in height in the subsequent ones. The height of chambers of eight volutions above the tunnel averages 32, 48, 64, 86,

Table 3. Measurements of *Psudofusulinella* (*Kanmeraia*) *japonica* sp. nov. in mm. unless otherswic stated.

Speci-men	Rg. No.	Fig. in Plate	Length	Width	Form ratio	Diam prol.	Form ratio	Height of volutions 1	2	3	4	5	6	7	8
1	15001	1, 2	4.02	1.68	2.4	.096	7.5	.024	.048	.056	.080	.120	.120	.176	.210
2	15002	4	3.73	1.56	2.5	.112	8	.032	.048	.048	.080	.080	.128	.176	.194
3	15003	5	3.90	1.56	2.3	.064	7.5	.024	.032	.032	.048	.080	.104	.160	.210
4	15004	6	4.22	1.60	2.6	.088	7.5	.032	.048	.048	.064	.080	.088	.160	.194
5	15005	7.9	3.03	1.31	2.3	.096	6	.032	.048	.080	.112	.114	.176	—	—
6	15011	16, 17	3.20	1.23	2.6	.080	7	.032	.064	.064	.096	.112	.176	.176	—
7	15020	20	—	1.39	—	.080	7	.032	.048	.080	.080	.112	.144	.210	—
8	15021	3, 21	—	1.48	—	.070	7.5	.032	.032	.048	.052	.104	.136	.176	.176
		Max.	4.22	1.85	2.6	.128	8	.048	.064	.112	.128	.114	.210	.210	.210
		Min.	3.26	1.00	2.1	.064	5.5	.024	.032	.032	.048	.080	.088	.160	.176
		Aver.	3.60	1.50	2.4	.094	7	.032	.048	.064	.086	.115	.152	.176	.191
			21	23	25	18	19	19	20	20	20	20	20	13	6

Specimen	From ratio of volutions 1	2	3	4	5	6	7	8	Thickness of spirotheca* (μ) 1	2	3	4	5	6	7	8	Tunnel angles (in degree) 2	3	4	5	6	7
1	1.5	1.9	2.1	2.2	2.3	2.4	2.4	—	6	8	12	14	23	27	29	29	12	18	17	22	30	—
2	1.5	2.0	2.2	2.3	2.3	2.5	2.4	2.4	4	7	8	12	16	21	25	29	—	—	17	17	24	35
3	1.7	2.1	2.2	2.3	2.4	2.3	2.3	—	4	7	8	12	16	21	22	29	—	—	19	29	36	40
4	1.7	2.0	2.2	2.5	2.5	2.4	2.6	—	4	7	8	12	16	16	18	27	—	11	12	18	23	30
5	1.4	2.0	2.1	2.2	2.2	2.3	—	—	6	8	8	10	16	21	—	—	12	13	13	23	—	—
6	1.3	1.7	2.0	2.2	2.4	2.6	2.5	—	4	6	10	12	25	21	29	—	—	—	22	25	22	—
7	—	—	—	—	—	—	—	—	4	6	8	8	12	21	?	—	—	—	—	—	—	—
8	—	—	—	—	—	—	—	—	4	8	10	12	16	21	25	28	—	—	—	—	—	—
Max.	1.8	2.1	2.3	2.7	2.7	2.8	2.7	2.4	6	8	12	16	25	27	29	29	14	19	25	32	38	40
Min.	1.3	1.7	2.0	2.0	2.0	2.1	2.2	2.4	4	4	8	8	12	16	18	27	12	12	12	16	20	30
Aver.	1.5	2.0	2.2	2.2	2.3	2.4	2.4	2.4	4	6	8	11	16	20	24	29	13	15	15	24	29	35
	16	17	17	17	17	14	9	4	19	20	20	20	20	19	12	6	3	11	16	17	11	4

* tectum+diaphanotheca

(Continued from Table 3)

Specimen	Septal counts						
	1	2	3	4	5	6	7
7	9	13	14	14	15	16	22
8	7	12	13	15	15	19	22
9	6	12	13	15	15	19	23
Aver.	8/4	12/4	14/4	15/4	16/4	18/4	22/3

115, 152, 176 and 191 microns respectively for 20 specimens. The proloculus is minute and spherical, and its outside diameter ranges from 64 to 128 microns, averaging 94 microns for 18 specimens. The spirotheca is composed of a tectum and a diaphanotheca, and its upper and lower surfaces are discontinuously covered with dense deposits of the same material as the chomata. The perforations of the wall are not observed in the present specimens. Averages of the combined thickness of the tectum and the diaphanotheca in the first to eighth volution of 19 specimens are 4, 6, 8, 11, 20, 24 and 29 microns respectively. The septa are gently or rather irregularly folded in the polar regions. Average septal counts of the first to seven volution of four specimens are 8, 12, 14, 15, 16, 18 and 22 respectively. The chomata are massive and highly assymmetrical, and extend nearly to the poles in the inner three or four volutions. Their tunnel sides are steep and gradually lowered towards the polar ends. The tunnel is narrow and about half as high as the chambers. Average tunnel angles of the second to sixth volution of seventeen specimens are 13, 15, 18, 24, 29 and 35 degrees respectively. Measurements of this specimens are given in Table 3.

Discussion :—*Pseudofusulinella* (*Kanmeraia*) *japonica* sp. nov. is similar in general characters to *P.* (*K.*) *utahensis* THOMPSON and BISSEL, the type-species of the subgenus *Kanmeraia*, from the Lower Wolfcampian Oqirrh Formation of Utah, Sublett Range and the Wood River Formation of Idaho, and to *P.* (*K.*) *antiqua* SKINNER and WILDE from the McCloud Limestone in northern Califormia. The former, is however, distinguished from the latter two species by the smaller and more inflated shell and the more gently folded septa in the axial and polar regions. This species also resembles *Fusulinella usvae* DUTKEVITCH from the Central Ural, the Samara River area of Southern Ural and Spitsbergen, which is referable to *Pseudofusulinella* (*Kanmeraia*) in the present classification, but the latter has a slenderer shell with sharply pointed poles, more prominent chomata and more intensely and irregularly folded septa. KANUMA (1958) identified a *Pseudofusulinella* from the northern Mino Mountains with *P. utahensis*, I reexamined his specimens and found that they are identical with the present species.

Occurrence :—Abundant in a limestone of the lower part of the Raidenyama Formation at the summit of Mt. Raidenyama (coll. no. RA. 151). Associated with *Nankinella* sp. cf. *N. kawadai* (IGO) and *Schubertella* sp.

The ontogeny of *P.* (*Kanmeraia*) *japonica* sp. nov.

Studies on ontogeny are very effective and significant for a better understanding of the line of descent, because the phylogenetic development is frequently recaptulated in the ontogenetic development.

I take here the ontogeny of *P.* (*K.*) *japonica* sp. nov. For this purpose the change of shell structure throughout the whole growth-stages of *P.* (*K.*) *japonica*

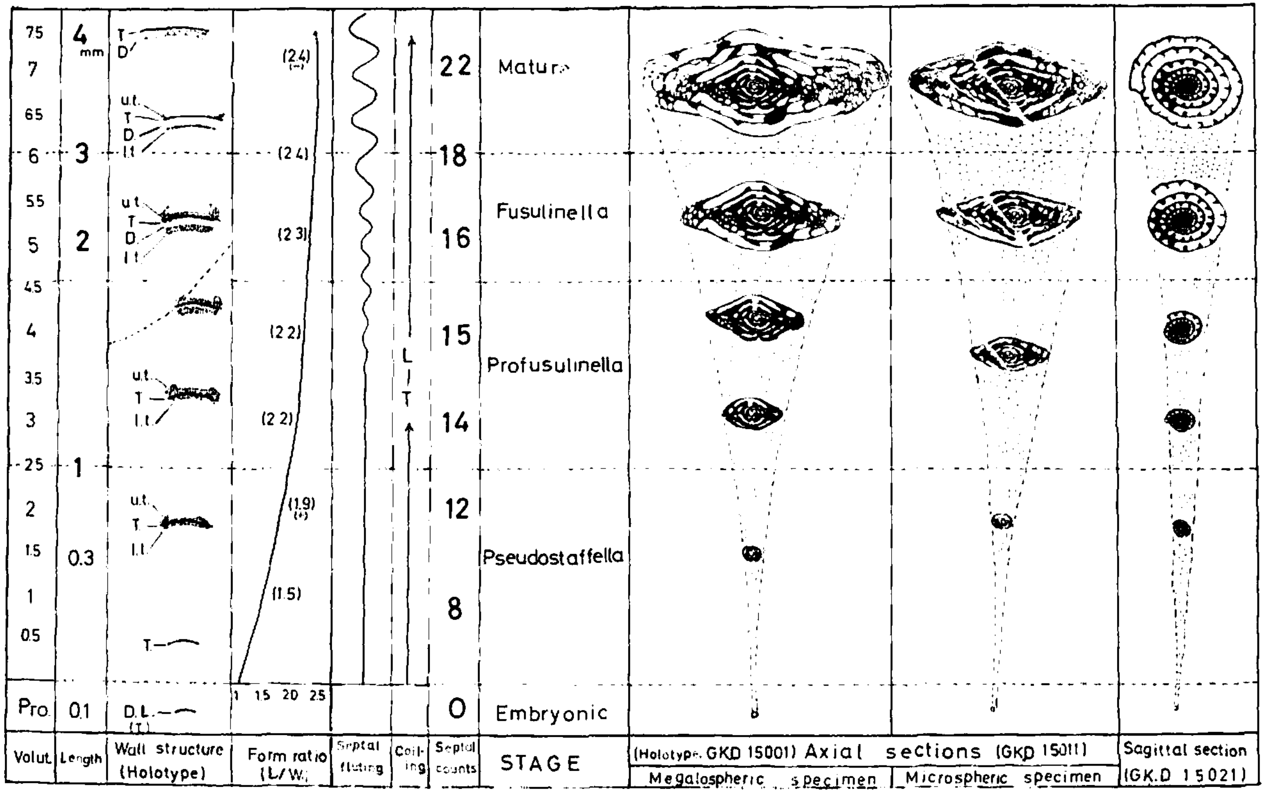


Fig. 6. Ontogenetic development of *Pseudofusulinella (Kanmeraia) japonica* sp. nov.

(Volut., volution, L., length, W., width, D. L., single dense layer, T., tectum, u. t., upper tectorium, l. t., lower tectorium, Septal counts, numbers of each volution)

Explanation of Plate 14

(all figures are × 8, except for Figs. 1, 3, 11 and 12 which are ×16)

Pseudofusulinella (*s. s.*) and *Pseudofusulinella* (*Kanmeraia*)

Figs. 1-3. *P.* (*Kanmeraia*) *utahensis* THOMPSON and BISSELL, 1954, The type-species of *P.* (*Kanmeraia*).

