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PERMIAN FUSULINIDS FROM THE SETAMAI-YAHAGI  
DISTRICT, SOUTHERN KITAKAMI MOUNTAINS,  
N.E. JAPAN

by

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(with 3 Tables, 12 Figures and 20 Plates)

(Contribution from the Department of Geology and Mineralogy,  
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## Abstract

The Permian System was studied in the Setamai-Yahagi district in the Southern Kitakami mountains. Amongst fossils collected fourtysix fusulinids described and illustrated in this monograph. Of them four species are new. Phylogenetic relations particularly in *Colania-Lepidolina* series, *Hemifusulina-Ferganites-Monodiexodina* series and in *Hemifusulina-Nagatoella-Nipponitella* series are discussed. Altogether six fusulinid zones and four subzones are distinguished in the studied area, and their correlation to the other fusulinid faunas in Japan and its adjacence is presented.

## I. INTRODUCTION

Permian formations are well developed in the Southern Kitakami Mountains, N. E. Japan. The Setamai-Yahagi district in these mountains has long been mapped by the staffs of the Department of Geology and Mineralogy, Faculty of Science, Hokkaido University, under the leadership of Prof. M. MINATO. The author has also devoted himself to carry on mapping in the relatively narrow strip of the Setamai-Yahagi district since 1966, and to study fossils, especially on fusulinid foraminifera.

As a result, the stratigraphy and fusulinid biostratigraphy of the whole Permian in this area became much clarified than before. Therefore, the descriptive data of Permian fusulinid fauna with short remarks on correlation and zonation are presented here. In a forthcoming paper, geology of the whole Permian of this area concerned will be presented.

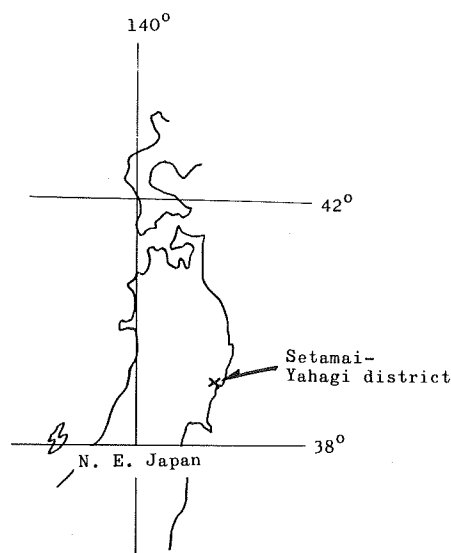


Fig. 1. Index map, showing the location of Setamai - Yahagi district.

Fossil localities are indicated by numbers in figures 2 and 3. Their stratigraphical levels are also shown in figures 4-9.

All specimens described in this article are preserved at the Department of Geology and Mineralogy, Faculty of Science, Hokkaido University.

The author here acknowledges Prof. Masao MINATO for his supervision and encouragement throughout the present study in field and in laboratory. He also critically read the paper in manuscript and gave valuable suggestions. The author is greatly indebted to Prof. Makoto KATO for continuous assistance for this work and making criticism in many points. His hearty thanks are also extended to the staffs of our Department, who rendered him every possible assistance, and Prof. K. KANMERA, and Dr. T. OZAWA of Kyushu University, who kindly provided the author some copies of Russian literatures. Some of the specimens described and illustrated in this paper were collected by Messrs. Hiroshi SUTOMI, Matajiro KATO, Masaru TAKAIWA, Yoichi AMANO (HIRATA), and Fumio SUDO to whom his cordial thanks are offered.

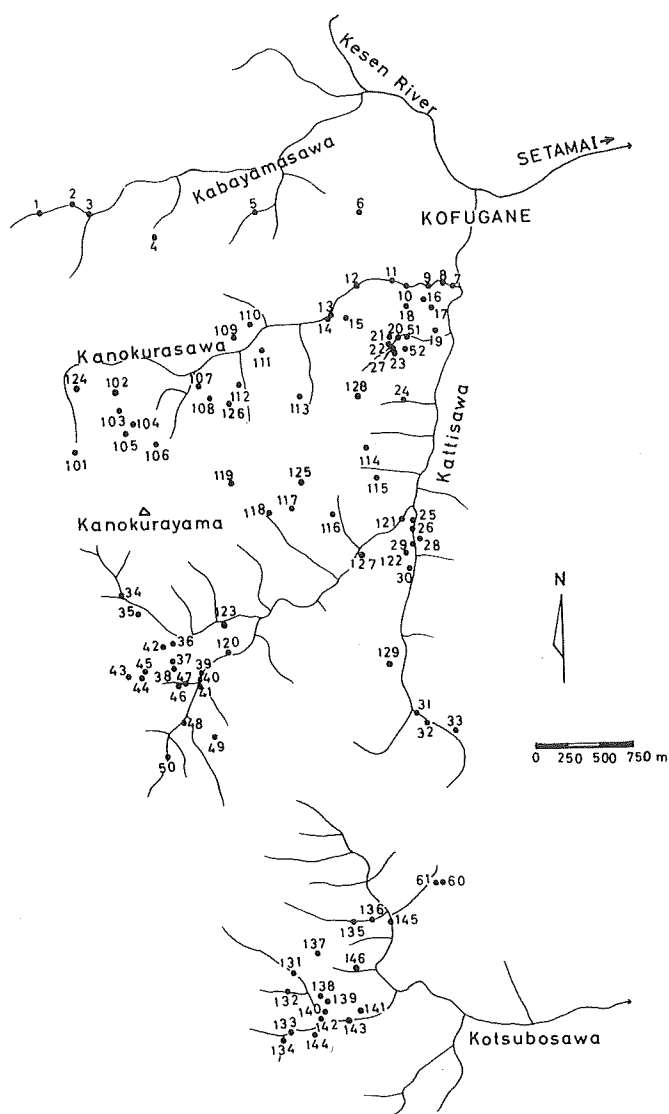


Fig. 2. A map showing fossil localities in the Kanokurasawa and Kotsubosawa area. Numerals indicate fossil localities.

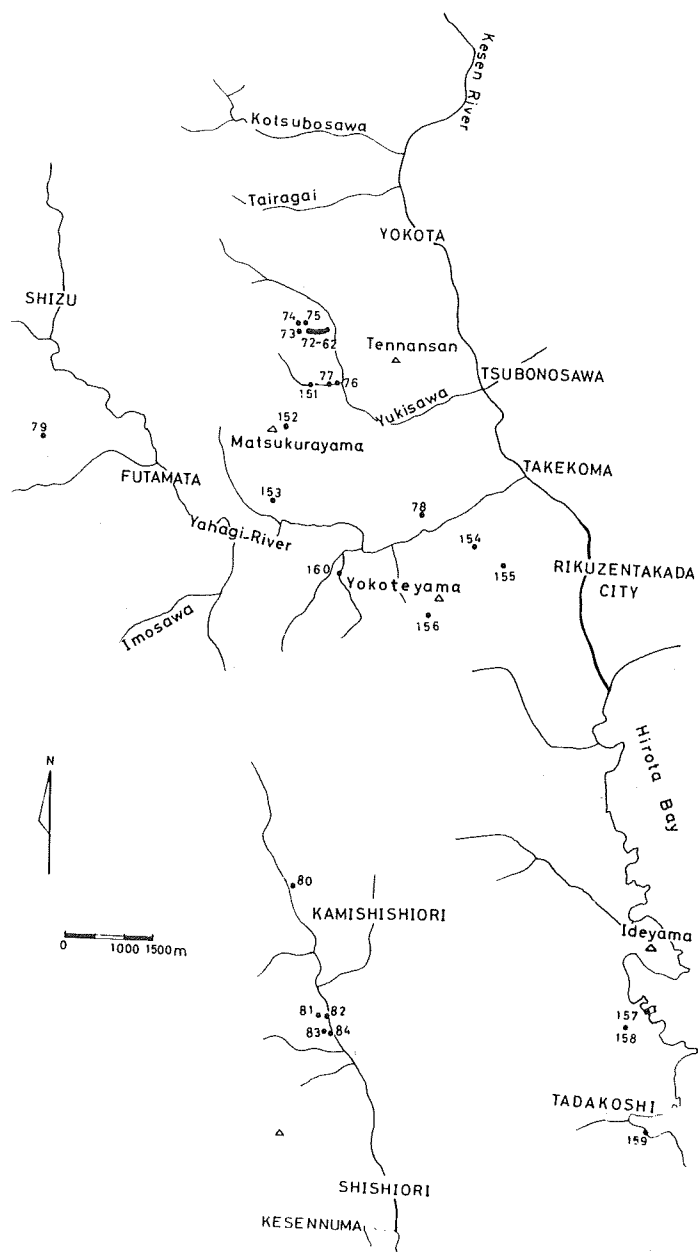


Fig. 3. A map showing fossil localities in the Yahagi and Karakuwa areas.

