PERMIAN FUSULINIDS FROM IMO, SOUTHERN KITAKAMI MOUNTAINS, N. E. JAPAN

by

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(With 1 Table, 4 Text-figures and 7 plates)

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Southern Kitakami Mountains have long been considered as one of type areas for the Japanese Permian.

Fusulinids are by no means uncommon there, however, they are generally so badly recrystallized and strongly deformed as to prevent detailed palaeontological investigation on them. Furthermore, fusulinids are more or less confined to limestone facies, and consequently, considerable portion of the Kitakami Permian is barren in fusulinids, due to its non calcareous facies.

The Kattisawa stage of the Kanokura series is, for instance, almost wholly composed of greenish grey sandstone in the type area. And no fusulinids have been known to occur in this part of Permian succession in the Kitakami Mountains, apart from the sporadical occurrence of external moulds of either *Monodiexodina* or *Parafusulina* in sandstone.

During the course of his fossil collections in the Imosawa area in Iwate Prefecture, Dr. K. NAKAMURA of the Hokkaido University found exceptionally well preserved fusulinids for the Kitakami Permian in a small limestone lens intercalated in sandstone and shale of the Kattisawa stage. This new finding drew the writer's attention. As a part of his detailed stratigraphical investigation on the Permian of the Southern Kitakami Mountains, the writer made mapping and collection of fusulinids in the tributary of Imosawa, Yahagi-Cho, Rikuzentakada City, Iwate Prefecture.

Geological structure of the area surveyed is dominated by a syncline running through the center of the area. The axis of syncline is lifted in the center of it, where *Pseudofusulina* bearing relatively thick limestone is exposed. This limestone is correlatable to the upper part of Sakamotosawa series developed in the adjacent Setamai-Yahagi district, from where *Misellina* cf. *claudiae*, *Pseudofusulina kraffti*, *Nagatoella minatoi* and others are found.

Near the mouth of the tributary of Imosawa, fine conglomerate, corresponding to the base of the Kanokura series, is developed. And in the middle to upper tri-

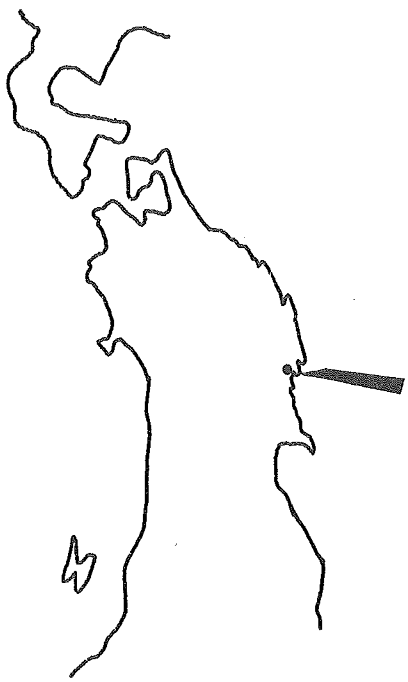

Fig. 1
Index map.

butary of Imosawa, there develops greenish sandstone of the Kanokura series with the intercalation of thin limestone beds or lenses bearing abundant fusulinids and corals. And plentiful brachiopods have been obtained from some horizons in sandstone.

Iwaizaki stage, the upper part of the Kanokura series, begins from a thin limstone bed yielding *Yabeina* (*Lepidolina*) *multiseptata shiraiwensis*, *Verbeekina verbeeki* and others. Above the limestone, Usuginu type conglomerate, bearing pebbles, is often found within very coarse to granule sandstone.

Thus the whole stratigraphical section of the Kattisawa stage bounded from the Sakamotosawa series and Iwaizaki stage of the Kanokura series is exposed in the tributary of Imosawa.

Lithologically, the Kattisawa stage is divided into two major parts by the upper surface of slate bed intercalated in the middle part of the stage.

As to the fusulinids, the following twenty species in all have been discriminated.

Pseudofusulina kraffti (Schellwien & Dyrenfurth) (loc. 7)
Pseudofusulina sp. A (loc. 1)
Pseudofusulina sp. B (loc. 4)

Table 1

<table>
<tr><th>AKASAKA
HONJO (1959)</th><th>AKIYOSHI
HASEGAWA (1963)</th><th colspan="3">KITAKAMI</th></tr>
<tr><td>Yabeina globosa</td><td>Lepidolina shiraiwensis</td><td rowspan="9">Kanokura series</td><td>Iwaiza-ki st.</td><td>Lepidolina shiraiwensis
Lepidolina kumaensis</td></tr>
<tr><td>Gifuella douvillei</td><td>Gifuella douvillei</td><td rowspan="8">Kattisawa stage</td><td rowspan="8">Pseudodoliolina elongata

Monodiexodina matsubaishi
Parafusulina
Chusenella
Cancellina</td></tr>
<tr><td rowspan="2">Neoschwagerina margaritae</td><td>Verbeekina verbeeki</td></tr>
<tr><td>Neoschwagerina haydeni</td></tr>
<tr><td rowspan="2">Neoschwagerina craticulifera</td><td>Verbeekina heimi</td></tr>
<tr><td>Neoschw. craticulifera</td></tr>
<tr><td>Pseudodoliolina ozawai</td><td rowspan="3">Parafusulina kaerimizensis</td></tr>
<tr><td>Minoella nipponica</td></tr>
<tr><td>Parafusulina granum-avenae</td></tr>
</table>

Pseudofusulina? sp. A (loc. 3)
Pseudofusulina? sp. B (loc. 10)
Parafusulina motoyoshiensis (MORIKAWA) (loc. 2, 3, 4, 5, 7, & 8)
Parafusulina iwaizakiensis (MORIKAWA) (loc. 4)
Parafusulina sp. A (lo.c 5)
Parafusulina sp. B (loc. 5)
Monodiexodina matsubaishi (HUZIMOTO) ? (loc. 6)
Monodiexodina sp. (loc. 5)
Chusenella pseudocrassa (KANMERA) (loc. 1, 2, 3, 4 & 6)
Chusenella aff. *choshiensis* CHISAKA (loc. 3)
Cancellina sp. (loc. 2)
Pseudodoliolina elongata sp. nov. (loc. 9)
Verbeekina verbeeki (GEINITZ) (loc. 10–12)
Yabeina (Lepidolina) multiseptata shiraiwensis (OZAWA) (loc. 10–12)
Codonofusiella explicata KAWANO (loc. 2, 3, 4, 7 & 8)
Codonofusiella sp. (loc. 10)
Rauserella alveolaris sp. nov. (loc. 3 ?, 7 & 8)

Their stratigraphic ranges are shown in Text-figure 3.

Besides, the writer found *Pseudofusulina fusiformis*, *Pseudofusulina kraffti*, *Nagatoella minatoi*, *Eoverbeekina?* sp. and others from the limestone matrix of basal conglomerate of the Kattisawa stage developed at Kotsubosawa, Yokota-Cho, Rikuzentakada City.

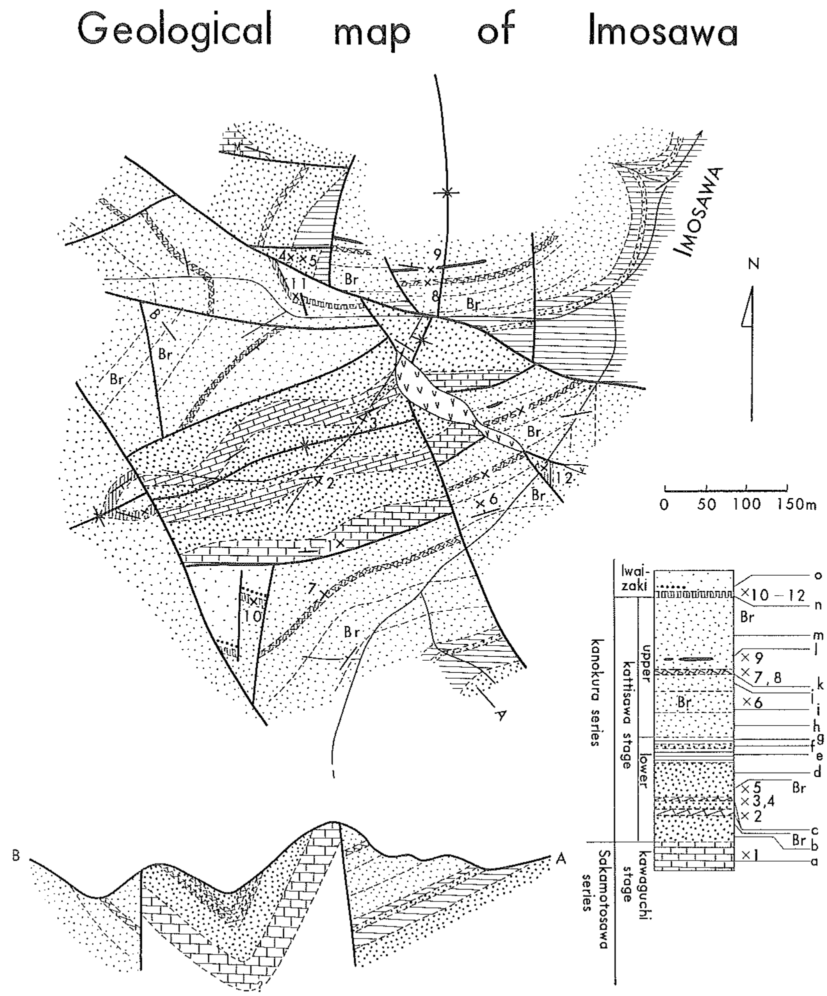

Fig. 2
Geological map of Imosawa.
Br; " Brachiopod zone " a; Fossiliferous bedded limestone. b, d & f; Greenish grey medium grained sandstone. c; Fossiliferous impure limestone. e & g; Dark grey sandy slate bearing small pyrite grains. h, j & m; Greenish grey medium sandstone. i; Fine sandstone bearing abundant brachiopods. k; Dark grey compact " fusulina " limestone. l; Sandy limestone. n; Fossiliferous dark grey limestone. o; Very coarse sandstone with pebbles.

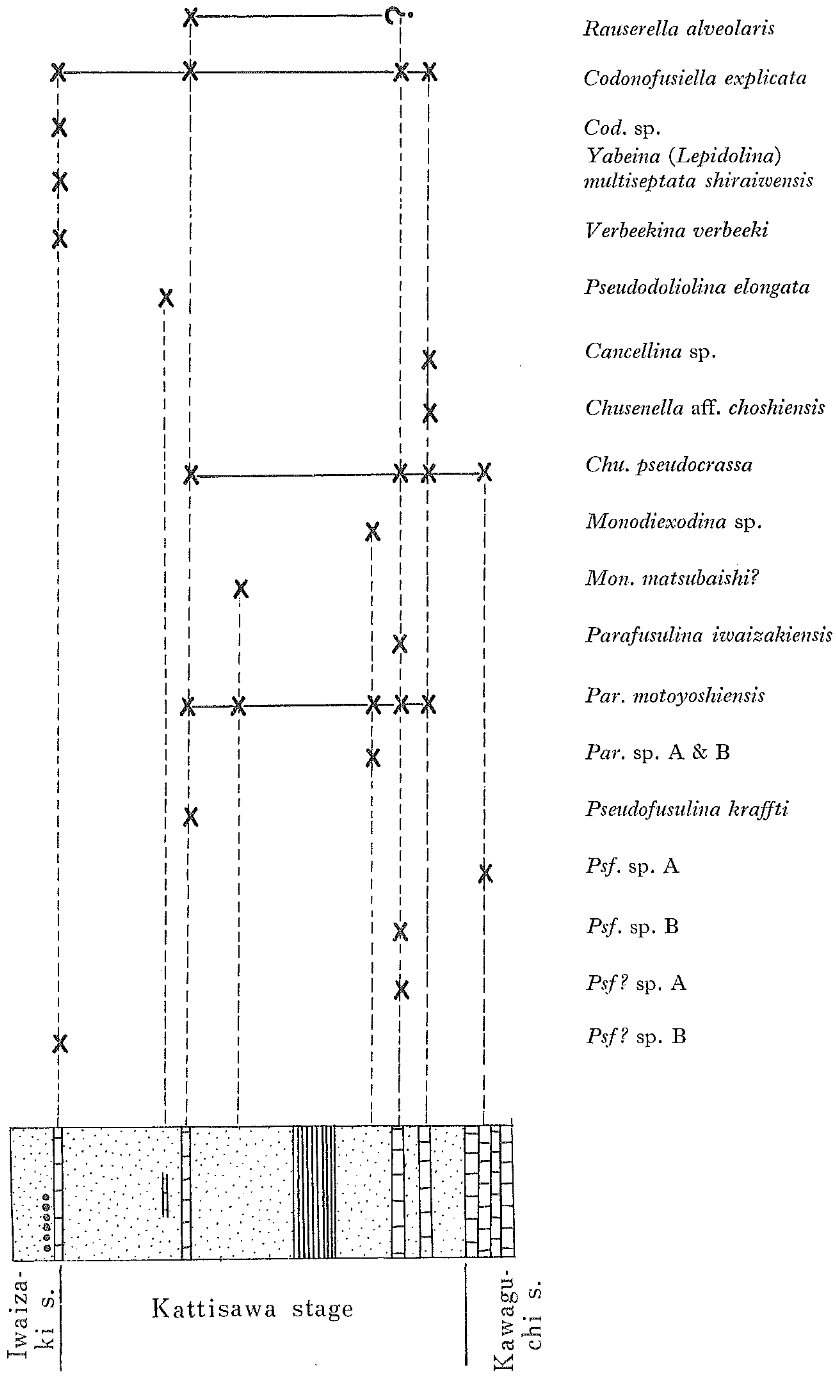

Fig. 3. Range chart of fusulinids produced from Imosawa.