1. Axial section of the holotype from the Lower Wolfcampian of the Oquirrh Formation, Utah, U. S. A. (after THOMPSON, 1954).

2, 3. Axial and sagittal sections from the Lower Wolfcampian of Sublett Range, Idaho, U. S. A. (after THOMPSON DODGE and YOUNGQUIST, 1958).

Fig. 4. *P.* (*Kanmeraia*)? *alta* VERVILLE, THOMPSON and LOKKE, 1956. Axial section of the paratype from the Middle Desmoinesian of the Ely Limestone in the Cherry Creek Mountains, White Pine Country of eastern Neveda, U. S. A. (after VERVILLE, THOMPSON and LOKKE, 1956).

Fig. 5. *P.* (*Kanmeraia*) *logandarensis* CASSITY and LANGENHEIM, 1966. Axial section of the holotype from Missourian of the Bird Spring Group, Arrow Canyon, Clark Country, Nevada, U. S. A. (after CASSITY and LANGENHEIM, 1966).

Fig. 6. *P.* (*Kanmeraia*) sp. Axial section from the Virgilian of the same locality as Figs. 2 and 3 (after THOMPSON, DODGE and YUNGQUIST, 1958).

Fig. 7. *P.* (*Kanmeraia*) *japoniac*, sp. nov. (see also Pl. 15, Figs. 1-21) Axial section of the holotype from the Lower Wolfcampian of the Raidenyama Formation, southeastern Kwanto massif, Central Japan.

Fig. 8. *P.* (*Kanmeraia*) *meeki* SKINNER and WILDE, 1965. Axial section of the paratype from the Lower Wolfcampian of the McCloud Limestone, Shasta Lake Area, northern California, U. S. A.

Fig. 9. *P.* (*Kanmeraia*) *thompsoni* SKINNER and WILDE, 1965. Axial section of the paratype, from the Lower Wolfcampian of the same locality as Fig. 8.

Fig. 10. *P.* (*Kanmeraia*) *acuminata* SKINNER and WILDE, 1965. Axial section of the paratype, from the Middle Wolfcampian of the same locality as Fig. 8. (Figs. 8-10. after SKINNER and WILDE, 1965).

Figs. 11-12. *Pseudofusulinella* (*Pseudofusulinella*) *occidentalis* (THOMPSON and WHEELER), 1946. The type species of *P.* (*Pseudofusulinella*)

11. Axial section of the holotype, 12, sagittal section of paratype from the Middle Wolfcampian of the McCloud Limestone, northern California (after THOMPSON, WHEELER and HAZARD, 1946).

Fig. 13. *P.* (*Pseudofusulinella*) *tumida* SKINNER and WILDE, 1965. Axial section of the paratype.

Fig. 14. *P.* (*Pseudofusulinella*) *biconica* SKINNER and WILDE, 1965. Axial section of the paratype.

Fig. 15. *P.* (*Pseudofusulinella*) *solida* SKINNER and WILDE, 1965. Axial section of the paratype.

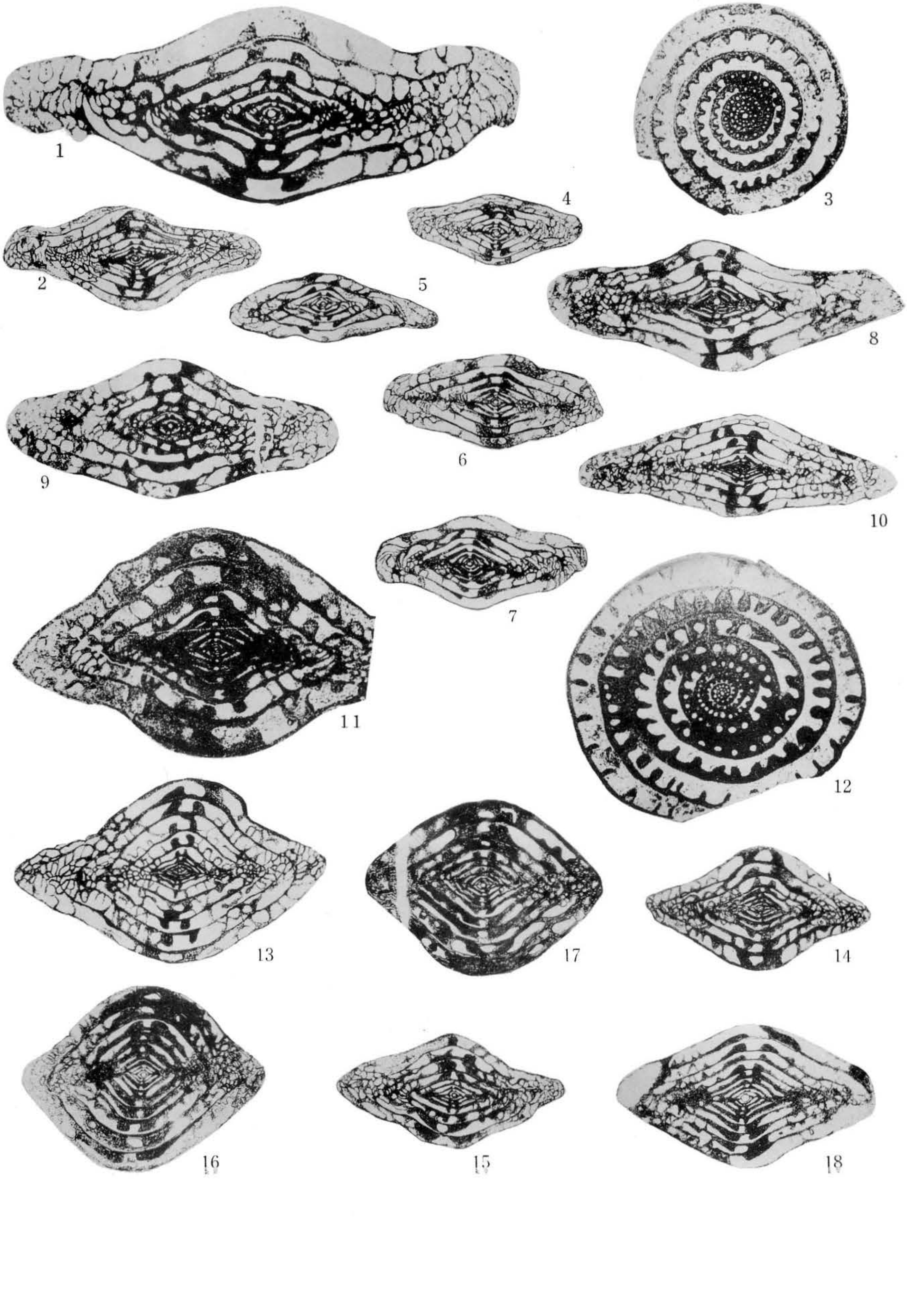
13-15. From the Middle Wolfcampian of the McClound Limestone, northern California (after SKINNER and WILDE, 1965).

Fig. 16. *P.* (*Pseudofusulinella*) *montis* (THOMPSON and WHEELER), 1946. Axial section of the topotype from the Upper Wolfcampian of the McCloud Limestone, northern California (after SKINNER and WILDE, 1965).

Fig. 17. *P.* (*Pseuofusulinella*) *pinguis* SKINNER and WILDE, 1965. Axial section of the holotype from the Upper Wolfcampian of the McCloud Limestone.

Fig. 18. *P.* (*Pseudofusulinella*) *alta* SKINNER and WILDE, 1965. Axial section of the holotype of *P. seaa* SKINNER and WILDE which should be refferred to a synonym of *P. alta*, from the Lower Leonardian of the McCloud Limestone.

(All figures are reproduced by the present author except for the Figs. 1, 3, 11 and 12)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described above have been examined in respect to the spirothecal structure, the mode of coiling, the shape and size of the shell, the septal fluting and the degree of development of the chomata. Shell features at several stages of representative examples in three well-oriented sections, i. e., two axial sections including a megalospheric specimen (Holotype, GK. D15001) and a microspheric one (Paratype, GK. D15011) and a sagittal section (Paratype, GK. D15021), are diagrammatically shown in Fig. 6.

(1) Embryonic stage.— The initial chamber (proloculus) is spherical in shape and approximately 100 to 130 microns in diameter in megalospheric specimens and 60 to 80 microns in microspheric ones. The proloculus wall of all the examined specimens is of single dense layer.

(2) *Pseudostaffella* stage (1st to 3rd volution).—The nepionic chambers are coiled around the initial one. At the stage of volution 1.5 to 2.5, the shell becomes subspherical in shape giving a form ratio 1.6 or a little more and 0.3 to 0.4 mm. in length. In the microspheric specimens, the first volution is coiled at high angles to the second one. The spirotheca is composed of a single dense layer (the tectum) or a tectum and upper and lower tectoria. The chomata first apper in this stage. The septa are plane. The shell characters of this stage assume those of the primitive species of *Pseudostaffella*, such as *P. needhami* and *P. antiqua*, and are at the same time similar to those of endothyrids.

(3) *Profusulinella* stage (3rd to 4th, rarely 5th volution).—The shell attains approximately 1 to 2 mm. in axial length. It is thickly fusiform or biconical in shape giving a form ratio 2.0 or so and is coiled tightly throughout as shown well in the saggittal section. The chomata are prominent. The septa are not fluted. The spirotheca is composed of a tectum and upper and lower tectoria. Judging from these features of the wall, this stage shows the characters of the mature stage of *Profusulinella* RAUSER-CHERNOUSOVA and BELYAEV.

(4) *Fusulinella* stage (4th to 6th volution).—This and the above mentioned stages overlap each other. In some specimens, the characters of this stage are already recognized in the fourth volution. The diaphanotheca first appears in the fourth or fifth volution. That is to say, the spirotheca in this stage comprises a tectum, a diaphanotheca and upper and lower tectoria. The septa are fluted in the polar regions. The coiling becomes loose. The shell is typically fusiform, measures 2.3 to 2.6 mm. in axial length and gives the form ratio 2.4. The characters recognized in this stage recall the diagnosis of *Fusulinella* MÖLLER.

(5) Mature stage (6th to 8th volution).—The shell becomes elongate fusiform with the form ratio 2.4 or so. The septa are fluted in the polar and axial regions. The axial length exceeds 4 mm. The spirotheca is composed of a tectum, a diaphanotheca and a less developed and discontinuous lower tectoria. No lower tectoria is recognized in the outermost volution. The spirothecal structure is more advanced than that of *Fusulinella*.