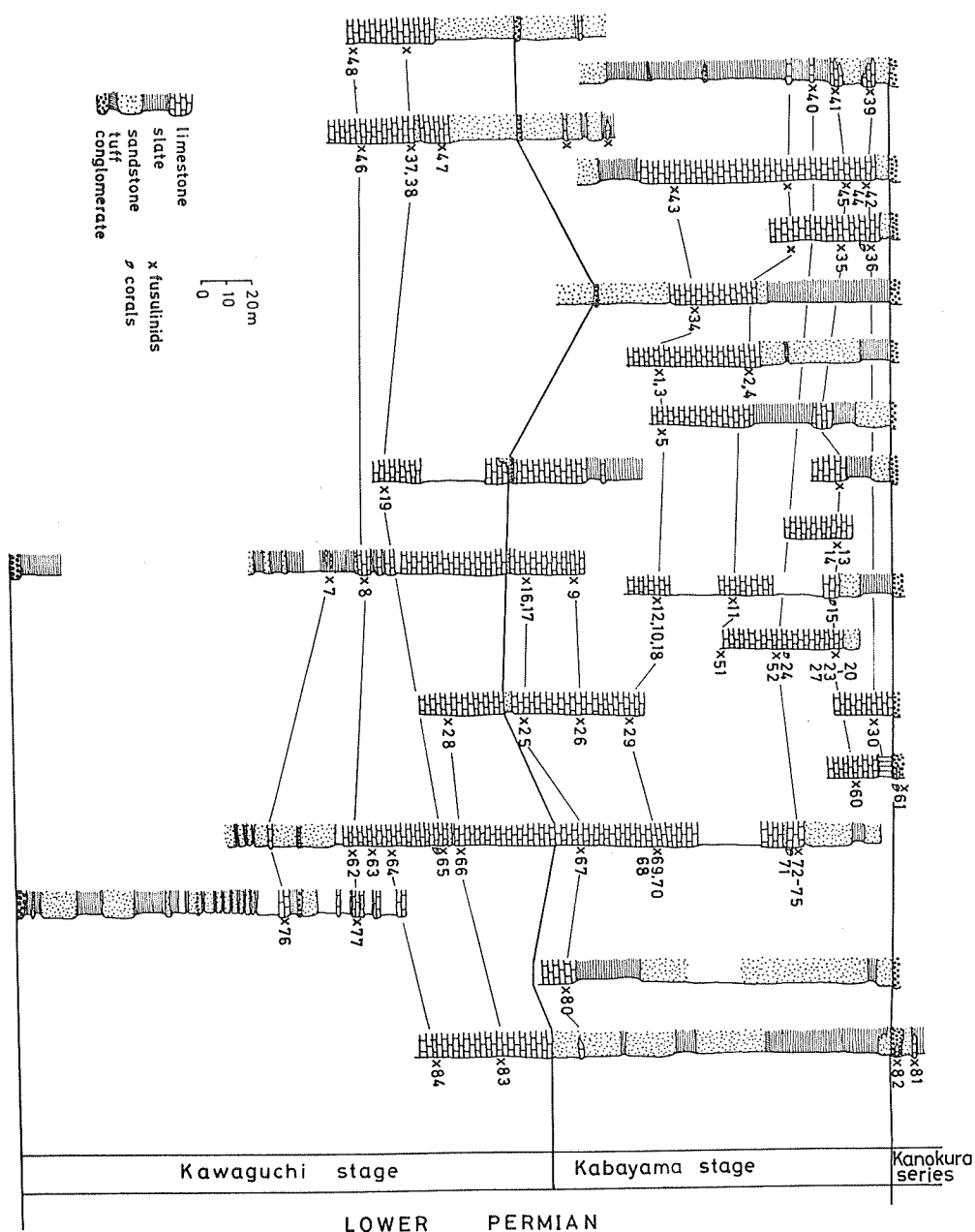


Fig. 4. Columnar sections of the lower Permian showing the stratigraphical levels of each fossil locality. See text:figs. 2-3.

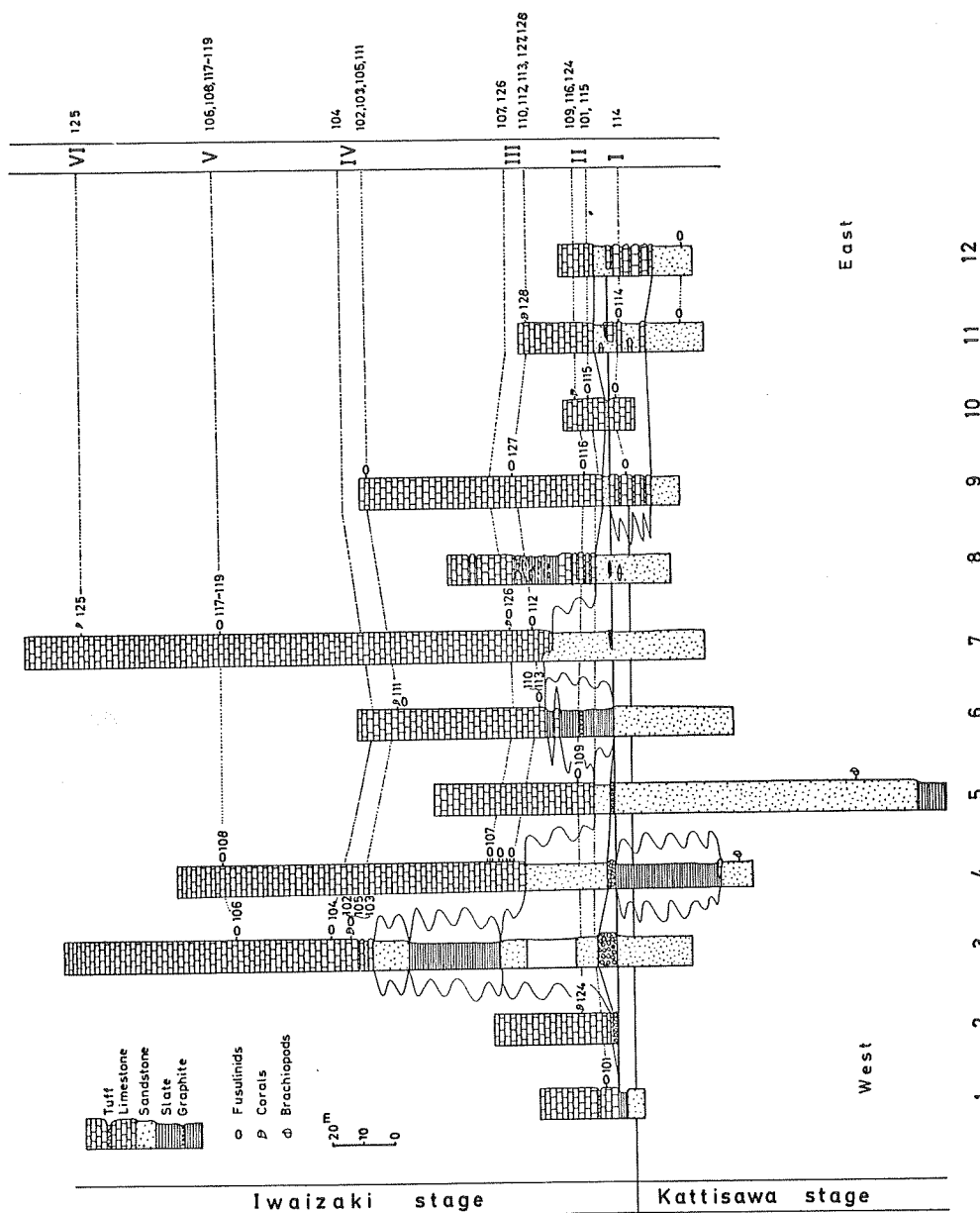


Fig. 5. Columnar sections of the middle and the upper Permian and the horizons of fossil localities in the Kanokurayama area. See also text-fig. 2. 1 & 2; Sumikasawa. 3; Kosumika and Sentsubo. 4; Eastern slope of Sentsubo. 5 & 6; The middle course of the Kanokurasawa and Ohbune. 7 Tairappara and Ohbune, east of the Kanokurayama. 8; Near the mouth of Onida, a tributary of the Kanokurasawa. 9; Tonokibora. 10; West of Toyokoro, a small tributary of the Kattisawa. 11 & 12; Ozokayo and Budosawa, tributaries of the Kattisawa.

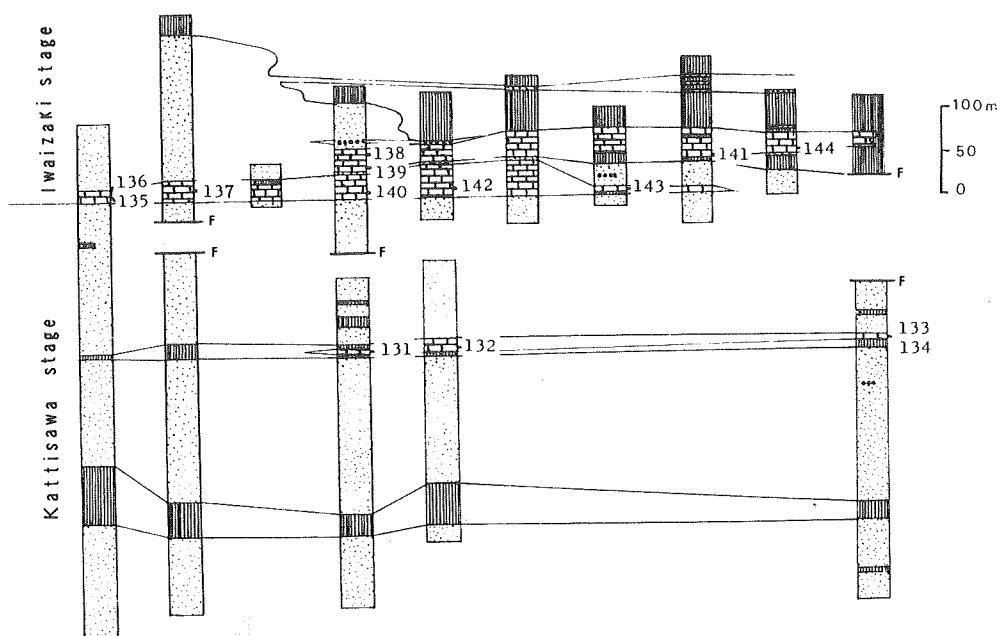


Fig. 6. Columnar sections of the middle and the upper Permian, and horizons of fossil localities in Kotsubosawa. See text-fig. 2.