In the tributary of Kattisawa, the writer collected *Monodiexodina matsubaishi* and *Parafusulina* sp. from the stratigraphical position some 30 to 40 m high from the basal conglomerate of it.

A detailed account on geology and the description of fusulinids of the whole Permian of the Setamai-Yahagi district will be presented in an other occasion.

Summarizing all the facts above mentioned, the lower part of the Kattisawa stage is characterized by the abundant occurrence of *Parafusulina*, typical *Chusenella*, and very rare production of *Cancellina*. Therefore this part is correlatable to *Minoella*, *Neoschwagerina simplex*, or *Parafusulina kaerimizensis* zone in S. W. Japan.

While the upper part is characterized by the occurrence of *Pseudodoliolina elongata*. This species is also described from the Atetsu Plateau (NOGAMI, 1961), where it is associated with *Neoschwagerina douvillei*, *Verbeekina verbeeki*, and *Pseudofusulina kusamensis*. Its horizon in Atetsu is quite identical with that of Imosawa. Therefore it is quite possible that the portion yielding *Pseudodoliolina elongata* at Imosawa is correlatable to *Neoschwagerina douvillei-Neoschwagerina margaritae* zone.

Accordingly, the middle portion between the above two zones is correlated to *Neoschwagerina craticulifera* zone. The Kanokura series in Imosawa district as a whole is correlated as is shown in table 1.

Before stepping into descritpion, the writer wishes to express his most sincere thanks to Professor M. MINATO of the Hokkaido University for his continuous guidance and encouragement. He also kindly allowed to use all of his personal reference library. Thanks are due to Drs. M. KATO and K. NAKAMURA for their kind guidance in the field and in laboratory. Especially the former helped me in completing this manuscript. The writer is also indepted to Drs. S. HONJO, Y. FUJIWARA and Mr. S. KUMANO for their kind helps in many ways.

Systematic description

Family Ozawainellidae THOMPSON & FOSTER, 1937

Subfamily Ozawainellinae THOMPSON & FOSTER, 1937

Genus ***Rauserella*** DUNBAR, 1944

Type species: *Rauserella erratica* DUNBAR, 1944

Generic diagnosis: Shell is minute, irregularly fusiform with irregular axis of coiling. Inner few volutions are planispiral, and coiled at a large angle to the later volutions which are in contrast fusiform in shape with irregular coiling.

Septa are straight throughout the shell.

Spirotheca is composed of tectum, and upper and lower tectoria in inner stage, while the outer tectum and lower less dense layer corresponding to diaphanotheca which in some species gradulally changes to keriothecal structure.

Chomata are rudimentarily developed in inner planispiral stage.

Remarks: *Rauserella alveolaris* sp. nov. described in this article possesses the wall composed of tectum and keriotheca in outer volutions. The state of transition from diaphanotheca to faint keriotheca in the wall of the outer volutions is detectable under high magnification in ill-oriented paralllel sections at hand.

However, so far as the previous diagnosis of genus *Rauserella* is concerned, it has never been referred to possess keriotheca in spirotheca.

Therefore the writer first considered the above form differs from *Rauserella*. Nevertheless it is still quite possible that it belongs to *Rauserella* in all available natures except for the structure of spirotheca.

And moreover, the general evolutionary trend of the fusulinid wall does not conflict with the fact in the wall in the above mentioned form, as is ascertained in many genera, *Pseudodoliolina*, *Lepidolina*, *Codonofusiella* (stated in this article), and so on.

Accordingly, the writer here treats this new from as *Rauserella*, and would like to correct the previous diagnosis on the structure of spirotheca. The writer considers that the structure of the wall of previously described *Rauserella* should be reexamined in future.

The following species of *Rauserella* have been known until present.

Rauserella erratica DUNBAR 1944
Rauserella fujimotoi KOBAYASHI, 1956
Rauserella minuta MIKLUCHO-Maclay, 1957
Rauserell staffi SKINNER & WILDE, 1966
Rauserella pachytheca CHOI, 1970
Rauserella alveolaris CHOI, sp. nov.

Geological distribution; *Neoschwagerina* to *Yabeina* zone.

Geographical distribution; Japan, Russia (Ussuri territory, Krimea, Caucasus), and North America.

Rauserella alveolaris sp. nov.

Pl. 10, figs. 5 & 11; pl. 11, fig. 8

Materials: Holotype, UHR 18971 (pl. 10, fig. 5), Paratypes, UHR 18884, UHR 18885, UHR 18887, UHR 18889, UHR 18890, UHR 18897, UHR 18965.

Diagnosis: This new species is characteristic in having minute subcylindrical shell with planispiral, tight inner volutions, and spirotheca consists of keriotheca in outer volutions.

Derivation of name: This new specific name is referring to the presence of alveolar structure in spirotheca in the present form.

Description: Shell minute, ellipsoidal to subcylindrical in external shape with gently concave mid-portion and rounded poles. The shell contains at least six volutions. The shell of the fifth volution is 3.18 mm long and 1.2 mm wide, giving form ratio of 2.6. In the inner $2\frac{1}{2}$ volutions the shell is planispiral, but beyond that it suddenly takes ellipsoidal shape with the change of coiling axis and with loose coiling. The height of volution is 0.07 mm to 0.08 mm in the first volution, 0.08 mm to 0.09 mm in the second, 0.11 mm to 0.14 mm in the third, and 0.20 mm in the fourth.

Proloculus is minute, spherical and measures 0.07 to 0.08 mm in outside diameter.

Spirotheca is composed of tectum, upper and lower tectoria in inner two volutions, while in the outer composed of thin tectum and lower, massive, homogeneous layer, corresponding to diaphanotheca which assumes gradually keriothecal in structure towards the outer volutions. Spirotheca is very thin in planispiral stage; 5 to 7.5 microns, while it is rather thick in the fourth volution; 24 to 45 microns.

Septa are straight. The number of septa is 6 in the first volution, 10 in the second, and 9 to 10 in the outer volutions.

Chomata are feebly present in planispiral stage, but in some specimens they seem to be lacking.

Tunnel is low and broad. Tunnel angle in the third volution is nearly 90°.

Remarks: At a glance the present form reminds a species of *Toriyamaia*. However, the former has tight, planispiral inner volutions which are askew to the later volutions, and the spirotheca consisting of tectum, upper and lower tectoria. These characters are lacking in *Toriyamaia* in which the first and a half volution are staffelloidal in general shape, and possesses spirotheca consists of tectum and diaphanotheca. Therefore the present form from Kitakami Mountains can not be placed under the genus *Toriyamaia*.

On the other hand the present form resembles genus *Rauserella* in general appearance. But the structure of the spirotheca in the outer volutions consists of merely tectum and diaphanotheca. However so far as the general shape and the characters of inner stage and aberrant outer stage are concerned, it is quite possible that the present form still belongs to the group of *Rauserella*.

Rauserella erratica, the type species of genus *Rauserella* is readilly distinguishable from the present form by the presence of planispiral stage with comparatively numerous volutions, chomata and the wall structure without keriotheca.

M. KOBAYASHI (1957) described some *Rauserella* from Mt. Ibuki, Shiga Prefecture, Japan. One of them, *Rauserella fujimotoi* is also distinguishable from the Kitakami form in its small shell, small form ratio, rapid change of coiling axis, and thin spirotheca.

Rauserella sp. from Iwaizaki, South Kitakami Mountains reported by MORIKAWA (1960), seems somewhat similar to the present form at a glance, but no description and no well oriented illustration of that form are available for making detailed comparison with this present species in concern.

Family Schubertellidae SKINNER, 1931

Subfamily Boultoninae SKINNER & WILDE, 1954

Genus ***Codonofusiella*** DUNBAR & SKINNER, 1937

Type species: *Codonofusiella paradoxica* DUNBAR & SKINNER, 1937

Generic diagnosis: Shell is minute, fusiform in the inner volutions. Last volution is flared and uncoiled. Mature shell possesses 4 to $5\frac{1}{2}$ volutions. Inner few volutions are coiled at a large angle to the later volutions.

Spirotheca is very thin, and composed of tectum and lower dense layer.

In some highly advanced forms, it is composed of tectum and fine keriotheca.

Septa are highly fluted throughout the shell. Chomata are rudimentarily developed.

Remarks: As already mentioned by the writer (1970), *Codonofusiella inuboensis* from Iwaizaki, South Kitakami Mountains, described by himself surely possesses the wall provided with tectum and fine keriotheca in outer volutions, although he has not examined the wall of the holotype material of *Codonofusiella inuboensis* from Chosi Peninsula, Japan, reported by CHISAKA.

As to the wall structure of genus *Codonofusiella*, it has been generally considered that it is composed of tectum and lower less dense layer.

However, the newly found fact of the wall structure of *Codonofusiella* produced from Iwaizaki, shows that at least in some form of *Codonofusiella* possesses the wall composed of tectum and keriotheca, and that it is probable that the same fact will be found in future in some other highly advanced and well preserved forms.

Codonofusiella is safely discriminated from *Lantschichites* (=*Paraboultonia*) which was first established by TOUMANSKAYA as subgenus of *Codonofusiella*, by smaller, inflated shell with less intensely fluted septa which in most case does not show cuniculi of the former.

Geological distribution: Middle to upper Permian.

Geographical distribution: Japan, Korea, China, Timor, Mongolia, Russia (Krimea, Caucasus, PAMIRS, Ussuri territory), Turkey, Greece, North America (Texas, British Columbia).

Codonofusiella explicata KAWANO

Pl. 10, figs. 6–8

1960 *Codonofusiella explicata* KAWANO, pp. 225–226, pl. 24, figs. 3–14.

Description: Shell is minute, fusiform in coiled part with pointed poles. Uncoiled, flared portion of the shell is very long. At maturity the shell possesses 3 to $3\frac{1}{2}$ volutions, with length of about 0.48 mm, and 0.18 to 0.23 mm in width except uncoiled flared outermost volution which attains at most 1.2 mm in length in a sagittal section.

The shell in inner $1\frac{1}{2}$ to 2 volutions is coiled at right angle to the later volutions, and staffelloidal in shape with umbilical pole regions. Then the shell abruptly takes fusiform shape.

Proloculus is spherical with outside diameter of 40 microns.

Height of volution of an illustrated specimen (pl. 10, fig. 8) is 0.02 mm in the first, 0.022 mm in the second, and 0.03 mm in the third volution.

Septa are not fluted in inner volutions; while in the outer they are moderately fluted in somewhat narrow and high form. The number of septa in ill-preserved specimens is 6 to 7 in the first, about 13 in the second, and 16 to 17 in the third volution.

Spirotheca exceedingly thin, but composed of tectum and lower layer.

Chomata are absent throughout the shell.

Remarks: This form is one of the smallest *Codonofusiella* known to date, and is in every respect identical with *Codonofusiella explicata* KAWANO (1960) described from the upper Permian Aratani conglomerate in Yamaguchi Prefecture, Japan. The species is associated with *Ozawainella* aff. *kueichihensis* (CHEN) and *Parafusulina* sp. and is believed by KAWANO to represent the *Neoschwagerina* zone.

Other species are easily distinguished from the present form in possessing comparatively large shell, and less pronounced, flared volution.

Codonofusiella sp.