As stated above the ontogenetic development of *Pseudofusulinella* (*Kanmeraia*) *japonica* passed at least four stages; the embryonic, the *Pseudostaffella*, *Profusulinella* and *Fusulinella* stages until the species assumes characters of *Pseudofusulinella*. (Fig. 6) This process seems to approximately correspond with the phylogenetic development of *Pseudofusulinella*. In other words, the phylogenetic development of *Pseudofusulinella* is well reflected in its ontogenetic development. Similar ontogenetic development is also recognized in some species belonging to ancestral group of *Pseudofusulinella*. As the stratigraphic horizon becomes higher, tendency of reduction or omission of certain stages is well recognized in most of the highly evolved species of the *P.* (*K.*) *utahensis* group, *P.* (*P.*) *tumida* group and *P.* (*P.*) *occidentalis-P.* (*P.*) *montis* group. For example, *P.* (*P.*) *occidentalis*, the type-species of the genus, has only one or two tightly coiled juvenile volution (Pl. 14, Figs. 11, 12) which are followed by the subsequent ones with heavy chomata diagnostic for the genus *Pseudofusulinella*. Furthermore, in most evolved species, *P.* (*P.*) *alta* (Pl. 14, Fig. 18), a tightly coiling is hardly seen in the juvenile volutions. (Fig. 1) Thus tendecy of tachygensis (acceleration) is clearly observed in this genus as in many groups of the family Fusulinidae.

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Explanation of Plate 15

Figs. 1-21. *Pseudofusulinella* (*Kanmeraia*) *japonica* sp. nov.

1, 2. Axial sections of the holotype in different magnification. (×20 and ×10 respectively), Rg. No. Gk. D15001

3, 21. Sagittal sections of a paratype (×20 and ×10 respectively) Rg. No. GK. D15021

4–17, 19. Axial sections of paratypes (×10 except for 9 and 16 which are ×20) Rg. No. GK. D15002-15006, 15005, 15007-15015, 15016 and 15015, respectively

7, 9 and 16, 17. Same specimens in different magnification (7, 17 ×10 and 9, 16 ×20)

5, 16, 17. Microspheric specimens with endothyroid juvenarium.

13. Tangential section of a paratype. GK. D15014

20. Sagittal section of a paratype. ×10, Rg. No. GK. D15020

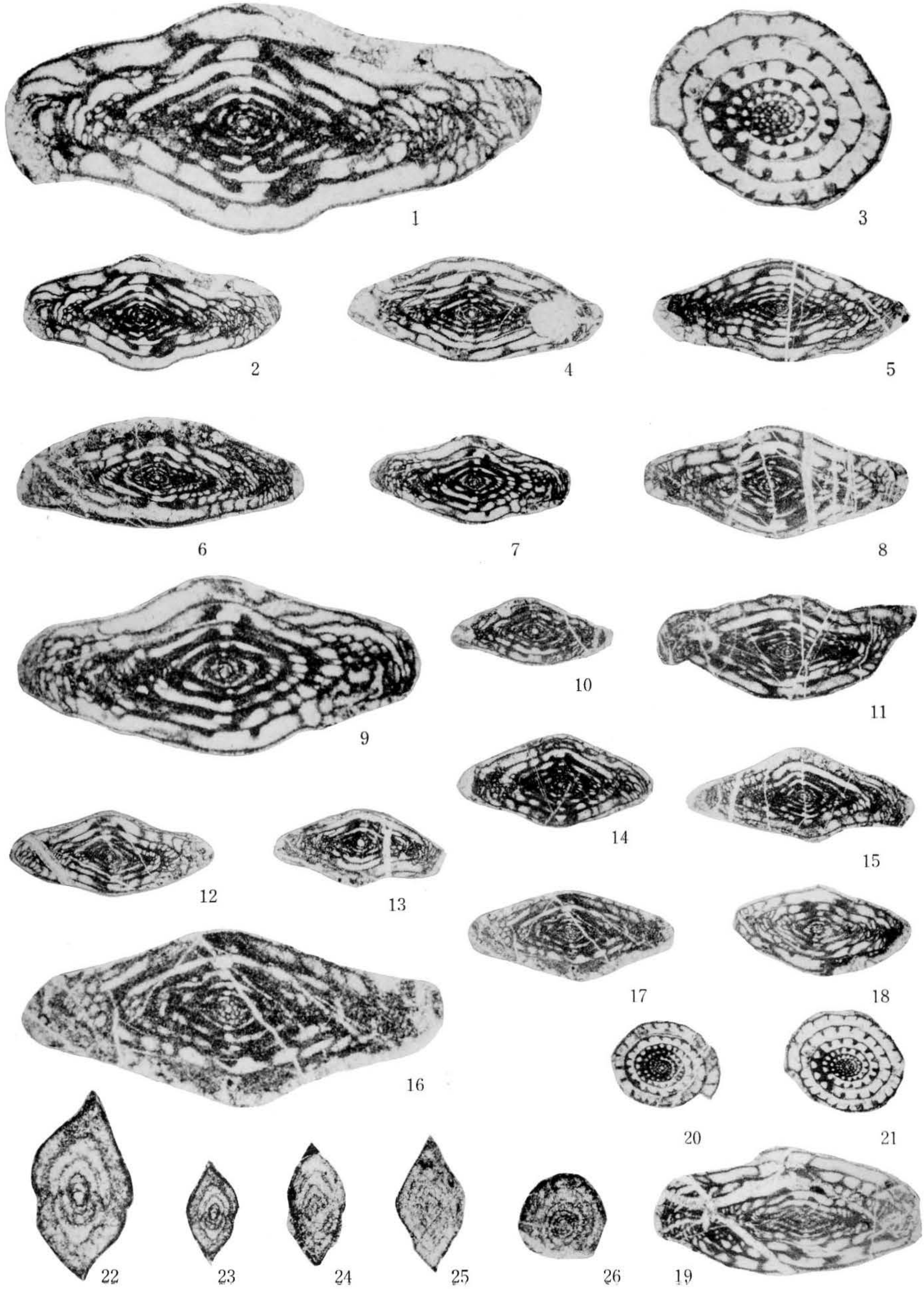
Figs. 22–26. *Nankinella* sp. cf. *N. kawadai* (IGO) (Associated species with *P.* (*K.*) *japanica* sp. nov.)

22–25. Axial sections (×10 except 22 which is ×20)

26. Sagittal section. ×10,

All specimens illustrated are kept in the Department of Geology, Kyushu University.

OZAWA photo



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Futamatao	二俣尾	Nariki	成木
Ikusabata	軍畑	Raidenyama	雷電山
Kitaosoki	北小曾木	Tamagawa	多摩川

Trans. Proc. Palaeont. Soc. Japan, N. S., No. 67, pp. 174-176, pl. 16, Dec. 25, 1967

530. *NUMMULITES* FROM IRAN*

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Iran 産 *Nummulites*: 小貫義男は1966年夏に北 Iran の 地域の地質調査に従事し同地域の Tekiyeh 峠で数多の *Nummulites* を採集し筆者にその研究を委嘱した。このものは全部同一種で Indonesia の Java 産の *Nummulites javanus* VERBEEK (micaospheric) 及び *Nummulites baguelensis* VERBEEK (megalospheric) に同定し得る。上記の2種は同一種における世代交番の現象である。そして前者は既に DOORNINK, 1932 によって欧州産 *Nummulites perforatus* (DE MONTFORT) に同定されている。最後に掲げたものは BOUSSAC, 1911 により良く研究されたものであり著しく個体変化に富むものとされている。筆者は DOORNINK 及び BOUSSAC の説に従って Iran 産のものを *Nummulites perforatus* DE MONTFORT)とする. 本有孔虫化石を産する Ziaran 層の時代は中部始新統最上部 Biarritzian 階である。

半 沢 正 四 郎

Introduction

Dr. Yoshio ONUKI recently completed stratigraphic work in the Taleghan Area in northern Iran. He collected a number of specimens of *Nummulites* and kindly submitted them to the writer for study. According to his verbal information, the Taleghan district is located in the central part of the Elburz Mountains, approximately 100 km northwest of Teheran. This district comprises an elongate area (25 km from east to west and 10 km from north to south) known as Taleghan Basin, a part of the Taleghan Hills and the Ziaran Basin. The basement of this area consists of Jurassic rocks, which are overlain by the Tertiary and Quaternary formations. The Tertiary rocks, which are extensively distributed in this district are divided into the marine Ziaran Formation and the non-marine Taleghan Formation on the basis of the remarkable lithofacies change. The Ziaran Formation, which is found in the northern part of the Ziaran Basin and the Taleghan Hills is composed largely of green tuff or tuff-breccia, tuffaceous sandstone, black shale, glauconitic sandstone or glauconitic limestone. A number of pyroxene-feldsper porphyrite sills intruded in this formation. The Nummulitic specimens dealt with in this article were collected from the tuffaceous sandstone of the lower Ziaran Formation exposed along the Tekiyeh Pass in the Taleghan Area together with some molluscan and other fossils.

* Received June 20, 1967; read June 18, 1967.

Description of Species

Family Nummulitidae (HANZAWA, 1963, p. 160)

Genus *Nummulites* LAMARCK, 1801 (HANZAWA and URATA, 1964, pp. 2-4)

Nummulites perforatus (DE MONTFORT)

Plate 16, figs. 1-6.

1896. *Nummulites javanus* VERBEEK (pars), pp. 1143-1147, pl. 3, figs. 45-50; pl. 4, figs. 58-67 (Microspheric form).
1896. *Nummulites baguelensis* VERBEEK (pars), pp. 1147, 1148, pl. 3, fig. 74; pl. 4, figs. 77-79 (megalospheric form).
1911. *Nummulites perforatus* (DE MONTFORT), BOUSSAC, pp. 66-75, pl. 3, figs. 1-7, 13, 14, 16.
1932. *Camerina perforata* (DE MONTFORT), DOORNINK, pp. 272-274, pl. 1, figs. 1-5 (microspheric form).
1932. *Camerina javana* (VERBEEK), DOORNINK, pp. 271, 272 (microspheric form).

VERBEEK's description and illustrations of *Nummulites javanus* var. β indicate that this species is large and consists of a very small proloculus (invisible) and a number of closely coiled whorls. Its lateral surfaces are rather smooth, but ornamented with numerous moderately sinuous septal filaments and small granules distributed evenly all over on them.

DOORNINK investigated the topotypes of *Nummulites javanus* VERBEEK and concluded that this species shows a wide range of variation in the external form and in the degree of the ramification and the sinuosity of septal filaments on the lateral surfaces of the test just as BOUSSAC found in his study of the European *Nummulites perforatus* (DE MONTFORT). DOORNINK identified *Nummulites javanus* (pars) with *Nummulites perforatus* (DE MONTFORT) and discarded the specific name of the former as a synonym of that of the latter.

According to DOORNINK, *Nummulites perforatus* from Java is 20 mm across and varies from a fairly strongly globose form with a blunt periphery to a flatter form with a very sharp border.