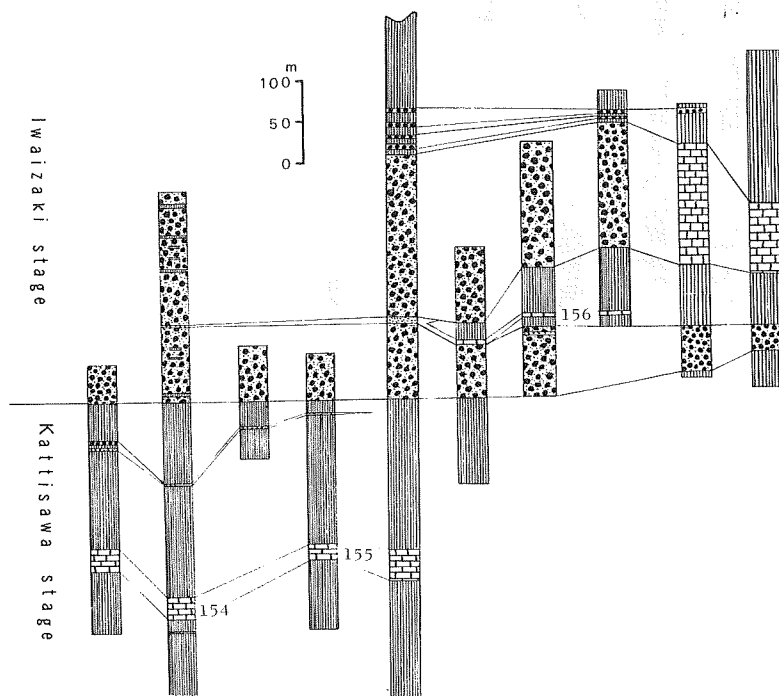


Fig. 7. Columnar sections of the middle and the upper Permian and horizons of fossil localities in Yokoteyama, Yahagi area. See text-fig. 3.



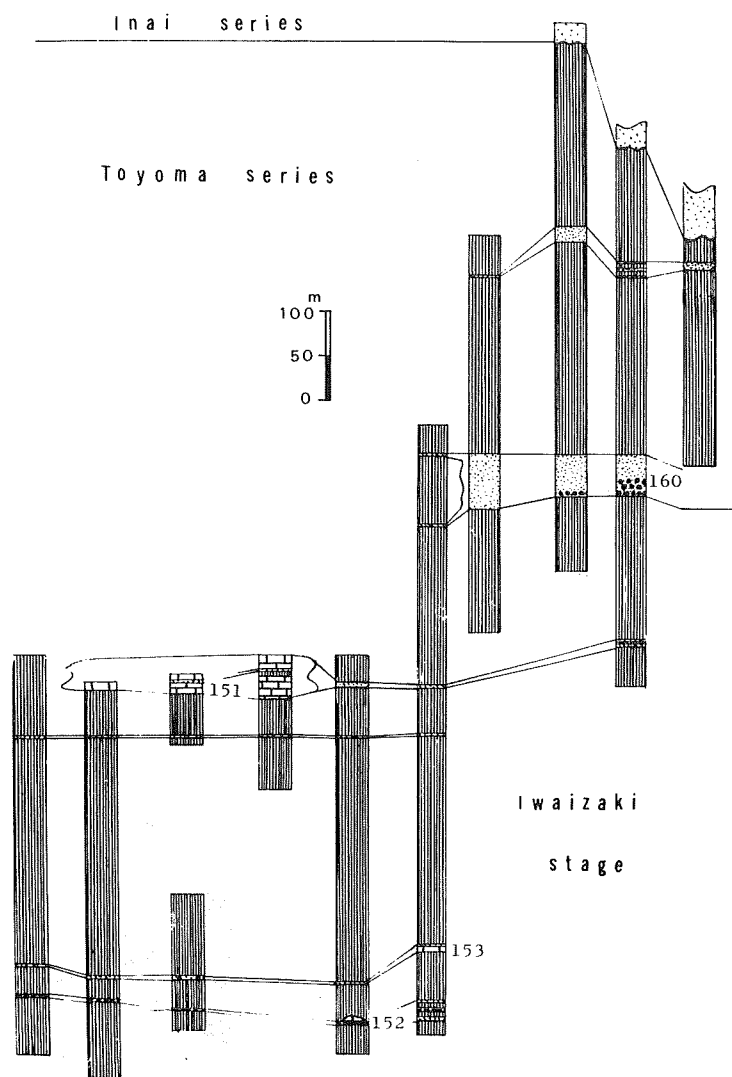


Fig. 8. Columnar sections of the upper Permian and horizons of fossil localities in Yahagi district. See text-fig. 3.

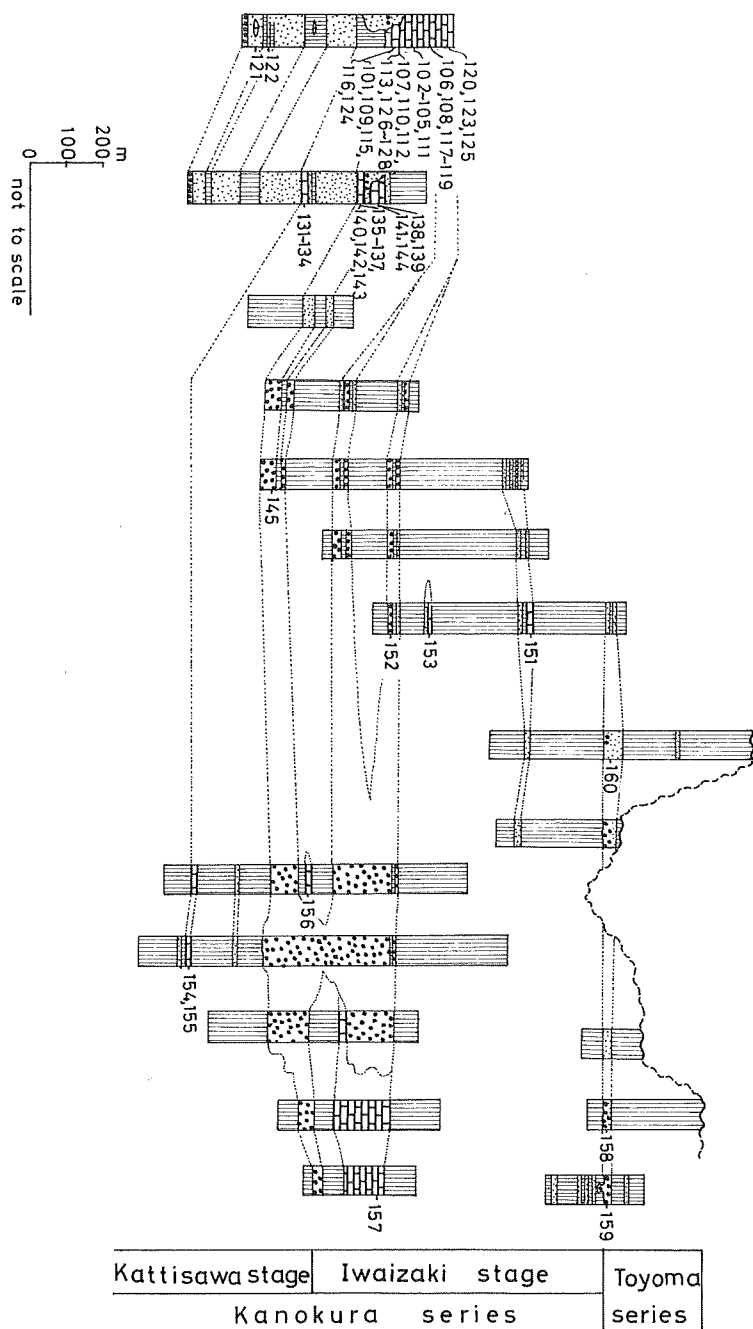


Fig. 9. Columnar sections of the middle and upper Permian in the Setamai-Yahagi district, showing stratigraphical levels of fossil localities.

## II. DESCRIPTION OF SPECIES

Family Schubertellidae SKINNER, 1931

Subfamily Boultoninae SKINNER & WILDE, 1954

Genus *Codonofusiella* DUNBAR and SKINNER 1937

*Type species: Codonofusiella paradoxa* DUNBAR & SKINNER, 1937.

*Generic diagnosis:* Shell is minute, fusiform in the inner volutions. Last volution is flared and uncoiled. Mature shell possesses 4 to 5½ 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 with occasional fine keriotheca (CHOI, 1970a). Septa are highly fluted throughout the shell. Chomata are rudimentarily developed.

*Codonofusiella explicata* KAWANO

Pl. 16, fig. 12

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

1970 *Codonofusiella explicata*, CHOI, p. 336, pl. 10, figs. 6-8.