Pl. 15, fig. 7

Description: Shell is small, fusiform with pointed poles. The shell possesses four volutions, and measures 1.65 mm long, 0.55 mm wide, and gives form ratio of

3.0, in a well oriented illustrated specimen.
Inner two volutions are coiled at a large angle to the fusiformed later volutions. Height of volution from the first to the fourth volution is 0.03, 0.05, 0.06, and 0.16 mm, respectively.

Proloculus minute with outside diameter of 0.05 mm.

Structure of spirotheca is not well observed, but seems to be composed of tectum, upper and lower tectoria. Thickness of the spirotheca is very thin but increases towards outward; 0.02 mm in the fourth volution.

Septa are rather intensely, highly and narrowly fluted in outer volutions.

Remarks: From all availabe features, this form is judged to be as a species of genus *Codonofusiella*.

This form differs from *Codonofusiella explicata* KAWANO, in the larger shell which is twice as large as the latter, and more intensely fluted septa of the former.

Codonofusiella cuniculata is distinguished from the present form by less intensely fluted septa.

Codonofusiella inuboensis (CHISAKA), described from Chosi Peninsula and Iwaizaki, Southern Kitakami Mountains, can be readily distinguished from this form by cylindrical shell with more intensely fluted septa and development of axial fillings.

Codonofusiella paradoxica DUNBAR & SKINNER seems to be somewhat resembled to this form. However, the latter possesses comparatively large shell and less intensely fluted septa.

Codonofusiella japonica MORIKAWA described from Iwaizaki, Southern Kitakami Mountains in 1960, differs from the present form by smaller shell, nature of the septal fluting and more flared last volution of the former.

SHENG (1963) described many new species of *Codonofusiella* from South China. But all of them are easily distinguishable from this form in many respects.

Family Schwagerinidae DUNBAR & HENBEST, 1930

Subfamily Schwagerininae DUNBAR & HENBEST, 1930

Genus ***Pseudofusulina*** DUNBAR & SKINNER, 1931

Pseudofusulina kraffti (SCHELLWIEN & DYRENFURTH)

Pl. 10, fig. 4

1909 *Fusulina kraffti* SCHELLWIEN & DYRENFURTH, pp. 169–170, pl. 13, figs. 1–6; pl. 16, figs. 1–9.
1925 *Schellwienia kraffti*, OZAWA, pp. 25–27, pl. 6, fig. 7; pl. 7, fig. 4.
1927 *Schellwienia kraffti*, OZAWA, pp. 147, text fig. 5a-c.
?1936 *Pseudofusulina kraffti*, HUZIMOTO pp. 80–81, pl. 14, figs. 3–8.
1936 *Pseudofusulina aganoensis* HUZIMOTO, pp. 70–71, pl. 10, figs. 4–8.

1955 *Pseudofusulina kraffti*, MORIKAWA, pp. 94–95, pl. 7, figs. 15–17.
1955 *Schwagerina motohashii* MORIKAWA, pp. 101–103, pl. 12, figs. 1–9.
1958 *Pseudofusulina kraffti* var. *magna* TORIYAMA, pp. 178–181, pl. 25, figs. 1–10; pl. 26, figs. 1–15.
1959 *Pseudofusulina kraffti*, KANUMA, pp. 70–71, pl. 7, figs. 1–3, & 6.
1959 *Pseudofusulina kraffti* var. *magana*, IGO, p. 244, pl. 1, fig. 8; pl. 3, fig. 3.
1959 *Pseudofusulina kraffti norikurensis* IGO, p. 244–245, pl. 2, figs. 1–3.
1960 *Pseudofusulina arataniensis* KAWANO, pp. 226–228, pl. 24, figs. 15–20; pl. 25, figs. 1–3.
1960 *Pseudofusulina paramotohashii* MORIKAWA, pp. 284–285, pl. 49, figs. 7–11.
1961 *Pseudofusulina kraffti magna*, NOGAMI, pp. 216–217, pl. 10, figs. 1–4.
1961 *Pseudofusulina kraffti*, MORIKAWA & ISOMI, pp. 20–21, pl. 14, figs. 1–10; pl. 15, figs. 5 & 6.
1961 *Pseudofusulina norikurensis*, MORIKAWA & ISOMI, p. 21, pl. 15, figs. 1–4; pl. 16, figs. 1–7.
1961 *Pseudofusulina kraffti* form A NOGAMI, pp. 217–219, pl. 10, figs. 5–8.
1963 *Pseudofusulina kraffti*, SHENG, pp. 65, 191–192, pl. 16, figs. 16–18.
1963 *Pseudofusulina kraffti*, CHANG, p. 206, pl. 4, fig. 11.
1963 *Pseudofusulina kraffti* var. *magna*, CHANG, p. 206, pl. 5, figs. 10, 11 & 13.
1965 *Pseudofusulina kraffti kraffti*, KANMERA & MIKAMI, pp. 300–301, pl. 44. fig. 7.
1965 *Pseudofusulina kraffti*, KALMIKOWA, pp. 123–125, pl. IV, figs. 1–5.
1967 *Pseudofusulina kraffti*, LEVEN pp. 146–147, pl. X, figs. 5 & 6.
1967 *Pseudofusulina norikurensis krafftiformis* LEVEN pp. 148, pl. 11, fig. 2.
1967 *Pseudofusulina magna*, LEVEN, p. 149, pl. 11, figs. 5 & 6.

Remarks: One relatively well oriented specimen is available for study.

Morphological characteristics of the specimen at the writer's disposal are quite identical with those of the lectotype of *Fusulina kraffti* SCHELLWIEN & DYRENFURTH (1909), first designated by KANMERA and MIKAMI in 1965. They are identical with each other in general shape, size and rate of expansion of the shell, the thickness of the spirotheca, and nature of septal fluting. However, they are slightly different in the mode of axial fillings and form ratio.

Recently KALMIKOWA restudied the many topotype materials of *Pseudofusulina kraffti*, and she clarified that there exists considerable variation in this species with respect to the form of the shell, the development of axial fillings, the tightness of coiling of the shell, and the height of septal fluting. She also regarded *Pseudofusulina parakraffti* MIKLUCHO-MACLAY synonymous with *Pseudofusulina kraffti*.

In this connection, *Pseudofusulina aganoensis* HUZIMOTO, *Schwagerina motohashii* MORIKAWA, *Pseudofusulina arataniensis*, and *Pseudofusulina paramotohashii* MORIKAWA are all best considered to be mere varieties of *Pseudofusulina kraffti*.

It is true that there may exist some form groups within *Pseudofusulina kraffti*; namely *magna* group, *norikurensis* group, and so on. But mutual relationship between these form groups are morphologically successive and difficult to determine as to their boundary with certainty. Therefore the writer treats here all the above mentioned form groups as one species, not dividing them into species.

Pseudofusulina sp.

Pl. 11, figs. 1–3

Description: Shell is thick fusiform with slightly concave mid portion and bluntly rounded poles. The shell possesses $8\frac{1}{2}$ to 9 volutions at maturity, and 9.6 to 10.4 mm in length and 4.0 to 4.4 mm in width, giving form ratio of 2.2 to 2.6.

The shell is coiled rather tight in inner few volutions, then it is abruptly expanded. The average height of volution from the first to the eighth volution in three specimens is 0.073, 0.093, 0.12, 0.17, 0.29, 0.36, 0.37, and 0.42 mm, respectively.

Proloculus is comparatively small with outside diameter of 0.22 to 0.27 mm.

Spirotheca is composed of tectum and keriotheca which is very distinct in outer volutions. Thickness of the spirotheca increases towards outward; 0.01 to 0.02 mm in inner volutions, up to 0.10 mm in outer volutions.

Septa are highly, narrowly, and rather irregularly fluted. Number of the septa from the first to the eighth volution in an illustrated sagittal section (pl. 11, fig. 2) is 8, 14, 20, 21, 23, 21, 24, and 26, respectively.

Axial fillings are weakly developed in narrow pole regions of the first to the fifth or the sixth volution.

Distinct chomata are not seen even in tightly coiled inner volutions.

Remarks: This form is characteristic in its thick fusiform shell, tightly coiled inner volutions, and loosely coiled outer volutions with thick spirotheca possessing distinct alveoli.

From these features, this form is here included in the genus *Pseudofusulina*, although the nature of tightly coiled inner volutions conflicts with it.

So far as the writer awares, no previously described species is identical with this form. Since no ideally cut axial sections have been obtained, it may be premature to propose a new species on the form herein treated.

Genus *Parafusulina* Dunbar & Skinner, 1931

Parafusulina motoyoshiensis (Morikawa)

Pl. 9, figs. 1–12; pl. 12, figs. 1, 3, 5 & 7

1960 *Pseudofusulina motoyoshiensis* Morikawa, pp. 283–284, pl. 47, figs. 13–15, 17–18.

1963 *Schwagerina nakazawae* Nogami, pp. 63–64, pl. 3, figs. 13–17.

Description: Shell is large, elongate, ellipsoidal to subcylindrical, with pointed poles and gently curved axis of coiling. The shell of $7\frac{1}{2}$ to $6\frac{1}{2}$ volutions is 8.4 to 9.5 mm long and 2.05 to 2.60 mm wide. The largest specimen of tangential section attains 12.3 mm long and 3.0 mm wide. Outer one or two volutions are always partly missing. Form ratio varies from 4.1 to 5.2.

Coiling of the shell is regular, tight in inner four volutions, rather loose in the fifth, beyond which it becomes again tight. The average height of volution for six specimens from the first to the sixth volution measures 0.06, 0.074, 0.094, 0.133, 0.204 and 0.227 mm, respectively.

The shell is ellipsoidal to subcylindrical in the first volution, then it is assumed to be elongated ellipsoidal shape. The form ratio of each volution rapidly increases until the fourth volution but remains almost constant beyond that. The average form ratio of volution of half length to radius vector in four specimens from the first to the sixth volution is, 1.6, 2.5, 3.6, 4.3, 4.4, and 4.2, respectively.

Proloculus is rather large for the size of the shell. Its outside diameter measures 0.30 to 0.34 mm.

Spirotheca consists of tectum and coarse alveoli which are particularly conspicuous in outer volutions. Thickness of the spirotheca gradually increases towards outer volutions; 17 microns in the third, 38 microns in the fourth, 49 microns in the fifth, and 51 microns in the sixth in average of five specimens.

Septa are composed of tectum and lower, homogeneous, dark layer. Their number is counted from the first to the fourth volution, as being 10, 15, 16, and 19, respectively in average. The septal fluting is irregular and fairly intense and becomes stronger towards pole regions. However, fluting is sometimes confined within the lower portion of septa, but may be high and narrow, or gentle, low and broad in some cases. The fluting of septa does not take distinct cuniculi.

Tunnel is low and broad. Tunnel angle at the fifth volution is 50° to 68°.

Chomata are not developed throughout the length of the shell.

Axial fillings are weakly developed in the axial region of the first to the third or the fourth volution.

Remarks: The present form is quite identical with *Schwagerina nakazawae* described by Nogami (1963) from Portuguese Timor except for the slightly thick spirotheca in outer volutions in the former. The species would be, however, better transferred to the genus *Parafusulina*, since it has elongated cylindrical shell with comparatively intensely fluted septa, and thin spirotheca, although the fluting of septa seems to be not typical cuniculi.

Prior to NOGAMI, MORIKAWA (1960) proposed a new species called *Pseudofusulina motoyoshiensis*, from Iwaizaki, Southern Kitakami Mountains, Japan. MORIKAWA's specimens contain slightly smaller shell with fewer volutions, but all such smaller specimens may have been missing in outer volutions. Nevertheless, other characterictics of it are quite identical with those of *Schwagerina nakazawae* NOGAMI from Timor as well as the present form. Therefore *Schwagerina nakazawae* may be the junior subjective synonym of *Pseudofusulina motoyoshiensis*.

CHEN (1956) described *Schwagerina hupehensis* from South China, which closely resembles the present form in many points. But the Kitakami specimens have weakly and broadly fluted septa, loosely coiled outer volutions, coarse keriotheca in outer volutions, and large proloculus. These two species must be accordingly distinct with each other.

Parafusulina subextensa CHEN (1934), described from the Chihsia limestone, is also resembled the present specimens now in concern, especially to pl. 9, fig. 8. However, the CHEN's species is distinguished from the latter in having the more smaller forms, large shell with regular and intense fluting of septa. CHEN illustrated only single specimen for his species, so the extent of specific variation in the Chihsia form is hardly known for us.

Schwagerina jenkinsi THORSTEINSON (1960) shows some similarity to the present form, but the former is definitly distinct from the latter in having phrenotheca, comparatively tight inner volutions in which pseudochomata are present.