All the specimens of *Nummulites* from Iran now at the writer's disposal are free from the matrix. Unfortunately, the surfaces of the tests are so poorly preserved that their characteristic features cannot be seen. But, the tangential sections parallel to the equatorial plane of the tests show that the septal filaments are moderately sinuous in the microspheric form and are merely radial in the megalospheric form. Besides, numerous small granules which are the heads of the pillars traversing through the spiral lamellae are evenly distributed all over the lateral surfaces of both the microspheric and megalospheric forms. The microspheric specimens from Iran are rather small, 15-20 mm across and 7-9 mm thick, and consist of a very tiny spherical proloculus, 10μ in diameter and 33-50 closely coiled whorls. The periphery of all the specimens is broadly rounded. These forms may be safely identified with the typical *Nummulites javanus* [=*Nummulites perforatus* (DE MONTFORT)]. The associated megalospheric form is 3.2-5.4 mm across and 1.2-2.0 mm thick and consists of a spherical proloculus, 260-840μ in diameter and 5-7 closely coiled whorls; the periphery is rather obtuse. This form is identified with *Nummulites baguelensis* VERBEEK (pars) [=megalospheric form of *Nummulites perforatus* (DE MONTFORT)].

Fortunately the writer made some well-centered equatorial sections cut through the proloculus (10μ across) of the microspheric specimens of *N. perforatus*. The statistics of the height of whorls and the number of chambers in the whorls in the earier part of the microspheric specimens as welll as those of the megalospheric forms are given below:

Geologic Horizon and Locality:—Biarritzian Ziaran Formation, the Tekiyeh Pass in the Taleghan Area, Central Elburz Mountains, northern Iran. IGPS coll. cat. no. 85491.

Microspheric form (earlier whorls alone)

Whorls	Height of whorls (in μ)	Number of chambers
I	59-74	7
II	170-202	9-11
III	364-417	11-12
IV	650-740	16-17
V	1,200	17-19
VI	1,440-1,660	24-25
VII	1,940-2,000	22

Megalospheric form

Whorls	Height of whorls (in μ)	Number of chambers
I	1,090-1,300	5-7
II	1,820-2,260	14-16
III	2,500-2,620	18-22
IV	3,140-3,310	22-28
V	3,820-3,900	24-32
VI	4,350-4,700	39
VII	4,800-5,350	

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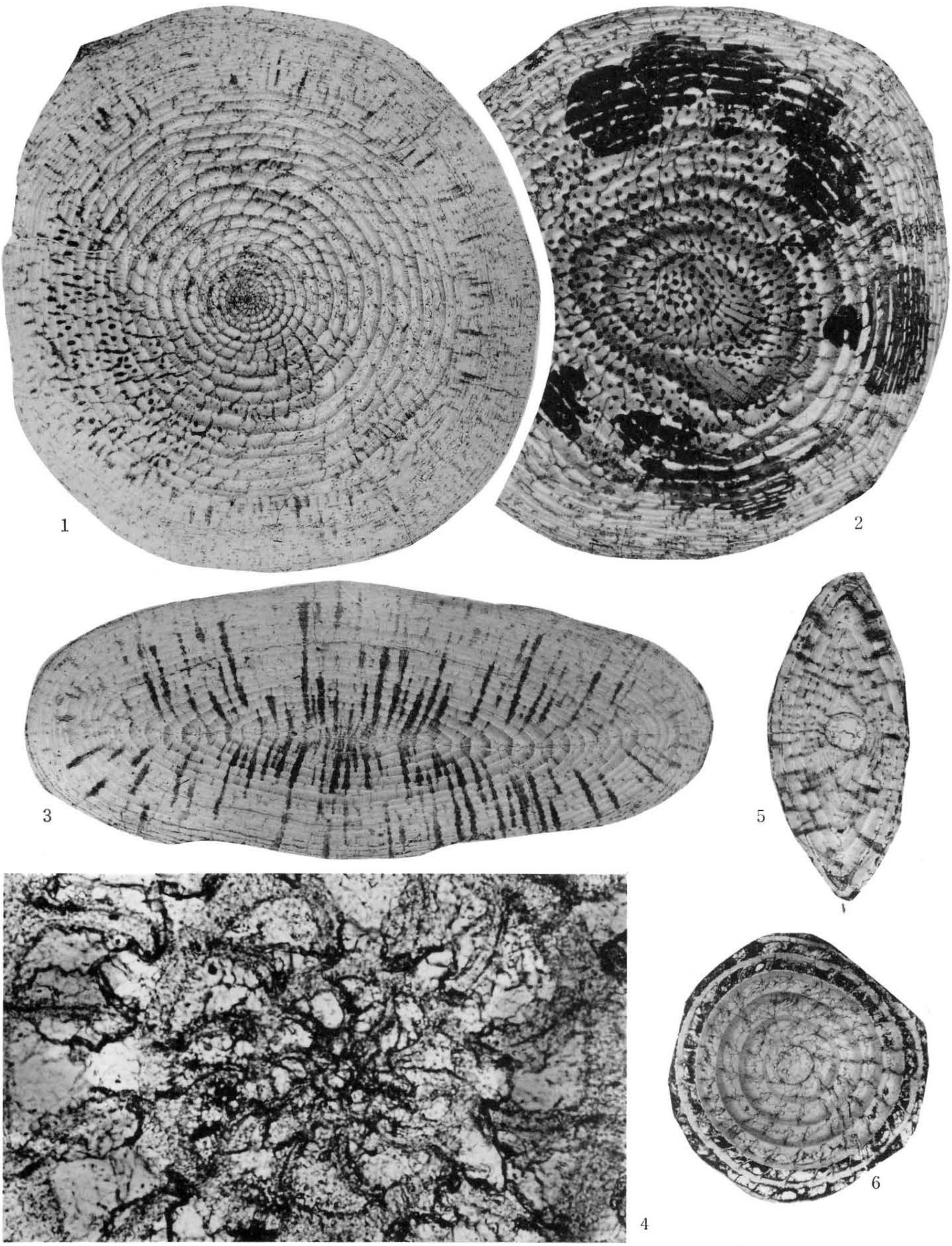
Explanation of Plate 16

Nummulites perforatus (DE MONTFORT)

1-4. Microspheric form.
 1. Equatorial section. ×5.
 2. Tangential section parallel to equatorial section showing the features of pillars and septal filaments. ×5.
 3. Axial section. ×5.
 4. Equatorial section of the earlier whorls showing the details of them and the microspheric proloculus. ×200.

5, 6. Megalospheric form.
 5. Axial section. ×10.
 6. Equatorial section. ×10.



KUMAGAI photo,

Trans. Proc. Palaeont. Soc. Japan, N.S., No. 68, pp. 177-184, pls. 17-19, Dec. 25, 1967

531. A NEW RADIOLARIA FROM THE SŌMACHI FORMATION, KIKAI-JIMA, KAGOSHIMA PREFECTURE, JAPAN

TUNYOW HUANG

Chinese Petroleum Corporation

喜界島産化石放散虫の一新属・新種：鹿児島県喜界島の早町層より放散虫の新属・新種が発見されたので，*Hataina ovata* と命名し，その記載並びに属位的，及び地理的分布を報告する。

黄　敦　友

A small, white colored, oval shaped, so-called "OST" MORISHIMA, *et al.*, 1949) is a problematical fossil of frequent occurrence and wide distribution in the younger Tertiary formations in Japan. It has also been recorded from the Sōmachi Formation in Kikai-jima, Kagoshima Prefecture (HUANG, 1966).

This problematica is, according to literature as well as the rock samples studied, rare in the Upper Miocene formations, common in the Pliocene formations, and is known from the Recent seas (MATOBA, 1966) of Japan and Taiwan (HUANG, Fig. 1, in this paper).

In the Pliocene sediments of the Sōmachi Formation in Kikai-jima the so-called "OST" is common and associated with abundant planktonic Foraminifera, siliceous sponge spicules and Radiolaria.

This problematical fossil, the scope of the present article was studied under high magnification, its thin sections and dissected specimens. As the result of the present study it was found that it can not be included in any previously described genus or species, and is here described as new to science.

* Received June 20, 1967.

Acknowledgement

The writer expresses his sincere gratitute to Professor Kotora HATAI of the Institute of Geology and Paleontology, Faculty of Science, Tohoku University for his kind guidance throughout this study. Thanks are also due to Professor Rikizo IMAIZUMI and Dr. Keiji OIDE of the College of Arts and Science, Tohoku University for their helpful advice on the statocysts of prawns and optical properties of the test of those organism.

Thanks are due to Professor Veichow C. JUAN and Professor Tsu-you CHU of the National Taiwan University for supplying the samples of bottom sediments from near Taiwan.

Acknowledgement is also made for the partial financial support of this investigation through a grant from the Japan—U.S. Cooperative Science Program.

Paleontology

The problematica, as the result of micropaleontological investigation, as stated in detail later, is an undescribed radolarian of rather common occurrence, extensivie distribution, rather short geological range, and with associated fauna comprised of foraminifers and sponge spicules.

This interesting microfossil is here named *Hataina ovata* HUANG, gen. and sp. nov., and described below.

Description

Subclass RADIOLARIA MULLER, 1858

Order PORULOSIDA HAECKEL, 1887

Suborder SPUMELLINA EHRENBERG, 1875

Division SPHAERELLARI HAECKEL, 1882

Superfamily LARACARIICAE HAECKEL, 1887

Family LARACARIIDAE HAECKEL, 1887

Genus *Hataina* HUANG, new genus

Type species:—*Hataina ovata* HUANG, sp. nov.

Description:—Shell or test simple, a single latticed shell, lentelliptical in outline, with simple shell-cavity; shell-pores prolonged, cylindrical appear as tubuli; without medullary shell or internal rods, no radial spines preserved; aperture on middle part of oval margin growth unequal in three axes.

Remarks:—The genus is named in honour of Professor Kotora HATAI, an eminent paleontologist under whose direction the present work was accomplished.

The new genus *Hataina* is characterized by the lentelliptical fine fenestrated shell without any accessary structure but with an aperture opened on the middle part of the oval margin and the unequal growth in 3 axes. The new genus shows close resemble to *Cenolarchus*, which according HAECKEL (1887) and CAMPBELL (1954), belongs to the Laracariicae. And, from the resemblance with that genus. The present one is included in the same family.

The shell structure is similar to *Cenosphaera* and *Ethmosphaera* among the Liosphaeridae, to *Cenodiscus* among the Cenodiscidae, to *Cenellipsis* among the Ellipsidiidae, and to *Cenolarchus* among the Laracarriidae. Although superficial resemblance to *Hataina* to the genera mentioned above exists, the present one can be distinguished from them by the small aperture on the oval side, and the typical lentelliptical form, and triaxial ellipsoid with three dimension axes of unequal length. Based on the last mentioend character this species should be included in the Laracarriidae.

The most important biocharacters are the shell form, the position of the aperture, and shell structure as described above.

Range:—Upper Miocene to Recent.