*Material:* UHR 19330-8, UHR 19333-7 and others.

*Locality:* 151, Yukisawa.

*Remarks:* Some ill-preserved specimens are at hand amongst numerous thin sections prepared. It possesses very small shell with awfully long flared last volution. Although specimens at hand are ill-preserved and ill-oriented, all available informations show close similarity to *Codonofusiella explicata*, first described by KAWANO from the upper Permian Aratani conglomerate in Yamaguchi Prefecture, Japan, and lately by the present author from Imo (CHOI, 1970b), Southern Kitakami Mountains. This form composes one of the uppermost fusulinid elements of the highest fusulinid zone of the area concerned. Since it occurred from near the base of the kattisawa stage in Imo, its specific range extends throughout the Kanokura series, upper Permian in the Kitakami Mountains.

Genus *Minojapanella* FUJIMOTO and KANUMA, 1953

*Type-species: Minojapanella elongata* FUJIMOTO and KANUMA, 1953

*Minojapanella elongata* FUJIMOTO and KANUMA

Pl. 1, figs. 8-11

1953 *Minojapanella elongata* FUJIMOTO and KANUMA, p. 152, pl. 19, figs. 1-11.

1961 *Minojapanella elongata*, MORIKAWA and ISOMI, p. 7, pl. 2, figs. 10-15.

1965 *Minojapanella elongata*, KANMERA, and MIKAMI, pp. 280-281, pl. 45, fig. 10; pl. 48, fig. 16.

*Material:* A number of specimens have been obtained from locs. 79, 83 and 84. They are registered as UHR 19217-1 ~ 19 and UHR 19431.

*Remarks:* This form quite agrees with *Minojapanella elongata* in shell shape and size, expansion of the shell, nature of septal fluting, thickness of the spirotheca. KANMERA and MIKAMI's form from Sakamotosawa possesses four volutions, but the present form has five volutions and provides larger shell than the former.

Subfamily Schubertellinae SKINNER, 1931

Genus *Schubertella* SKINNER, 1931

*Schubertella irumensis* (HUZIMOTO), 1936

Pl. 2, figs. 3-7

1936 *Fusulinella irumensis* HUZIMOTO, pp. 38-40, pl. 2, figs. 1-8, 27?.

*Material:* UHR 19590-10, 14, 32 & 36, UHR 19592-1b & 1c, and others.

*Description:* Shell is minute, inflated to elongate fusiform with bluntly rounded poles. The shell possesses  $4\frac{1}{2}$  to 5 volutions, and it is 0.8 to 0.98 mm long and 0.4 to 0.6 mm wide giving form ratio of 1.6 to 2.0. The shell expands relatively rapidly. The height of volution of the shell is 20 to 40 microns in inner two volutions, and 100 to 110 microns in the outermost volutions. The endothyroidal immature shell is coiled at a large angle to the later volutions.

Proloculus is very small, 30 to 40 microns in the outside diameter.

Spirotheca is very thin, composed of tectum and lower dense layer. It does not exceed 15 microns even in the outermost volution.

Septa are not fluted. The number of the septa is counted 14 to 16 in the outer volutions.

Low and small chomata present throughout the shell.

Tunnell is low and broad.

*Remarks:* This form is identical with *Fusulinella irumensis* HUZIMOTO, (=FUJIMOTO) from the Kwanto-mountainland in shell form, expansion of the shell, nature of coiling of the shell, mode of development of chomata, size of proloculus, number of the septa, although the former appears to possess thinner spirotheca than the latter. According to HUZIMOTO, the latter is associated with *Pseudofusulina japonica*, *Pseudofusulina ambigua*, *Pseudofusulina krafftii*, *Misellina caludiae*, *Neoschwagerina craticulifera*, *Pseudofusulina vulgaris* var. *globosa*, *Pseudofusulina* cf. *ambigua*, and *Pseudofusulina* cf. *krafftii*.

Genus *Yangchienia* LEE, 1934

*Yangchienia kwangsiensis* CHEN 1956

Pl. 2, fig. 14

1956 *Yangchienia kwangsiensis* CHEN, p. 20, pl. 1, figs. 8-11.

1963 *Yangchienia kwangsiensis*, SHENG, p. 161, pl. 4, figs. 28-29.

*Lectotype*: As CHEN (1956) and SHENG, (1963) have not designated the holotype or lectotype of the present species, the author here chooses the lectotype as fig. 10, on pl. 1, by CHEN (1956).

*Material*: UHR 19435-6.

*Locality*: 81

*Description*: Only one diagonally cut section is available for study. The following description is therefore entirely based on it.

Shell is small, inflated fusiform with concave lateral portions and broadly pointed poles. The shell possesses 6 volutions, probably attains 1.9 mm or more (twice a half length), and 1.1 mm in width with form ratio of 1.7. The shell is coiled regularly and compactly throughout growth. Inner two volutions which are endothyroidal in shape are coiled largely askew to the later volutions. Height of volutions from the first to the fifth volution is 40, 55, 70, 90 and 110 microns, respectively.

Proloculus is small, and measures approximately 60 microns in outside diameter.

Spirotheca consists of thin dark layer which is coated with dense material continuous with chomata, and lower homogeneous thicker layer. Thickness of the spirotheca is 5 microns in the first, 7.5 microns in the second, 11 microns in the third, 12 microns in the fourth, 14 microns in the fifth volution.

Septa are unfluted throughout the shell. Number of the septa is not counted because of absence of sagittal sections at hand.

Broad and massive chomata present in all growth stages. They are gently sloped towards pole regions, but sharply inclined towards tunnel portion in cross section.

*Remarks*: The present form is characterized by the inflated fusiform shell with depressed lateral portions and massive chomata, which play a good role of criterion in distinguishing this species from the others.

*Yangchienia kwangsiensis* described by CHEN in 1956 from the Maokou limestone, developed in Kwangsi province, completely identical with the present Kitakami form in highly vaulted shell in mid-portion with concave lateral slopes and comparatively thin spirotheca. In this connection, *Yangchienia antique* which is most closely related to the present form, and *Yangchienia compressa*, *Yangchienia tobleri* and *Yangchienia haydeni* are readily distinguishable from *Yangchienia kwangsiensis* by less vaulted larger shell with more numerous volutions than the latter.

*Occurrence*: This species was found in conglomeratic limestone just above the basal conglomerate of the Kanokura series, in Shishiori, Kesenuma

district. Collected by Fumio SUDO in 1970. None of the fusulinid species is associated with this form.

Family Ozawainellidae THOMPSON and FOSTER, 1937

Subfamily Staffellinae M.-MACLAY, 1949

Genus *Eoverbeekina* LEE, 1933

*Eoverbeekina* sp.

Pl. 2, figs. 12, 13

*Material*: UHR 19307-2, 4, 6 & 7.

*Remarks*: Small and highly mineralized form was obtained in association with *Pseudofusulina fusiformis*. From its highly mineralized discoidal shell with broadly rounded periphery and umbilicate pole regions, the present form is assignable to genus *Eoverbeekina*.

So far as the shell form and size is concerned, the present form resembles *Eoverbeekina intermedia* LEE, the type species of genus *Eoverbeekina*, from Chihsia limestone. However, as the detailed natures of the shell and the development of the parachomata are unknown owing to ill-preservation of the specimens at hand, more precise comparison with it is almost difficult to make.

Stratigraphically this species occurs from *Pseudofusulina fusiformis* zone, the uppermost Sakamotosawa series in the Southern Kitakami Mountains. It was also found in this sections of fusulinid fossils deposited in our university yielded in Maiya, Southern Kitakami Mountains.

Genus *Nankinella* LEE, 1933

*Type species*: *Staffella discoides* LEE, 1931

*Generic diagnosis*: Shell is medium to small in size, discoidal and planispiral throughout the growth with short axis of coiling and umbilical pole regions. Spirotheca is highly replaced by secondary mineralization, and its structure is usually difficult to determine. But in well preserved specimens it seems to be composed of tectum and lower less dense layer. Septa are numerous and unfluted. Low chomata present.

*Nankinella* sp. A

Pl. 18, fig. 6?; pl. 20, fig. 3

*Material*: Axial section; UHR 19330-7, tangential sections; UHR 19330-4 & UHR 19323-2(?), and parallel section; UHR 19330-6 & UHR 19330-8.

*Localities*: 151 and 140

*Description*: Several highly recrystallized specimens have been obtained. Shell is lenticular, and angular in median portion. The shell possesses nine or more volutions in mature specimens. An illustrated specimen (pl. 20, fig. 3)

having eight and a half volutions is 2.15 mm long and 2.96 mm wide.

Coiling of the shell is uniform and convolute throughout the growth of the shell except for the first and the second volution which are in contrast slightly umbilical in axial regions. Radius vector of the first to the eighth volution of the illustrated specimen is 0.12, 0.20, 0.28, 0.41, 0.61, 0.85, 1.08 and 1.33 mm, respectively. Form ratio of half length to radius vector from the first to the eighth volution is 0.5, 0.53, 0.59, 0.61, 0.60, 0.56, 0.57, and 0.60, respectively in the same specimen.

Proloculus is small and spheroidal. It is difficult to measure the true diameter of the proloculus owing to the absence of ideally cut axial sections. However, it measures about 0.08 mm in the above illustrated specimen.