Parafusulina iwaizakiensis (MORIKAWA)

Pl. 12, figs. 14 & 15

1960 *Pseudofusulina iwaizakiensis* MORIKAWA, pp. 290–291, pl. 48, figs. 1–9.

Remarks: The present form is identical with *Pseudofusulina iwaizakiensis* MORIKAWA, from Iwaizaki, Southern Kitakami Mountains, in many respects.

The writer, however, considers that the present species would be better transferred to the genus *Parafusulina*, because of having elongate shell with intensely fluted septa and thin spirotheca, although cuniculi is not definitely observed.

Parafusulina sp.

Pl. 12, fig. 4

Remarks: only a few specimens are available for this species. The present form may be somewhat resembled *Pseudofusulina nobilis*, described by MORIKAWA (1960) from Iwaizaki. The latter, however, contains specimens having more regularly fluted septa, more round poles, and arcuate axis of coiling than the specimens at the writer's disposal, which are too scanty to make more detailed comparison.

Genus ***Monodiexodina*** SOSNINA, 1956

Monodiexodina sp.

Pl. 12, fig. 8

Remarks: The present form possesses strongly elongated shell with pointed poles, comparatively low and regularly fluted septa, and well developed axial fillings. Therefore this form may be placed under the genus *Monodiexodina*.

Among *Monodiexodina*, *Monodiexodina matsubaishi* (HUZIMOTO) may be closely similar to the present form. The present specimens show to have more sharply pointed poles, especially in inner volutions.

Monodiexodina matsubaishi seems to be closely allied to *Monodiexodina sutschanica* (DUTKEVITCH), the type species of genus *Monodiexodina* in shell shape, nature of septal fluting, and the mode of development of axial fillings. The morphological relationship between these two species should be reexamined in future.

Genus ***Chusenella*** HSÜ, 1942 emend. CHEN, 1956

Chusenella aff. ***choshiensis*** CHISAKA

Pl. 13, fig. 7

Compare with:

1960 *Chusenella choshiensis* CHISAKA, p. 245, pl. 3, figs. 1–8; pl. 4, figs. 7 & 8.

Description: Only single comparatively well oriented specimen is available for study. Accordingly, following description is entirely based on it.

Shell is rather large, fusiform with concave lateral slopes. The shell possesses nine volutions and it is 11.2 mm long and 3.8 mm wide, giving form ratio of about 3.0.

Coiling of the shell is tight in inner few volutions, while rather loose beyond the third or the fourth volution. The height of volution is 0.06 to 0.08 mm in the first two volutions, and 0.43 mm in the outermost volution.

Proloculus is small and measured 0.12 mm in diameter.

Spirotheca consists of tectum and lower thick, coarse alveolar layer. Thickness of the spirotheca is about 0.01 mm in the first, 0.06 mm in the fourth, and 0.09 mm in the outermost volution.

Septa are fluted high but broad, although they are almost straight near tunnel portion. They form sometimes rectangular shape in axial section.

Axial fillings are very well developed in the axial regions of the second to the sixth volution.

Chomata seem to be rudimentarily present in inner few volutions, but they definitely lack in outer.

Tunnel is low and rather narrow. Tunnel angle is 25° to 30° in outer volutions.

Remarks: This form should be placed in the genus *Chusenella*, because of having fusiform shell with concave lateral slopes, pointed poles, tightly coiled inner volutions, well developed axial fillings and so on.

The present form may be closely similar to *Chusenella choshiensis* CHISAKA, 1960, described from Choshi Peninsula, Chiba Prefecture, Japan, except for obvious difference in the nature of septal fluting. Nevertheless, detailed comparison is eventually impossible, since only one specimen is available for study.

Chusenella ishanensis HSÜ is easily distinguished from the present form by more tightly coiled inner volutions, convex mid-portion and more severely fluted septa of the former.

Chusenella pseudocrassa (KANMERA)

Pl. 10, figs. 1–4, 9–10; pl. 11, figs. 4–7

1935 *Pseudofusulina crassa*, GUBLER, pp. 79–81, pl. 1, figs. 5 & 6. (non *Fusulina crassa* DEPRAT, 1913)

1954 *Schwagerina pseudocrassa* KANMERA, pp. 9–11, pl. 1, figs. 6 & 7.

Description: Shell is highly inflated fusiform with nearly straight axis of coiling and bluntly pointed poles. The shell possesses nine volutions. Outer one or two volutions are sometimes missing by erosion. Specimens in the full grown stage of 7½ to 9 volutions are 7.9 to 8.6 mm long and about 4.4 to 4.8 mm wide with form ratio of 1.7 to 1.9.

Coiling of the shell is tight in inner three volutions, while it becomes loose in outer volutions. The height of an illustrated specimen (pl. 10, fig. 3) is 0.08, 0.08, 0.11, 0.26, 0.33, 0.43, and 0.42 mm from the first to the seventh volution, respectively. In inner three volutions, the shell is fusiform in general but outer volutions tend to be inflated fusiform. The form ratio of each volution in the above mentioned typical specimen is 1.7 in the first, 2.7 in the second, 2.9 in the third, 2.4 in the fourth, 2.1 in the fifth, and 1.9 in the sixth and seventh volution.

Proloculus is spherical. Its outside diameter is about 0.2 to 0.3 mm.

Spirotheca is composed of tectum and keriotheca. Thickness of spirotheca in inner three volutions is nearly constant, being 17 to 25 microns. In the outer volutions it abruptly increases up to 70 microns.

Septa are thin and composed of tectum and lower dark layer. They are almost plane in inner two volutions. Beyond the second volution, they are, however, broadly and irregularly fluted throughout the shell. The number of septa gradually increases towards later volutions viz. 10 to 17 in inner three volutions and about 29 to 32 in the seventh volution.

Axial fillings are slightly developed, being confined in inner four and rarely six volutions. Rudimentary chomata are present in the first two volutions.

Remarks: This form is quite identical with *Pseudofusulina crassa*, described by Gubler in 1935 from Cambodge. As already referred by Kanmera (1954), Gubler's *Pseudofusulina crassa* (pl. 1, fig. 6) obviously differs from *Fusulina crassa* of Deprat (1913).

Kanmera established a new species *Schwagerina pseudocrassa*, based on the materials from the Kuma formation, for which he referred the Gubler's *Pseudofusulina crassa.*

However, the holotype specimen of *Schwagerina pseudocrassa* illustrated by Kanmera is somewhat obliquely cut axial section. Its external shape is accordingly not correctly known. Further, Gubler's form seems to the present writer to be better considered as a *Chusenella.* Such being the case, the writer has been doubtful whether these two forms may be conspecific with each other. Nevertheless, the writer finally reached the conclusion that these forms including the Kitakami specimens may be eventually belonging to a single species and should be treated as a *Chusenella.*

Pseudofusulina ozakii Chisaka, from Takagami conglomerate, Choshi Peninsula, resembles the present species in the external shell shape. The former yet possesses the shell with larger proloculus and loosely coiled inner volutions.

Family Verbeekinidae STAFF & WEDEKIND, 1910

Subfamily Verbeekininae STAFF & WEDEKIND, 1910

Genus ***Pseudodoliolina*** YABE & HANZAWA, 1932

Type species : *Pseudodoliolina ozawai* YABE & HANZAWA, 1932

Generic diagnosis : Shell is medium to large in size, ellipsoidal to cylindrical with broadly rounded poles and nearly straight axis of coiling. The shell expands uniformly throughout the volutions.

Spirotheca is composed of tectum and lower less dense layer in primitive forms, but differentiated into tectum, diaphanotheca with fine alveoli, and lower tectorium in outer volutions in advanced forms.

Parachomata are well developed throughout the length of the shell. Some highly developed forms possess the parachomata which show high and thin bar-like shape in section in outer volutions.

Foramina are abundantly present.

Geological distribution : *Neoshwagerina simplex*, *Parafusulina kaerimizensis* to *Yabeina-Lepidolina* zone.

Geographical distribution : Japan, Korea, Russia (Sihote-Aline, Pamir, Krimea), China, Yugoslavia, North America.

Remarks : Genus *Pseudodoliolina* was established in 1932 by YABE & HANZAWA. They stated " For a long time authors neglected the fact that *Doliolina lepida* SCHWAGER, the genotype of the genus *Doliolina*, has its shell wall provided with keriotheca and in extreme case, the genus was defined as to include forms with shell wall lacking keriotheca. The senior author of the present article is probably much responsible for this misconception, as he first identified a foraminifera in the Permian limestone of Akasaka, province Mino, bearing a shell free from keriotheca and simply composed of a tectum with *Doliolina lepida*. . . . Hence there is a need of new generic and specific name for the foraminifera " *Doliolina lepida* " auct., non SCHWAGER, and we wish to propose at this place *Pseudodoliolina* and *Pseudodoliolina ozawai* for the genus and species respectively."

Following YABE & HANZAWA, THOMPSON & FOSTER (1934) designated the specimen illustrated by DEPRAT as figure 12 on his plate 3 as the lectotype of *Pseudodoliolina ozawai.*

A number of *Pseudodoliolina* have been described mainly from Asia and some from America and Europe.

In reexamining the various forms of *Pseudodoliolina* described until present, the writer reached the conclusion that it may be possible to divide them into 4 species groups ; namely, *Pseudodoliolina ozawai* group, *Pseudodoliolina pseudolepida* group, *Pseudodoliolina elongata* sp. nov. group (described in this article), and *Pseudodoliolina gravitesta* group.

Among them, in the *Pseudodoliolina ozawai* group, the following species may be included; *Pseudodoliolina ozawai* YABE & HANZAWA, *Pseudodoliolina ozawai minima* MIKLUCHO-MACLAY, *Pseudodoliolina oliviformis* THOMPSON, WHEELER & DANNER, *Pseudodoliolina chinghaiensis* SHENG, and *Pseudodoliolina cylindrica* SKINNER & WILDE. This group is the most primitive group in which most species have comparatively small shells, 3.0 to 5.2 mm (mainly 3.5 to 4.8 mm) in length, 1.2 to 3.0 mm (1.5 to 2.2 mm) in width, with form ratio of about 1.9 to 2.6, in mature specimens. Spirotheca is very thin, composed of one layer though sometimes reveals the alveolar structure in outer volutions. Its thickness is mostly within 20 microns even in the outer volutions. As to the shell form, *Pseudodoliolina chinghaiensis* possesses thick fusiform and rather large shell, and *Pseudodoliolina oliviformis* also has shell of inflated mid-portion. Nevertheless the writer still considers these two species to be included in the present group considering the above described common features between them.

The second group is represented by *Pseudodoliolina pseudolepida* (DEPRAT), and *Pseudodoliolina pulchra* SHENG. They possess the larger and cylindrical shell (over 5.0 mm in length), with more numerous volutions, slightly thicker and differentiated spirotheca in outer whorls, and more developed parachomata than *Pseudodoliolina ozawai* group.

Pseudodoliolina elongata sp. nov. is grouped in the third group. This species is found from the Atetsu Plateau and Kitakami Mountains. This species is typical

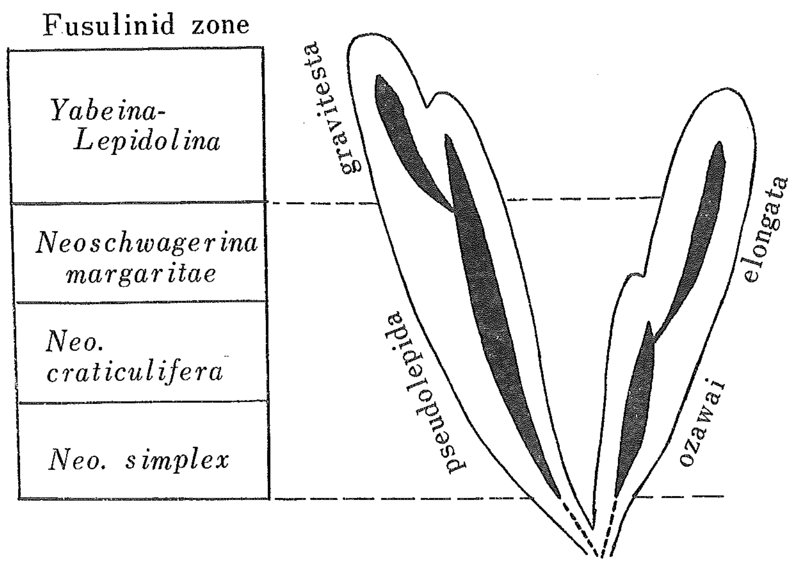

Fig. 4
Suggested phylogeny of *Pseudodoliolina*

in its elongate large shell. Features of the inner volutions are just like that of *Pseudodoliolina ozawai*. This new species ranges from the *Neoschwagerına douvillei* zone to the lower part of *Yabeina-Lepidolina* zone. Therefore, it is highly possible that it is a direct descendant of *Pseudodoliolina ozawai*.