Hataina ovata HUANG, new species

Pl. 17, figs. 1-6; pl. 18, figs. 1-4; pl. 19, figs. 1-6

Holotype:—Plate 17, figs. 1 to 3, IGPS coll. cat. no. 88026 from locality No. 409, the locality is shown in a paper by HUANG (1966).

Paratype:—Plate 17, figs. 4 to 6; plate 18, figs. 1 to 4; plate 19, figs. 1 to 6. Specimens on the slide No. 1. From the smae sample to the same locality as the holotype.

Thin section:—Slide No. 1, IGPS coll. cat. no. 88027.

Depository:—The holotype, paratype, and thin section are deposited in the Institute of Geology and Paleontology, Faculty of Science, Tohoku University, Sendai, Japan.

Description:—Shell simple, small, lentelliptical latticed shell, subsphaerical to elliptical in outline, rather thin-walled, surface a little rough; pores very fine, numerous, circular, regular in arrangement, uniform in size and form, deeply set into wall, cylindrical tubuli, treble as broad as elevated bars; about 13 pores on half of longest axis, 10 on half of shortest axis; pores slightly prolonged outward in cylindrical tubules, their outer opening nearly as broad as inner ones and as broad as their height; aperture very small, simple, on middle part of oval margin, without any accessary elements. Diameter of small opening 15μ.

Proportion of the three dimension axes: 1 : 1.3 : 1.8.

Inner portion sometimes with very fine honey-comb structure.

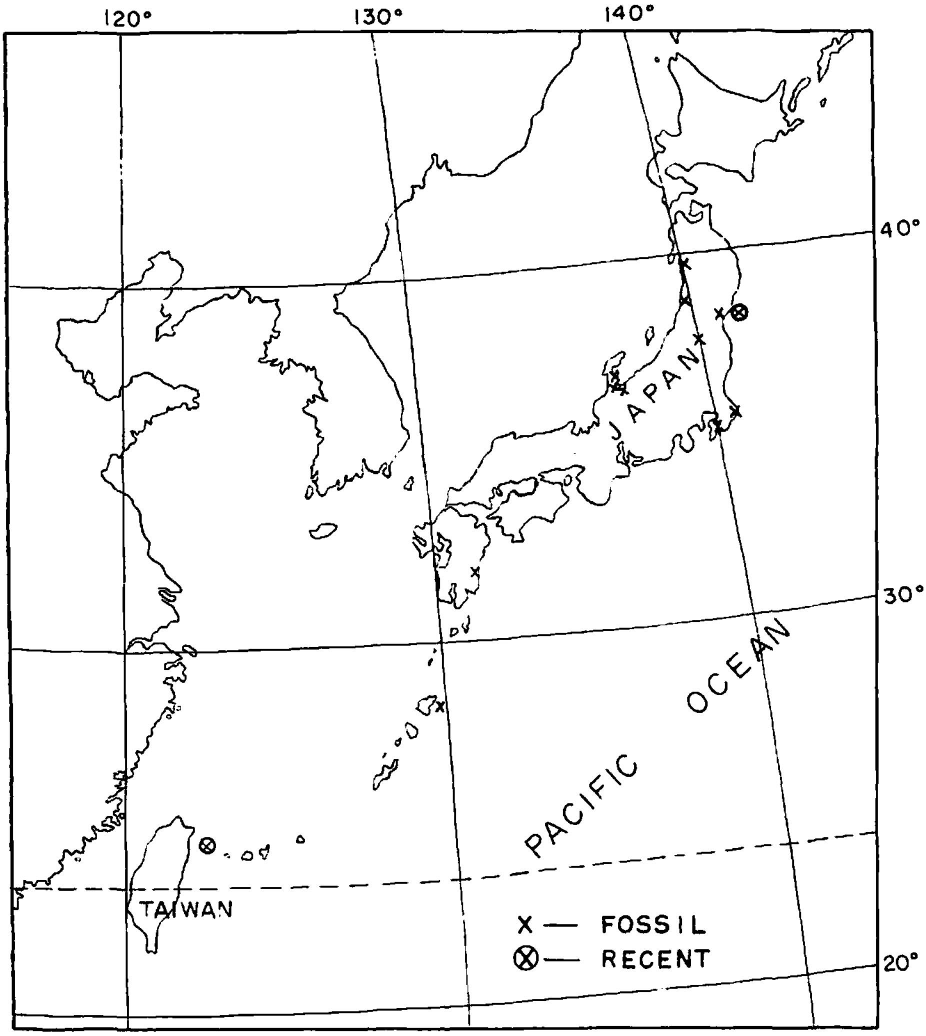


Fig. 1. Map showing the geographic distribution of *Hataina ovata* HUANG, n. sp.
× Fossil. ⊗ Recent.

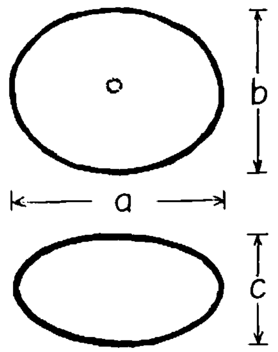


Fig. 2. Diagramatic sketches to illustrate the measurements of *Hataina ovata* Huang, n. sp.

a longitudinal axis, length of test.
b lateral axis, width of test.
c equatorial axis, thickness of test.

The definition of the three dimension axes are show Fig. 2.

The measurements of the three dimension axes are in Table 1.

Remarks:—The simple latticed shell of this species is similar to but differs from *Cenolarchus primordialis* HAECKEL in having the little rough surface, numerous fine pores and a small aperture on the middle part of the oval margin.

The diameter of the test is, in general, between 0.15 mm and 0.175 mm, the latter being the maximum.

The entire surface of the test seems to be smooth under low power microscopic observation, but under high power, numerous small pit-like depressions, which are regular and circular in form can be seen. The neighbouring equidistant pits are alway surrounded by regular frames of equal size, and the fine crests of these frames make a regular polygonal structure (Pl. 17, figs. 1-3). According to the different positions to which the focus of the microscope is brought, the polygonal structures appear different, and a rough surface can be seen. Based on the observation of the sections and slides of the test, the pit-like depressions are found to be regular small cavities penetrating the test, and they possess an inner and an outer opening. These intraparietal cavities are cylindrical and without dilatation in the middle part (Pl. 17, fig. 4).

Optical observation

Generaly, the specimens are colorless in thin sections. In the great majority of the specimens, the internal cavity is filled up by secondary honey-comb struc-

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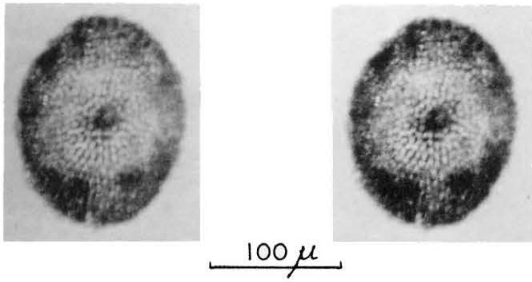
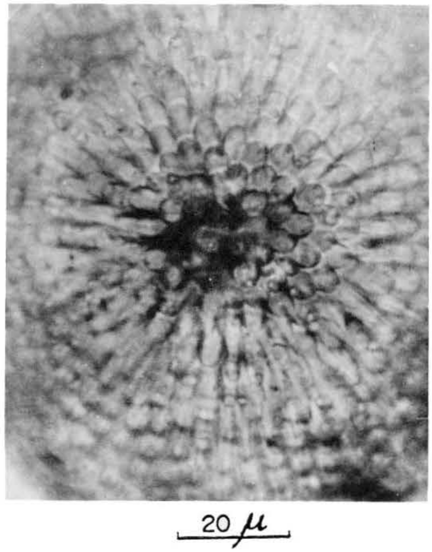
Explanation of Plate 17

Figs. 1-3. *Hataina ovata* HUANG, new species. Holotype. From sample no. 409, the Sōmachi Formation, Kikai-jima, Kagoshima Prefecture, Japan.
1. Aperture view of the holotype (IGPS coll. cat. no. 88026). The illustration is stereophotomicrograph and only the right-hand member of the stereo-pair is numbered.
2. Showing the simple aperture and regular pores.
3. Showing the form of pores and its frames.

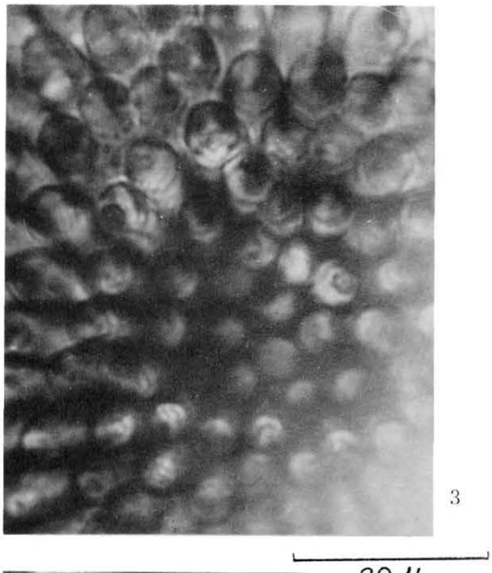
Figs. 4-6. *Hataina ovata* HUANG, n. sp., paratype in thin section No. 1 (IGPS coll. cat. no. 88027). From sample no. 409, the Sōmachi Formation, Kikai-jima, Kagoshima Prefecture, Japan.
4. Vertical section through the test.
5. Showing the test and inner honey-comb structure with central cavity.
6. Showing the central cavity filled up with some limonite.


100 μ

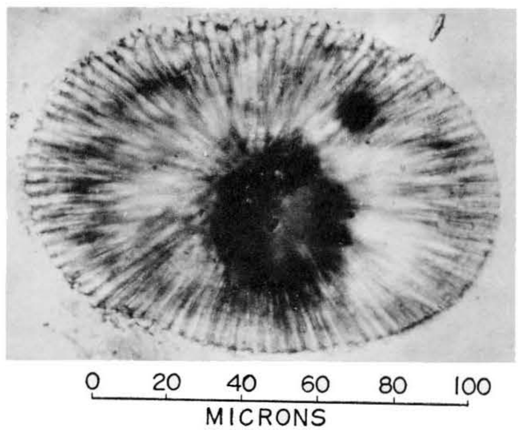
1


20 μ

2


20 μ

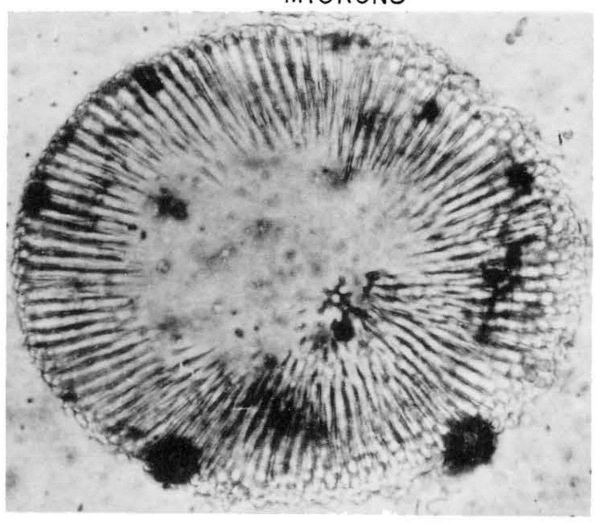
3


0 20 40 60 80 100
MICRONS

6


20 μ

4


0 20 40 60 80 100
MICRONS

5

ture of siliceous, very thin, hexagonal, tubular frame-structure growth extending from the inner wall to the shell center (Pl. 17, figs. 5, 6; pl. 18, fig. 3; pl. 19, figs. 1, 3, 5.); sometimes there remains a small space in central part (Pl. 19, fig. 5; pl. 18, fig. 3; pl. 19, fig. 1.). But in some specimens the central part is empty (Pl. 18, fig. 1.). The internal cavity of the fossil specimens is sometimes filled up with limonite (Pl. 19, fig. 6; pl. 19, fig. 5). The different growth stages of the honey-comb structure can be observed in the thin sections under the microscope.