Spirotheca is thoroughly replaced by heavy secondary mineralization. As the consequence, it is difficult to observe its structure with certainty. But it seems to be composed of tectum and rather thick diaphanotheca-like homogeneous layer. Thickness of the spirotheca seems nearly uniform throughout volutions, measuring 7.5 to 10 microns.

Septa are straight. Twentyeight to 30 septa are counted in outer few volutions.

Characters of chomata are not visible because of high replacement of the specimens at hand.

*Remarks:* The present form seems to be closely allied to *Nankinella* sp. A, described by NOGAMI (1958) from Maizuru zone, Southwest Japan, in many points. The latter is associated with *Lepidolina kumaensis*, and *Yabeina columbiana*. It is unfortunate however that both Kitakami and Maizuru forms are too poorly preserved to make detailed comparison.

Concerning only to the shell shape, *Nankinella compacta* SHENG is similar to the present Kitakami form. The former has more volutions and more tightly coiled outer volutions than the latter.

*Nankinella hunanensis* (CHEN) from South China associated with *Sumatrina annae* and *Neoschwagerina craticulifera*, is also distinguishable from the latter in having slightly smaller shell, smaller form ratio and smaller expansion of the shell. Nevertheless, close similarity is certainly present between Chinese and Kitakami form.

*Association:* This form is associated with *Codonofusiella explicata*, *Kahlerina* sp., *Lepidolina multiseptata*, and *Schwagerina acris*.

Genus *Kahlerina* KOCHANSKY-DEVIDÉ & RAMOVŠ 1955

*Type species:* *Kahlerina pachytheca* KOCHANSKY-DEVIDÉ & RAMOVŠ 1955.

*Generic diagnosis:* Shell is small, spheroidal with umbilical pole regions. Inner few volutions are endothyroidal, while later spheroidal. Spirotheca is

composed of tectum and lower thicker layer with occasional fine alveoli. Septa are plane. Chomata are rudimentarily present.

*Geological distribution:* Middle to upper Permian.

*Geographical distribution:* Tethys Sea region (Tunisia, Turkey, Yugoslavia, China, Japan), and Russia (Shihote-Aline).

***Kahlerina pachythea* KOCHANSKY-DEVIDÉ & RAMOVŠ**

Pl. 16, figs. 4 & 5; pl. 20, fig. 6

1955 *Kahlerina pachythea* KOCHANSKY-DEVIDÉ & RAMOVŠ, pp. 414-415, pl. 2, figs. 7-11; pl. 3, figs. 1-6, 9-13; pl. 8, figs. 2-5.

1958 *Kahlerina pachythea*, KOCHANSKY-DEVIDÉ & RAMOVŠ, p. 63, pl. 4, figs. 6-8.

1963 *Kahlerina pachythea*, HANZAWA & MURATA, pp. 20-21, pl. 7, figs. 5 & 6.

*Holotype:* pl. 3, fig. 2 by KOCHANSKY-DEVIDÉ & RAMOVŠ in 1955.

*Localities:* A number of specimens have been obtained from localities 101-103, 108, 110, 111, 120, 133, 135, 141, and others.

*Description:* Shell is small, subspherical and umbilicated in pole regions. Length, 1.32 to 1.72 mm and width, 2.22 to 2.36 mm, giving form ratio of 0.56 to 0.77. The mature shell possesses as much as 4½ volutions, in which the shell of the outer volution is however partly missing.

Inner two or three volutions are endothyroidal in shape while the outer spheroidal. In general, the shell of the first volution has different axis of coiling to that of the later stage. The shell expands rapidly but uniformly. Height of volution from the first to the fourth volution in average is 105, 178, 247 and 380 microns, respectively.

Proloculus is spherical and very large for the size of the shell, the outside diameter of which measures about 170 microns.

Spirotheca is composed of thin dense layer in inner two or three volutions, and in outer volutions it is abruptly thickened and becomes to be composed of tectum and much thicker homogeneous layer. Average thickness of the spirotheca is about 20 microns in the third, and 63 microns in the fourth volution.

Septa are almost straight. Number of the septa is 6 to 9 in the outer volutions.

Chomata are very rudimentarily present in earlier volutions.

*Remarks:* The specimens now at the author's disposal are all very characteristic in having rather large and rapidly expanding shell with small form ratio.

In all probability they are very much resembled *Kahlerina pachythea* described by KOCHANSKY-DEVIDÉ & RAMOVŠ (1955) from Bledu, Yugoslavia.



The latter possesses a little smaller and less expanded shell than the present.

The present form is quite identical in many points with the specimens described by HANZAWA & MURATA, (1963) from Towacho (town), Miyagi prefecture, Southern Kitakami Mountains.

Compared to *Kahlerina siciliana* SKINNER & WILDE (1966), the present form contains much smaller shell with smaller form ratio, but possesses rather larger proloculus and thin spirotheca. The specific distinction between the two is therefore obvious.

*Occurrence:* *Kahlerina pachythea* with sphaerical shell is frequently associated with fusulinids possessing elongate fusiform to cylindrical shell, such as *Lepidolina minatoi*, *Lepidolina kumaensis* and *Pseudodoliolina*. The limestones containing *Kahlerina pachythea* possess micritic to microsparitic matrix and the abrasion of the shell is relatively weak. These facts reveal that *Kahlerina pachythea* as well as *Lepidolina kumaensis*, *Lepidolina minatoi* or *Pseudodoliolina* may have adapted to relatively gentle marine conditions.

Subfamily Ozawainellinae THOMPSON & FOSTER, 1937

Genus *Toriyamaia* KANMERA 1956

*Type-species:* *Toriyamaia laxiseptata* KANMERA 1956.

*Toriyamaia laxiseptata* KANMERA, 1956

Pl. 2, figs. 8-11

1956 *Rauserella?* sp. KAWANO, p. 227, pl. 32, figs. 10-12.

1956 *Toriyamaia laxiseptata* KANMERA, pp. 252-255, pl. 36, figs. 1-14.

1961 *Rauserella* sp. KAWANO, p. 58, pl. 1, fig. 1.

1963 *Toriyamaia laxiseptata*, KANMERA, pp. 87-88, pl. 11, figs. 1-4; pl. 19, figs. 8 & 9.

1963 *Toriyamaia laxiseptata*, SHENG, p. 157, pl. 4, figs. 36 & 37.

1965 *Toriyamaia laxiseptata*, KANMERA and MIKAMI, pp. 277, 279, pl. 46, figs. 9 & 10.

*Material:* UHR 19592-2b, 7b, UHR 19668, UHR 19699 etc.

*Remarks:* The lower limit of stratigraphical range of this species extends down to the Kawaguchi stage, lower Sakamotosawa series, where it is associated with *Triticites* sp. A, *Triticites* sp. B, *Ferganites langsonensis*, *Pseudofusulina pseudoanderssoni*, *Pseudofusulina* aff. *japonica*, *Pseudofusulina* sp. A, and *Misellina otakiensis*. Localities and associated species are shown in table 3.

Family Schwagerinidae DUNBAR and HENBEST, 1930

Subfamily Schwagerininae DUNBAR and HENBEST, 1930

Genus *Triticites* GIRTY, 1904

*Triticites* sp. A

Pl. 4, figs. 12 &amp; 13

*Material:* 19592-10a & 10b and others.

*Remarks:* Two tangential sections with other ill-oriented specimens are at hand. The present form is characterized by fusiform shell with pointed poles, well developed chomata and tightly coiled inner volutions. As no well oriented specimens have been obtained more references cannot be made.

*Triticites* sp. B

Pl. 4, figs. 9-11

*Material:* UHR 19592-6c, 7a & 7c, and some other ill-oriented specimens.

*Remarks:* This form is characteristic in possession of subcylindrical shell with rounded poles, tightly coiled inner volutions, massive chomata, moderately fluted septa and weakly alveolar wall. It somewhat resembles *Ferganites langsonensis* (SAURIN) in subcylindrical shell, but the former is readily distinguishable from the latter in more tightly coiled inner volutions and more massive chomata than the latter.

*Triticites* sp. A in this article possesses more sharply pointed poles than the present form.

So far as investigated, no previous forms seem to be referable to the present form. But material is poor in number and more or less deformed, so more detailed discussion is impossible to be made at present.

The present form constitutes one of the fusulinid elements of the lower Sakamotosawa series. It is associated with *Triticites* sp. A, *Ferganites langsonensis* (SAURIN), *Misellina otakiensis* (FUJIMOTO), *Pseudofusulina* sp. A, *Pseudofusulina pseudoanderssoni*, *Pseudofusulina* aff. *japonica*, and *Toriyamaia laxiseptata*.

Genus *Ferganites* M. -MACLAY, 19591959 *Ferganites* M. -MACLAY, pp. 12-13, 16.1960 *Eoparafusulina* COOGAN, p. 262.1963 *Ferganites*, M. -MACLAY, pp. 202, 236.1965 *Eoparafusulina*, SKINNER and WILDE, pp. 73-76.1966 *Alaskanella* SKINNER and WILDE, p. 57.1967 *Eoparafusulina* (*Eoparafusulina*), ROSS, pp. 944-945.non 1967 *Eoparafusulina* (*Mcclaudia*) ROSS, pp. 945-946.*Type species:* *Triticites ferganensis* M. -MACLAY, 1950.