The *Pseudodoliolina gravitesta* group here designated includes single species described by ISHII and NOGAMI (1961) under the name of *Metadoliolina gravitesta*. ISHII and NOGAMI especially placed stress on its structure of the wall distinctly diffentiated into three layers, and possessing alveolar structure in the outer volutions. They also assumed this species to be stratigraphically as high as the *Yabeina-Lepidolina* zone. The writer agrees that the wall structure may be one of the important criteria distinguishing species in *Pseudodoliolina*. However, he thinks that this can not be suitable enough for generic separation, at least in the group now in concern.

As stated above, these four groups seems to show different geological range with each other and a compiled phylogeny will be shown as text-fig. 4.

Here arise the problems how to consider the relationship between *Metadoliolina* ISHII and NOGAMI, 1961, and *Neomisellina* SHENG, 1963. So far as the diagnosis of *Neomisellina* is concerned, it does not conflict with that of *Metadoliolina*. *Neomisellina multivoluta* SHENG, *Neomisellina sphaeroidea* SHENG, *Neomisellina douvillei* (GUBLER) are still assumed to differ from *Metadoliolina gravitesta*, the type of genus *Metadoliolina*, in having *Misellina* like inner volutions, ellipsoidal melon shaped shell, comparatively thick spirotheca, and the mode of development of parachomata of the former. The writer considers that it is necessary to make more detailed examination on their morphological and phylogenetical relation in future.

Pseudodoliolina elongata sp. nov.

Pl. 14, figs. 1–6.

1961 *Pseudodoliolina* sp. indet., NOGAMI, pp. 166–167, pl. 1, fig. 12.

Materials: Holotype, UHR 19065 (pl. 14, fig. 1). Paratypes, UHR 19060–19064, and UHR 19096–19101.

Diagnosis: *Pseudodoliolina* with relatively large, elongate cylindrical shell with thin and slightly rugose spirotheca.

Description: Shell is relatively large, elongate cylindrical with bluntly rounded poles. The shell possessing 13 to $14\frac{1}{2}$ volutions is 8.0 to 8.8 mm in length and 2.2 to 2.4 mm in width giving form ratio of 3.7 to 4.1.

The shell is tightly and uniformly coiled. Height of volution gradually increases towards outer volutions ; 0.04 mm in the first two volutions, 0.12 to 0.13 mm in the outer volutions.

Proloculus is medium in size ; 0.13 to 0.15 mm in outside diameter.

Spirotheca consists of tectum and lower massive layer. It is very thin throughout the shell, and does not exceed 0.015 mm even in outer volutions. The spirotheca shows slight rugosity in some parts.

Septa are straight throughout the shell. As no ideal sagittal sections could be obtained, it is impossible to give the exact counting of the septa per volution. However, they are 7 to 11 in inner two volutions, and approximately 40 to 45 in the outermost few volutions.

Parachomata are prominent. They are $\frac{1}{2}$ the height of the chamber at the lowest part, and are rectangular in shape with rounded upper surface in section.

Foramina are small and circular, and open between the parachomata.

Remarks : As already mentioned in the specific diagnosis, this new species is characteristic in its elongate cylindrical shell with thin spirotheca which does not show alveolar structure even in outer volutions. This new species may be likely to be conspecific with *Pseudodoliolina* sp. indet., described by NOGAMI from the Atetsu Plateau, Southwest Japan, in elongate shell shape, size, coiling of the shell and thin spirotheca with slight rugosity.

This form is easily distinguishable from *Pseudodoliolina ozawai* by larger shell and more elongate cylindrical shell shape. The inner characters of this form are very close to *Pseudodolilina ozawai*. In consideration of the horizon of this species together with the above characteristics of this form, it may be highly probable that this form is a direct descendant of *Pseudodoliolina ozawai*.

The writer also found specimens to be specifically identical with this new species from the lower part of *Yabeina* limestone developed in Kanokurayama, Sumita-Cho, Southern Kitakami Moutains, in association with *Yabeina* (*Lepidolina*) *multiseptata shiraiwensis*, *Pseudodoliolina gravitesta*, *Kahlerina* sp. and others. Therefore this species ranges from the *Neoschwagerina douvillei* to the lowers part of *Yabeina-Lepidolina* zone.

Genus ***Verbeekina*** STAFF, 1909

Verveekina verbeeki (GEINITZ)

Pl. 15, figs. 1–3

1876 *Fusulina verbeeki* GEINITZ, pp. 399–400.
1912 *Schwagerina verbeeki*, DEPRAT, pp. 40–41, pl. 1, figs. 7–11.
1925 *Verbeekina verbeeki*, OZAWA, pp. 48–51, pl. X, figs. 6 & 7.
1935 *Verbeekina verbeeki*, GUBLER, (without description), pl. 1, figs. 10–16.
1936 *Verveekina verbeeki*, THOMPSON, pp. 197–200, pl. 24, figs. 1–8.

1936 *Verbeekina verbeeki*, HUZIMOTO, pp. 101–104, pl. 9, fig. 8; pl. 21. figs. 1–3.
1956 *Verbeekina verbeeki*, CHEN, pp. 9, 47–48, pl. IX, figs. 5 & 6; pl. XIII, figs. 1 & 2.
1957 *Verbeekina verbeeki*, KOBAYASHI, pp. 301–302, pl. IX, figs. 5–7.
1958 *Verbeekina verbeeki*, TORIYAMA, pp. 205–208, pl. 37, figs. 1–6; pl. 38, figs. 1–6.
?1960 *Verbeekina* sp., MORIKAWA, p. 296, pl. 53, figs. 10 & 11.
1961 *Verbeekina verbeeki*, NOGAMI, pp. 167–169, pl. 2, figs. 1–4.
1963 *Verbeekina verbeeki*, SHENG, pp. 85–86 & 215–216, pl. 26, figs. 1–5.
1964 *Verbeekina verbeeki*, IGO, pp. 62–63, pl. 2, fig. 1.
1965 *Verbeekina verbeeki*, ISHII & NOGAMI, p. 24, pl. 8, figs. 4–6.

Description: Shell is spherical with slight umbilical pole regions. The shell in the mature stage of 15 to 16 volutions is about 8 mm or more in length and in width.

Coiling of the shell is very tight in inner few volutions, taking staffelloidal shape, but abruptly expanded in the fourth to the sixth volution and beyond that it is uniform although it gradually tends tight outward. Height of volution in an illustrated specimen (pl. 15, figs. 2) is up to 0.10 mm in inner few volutions, and 0.29 to 0.34 mm in outer ones.

Proloculus seems to be minute, but its diameter is not correctly measured because of the lack of ideal sections.

Spirotheca is composed of tectum and lower thicker dark layer with fine alveoli. Thickness of the spirotheca gradually thickened towards outward; 0.010 to 0.015 mm in inner volutions and 0.055 mm or more in outer volutions.

Parachomata tend to devlop in the eighth to nineth volution, gradully become distinct towards mature stage. They are small, triangular and conspicuous especially near the septa.

Foramina are very small and elliptical. They occur at the lower part of the septa.

Remarks: This form is identical with *Verbeekina verbeeki* in every respect.

MORIKAWA once illustrated *Verbeekina* sp. (which he referred as *Verbeekina verbeeki* in 1958) from Iwaizaki, Southern Kitakami Mountains in 1960. One of his specimens (pl. 53, fig. 10) shows strong similarity to the specimens now in consideration. Unfortunately most specimens treated by MORIKAWA are strongly deformed and too poorly preserved to make more detailed comparison.

Subfamily Neoschwagerininae DUNBAR & CONDRA, 1928

Genus *Cancellina* HAYDEN, 1909

Cancellina sp.

Pl. 12, fig. 13

Description: Only single specimen is at hand.

Shell is minute, inflated spheroidal. It possesses seven or eight volutions, with the length of 0.84 mm, the width of 0.55 mm and form ratio of 1.6.

The shell is coiled tightly and uniformly. Height of volution gradually increases towards outward; about 0.02 mm in inner volutions, and 0.05 to 0.06 mm in outer.

Proloculus is not observed due to ill-orientation of the specimen.

Structure of spirotheca is not thoroughly observable because of poor preservation of the specimen. However, it seems to be composed of tectum and lower layers. Above the tectum, there is thin but dark layer which looks like to be continuous with parachomata. Thickness of the tectum and lower massive layer is within 0.015 mm even in the outer volutions.

The parachomata are well developed throughout the shell. They are narrow, high, and triangular shaped in the tangential section.

Septa are straight, but they can not be well counted for each volution.

Remarks: This form may be referable to the genus *Cancellina* sensu KANMERA (1957) from its minute inflated spheroidal shell, thin spirotheca, narrow and high parachomata, and the development of transverse septula, although the division of genus *Cancellina*, *Minoella* (HONJO, 1959), *Neoschwagerina* are somewhat confused.

Since no sagittal section for this specimen was available, it is almost impossible to examine the nature of axial septula, based on the method proposed by MINATO and HONJO (1959, 1966).

So far as all observable features are concerned, the present form is now assumed to be one of the smallest *Cancellina* known to date. All previous species are readily distinguished from this form in this connection.

Genus *Yabeina* DEPRAT, 1914

Subgenus *Lepidolina* LEE, 1933

Yabeina (*Lepidolina*) *multiseptata shiraiwensis* (OZAWA)

Pl. 13, fig. 8; pl. 15, figs. 4–6.

1925a *Neoschwagerina* (*Yabeina*) *shiraiwensis* OZAWA, (without description), pl. 3, fig. 8; pl. 4, figs. 1–3.

1925b *Yabeina shiraiwensis*, OZAWA, pp. 63–64, pl. 2, figs. 2b, 5c. 7b; pl. 10, figs. 1 & 2.
1936 *Yabeina shiraiwensis*, HUZIMOTO, pp. 122–123, pl. 26, figs. 1–7.
1942 *Yabeina shiraiwensis*, TORIYAMA, pp. 245–246, pl. 24, figs. 14 & 15; pl. 25, figs. 1–6.
1942 *Yabeina yasubaensis* TORIYAMA, pp. 246–247, pl. 25, figs. 8–14.
1954 *Yabeina yasubaensis*, KANMERA, pp. 18–19, pl. 2, figs. 10–13; pl. 5, figs. 14–19.
1956 *Yabeina shiraiwensis*, CHEN, pp. 13, 64–65, pl. 14, figs. 8–10.
1956 *Yabeina shiraiwensis*, MORIKAWA, pp. 254–256, pl. 33, figs. 1–11; pl. 34, figs. 8 & 9.
1958 *Yabeina shiraiwensis*, TORIYAMA, pp. 236–241, pl. 44, figs. 1–15; pl. 45, figs. 1–11.
1958 *Yabeina yasubaensis*, TORIYAMA, pp. 241–244, pl. 45, figs. 12–14; pl. 46, figs. 1–16.
1958 *Yabeina yosubaensis*, NOGAMI, pp. 102–103, pl. 1, fig. 8.
1958 *Yabeina shiraiwensis*, MORIKAWA et al., p. 89, pl. 6, fig. 9 & 10.
1960 *Yabeina shiraiwensis*, MORIKAWA, pp. 296–297, pl. 53, figs. 1–9.
1960 *Yabeina shiraiwensis*, CHISAKA, pp. 248–249, pl. 5, figs. 1–10; pl. 6, fig. 5 ?.
1961 *Yabeina shiraiwensis*, NOGAMI, pp. 186–190, pl. figs. 1–8.
1962 *Yabeina shiraiwensis*, ISHII & NOGAMI, pp. 63–66, pl. 1 & 2.
1962 *Yabeina shiraiwensis*, CHISAKA, pp. 546–547, pl. 8, fig. 7.
1964 *Yabeina multiseptata shiraiwensis*, ISHII & NOGAMI, (without description), pl. 5, figs. 1–3.

Remarks: The present Kitakami specimens are more or less deformed. Nevertheless all observable fearures, however, reveal its close similarity to *Neoschwagerina* (*Yabeina*) *shiraiwensis* OZAWA in 1925, which was lately redefined by ISHII and NOGAMI (1964).

Lepidolina multiseptata group and *Yabeina globosa* group are obviously alike with each other, except for the apparent difference in proloculus size. Notwithstanding of this, it is ridiculous that they have never been found in association.