Two kinds of mineralogical features of the organic structure of this species were observed in the thin sections under crossed nicols; there are that of the test and inner portion. The test is considered to be of rather primitive material, being constituted of silicate material that does not dissolve by acid. It shows an anisotropic optical nature, appearing as quartz, is quite colorless, the relief is low, n is about the same as that of balsam under the polarizing microscope. The inner portion appears non-crystalline or microscopicalls amorphous (Pl. 18, figs. 2, 4; pl. 19, figs. 2, 4, 6) and also colorless, the relief is moderate, but n is lower than balsam.

Although the inner structure portion have been found in the sections but there structure may be constructed in latter time. Because of the difference of the

Dimensions:—

Table 1.

Specimen No.	Maximum diameter (mm)	Minimum diameter (mm)	Height (mm)	Thickness
1	0.25	0.163	0.1	
2	0.15	0.125	0.1	
3	0.175	0.138	0.113	
4	0.15	0.125	0.1	
5	0.25	0.138	0.1	
6	0.163	0.125	0.113	
7	0.125	0.1	0.081	
8	0.188	0.138	0.1	
9	0.163	0.125	0.088	
10	0.175	0.138	0.113	
11	0.138	0.113	0.088	
12	0.15	0.113	0.1	
13	0.163	0.1	0.1	
14	0.15	0.113	0.088	
15	0.175	0.138	0.113	
16	0.225	0.175	0.125	
17	0.213	0.15	0.113	
18	0.175	0.125	0.081	
Holotype	0.15	0.12	0.08	
aperture	0.015			
pores	0.006			
test				0.0015

mineralogical characters of the material of the test and inner honey-comb, the structures are easily distinguished under the optical microscope.

The behavior of silica in low-temperature environts has been discussed by KRAUSKOPF (1959). And, his explanations seem to have intimate bearing on the silica of the specimens under the consideration.

Accordingly, the amorphous silica of the inner portion of the specimens may have been build when the animal was on the sea bottom. The development of the honey-comb structure is considered to have been promoted by the water dissolution and precipitation of silica after death of the animal. The state of growth of the inner structure and some photomicrographs under cross nicols were shown in plates 1 to 3.

Based on the optical observation and different stages of growth, the external and internal parts are inferred to be due to different processes. The writer considers that the inner structure portion is due to secondary material of inorganic rigion.

Distribution

Although this peculiar species is described for the first time from the Pliocene Sōmachi Formation in Kikai-jima, Kagoshima Prefecture, it has been recorded from the Upper Miocene through the Pliocene (MORISHIMA, *et al.*, 1949; NAKASEKO, 1954, and 1956; HUANG, 1966) to Recent (MATOBA, 1966; HUANG, in this paper). According to the investigation of MORISHIMA *et al.* (1949), and NAKASEKO (1954, and 1956) this species is an important marker species, and by it they distinguished the OST Zone in the Neogene Tertiary formation distributed in Toyama and Yamagata Prefectures, Japan.

There are two more interesting occurrences; one is from the Recent sea bottom sediments off Kinkazan (MATOBA, 1966) near Sendai, Miyagi Prefecture, Japan. Here it occurrs in shallow water, and the other is from the Recent deep sea bottom sediments from 20 km off Ilan, northeastern Taiwan. This sample was collected by the Research Vessel *Yang Ming* during the CSK* project with

* A Cooperative study of the Kuroshio Current and its adjacent area.

Explanation of Plate 18

Figs. 1, 2. *Hataina ovata* HUANG, new species.

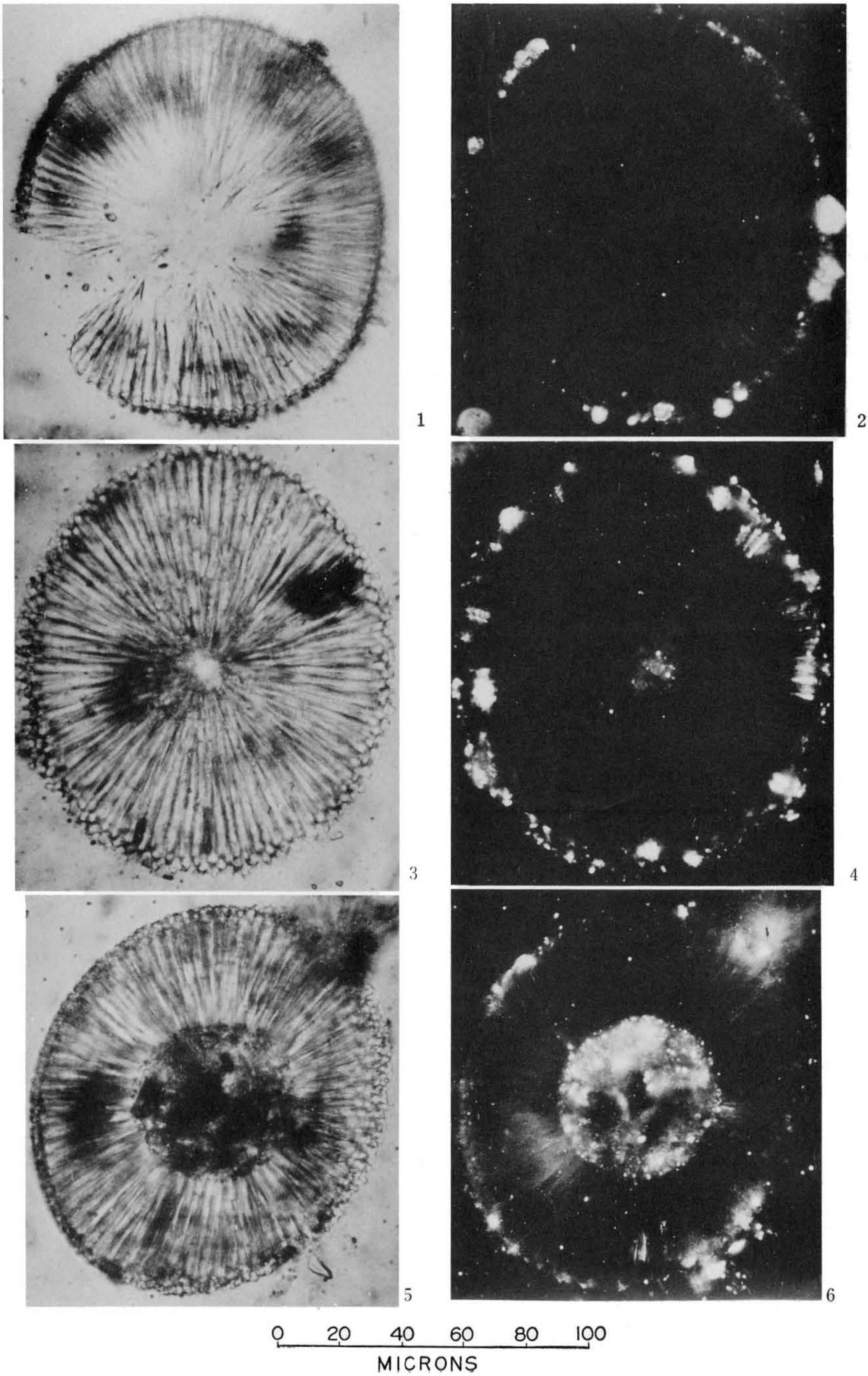
1. Showing simple test without inner honey-comb structure (ordinary illumination).
2. Showing the same specimen under the polarization cross nicols. The test is unamorphous silica, some extinction in it.

Figs. 3–4. *Hataina ovata* HUANG, new species.

3. Showing different stages of growth of inner honey-comb structure that may have been built at a latter time (ordinary illumination).
4. Showing the same specimen, the inner honey-comb structure portion is in amorphous and test is unamorphous optical nature, some extinction in it, under the pslarization cross nicols.

The specimens are all from sample no. 409, the Sōmachi Formation, Kikai-jima, Kagoshima Prefecture, Japan.

Thin section No. 1 (IGPS coll. cat. no. 88027).


1
2
3
4
5
6
0 20 40 60 80 100
MICRONS

Trans. Proc. Palaeont. Soc. Japan, N. S., No. 68, pp. 185-192, pls. 20, 21, Dec. 25, 1967

532. SOME MIOCENE LIMID FOSSILS FROM THE AREA AROUND THE WANIBUCHI MINE, IZUMO PROVINCE, SOUTHWEST JAPAN*

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出雲鰐淵鉱山附近からの中新世 オオハネガイ 化石について：島根県平田市鰐淵鉱山附近の中〜上部中新統大社層？ および鰐淵層群から産出したオオハネガイ亜属3種を記載し，若干の考察を加えた。それらのうち2種は多数のあらい放射肋で装飾され，新種の可能性が強い。

岡本和夫・中野光雄

Introduction and Acknowledgements

Through the first author's geological survey of the area around the Wanibuchi mine, Izumo Province, Shimane Prefecture, Southwest Japan in 1965-'66, he has found some interesting specimens of *Lima* (*Acesta*) having numerous coarse radial ribs on their large shell from the Miocene Taisha, Tadaura and Wanibuchi formations. Recently, he had a good chance of studying them in cooperation with the second author. As a result, the following forms are discriminated.

Lima (*Acesta*) aff. *amaxensis* YOKOYAMA
L. (*A*). cf. *smithi* SOWERBY
L. (*A*.) sp.

The former two forms have not yet been reported from Japan and her adjacent areas. In this respect, they may be new to sience. Therefore, the authors give here the notes and descriptions of these Limid fossils.

The materials dealt with in this paper are stored in the Shinonome Branch School, Faculty of Education, Hiroshima University.