*Diagnosis:* Shell is moderate to large, elongate cylindrical with rounded poles. The shell of *Triticites*-like infant stage possesses tightly coiled fusiform shell with small proloculus, chomata and pointed poles. While the mature shell

contains relatively loosely coiled, thick to slender cylindrical shell with rounded poles and free from chomata. Spirotheca is moderate in thickness, composed of tectum and keriotheca. Septal fluting is gentle to intense, regularly spaced, being confined within lower margins of septa, forming semicircular in shape in cross section. Cuniculi are absent. Axial fillings are commonly present.

*Discussion:* Genus *Ferganites* was first established by M. MACLAY, *Triticites ferganensis* from Fergana as the type species in 1959. *Triticites ferganensis* is characteristic in possession of cigar-shaped cylindrical shell with tightly coiled inner volutions with chomata and small proloculus, more loosely coiled outer volutions, and low and regularly fluted septa.

In the next year (1960), COOGAN proposed a new subgenus *Eoparafusulina* of the genus *Parafusulina*. He selected *Fusulina gracilis* MEEK, redescribed by THOMPSON and WHEELER (1946), as type species of that subgenus.

SKINNER and WILDE discussed in detail the subgenus *Eoparafusulina*, reexamining the topotype collection of *Fusulina gracilis* MEEK, and they raised it to generic rank. Thus the generic contension of *Eoparafusulina* was emended by them.

SKINNER and WILDE, in the following year (1966), established another new genus *Alaskanella* which differs from *Eoparafusulina* in absence of cuniculi in the former, according to them. With regard to *Eoparafusulina* and *Alaskanella*, there is a detailed discussion by ROSS (1967) who suppressed the latter into the former, and newly discriminated two subgenera in the former; *Eoparafusulina*, represented by *Fusulina gracilis*, the type of *Eoparafusulina*, and the other *Mcclaudia* newly proposed by him, which is characteristic mainly in thick cylindrical shell with relatively thick spirotheca. He chose *Eoparafusulina contracta* SKINNER and WILDE as type of subgenus *Mcclaudia*. At the same time ROSS considered the phylogenetical stock of *Eoparafusulina* (*Eoparafusulina*)-*Monodiexodina*.

ROSS' opinion appears to be essentially reasonable to the author. However, some of the species of subgenus *Mcclaudia*, *Mcclaudia certa* (SKINNER and WILDE) or *Mcclaudia proba*, for instance, possess quite similar characteristics to genus *Nagatoella* THOMPSON especially such species as *Nagatoella minatoi* KANMERA and MIKAMI, or *Nagatoella ikenoensis* in essential skeletal natures, although *Mcclaudia contracta*, the type of subgenus *Mcclaudia*, has smaller shell with less numerous volutions and lacks axial fillings compared to *Nagatoella orientis*, the type species of genus *Nagatoella*. But the generic variation of genus *Nagatoella* is well demonstrated in comparing *Nagatoella orientis*, *N. kobayashii*, *N. fusimotoi*, *N. minatoi*, *N. ikenoensis*, as to their shell form and size, development of chomata, degree of septal fluting, thickness of

the spirotheca, mode of development of axial fillings.

In this respect, essential characteristics of subgenus *Mcclaudia* do not conflict with those of *Nagatoella*, and therefore the former is better considered to be congeneric with the latter. Since the latter has priority, the former is considered as junior subjective synonym of the latter. Stratigraphical evidences and ontogenetical changes suggest that *Mcclaudia* may be one of primitive forms of *Nagatoella*.

On the other hand, *Ferganites ferganensis* is closely akin to *Eoparafusulina thompsoni* or *Eoparafusulina gracilis*, the type species of *Eoparafusulina*, although the former contains less tightly coiled inner shell and almost unfluted septa. The author, however, thinks that these differences are within specific variation in *Ferganites*, and generically both are difficult to be separated. Therefore, *Eoparafusulina* is considered to be synonymous with *Ferganites*. As the latter possesses priority of 11 years than the former, the latter is valid. This opinion was once briefly mentioned by KANMERA (1963).

Genus *Kansanella*, represented by *Kansanella joensis* THOMPSON, is similar to *Ferganites* in elongate subcylindrical shell. These two genera seem to have commonly budded from *Hemifusulina* in the uppermost Moscovian. *Kansanella*, however, provides more irregular septal fluting than *Ferganites*. *Kansanella* is considered to be one of the ancestors of *Parafusulina* stock.

Genus *Hemifusulina* may also be ancestral to *Ferganites* and *Nagatoella* from its general shell characteristics, nature of septal fluting, structure of wall, geographical distribution and stratigraphical occurrence. One of the evolved forms of *Hemifusulina* such as *Hemifusulina moelleri* RAUSER-CHERNOUSOVA may have given rise to *Ferganites* and on the other hand one of the thick cylindrical forms such as *Hemifusulina bocki* MOELLER to *Nagatoella* in the uppermost Moscovian.

The distinction between *Hemifusulina* and *Nagatoella* or *Ferganites* is mainly based on the difference in the wall structure. The former possesses tectum and diaphanotheca sometimes with protheca, but the latter two have tectum and keriotheca in the outer wall.

The morphological boundary between *Ferganites* and *Monodiexodina* is gradual. No significant differences seem to lie between the two, yet the latter generally provides larger shell with more intensely fluted septa, and heavier chomata. Stratigraphically the latter usually occurs from higher horizon than the former.

*Ferganites*, *Nagatoella*, *Monodiexodina* and *Nipponitella* are considered to constitute a phylogenetical stock. This stock is characterized by thick or slender cylindrical shell with regularly arranged, low septal fluting, and relatively thin alveolar wall. The phylogenetical relationships of these genera

are suggested as is shown in fig. 10.

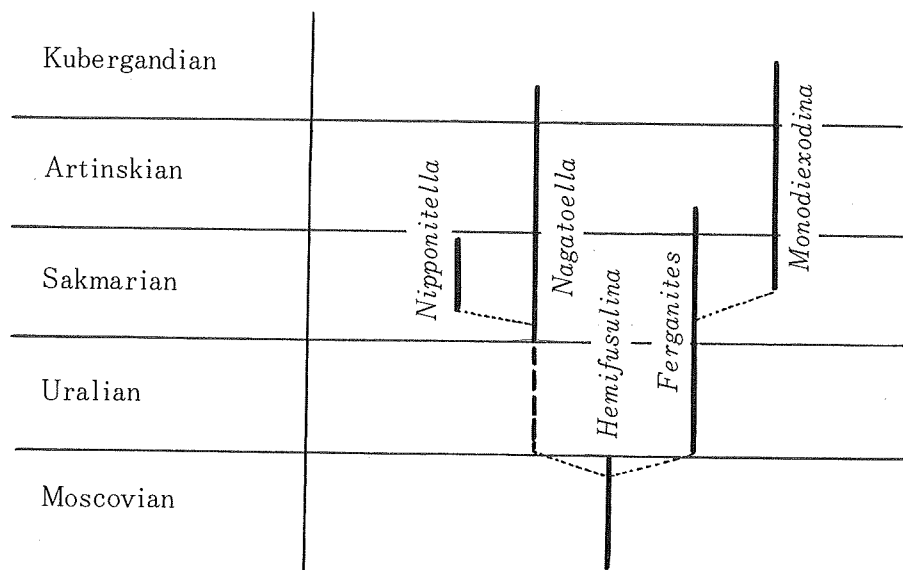


Fig. 10. Compiled phylogeny of *Ferganites*, *Nagatoella*, *Monodioxodina*, *Nipponitella* and *Hemifusulina*.

The following species and forms are included in genus *Ferganites* herein emended.

*Eoparafusulina gracilis* (MEEK), 1864

*Triticites pusilla* (SCHELLWIEN), 1898

*Triticites densimediis* CHEN, 1934

*Ferganites ferganensis* var. *schienensis* M. -MACLAY, 1949

*Ferganites ferganensis* M. -MACLAY, 1950

*Triticites langsonensis* SAURIN, 1950

*Schwagerina parilinearis* THORSTEINSSON, 1960

*Pseudofusulina tschernyschewi* (SCHELLWIEN) of GROZDYLOVA and LEBEDEVA, 1961

*Pseudofusulina tschernyschewi* forma *minima* GROZDYLOVA and LEBEDEVA, 1961

*Pseudofusulina tschernyschewi* forma *oblonga* GROZDYLOVA and LEBEDEVA, 1961

*Pseudofusulina* (?) *recondita* GROZDYLOVA and LEBEDEVA, 1961

*Triticites mancus* GROZDYLOVA and LEBEDEVA, 1961

*Pseudofusulina* (?) *perplexa* forma *pertenia* GROZDYLOVA and LEBEDEVA, 1961

*Pseudofusulina* (?) *perplexa* GROZDYLOVA and LEBEDEVA, 1961

*Triticites duplex* GROZDYLOVA and LEBEDEVA, 1961

*Monodiexodina* sp. A, by ROSS and DUNBAR, 1962  
*Schwagerina?* sp. C, by ROSS, 1963  
*Eoparafusulina thompsoni* SKINNER and WILDE, 1965  
*Eoparafusulina cylindrica* SKINNER and WILDE, 1965  
*Eoparafusulina potterensis* SKINNER and WILDE, 1965  
*Eoparafusulina depressa* SKINNER and WILDE, 1965  
*Alaskanella laudoni* SKINNER and WILDE, 1966  
*Alaskanella yukonensis* SKINNER and WILDE, 1966  
*Eoparafusulina allisonensis* ROSS, 1967  
*Eoparafusulina mendenhalli* PETOCZ, 1970  
*Eoparafusulina waddeli* PETOCZ, 1970

*Geographical distribution:* *Ferganites* ranges from the upper Carboniferous to the lower Permian. Carboniferous forms occur from the western Tethys Sea region; *Ferganites ferganensis* and *Ferganites schiensis* from Fergana, and *Ferganites pusilla* from Yugoslavia. In the lower Permian it shows very broad distribution, mainly in arctic regions, less frequently in Tethys Sea areas and north America; Timan, Spitsbergen, Alaska, Grinnel Peninsula, Greenland, Afghanistan, South East Asia, South China, Japan, California, and Texas. None of species is yet known to occur from South America.