The writer is accordingly of the opinion that they belong to phylogenetically different stocks as MINATO and HONJO (1959), and HASEGAWA (1965) advocated. So he tentatively treats *Lepidolina* as a subgenus of *Yabeina*.

References cited

CHANG, L. H. (1963): Upper Carboniferous fusulinids from Kelpin and neighbouring area, Hsin-Kiang. (in Chinese and Russian). *Acta. Palaeont. Sinica.*, vol. 11, no. 2, pp. 200–227, pls. 4–9.

CHEN, S. (1934): Fusulinidae of South China. part I. *Palaeont. Sinica*, ser. B, vol. IV, fas. 2, pp. 1–133, pls. I-XVI.

CHISAKA, T. (1960): On some Permian fusulinids from the Takagami conglomerate, Chosi Peninsula, Chiba prefecture, Japan. *Jour. Coll. Arts & Sci., Chiba Univ.*, vol. 3, no. 2, pp. 235–250, pls. 1–9.

——— (1962): Fusulinids from the vicinity of Maiya Town, Kitakami Mountainland, and upper Permian fusulinids of Japan. *ibid.*, vol. 3, no. 4, pp. 519–551, pls. I-VIII.

CHOI, D. R. (1970): On some Permian fusulinids from Iwaizaki, N. E. Japan. *Jour. Fac. Sci. Hokkaido Univ.*, ser. Geol. & Min., This volume.

GUBLER, T. (1935): Les Fusulinidés du Permien du l'Indochine, leur structure et leur classification. *Soc. Géol. France, Mém.* n. sér., tome XI, Fasc. 4, no. 26, pp. 1–173, pl. I–VIII.

HASEGAWA, Y. (1965): '*Lepidolina*' from the Ohtani Conglomerate, central Japan. *Earth Sci.* (*Chikyu Kagaku*), no. 76, pp. 25–33, pls. I-III.

HONJO, S. (1959): Neoschwagerinids from the Akasaka limestone. *Jour. Fac. Sci. Hokkaido Univ.*, ser. IV, Geol. & Min., vol. X, no. 1, pp. 111–161, pl. I-XII.

HUZIMOTO, H. (1936): Stratigraphical and palaeontological studies of the Titibu system of the Kwanto-Mountainland. Part II. Palaeontology. *Sci. Rep. Tokyo Bunrika Daigaku*, ser. C, vol. 1, no. 2, pp. 29–125, pls. 1–26.

——— (1956): A new species of *Parafusulina* from the Kitakami Massif, Japan. *Trans. Proc. Palaeon. Soc. Japan.* n.s., no. 21, pp. 157–160, pl. 25.

IGO, H. (1959): Some Permian fusulinids from the Hirayu district, southern part of the Hida Massif, central Japan. *Sci. Rep. Tokyo Kyoiku Daigaku*, sec. C, vol. 6, no. 56, pp. 231–254, pls. 1–4.

ISHII, K. & NOGAMI, Y. (1961): On the new genus *Metadoliolina*. *Trans. Proc. Palaeont. Soc. Japan.* new ser., no. 44, pl. 161–166. pl. 25.

——— (1962): On *Yabeina shiraiwensis* Ozawa and *Yabeina yasubaensis* TORIYAMA. *Jour. Geosci., Osaka City Univ.*, vol. 6, art. 2, pp. 59–72. pls. I–II.

——— (1964): Contributions to Geology and Palaentology of Cambodia. Part 1, Permian Fusulinids. *ibid.*, vol. 8, art. 2, pp. 9–40, pl. I–VIII.

KALMIKOWA M. A. (1965): Ревизия Групп *Pseudofusulina vulgaris* и *Pseudofusulina krafftі*: Вопросы Микропалеонтологии. vol. 9, pp. 111–128, pls. I-IV.

KANMERA, K. (1954): Fusulinids from the upper Permian Kuma formation, southern Kyushu, Japan—with special reference to the fusulinid zone in the upper Permian of Japan. *Mem. Fac. Sci. Kyushu Univ.*, ser. D, no. 1, pp. 1–38, pls. 1–6.

——— (1957): Revised classification of *Cancellina* and *Neoschwagerina*, and evolution of Sumatrininae and Neoschwagerininae. *Mem. Fac. Sci. Kyushu Univ.*, ser. D, Geol., vol. VI, no. 1, pp. 47–64, pls. 19 & 20.

——— (1963): Fusulines of the middle Permian Kozaki formation of southern Kyushu. *ibid.*, ser. D, Geol., vol. XIV, no. 2, pp. 79–141, pls. 11–19.

——— & MIKAMI, T. (1965): Fusuline zonation of the lower Permian Sakamotozawa series. *ibid.*, ser. D, Geol., vol. XVI, no. 3, pp. 275–320, pls. 44–53.

KANUMA, M. (1958): Stratigraphical and Palaeontological studies of the southern part of the Hida Plateau and the north-eastern part of the Mino Mountainland, central Japan. part. II, Palaeontology. *Bull. Tokyo Gakugei Univ.* vol. 10, pp. 59–83, pls. 4–9.

KAWANO, M. (1960): Some fusulinids from the Aratani conglomerate in the northern part of Yamaguchi city. *Sci. Rept. Tohoku Univ.*, 2nd ser. (Geol.), spec. vol., no. 4, pp. 223–230, pls. 24 & 25.

KOBAYASHI, M. (1957): Palaeontological study of the Ibukiyama limestone, Shiga prefecture, central Japan. *Sci. Rep. Tokyo Kyoiku Daigaku*, sec. C, vol. 5, no. 48, pp. 95–159, pls. I-X.

LEVEN, E. YA (1967): О стратиграфическом значении рода *Polydiexodina* DUNBAR et SKINNER, 1931. Вопросы Микропалеонтологии vol. 9, pp. 129–146, pls. I-VI.

——— (1967): Стратиграфия и фузулиниды Пермских Отложений Памира. Труды Геол. ИН-ТА АН СССР, vol. 167, pp. 1–224, pls. I-XXXIX.

MINATO, M & HONJO, S. (1959): The axial septula of some Japanese Neoschwagerininae with special reference of the phylogeny of the subfamily Neoschwagerininae DUNBAR and CONDRA, 1928. *Jour. Fac. Sci. Hokkaido Univ.*, ser. IV, Geol. & Min., vol. X, pp. 305–336, pls. I-VI.

——— & ——— (1966): Филогения подсемейства Neoschwagerininae. Вопросы Микропалеонтологии, vol. 10, pp. 109–124, pl I-III.

MORIKAWA, R. (1955): Schwagerininae in the vicinity of the Shomaru pass, eastern part of Kwanto Mountainland, central Japan. *Sci. Rep. Saitama Univ.*, ser. B, vol. II, no. 1, pp. 45–114, pls. V-XV.

——— (1960): Fusulinids from the Iwaizaki limestone. *ibid.*, ser. B, vol. 3, no. 3, pp. 273–299, pls. 46–53.

——— & ISOMI, H. (1960): Studies of Permian fusulinids in East of Lake Biwa, central Japan. *Geol. Surv. Japan. Rep.*, no. 191. pp. 1–29, pls. 1–21.

NOGAMI, Y. (1958): Fusulinids from the Maizuru zone, southewest Japan. part I, *Mem. Coll. Sci. Uni. Kyoto*, ser. B, vol. XXV, no. 2, Geol. & Min., art. 4, pp. 97–114, pls. 1 & 2.

——— (1961): Permische Fusuliniden aus dem Atetsu-Plateau Sudwestjapans. Teil. I, *ibid.*, ser. B, vol. XXVII, no. 3, art. I, pp. 159–248, pls. 1–11.

——— (1961): Permische Fusuliniden aus dem Atetsu Plateau Sudwestjapans. Teil 2. *ibid.*, vol. 28, no. 2, art, 3, pp. 159–242, pls. 1–7.

——— (1963): Fusulinids from Portuguese Timor (Palaeontological Study of Portuguese Timor, I). *ibid.* ser. B, vol. XXX, no. 2, Geol. & Min., pp. 59–67, pl. 3.

OZAWA, Y. (1925a): On the classification of fusulinidae. *Jour. Coll. Sci., Tokyo Imp. Univ.* vol. 45, art. 4, pp. 1–26, pl. 1–4.

——— (1925b): Palaeontological and stratigraphical studies on the Permo-Carboniferous limestone of Nagato. Part II, Palaeontology. *Jour. Coll. Sci., Imp. Univ. Tokyo*, vol. 45, art. 6, pp. 1–90, pls. 1–14.

——— (1927): Stratigraphical studies of the fusulina limestone of Akasaka, Province of Mino. *Jour. Fac. Sci., Imp. Univ. Tokyo*, vol. II, part 3, pp. 121–164, pls. 34–45.

ROSS, C. A. (1967): Late Palaeozoic fusulinacea from northern Yukon territory. *Jour. Palaeont.*, vol. 41, no. 3, pp. 709–725, pls. 79–86.

SHENG, J. C. (1963): Permian fusulinids of Kwangsi, Kueichow Szechuan. *Palaeont Sinica*, new ser. 10, pp. 1–119, 120–247, pls. 1–36.

SCHELLWIEN, E. & DYRENFURTH, G. (1909): Monographie der Fusulinen. Teil II. Fusulinen von Darwas. *Palaeontogr.*, pp. 137–176, pls. 13–16.

SUYARI, K. (1962): Geological and palaeontological studies in central and eastern Shikoku, Japan. Part II, Palaeontology. *Jour. Gakugei Tokushima Univ.*, vol. XII, pp. 1–64, pls. 1–12.

THOMPSON, M. L. (1936): The fusulinid genus *Verbeekina*. *Jour. Palaeont.*, vol. 10, no. 3, pp. 193–202, pl. 24.

——— (1948): Studies of American fusulinids. *Uni. Kansas Palaeont.* Contr., Protozoa, art. 1, pp. 1–184, pls. 1–38.

TOYIYAMA, R. (1958): Geology of Akiyoshi. *Mem. Fac. Sci. Kyushu Univ.*, ser. D, Geol., vol. VII, pp. 1–264. pls. 1–48.

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PLATE 9 AND EXPLANATION

Explanation of Plate 9

All figures are × 10

Parafusulina motoyoshiensis (MORIKAWA)

Figs. 1, 2, 8, 10 & 11. Axial sections showing variation in the mode of septal flutings. 1. UHR 18970, 2. UHR 18884, 8. UHR 18974, 10. UHR 18975, 11. UHR 18882.

Figs. 3, 5 & 6. Sagittal sections.
3. UHR 18893, 5. UHR 18885, 6. UHR 18974.

Fig. 12. Oblique sagittal section. UHR 18899.

Fig. 9. Oblique section. UHR 18883a.

Figs. 4 & 7. Tangential sections. 4. UHR 18887, 7. UHR 18883b

All specimens are from loc. 7.

All specimens are from the Kanokura series, middle Permian, developed in Imo-Sawa, Yahagi-Cho, Rikuzentakada City, Iwate Prefecture.