The authors wish to express their sincere thanks to Dr. Tokubei KURODA, Emeritus President of the Malacological Society of Japan, and Dr. Saburo KANNO of the Tokyo University of Education for their kind suggestions. Acknowledgements are due to Mr. Masakichi SUGITANI, Principal of the Wanibuchi Primary School of Hirata City, and Messers Harue ARAKI and Minoru TAKAHASHI in Hirata City of Shimane Prefec-

* Received July 10, 1967 ; read Sept. 23, 1967.

ture for supply of the specimens. Thanks are also due to Dr. Norio KIKUCHI, Vice-director of the Nishinomiya Kaisei Hospital in Nishinomiya City of Hyogo Prefecture for his permission to study the shell specimens stored there. The authors acknowledge the kind helps given by Professor Emeritus Teiichi KOBAYASHI of the University of Tokyo. The authors tender their cordial thanks to Professor Emeritus Sotoji IMAMURA and Professors Hisashi KUSUMI and Akira HASE of the Hiroshima University for their encouragements.

This study was supported in part by the Grant in Aid for Science Researches from the Ministry of Education.

Notes on the Geology of the Area around the Wanibuchi Mine

There are a number of reports on the detailed mining geology of the area around the Wanibuchi mine, but a few on the stratigraphy and geology. According to KATO, Y. (1950), KOBAYASHI (1950), NISHIYAMA (1962) etc., the Neogene strata of the area tentatively divided into the Taisha, Tadaura, Ômori, Wanibuchi, and Furue formations in ascending order. The division mentioned above, however, does not seem to be sufficient to explain the stratigraphy of the area on account of remarkable change of lithofacies and complicated geologic structure.

The Taisha formation is made up of coarse-grained sandstone and dark gray shale accompanied with pyroclastics. The Tadaura formation consists of green pyroclastics of plagioliparite origin and dark gray shale. The Ômori formation is composed of basalts and andesites. The Wanibuchi formation is subdivided into two members, the Aishiro in the lower and the Wanibuchi (s. s.) in the upper, and this formation made up of green to variegated volcanic conglomerate and sandstone, and dark gray shele. The Furue formation is composed of dark gray mudstone.

As to the fossils, KATO, Y. (1950) collected *Palliolum* (*Delectopecten*) *peckhami* (GABB) from the Aishiro member and he also listed the following fossils out of the Wanibuchi member.

Yoldia laudabilis YOKOYAMA
Propeamussium (*Propeamussium*) cf. *tateiwai* KANEHARA
Palliolum (*Delectopecten*) *peckhami* (GABB)
Lima (*Acesta*) *goliath* SOWERBY

On the other hand, NISHIYAMA (1962) noted that *Corbicula* sp. was discovered in a sandstone of the Taisha formation and that the followings from his Aishiro and Wanibuchi members were listed.

Aishiro member
Delectopecten peckhami (GABB)
Doliocassis yokoyamai (NOMURA and HATAI)
Phos nakamurai (KURODA)
Fulgolaria striata (YOKOYAMA)
Coptothyris grayi (DAVIDSON)

Wanibuchi member
Cardita siogamensis (NOMURA)
Conchocele nipponica (YABE and NOMURA)
Dosinia (*Kaneharaia*) *kaneharai* YOKOYAMA
Doliocassis yokoyamai (NOMURA and HATAI)
Nautilus izumoensis YOKOYAMA
Coptothyris grayi (DAVIDSON)

In his geological survey of the area around the Wanibuchi mine, the first author collected *Bellamya* cf. *kosasana* (UEJI) from a bluish gray tuffaceous shale of the Taisha formation and *Lima* (*Acesta*) aff. *amaxensis* YOKOYAMA from a lapilli tuff or volcanic conglomerate of the possible same formation. He also gathered *Lima* (*Acesta*) sp. cf. *L.* (*A.*) *smithi* SOWERBY from a lapilli tuff or volcanic conglomerate of the probable

Tadaura formation, and he found in the Wanibuchi formation some molluscs such as *Delectopecten peckhami* (GABB), *Patinopecten* (*Kotorapecten*) *kagamianus* YOKOYAMA, *Lima* (*Acesa*) cf. *smithi* SOWERBY, *Lima* (*Acesta*) sp., *Buccinum* ? sp. and others. The occurrence of the fossils in the Wanibuchi formation seems to be very sporadic in coarse-grained sediments, though *Delectopecten peckhami* are abundantly found in fine-grained deposits.

The age of the Taisha to Wanibuchi formations is placed at Middle to Upper Miocene (Burdigarian to Helvetian) from the viewpoint of molluscs, and bethonic and planktonic foraminifera (TAI, 1959; KATO, J., 1967).

Notes on the *Lima* (*Acesta*) Having Coarse Radil Ribs from Japan

Among the Limid fossils, the following *Lima* (*Acesta*) having numerous coarse radial ribs on shell surface, like *L.* (*A.*) aff. *amaxensis* and *L.* (*A.*) cf. *smithi* described below, are reported from the Cenozoic formations of Japan.

amaxensis YOKOYAMA, 1911
sameshimai OYAMA et MIZUNO, 1958
smithi SOWERBY, 1888
takeyamai OZAKI, 1956

Lima (*Acesta*) *amaxensis* " is ornamented with about fifty simple, straight, narrow, equal, radiating ribs separated by intervals nearly as wide as the ribs themselves " (YOKOYAMA, 1911) on shell. Its shell is ovately oblong in outline and 55 mm. high and 50 mm. long in YOKOYAMA's holotype, but NAGAO's specimen (1928, p. 104, pl. 22, fig. 35) is more than 70 mm. high and 50 mm. long. They are collected from the Itchoda sandstone of the Eocene Sakasegawa group in Kyushu.

Lima (*Acesta*) *sameshimai* is sculptured with radial ribs " being strong, not squamated, somewhat round-topped, separated by wider interspaces, sixteen to twenty one in number, of which few being on anterior ear " (OYAMA et MIZUNO, 1958) on somewhat trigonally ovate shell which is about 82 mm. high and some 67 mm. long. In the character mentioned above, this form is clearly distinct from *amaxensis*, *smithi* and *takeyamai*. This species is obtained from a dark bluish calcareous tuff of the upper Oligocene Takizawa subgroup in Central Japan, and is accompanied with *Minolia tsuchii* OYAMA et MIZUNO, *Molopophorus* sp., *Conus* sp., *Septifer* sp. and *Nemocardium* sp.

On the shell surface of *Lima* (*Acesta*) *smithi*, " costis circ. 40, rotundalis, mediocriter elevatis, levissime undulatis instructa " (SOWERBY, 1888). PILSBRY (1895) noted that this form has " strong rounded ribs separated by intervals of about their own width, —. Ribs at the periphery 39 in number ". According to OYAMA (1943), the ribs including them on posterior auricle are 47–56 in number. The first author counted about 55 ribs from lunular ridge to postero-dorsal margin on a recent specimen (99mm. high, 79mm. long) from the water off Izu Peninsula of Central Japan. The recent forms have the fairly ovate outline and it is said that the shell size attains, in large specimens, about 100 mm. in longest diameter. These are collected from the water at 100-300 m. depths around Central and Northeast Japan. KURODA (1932) recorded that there is an intermediary type between *L.* (*A.*) *smithi* and *L.* (*A*) *goliath* SOWERBY, the latter of which occurred in the Miocene to Recent of Japan. HABE and ITO (1956) also suggested that this species is similar to the immature of *L.* (*A.*) *goliath*. This form and related ones are reported from the Pliocene Nokogiriyama formation of Chiba Prefecture, the Miocene of Chichibu Basin in Saitama

Prefecture, and the Fuganji mudstone member of the Miocene Tottori group in Tottori Prefecture, the last of which yields *Dentalium yokoyamai* MAKIYAMA and *D. totomiensis* MAKIYAMA as the associated fossils.

Lima (*Acesta*) *takeyamai* is "cancellated by 40 straight, elevated radial ribs—separated by intervals of subequal breadth" (OZAKI, 1956a) on shell. At first, this form was reported as *L.* (*A.*) *smithi* SOWERBY by TAKEYAMA (1933) from a shell sandstone of the Miocene Namigata formation in Okayama Prefecture, and thereafter OZAKI (1956a) established this form as a species named *L.* (*A.*) *takeyamai* because of the specimens having 40 radial ribs on shells which seem to be not well preserved. This is found with *Acila* (*Truncacila*) *gottschei* (BÖHM), *Pecten* (*Chlamys*) *namigataensis* OZAKI, *Ostrea* sp., *Coptothyris grayi* (DAVIDSON) and others.

In the fact mentioned above, it will be noteworthy that there is some resemblance to the character of ribs among *amaxensis*, *smithi* and *takeyamai*, excluding *sameshimai* and they have been sometimes reported and collected from the Cenozoic formations in Central and Southwest Japan, especially in the latter.

Description of Species

Family Limidae

Genus *Lima* BRUGUIÈRE, 1797

Subgenus *Acesta* H. et A. ADAMS, 1858

Lima (*Acesta*) aff. *amaxensis* YOKOYAMA

Pl. 20, Figs. 1a-b.

Compare:—

1911. *Lima amaxensis* YOKOYAMA, *Jour. Coll. Sci. Imp. Univ. Tokyo*, Vol. 27, Art. 20, p. 15, pl. 3, fig. 2.

1928. *Lima amaxensis*, NAGAO, *Sci. Rep. Tohoku Imp. Univ., Ser. 2*, Vol. 9, No. 3, p. 104 (8), pl. 20 (3), fig. 35.

1943. *Lima* (*Acesta*) *amaxensis*, OYAMA, *Conch. Asiat.*, Vol. 1, pp. 43–44, pl. 5, fig. 1.

1960. *Lima* (*Acesta*) *amaxensis*, OYAMA, MIZUNO and SAKAMOTO, *Illust. Handb. Japan. Paleog. Moll.*, p. 125, pl. 33, figs. 3a-b.

Material:—Only one fairly well-preserved specimen (Reg. No. GSEH-OK-S001) collected by ARAKI is at hand.

Description:—Shell large in size, opisthocline, trigonally ovate and inequilateral exclusive of auricles, a little higher than broad, gently convex from umbo to venter and from anterior to posterior; antero-dorsal margin slightly concave and about a half as long as the shell, sloped subvertically downward; antero-ventral rounded but somewhat subangulated at junction with antero-dorsal, passing gradually into broadly arched ventral as can be judged from the growth-lines; postero-dorsal gently arcuated and nearly a half as long as the shell, forming an angle of some 120 degrees with the hinge-line which is straight and about a third of the shell length; umbo prominent and central; anterior auricle small, slightly protruded, somewhat depressed and triangular; posterior one triangular, large and about twice as large as the anterior but not so depressed; lunule fairly large, cordiform and well excavated.