***Ferganites langsonensis* (SAURIN)**

Pl. 4, figs. 7-8; pl. 7, fig. 7

1950 *Triticites langsonensis* SAURIN, pp. 23-25, pl. 4, figs. 1-11, 13-15.

1954 *Triticites langsonensis*, SAURIN, pp. 25-26, pl. 4, figs. 7-13.

1965 *Monodiexodina (Ferganites) langsonensis*, KANMERA and MIKAMI, pp. 288-289, pp. 4, figs. 1-11.

*Material:* UHR 19592-2a, 4a, 7d, and UHR 19591-1c.

*Localities:* 19 and 64.

*Remarks:* Quite recently LEVEN (1971) described *Pseudofusulina ferganensis* (originally described as *Pseudofusulina pailensis* var. *ferganensis* by DUTKEVITCH in 1934) and *Triticites? pusillus* from the lower Permian of Afghanistan. These two forms are safely included in *Ferganites*. So the specific name of the former is inadequate because it is regarded as secondary homonym of *Ferganites ferganensis*, the type species of genus *Ferganites*. Therefore another name should be given for it. It possesses larger shell with more rapid expansion in inner volutions than *Ferganites langsonensis*.

*Ferganites langsonensis* is one of the most representative fusulinid species among those of the Kawaguchi stage, lower Sakamotosawa series, lower Permian in the Kitakami Mountains.

Genus *Nagatoella* THOMPSON, 1936

- 1936 *Nagatoella* THOMPSON, pp. 196-198.  
 1948 *Nagatoella*, THOMPSON, p. 53.  
 1957 *Darvasites* M. MACLAY, p. 108.  
 1959 *Darvasites*, M. MACLAY, pp. 12-13, 16-17.  
 1963 *Darvasites*, M. MACLAY, pp. 202, 239.  
 1963 *Nagatoella*, SHENG, p. 206.  
 1963 *Nagatoella*, KANMERA, p. 92.  
 1964 *Nagatoella*, THOMPSON, p. C418.  
 1964 *Darvasites*, THOMPSON, in *Treatise*, p. C434.  
 1967 *Eoparafusulina* (*Mcclaudia*) ROSS, pp. 945-946.

*Type species: Schellwienia ellipsoidalis* var. *orientis* OZAWA, 1925.

*Diagnosis:* Shell is thickly to moderately cylindrical with rounded poles. The shell is coiled regularly and tightly throughout the shell, but more tight in inner volutions. Proloculus is small in general, but in some form it is moderately large. Septa are very weakly fluted in primitive forms, but comparatively intense and regular in more advanced forms. Septal folds commonly do not exceed one half the chamber height, and folding crests are semicircular or rectangular with rounded upper surface. Chomata are massive, very well developed in some forms, but rather weakly in inner volutions in others.

*Discussion:* From the Southern Kitakami mountains, and the East of the Lake Biwa, central Japan, *Nagatoella ikenoensis* were described. Not only stratigraphical evidences but also morphological features suggest that the species is primitive against such advanced forms of *Nagatoella* as *Nagatoella kobayashii*, *Nagatoella minatoi* and *Nagatoella orientis*.

In examining the primitive forms of *Nagatoella*, the author noticed that *Triticites truncatus* CHEN, *Triticites contractus* SCHELLWIEN and DYHRENFURTH, *Triticites ordinatus* CHEN, *Triticites sinensis* CHEN, and *Triticites ventricus* var. *medialis*, all of which were described by CHEN (1934) from lower Permian Maping limestone or Swine limestone, South China, and later transferred to *Hemifusulina* by CHANG (1963a), have close similarity to *Nagatoella*, although some of them possess slightly more inflated shell with larger proloculus than the typical *Nagatoella*. The latter contains thick cylindrical shell with small proloculus and tightly coiled inner volutions.

CHANG's (1963a) opinion to include the above listed forms in genus *Hemifusulina* can not be accepted, because the wall of genus *Hemifusulina* essentially differs from that of Schwagerininae; that of the former consists of tectum and protheca penetrated by pores, whereas the latter tectum and keriotheca. CHANG's listed species possess distinct alveoli, which are ascertain-

ed both in his descriptions and illustrations. Furthermore, none of *Hemifusulina* has been known to occur from lower Permian or upper Carboniferous, but it occurs from middle Carboniferous, Bashkirian and Moscovian. Therefore CHANG's *Hemifusulina* should be separated from *Hemifusulina* and better transferred to Schwagerininae.

M. -MACLAY (1959) referred the above listed CHEN's *Triticites* to *Darvasites*. After all, to distinguish *Nagatoella* from *Darvasites* became very difficult for the author. He considers that essential differences are not present between these two genera. The former has priority, so the latter should be suppressed into the former.

As stated elsewhere (in genus *Ferganites*) in this article, Ross' (1967) *Eoparafusulina* (*Mcclaudia*) from North America may be synonymous with *Nagatoella*.

The following species and forms are included in *Nagatoella*.

*Triticites contractus* SCHELLWIEN and DYHRENFURTH, 1909

*Nagatoella orientis* (OZAWA), 1925

*Triticites sinensis* CHEN, 1934

*Triticites tenuithecæ* CHEN, 1934

*Triticites ordinatus* CHEN, 1934

*Triticites ventricus* var. *medialis* (SCHELLWIEN and STAFF) by CHEN, 1934

*Nagatoella kobayashii* THOMPSON, 1936

*Nagatoella fujimotoi* MORIKAWA, 1951

*Nagatoella ikenoensis* MORIKAWA and ISOMI, 1961

*Triticites elatus* GROZDYLOVA and LEBEDEVA, 1961

?*Pseudofusulina polymorpha* SHYOMINA, 1961

*Nagatoella?* *parva* SHENG, 1963

*Nagatoella minatoi* KANMERA and MIKAMI, 1965

*Eoparafusulina contracta* SKINNER and WILDE, 1965

*Eoparafusulina spissa* SKINNER and WILDE, 1965

*Eoparafusulina ovata* SKINNER and WILDE, 1965

*Eoparafusulina regularis* SKINNER and WILDE, 1965

*Eoparafusulina certa* SKINNER and WILDE, 1965

*Eoparafusulina modica* SKINNER and WILDE, 1965

*Eoparafusulina brevis* SKINNER and WILDE, 1965

*Eoparafusulina minuta* SKINNER and WILDE, 1965

*Eoparafusulina nitida* SKINNER and WILDE, 1965

*Eoparafusulina proba* SKINNER and WILDE, 1965

*Eoparafusulina tarda* SKINNER and WILDE, 1965

*Eoparafusulina alta* SKINNER and WILDE, 1965

*Eoparafusulina concisa* SKINNER and WILDE, 1965



*Eoparafusulina rotunda* SKINNER and WILDE, 1965

*Eoparafusulina bellula* SKINNER and WILDE, 1965

?*Darvasites zulumartensis* LEVEN, 1969

*Pseudofusulina griesbacheri* LEVEN, 1971

*Pseudofusulina haydeni* LEVEN, 1971

*Pseudofusulina mikhailovi* LEVEN, 1971

*Stratigraphical range:* Lower to middle Permian. Upper Carboniferous forms will be found in future.

*Geographical distribution:* Tethys Sea region (Pamir, Afghanistan, South China, and Japan), Alaska and North California.

*Nagatoella ikenoensis* MORIKAWA and ISOMI, 1961

Pl. 1, figs. 1-7; pl. 2, fig. 15

1961 *Nagatoella ikenoensis* MORIKAWA and ISOMI, pp. 22-23, pl. 20, figs. 6-13.

*Material:* UHR 19217-4, 9, 10, 11, 13, UHR 19439, and UHR 19463.

*Description:* Shell is rather small in size, thick cylindrical to fusiform in shape with rounded poles and nearly straight axis of coiling. Mature shell possesses 10 to 11 volutions, and it is 4.6 to 4.7 mm long and 1.8 to 2.1 mm wide, giving form ratio of 2.4 to 2.5. The shell is tightly coiled in inner four volutions, but abruptly expanded from the fifth to the outer volutions, and then evenly coiled. The height of volution of an illustrated specimen (pl. 1, fig. 7) from the first to the eleventh volution is, 25, 32, 40, 50, 80, 110, 150, 190, 210, 210 and 210? microns, respectively.

The exact size of proloculus is unknown because of absence of ideally cut sections at hand.

Spirotheca is finely alveolar. Its thickness is 8 to 10 microns in the first few volutions, 10 to 15 microns in the middle, and 30 to 40 microns in the outer volutions.

Septa are numerous. They are almost straight in mid-portion, but low and gently fluted towards pole regions. Number of the septa is counted 6 to 13 in the first few volutions, and 26 to 30 in the outer volutions.

Chomata are well developed throughout the length of the shell, especially they are distinct in inner volutions.