Plate 9

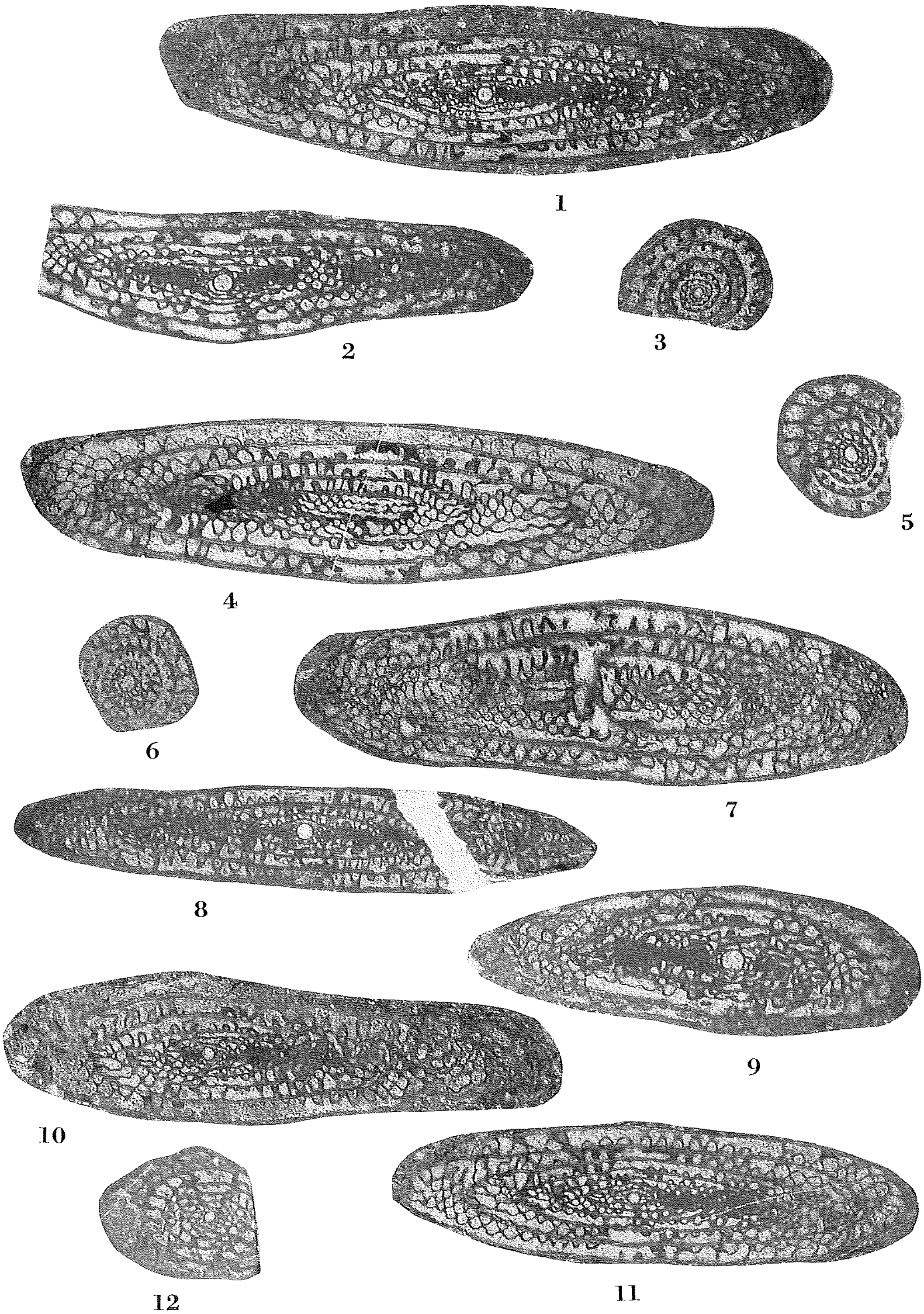


PLATE 10 AND EXPLANATION

Explanation of Plate 10

Chusenella pseudocrassa (KANMERA)

Figs. 1 & 3. Slightly oblique axial setions.
1. UHR 18968 × 20, 3. UHR 18887 × 20.

Fig. 2. Oblique section. UHR 18963 × 20.

Figs. 9 & 10. Sagittal sections.
9. UHR 18965 × 20, 10. UHR 18961 × 20.

Pseudofusulina kraffti (SCHELLWIEN & DYRENFURTH)

Fig. 4. Axial section. UHR 18972 × 10.

Rauserella alveolaris CHOI sp. nov.

Fig. 5. Holotype, axial section. UHR 18971 × 20.

Fig. 11. Enlarged part of fig. 5, showing the alveolar wall structure in the outer volution. × 100.

Codonofusiella explicata (KAWANO)

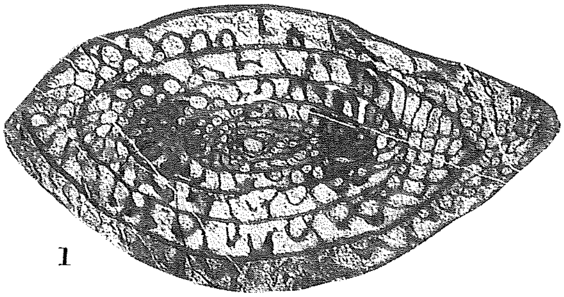
Fig. 6. Deep tangential section. UHR 18884 × 50.

Figs. 7 & 8. Sagittal sections.
7. UHR 18887a × 50, 8. UHR 18887b × 50.

All specimens are from loc. 7

All specimens were collected from the Kanokura series, middle Permian, developed in Imo-Sawa, Yahagi-Cho, Rikuzentakada City, Iwate Prefecture.

Plate 10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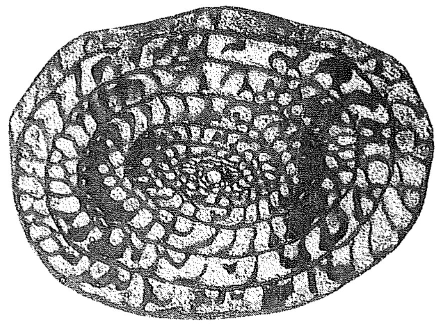
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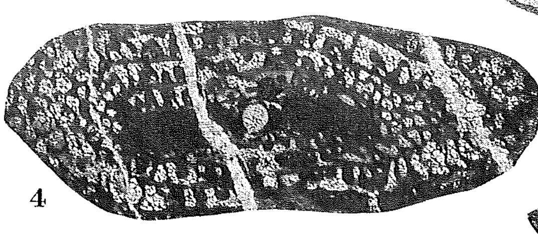
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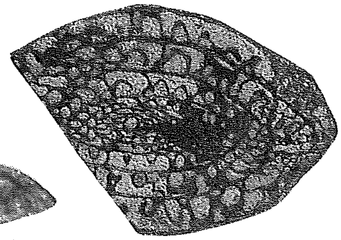
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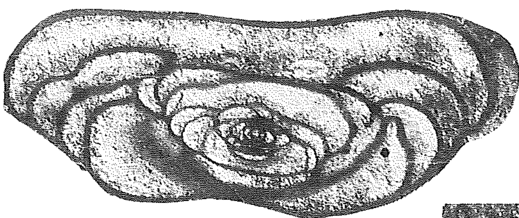
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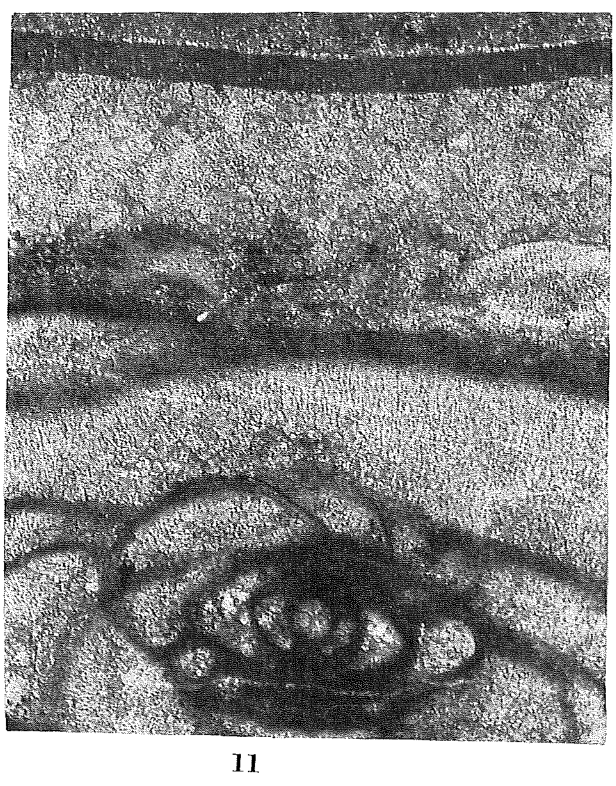
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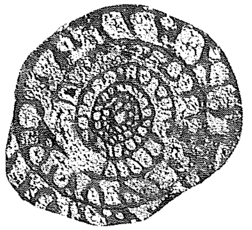
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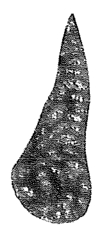
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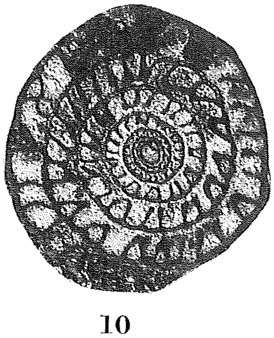
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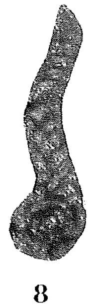
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PLATE 11 AND EXPLANATION

Explanation of Plate 11

All figures are × 10

Figs. 1–3. *Pseudofusulina* sp.

1. Axial section. UHR 19089.
2. Sagittal section showing tightly coiled inner volutions. UHR 19090.
3. Oblique axial section. UHR 19091.

Figs. 4–7. *Chusenella pseudocrassa* (KANMERA)

4. Sagittal section. UHR 19094.
5. Incomplete axial section showing well developed axial fillings. UHR 19095.
6. Typical axial section. UHR 19093.
7. Tangential section. UHR 19092.

Fig. 8. *Rauserella alveolaris* CHOI sp. nov.

Axial section of inner stage of a paratype specimen. UHR 18884

Figs. 1–7 are from. loc. 1, and fig. 8 is from loc. 7.

All specimens were collected from the Kanokura series, middle Permian, developed in Imo-Sawa, Yahagi-Cho, Rikuzentakada City, Iwate Prefecture.

Plate 11

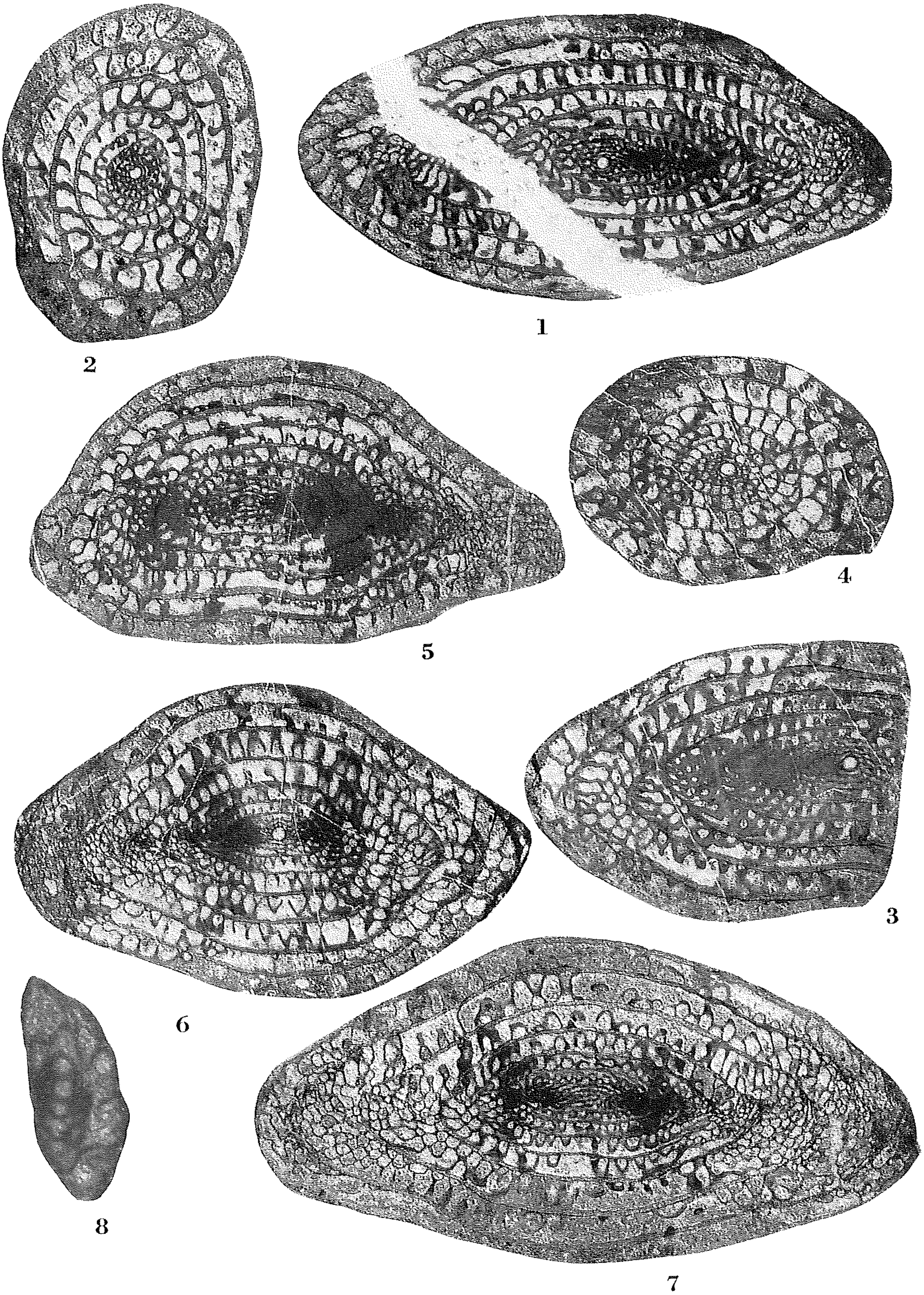

PLATE 12 AND EXPLANATION

Explanation of Plate 12

All figures except for figs. 11–13 are × 10. Fig. 11 is × 100 and figs. 12 & 13 are × 20.