Surface ornamented with numerous round-topped, radial ribs which are narrowly disposed and nearly equal in width to the umbonal part but somewhat broad and roof-topped and alternated with narrow grooves on the ventral side; 6 or more on the antero-dorsal part nearly straight or slightly curved anteriorly; about 30 on the median part of the shell almost straight and sometimes flexiated and rarely bifurcated but gradually become thinner toward the posterior; some 5 on the rest of the shell nearly straight and fairly thin; sculpture on the auricles and lunule not well observable. Growth-lines well developed on the whole surface, especially on the ventral periphery and the posterior side.

Internally, resilifer pit fairly large, triangular, and directs foward.

*Measurments** :—in mm.

Height = ab. 132	Obliquity = 135+
Width = 126	Half thickness = ab. 24

Remarks :—This is closely allied to *Lima* (*Acesta*) *amaxensis* YOKOYAMA from the Eocene of North Kyushu, but differs in more inflated orbicular and larger shell on which the posterior auricle is not so well defined than that of the latter. The recent *Lima* (*Acesta*) *smithi* SOWERBY from the sea around Japan is quite similar to the present form in nature and number of ribs, but is distinct in having more trapezoidal and larger shell. This form resembles *Lima* (*Acesta*) *diomedae* DALL from the Pacific ocean around the Galapagos Islands, but is separated in more ovate and larger shell from that of the latter.

Locality :—The very point of locality is uncertain. The present specimen, however, came probably out of the northern area of Yuya-dani, Yôkan, Taisha-machi, Shimane Prefecture.

Lithology :—Moderate brown to dark greenish gray lapilli tuff or volcanic conglomerate of the Taisha formation.

Lima (*Acesta*) cf. *smithi* SOWERBY

Pl. 21, Figs. 1a–b.

Compare :—

1888. *Lima smithi* SOWERBY, *Proc. Zool. Soc. London*, p. 207, pl. 11, fig. 12.

1895. *Lima smithi*, PILSBRY, *Cat. Mar. Moll. Japan*, p. 145.

1918. *Lima* (*Acesta*) *smithi*, THIELE, *Conch. Cab.*, Bd. 7, Abt. 2a, pp. 21–22, pl. 4, figs. 1–2.

1925. *Lima* sp. by YOKOYAMA, *Jour. Fac. Sci. Imp. Univ. Tokyo, Sec. 2*, Vol. 1, Pt. 3, p. 123, pl. 15, fig. 14.

1932. *Lima smithi*, KURODA, *Venus*, Vol. 3, No. 4, App. p. 115.

1943. *Lima* (*Acesta*) *smithi*, OYAMA, *Conch. Asiat.*, Vol. 1, pp. 45–46, pl. 4, figs. 3a–b; pl. 14, fig. 11.

1959. *Acesta smithi*, KIRA, *Colour. Illust. Shell. Japan*, p. 129, pl. 52, fig. 7.

1964. *Lima* (*Acesta*) *smithi*, SHIKAMA, *Select. Shell. World Illust. Colour.*, Vol. 2, pp. 55–56, pl. 37, fig. 3.

1965. *Acesta smithi*, HABE and ITO, *Shell. World Colour.*, Vol. 1, p. 120, pl. 38, fig. 16.

1966. *Lima* (*Acesta*) cf. *smithi*, YAMANA, *Expl. Text Geol. Map "Tottori Pref. (1/100,000)"*, pl. 3, fig. 5.

Material :—There are some specimens. A specimen (Reg. No. GSEH-OK-S002) obtained by TAKAHASHI is a somewhat well-preserved bivalved shell but an internal mould. The rest is fragmentary.

Description :—Shell large, equivalve, opisthocline, triangulary ovate, inequilateral, higher than long, gently convex from umbo to venter and from anterior to posterior; antero-dorsal nearly straight or slightly concave and about four-fifths of the shell-length, sloped downward vertically; antero-ventral slightly curved but somewhat subangulated at junctions with antero-dorsal and ventral margins; postero-dorsal gently arched, passing gradually into broadly arcuated ventral; umbo low but prominent and subcentral; anterior auricle not well observed; posterior one depressed, large, triangular, separated from the main part of the shell; dorsal margin of posterior auricle straight, forming an angle of about 120°

* Employed AOKI's method (See AOKI, 1956, p. 186, text-fig. 1)

degrees with the postero-dorsal margin; apical angle about 95 degrees; lunule fairly large, cordiform and somewhat well excavated; gaping narrow and lenticular; test fairly thin but it attains about 2 mm. at lunule.

Surface sculptured with numerous fairly broad, roof-topped radial ribs with narrow and shallow grooves, except for the anterior and posterior extremities where the radial ribs are somewhat thin and the grooves become broader than those of the central; ribs counted 12 or more on the antero-dorsal part of the shell almost straight and fairly thin; 33 on the median part of the shell nearly straight or somewhat flexiated; 6 or so on the rest of the shell almost straight and fairly thin; posterial auricle provided probably with several faint radial ribs with rather broad grooves; ventral margin plicate. Growth-lines well observable on the whole surface, especially on the ventral and posterior sides.

Measurements:—in mm.

Height=145	Obliquity =145
Width =105	Thickness= 50

Comparison and Observation:—In the present form, it is interesting to see that the costation on the shell presents remarkable change of characters in ontogenetic development. The shell (less than about 20 mm. near umbo) in the early stage is sculptured with flat-topped ribs with narrow grooves, but the ribs become gradually roof-shaped through round-topped.

The present form is closely allied to *Lima* (*Acesta*) *smithi* SOWERBY in surface sculpture and shell form, but is distinct in having the large shell on which antero-dorsal margin is long and the posterior auricle is well-defined. This is quite similar to *Lima* (*Acesta*) *amaxensis* YOKOYAMA, but differs in the tall and large shell which is more inflated than that of the latter. *Lima* (*Acesta*) aff. *amaxensis* described before has some resemblance to this form in surface costation and shell form, but it is easily distinguishable from this form by the more orbicular shell having not so depressed posterior auricle. This is very similar to *Lima oakvillensis* CLARK (WEAVER, 1942, p. 98, pl. 21, fig. 1; pl. 22, fig. 7) from the Oligocene of Washington in North Pacific side, but is distinct in having somewhat numerous ribs and the large shell.

Locality:—A quarry at Ôtoshi, Kawashimo-machi, Hirata City, Shimane Prefecture (Lat. 35°26′29″N., Long. 132° 44′01″E.).

Lithology:—Dark greenish gray medium-grained volcanic sandstone of the Wanibuchi formation.

Lima (*Acesta*) sp.

Pl. 20, Fig. 2; Pl. 21, Fig. 2

Material:—A single fragmentary inter-

Explanation of Plate 20

Lima (*Acesta*) aff. *amaxensis* YOKOYAMA .... p. 188

Figs. 1a-b. Lateral and anterior views of a natural cast of left valve specimen (Reg. No. GSEH-OK-S001). North of Yuya-dani, Yôkan, Taisha-machi, Shimane Pref. (Probable Taisha formation) ×0.8; Coll. H. ARAKI.

Lima (*Acesta*) sp. .... p. 190

Fig. 2. Lateral view of an imperfect internal mould of left valve specimen (Reg. No. GSEH-OK-S003). North or northeast of the Wanibuchi mine, Hirata City, Shimane Pref. (Wanibuchi formation) ×1.

1a

1b

2

nal mould of left valve (Reg. No. GSEH-OK-S003) is in the collection.

Description :—Shell large, not so much inflated; antero-dorsal margin fairly short, nearly straight or slightly concave and bluntly angulated at junction with antero-ventral which changes gradually into broadly arched ventral; lunule deeply excavated; several faint radial ribs on antero- and postero-dorsal extremities broader than interspaces; traces of radial striae observed in some places of surface; growth-lines fairly well developed in the later stage.

Remarks :—The outline of the shell may be ovate to orbicular and its largest diameter is more than 11 cm., though the posterior and ventral parts and the auricles are missing in this specimen. This form is, however, comparable with *Lima* (*Acesta*) *yagensis* OTUKA (YOKOYAMA, 1925, pl. 14, fig. 11; KANNO, 1960, pl. 37, figs. 1-4; pl. 38, fig. 1) or its allied form, namely, *Lima* (*Acesta*) *omorii* AOKI in having large and ovate or orbicular shell on which radial ribs are well observable in the anterior and posterior extremities.

Locality :—The very point also is uncertain. However, this specimen seems to be collected from the area north or northeast of the Wanibuchi mine, Kawashimo-machi, Hirata City, Shimane Prefecture.

Lithology :—Brownish gray to dark greenish gray lapilli tuff or volcanic conglomerate of the Wanibuchi formation.

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Aishiro	相 代	Furue	古 江
Hirata	平 田	Kawashimo	河 下
Ômori	大 森	Ôtoshi	大 才
Tadaura	唯 浦	Taisha	大 社
Wanibuchi	鰐 淵	Yôkan	遙 堪
Yuyadani	湯 屋 谷		

Explanation of Plate 21

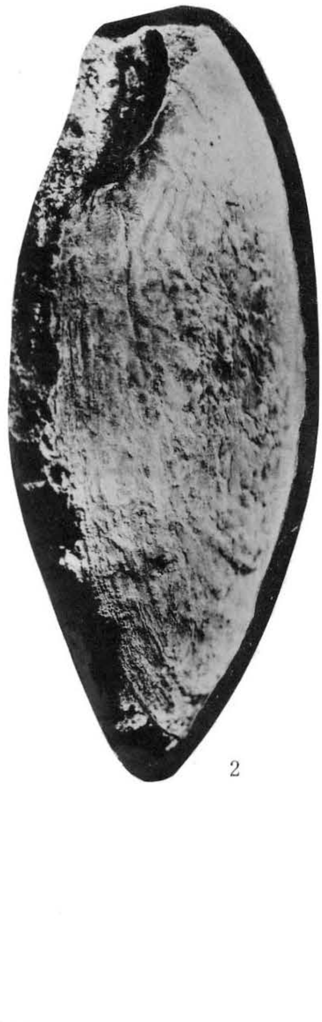
Lima (Acesta) cf. *smithi* SOWERBY .... p. 189

Figs. 1a-b. Lateral and anterior views of an internal mould of bivalved specimen (Reg. No. GSEH-OK-S002). A quarry in Ôtoshi, Kawashimo-machi, Hirata City, Shimane Pref. (Wanibuchi formation) ×0.9; Coll. M. TAKAHASHI.

Lima (Acesta) sp. .... p. 190

Fig. 2. Anterior view of an imperfect internal mould of left valve specimen (Reg. No. GSEH-OK-S003). North or northeast of the Wanibuchi mine, Hirata City, Shimane Pref. (Wanibuchi formation) ×1.

1a



2

1b

例　会　通　知

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Erratum

AOKI, N., Some fossil *Gobius* from Japan. *Trans. Proc. Palaeont. Soc. Japan, N. S.*, No. 67, p. 125-128, 1967.

The first and the bottom lines in the right column of page 126 were erroneously printed in regard to position. The both lines should be replaced with each other.

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