Fig. 1, 3, 5 & 7. *Parafusulina motoyoshienis* (MORIKAWA)

1, 3 & 5. Axial section. 1. UHR 19075. (loc. 5), 3. UHR 19074. (loc. 5), 5. UHR 19076. (loc. 5), 7. Sagittal section. UHR 19077. (loc. 5)

Fig. 4. *Parafusulina* sp. A

Axial section. UHR 19078. (loc. 5)

Fig. 6. *Parafusulina* sp. B Axial section. UHR 19080. (loc. 5)

Fig. 8. *Monodiexodina* sp. Axial section. UHR 19079. (loc. 5)

Figs. 2 & 9. *Pseudofusulina* sp. B

2. Sagittal section. UHR 19083. (loc. 4)
9. Poorly preserved axial section. UHR 19084. (loc. 4)

Fig. 10. *Pseudofusulina?* sp. A

Tangential section. UHR 19086. (loc. 4)

Figs. 11 & 12. *Codonofusiella explicata* KAWANO

11. Sagittal section. UHR 19082. (loc. 4)
12. Axial section. UHR 19081. (loc. 2)

Fig. 13. *Cancellina* sp.

Tangential section. UHR 19088. (loc. 2)

Figs. 14 & 15. *Parafusulina iwaizakiensis* (MORIKAWA)

14. Axial section. UHR 19087. (loc. 4)
15. Tangential section. UHR 19085. (loc. 4)

All specimens were collected from the Kanokura series, middle Permian, developed in Imo-Sawa, Yahagi-Cho, Rikuzentakada City, Iwate Prefecture.

Plate 12

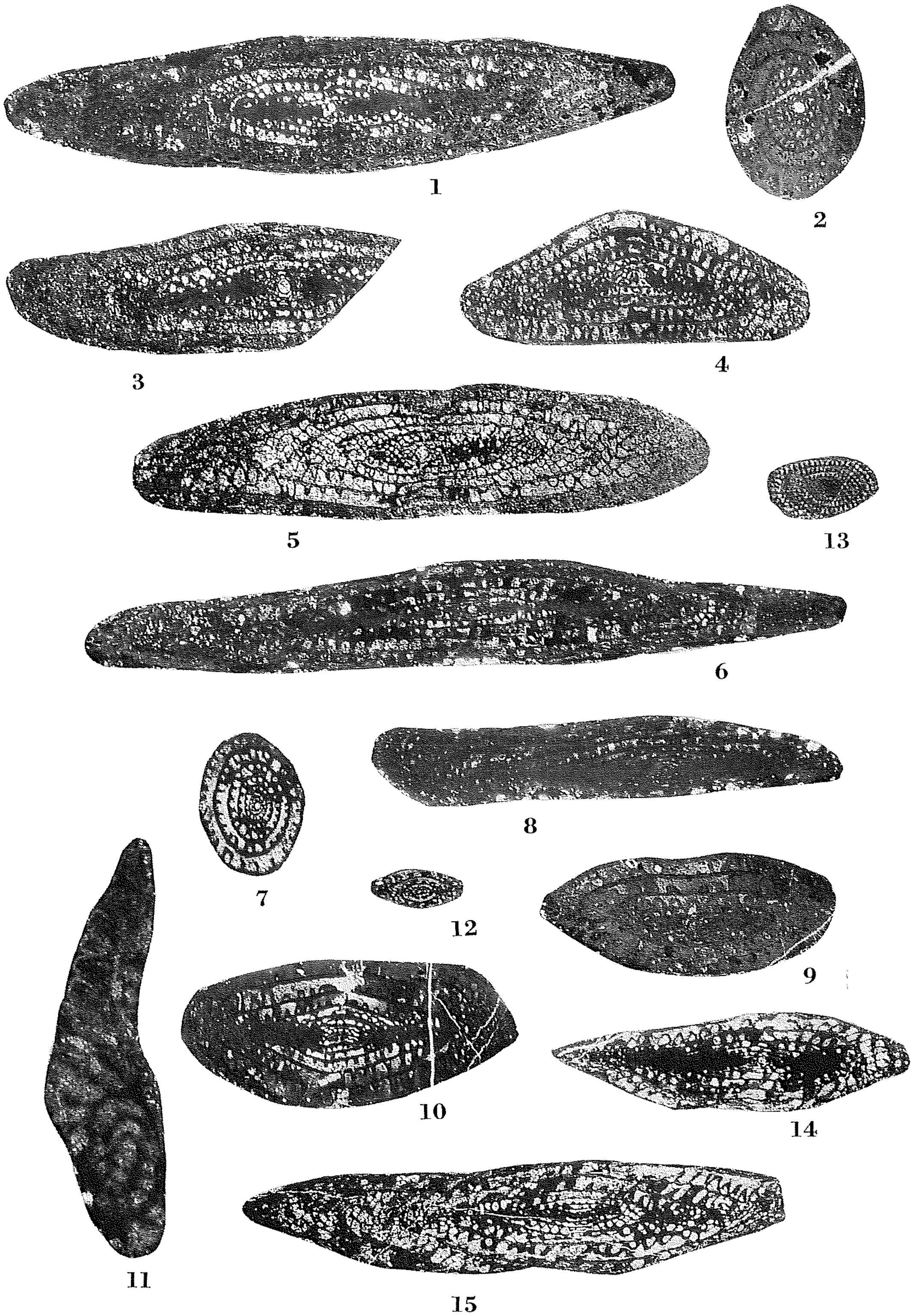

PLATE 13 AND EXPLANATION

Explanation of Plate 13

All figures except fig. 9 are × 10. Fig. 9 is × 20.

Figs. 1–6. *Parafusulina motoyoshiensis* (MORIKAWA)
1, 4 & 6. Axial sections. 1. UHR 19073. (loc. 2), 4. UHR 19069. (loc. 3), 6. UHR 19071. (loc. 2)
3. Tangential section. UHR 19068. (loc. 3)
2 & 5. Sagittal sections. 2. UHR 19070. (loc. 3), 5. UHR 19072. (loc. 3)

Fig. 7. *Chusenella* aff. *choshiensis* (CHISAKA)
Deep tangential section. UHR 19067. (loc. 2)

Fig. 8. *Yabeina (Lepidolina) multiseptata shiraiwensis* (OZAWA)
Sagittal section. UHR 19059. (loc. 10)

Fig. 9. *Pseudofusulina?* sp. B
Axial section. UHR 19066. (loc. 10)

All specimens were collected from the Kanokura series, middle Permian, developed in Imo-Sawa, Yahagi-Cho, Rikuzentakada City, Iwate Prefecture.

Plate 13

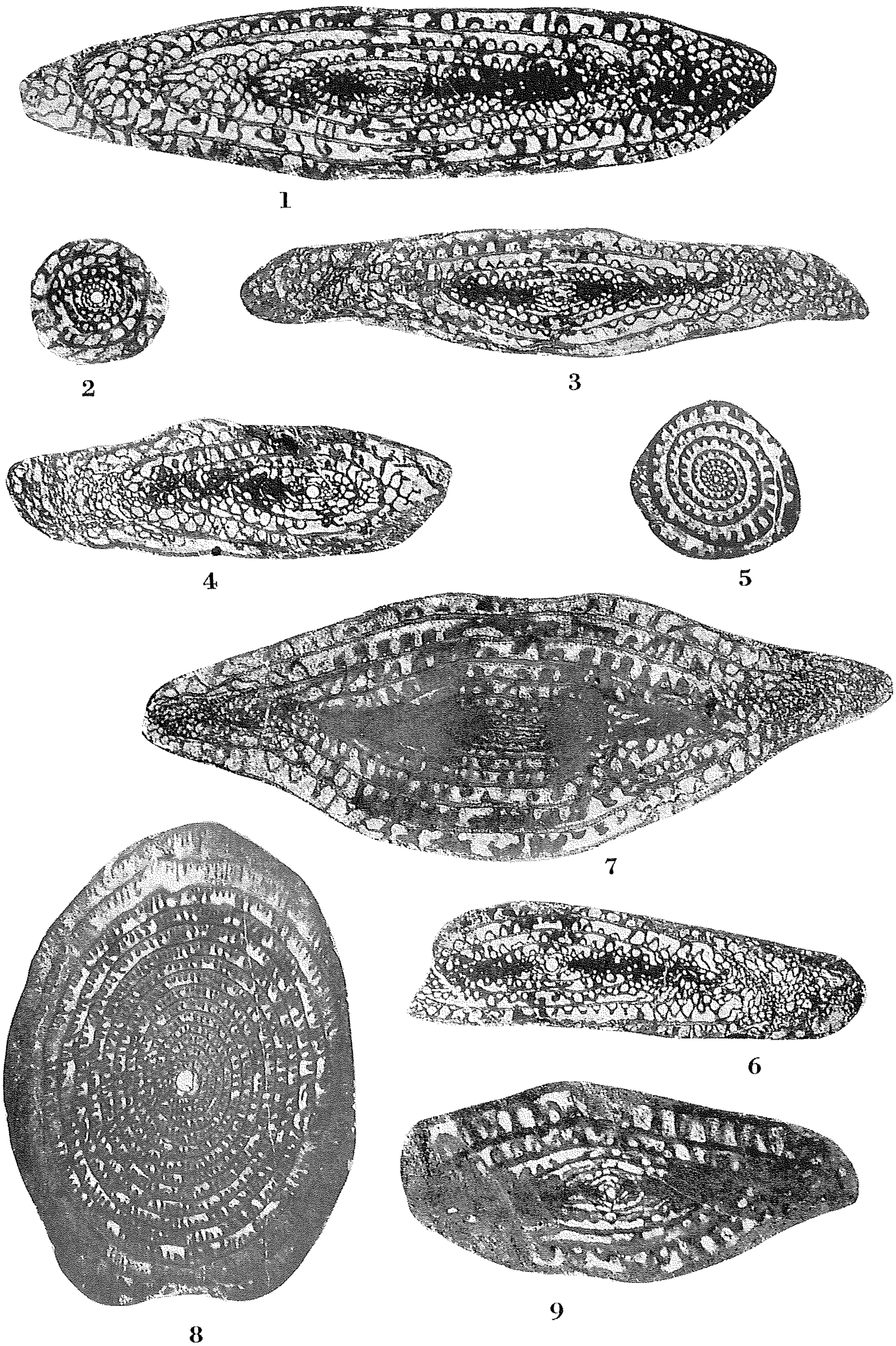

PLATE 14 AND EXPLANATION

Explanation of Plate 14

Pseudodoliolina elongata CHOI sp. nov.

Figures 1–5 are × 20. Fig. 6 is × 10.
Holotype is fig. 1. Others are paratypes.
Figs. 1 & 2. Axial sections. 1. UHR 19065, 2. UHR 19060.
Fig. 3. Slightly oblique section. UHR 19063.
Figs. 4 & 5. Sagittal sections. Fig. 5 is largely deformed. 4. UHR 19064, 5. UHR 19061.
Fig. 6. Deep tangential section. UHR 19062.
All specimens are from loc. 9.

All specimens were collected from the Kanokura Series, middle Permian, developed in Imo-Sawa, Yahagi-Cho, Rikuzentakada City, Iwate Prefecture.

Plate 14

PLATE 15 AND EXPLANATION

Explanation of Plate 15

All figures except for figs. 7 & 8 are × 10. Figs. 7 & 8 are × 20.

Figs. 1–3. *Verbeekina verbeeki* (GEINITZ)
1. Deep tangential section. UHR 19051.
2. Oblique section. Outer few volutions are missing. UHR 19052.
3. Parallel section. UHR 19053.

Figs. 4–6. *Yabeina (Lepidolina) multiseptata shiraiwensis* (OZAWA)
4 & 6. Two sagittal sections. 4. UHR 19054, 6. UHR 19056.
5. Axial section. UHR 19055.

Fig. 7. *Codonfusiella* sp.
Axial section. UHR 19057.

Fig. 8. *Codonofusiella explicata* (KAWANO)
Parallel section. UHR 19058.

All specimens are from loc. 4.

All specimens were collected from the Kanokura series, middle Permian, developed in Imo-Sawa, Yahagi-Cho, Rikuzentakada City, Iwate Prefecture.

Plate 15