*Remarks:* This form is characterized to provide primitive natures for *Nagatoella*. MORIKAWA and ISOMI (1961) described a primitive *Nagatoella*, *Nagatoella ikenoensis* from the East of the Lake Biwa, central Japan. The present form is most closely related to *Nagatoella ikenoensis* in shell form and size, expansion of the shell, thickness of the spirotheca. But the latter contains comparatively intensely fluted septa and numerous volutions. Nevertheless, these differences may be of intra-specific value, and these two forms may be

treated as conspecific with each other. According to MORIKAWA and ISOMI, *Nagatoella ikenoensis* is associated with *Pseudofusulina regularis* and *Misellina ibukiensis* (= *Misellina otakiensis* in the author's opinion), which indicate the lower Permian.

*Nagatoella fujimotoi* MORIKAWA from Shimokuzu, Aganomura, Kwanto Mountains, central Japan, possesses larger and thicker shell with thicker spirotheca than *Nagatoella ikenoensis*. *Nagatoella minatoi* KANMERA and MIKAMI from the southern Kitakami Mountains has larger and more loosely coiled shell with more intensely fluted septa, and thicker spirotheca than the present form.

This form comparatively abundantly occurs from Yahagi (loc. 79), somewhere in Komata, near Setamai, and rarely from Shishiori (loc. 83) in association with *Chalaroschwagerina vulgaris* (SCHELLWIEN and DYHRENFURTH), *Nipponitella explicata* Hanzawa, *Ferganites langsonensis* (SAURIN), *Mino-japanella elongata* FUJIMOTO and KANUMA, *Pseudofusulina? jenkinsi* THORSTEINSSON, and *Pseudofusulina* sp. A. Komata specimens are associated with *Misellina otakiensis*, and *Toriyamaia laxiseptata* KANMERA. This form is confined within Kawaguchi stage, *Ferganites langsonensis*-*Schwagerina* cf. *krotowi* subzone.

*Nagatoella minatoi* KANMERA and MIKAMI

Pl. 7, fig. 6; pl. 12, figs. 1-8

1952 *Waeringella?* sp. TORIYAMA, p. 132, pl. 3, figs. 3, 4.

1965 *Nagatoella minatoi* KANMERA and MIKAMI, pp. 307-308, pl. 50, figs. 9-11; pl. 53, figs. 7-9.

*Remarks:* This species shows broad stratigraphical range from the middle to the uppermost Sakamotosawa series. As KANMERA and MIKAMI thoroughly described the species, more references seem to be needless. It is one of the typical forms in the Sakamotosawa series in the Southern Kitakami Mountains.

Genus *Nipponitella* HANZAWA, 1938

*Nipponitella explicata* HANZAWA

Pl. 2, figs. 16, 17; pl. 3, fig. 2

1938 *Nipponitella explicata* HANZAWA, pp. 256, 257, figs. 8-16.

1938 *Nipponitella expansa* HANZAWA, pp. 257-259, figs. 3-7.

1965 *Nipponitella explicata*, KANMERA and MIKAMI, pp. 290-291, pl. 49, figs. 1-19.

1967 *Nipponitella* sp. cf. *Nipponitella explicata*, KANOMATA and MIYAWAKI, p. 161, pl. 1, figs. 6 & 7.

*Material:* UHR 19638, UHR 19212-1, 19210 and 19217-8a.

*Remarks:* Some of the illustrated specimens (pl. 2, figs. 16 & 17) obtained from Yahagi district are quite identical with *Nipponitella expansa* HANZAWA which was discovered by H. YABE in pebbles of calcareous sandstone in the river bed of the Yahagi River.

In establishing genus *Nipponitella*, HANZAWA discriminated three species; *Nipponitella explicata* (type species), *Nipponitella auricula* and *Nipponitella expansa*. He referred that the last species was related to the second one, and these two species was discernible with each other by the difference in septal interval.

As was illustrated by himself (fig. 3), however, *Nipponitella expansa* contains far thicker shell than *Nipponitella auricula* that is characteristic in containing minute and fusiform shell. In this meaning, *Nipponitella expansa* is considered to be more closely related to *Nipponitella explicata* than to *Nipponitella auricula*. After all, the difference between *Nipponitella explicata* and *Nipponitella expansa* lies merely in the length of the last flared volutions so far as HANZAWA's illustrations and description are concerned. As to this, KANMERA and MIKAMI (1965) illustrated numerous specimens of *Nipponitella explicata* from adjacent Sakamotosawa district. Their illustrations well demonstrate the variation of the development of the last aberrant volution in *Nipponitella explicata*. Based on this fact, *Nipponitella expansa* is considered as a mere variety of *Nipponitella explicata*.

*Nipponitella* may be a small off-shoot from some primitive *Nagatoella* in the lowest Permian.

#### Genus *Monodiexodina* SOSNINA, 1956

1956 *Monodiexodina* SOSNINA, pp. 24-26.

1958 *Monodiexodina*, COOGAN, p. 310

1959 *Monodiexodina*, Основы Палеонтологии, p.214.

1960 *Parafusulina* (*Monodiexodina*), COOGAN, p. 263

1962 *Monodiexodina*, ROSS and DUNBAR, pp. 45-46.

1963 *Monodiexodina*, KANMERA p. 103.

1963 *Monodiexodina*, MIKLUHO-MACLAY, p. 202, 246.

1963 *Monodiexodina*, ROSS, pp. 159-160.

1964 *Parafusulina*, THOMPSON, p. C420.

*Type species:* *Schwagerina wanneri* (SCHUBERT) var. *sutschanica* DUTKEVICH, 1935.

*Generic diagnosis:* Shell is large, elongate cylindrical to subcylindrical with broadly arcuate axis of coiling and rounded poles. Spirotheca is composed of tectum and keriotheca. Septa are regularly fluted. The upper half of the septum remains plain and lower half is fluted. The septal folding is small, rectangular to

semicircular in cross section. Tunnel is singular. Chomata are rudimentary or entirely absent. Axial fillings are massive and particularly well developed in pole regions in some forms, but weakly in other ones.

*Discussion:* In genus *Monodiexodina*, there present two main form groups though their morphological boundaries are successive. One is represented by *Monodiexodina sutchanica*, and the other is *Monodiexodina kattaensis*. The former generally contains more elongate shell with heavier axial fillings than the latter. In the former, *Monodiexodina matsubaishi*, *Monodiexodina sutchanica*, and *Monodiexodina shiptoni* may be included. While in the latter, *Monodiexodina kattaensis* (SCHWAGER), *Monodiexodina bispatulata* WILLIAMS., *Monodiexodina prolongata* (BERRY), *Monodiexodina steinmanii* (DUNBAR and NEWELL), *Monodiexodina wanneri* (SCHUBERT) and *Monodiexodina wanganensis* SOSNINA are covered. The latter may be morphologically intermediate between genus *Monodiexodina* s. str. and genus *Parafusulina*. Geographically, the former is found in the Kitakami Mountains, and USSR (Primoria, and Pamirs), whereas the latter shows rather broad distribution from the Tethys region to South and North America.

### *Monodiexodina kattaensis* (SCHWAGER)

Pl. 3, fig. 1

1887 *Fusulina kattaensis* SCHWAGER, pp. 985-987, pl. 76, figs. 1-11; pl. 78, fig. 4

1887 *Fusulina pailensis* SCHWAGER, pp. 987-988, pl. 77, figs. 1-6.

1887 *Fusulina longissima* MÖLLER, SCHWAGER, pp. 988-989, pl. 77, figs. 6-12; pl. 78, figs. 1-3.

1933 *Parafusulina kattaensis*, DUNBAR, pp. 408-412, pl. 22, figs. 1-2j.

1970 *Monodiexodina kattaensis*, DOUGLASS, pp. G6-G8, pls. 2-7.

*Lectotype:* DOUGLASS (1970) designated SCHWAGER's (1887) pl. CXXVI, fig. 3 as the lectotype.

*Remarks:* This species resembles *Parafusulina motoyoshiensis* in subcylindrical shell. The latter, however, provides more irregularly fluted septa than the latter. In this point the latter is definitely separated from genus *Monodiexodina*. Douglass (1970) well demonstrated the broad specific variation in *Monodiexodina kattaensis*, restudying the topotype material.

The distinction between such highly advanced *Ferganites* as *Ferganites yukonensis* or *Ferganites allisonensis*, and *Monodiexodina*, such as *Monodiexodina kattaensis* is difficult because of gradations of morphological characteristics between them. However, the former generally possesses larger shell with more intensely fluted septa than the latter.

*Monodiexodina matsubaishi* (FUJIMOTO)

Pl. 14, fig. 6

1956 *Parafusulina matsubaishi* FUJIMOTO, pp. 157-160, pl. 25, figs. 1-10.*Material*: UHR 19311-12, 14, 16, 17, 19, 20 & 21.*Remarks*: A primitive form of this species was obtained from the middle Sakamotosawa series at localities 18 and 83. The stratigraphical range of this species therefore is possible to fall down to the middle Sakamotosawa series.*Monodiexodina matsubaishi*, *Monodiexodina sutchanica* and *Monodiexodina shiptoni* are closely related in essential natures and composes a species group which is discriminated from *Monodiexodina kattaensis* species group.*Monodiexodina kofuganensis* sp. nov.

Pl. 14, figs. 1-5

*Material*: Axial sections, UHR 19311-6 & UHR 19311-21a, Tangential sections, UHR 19311-7, UHR 19311-19, & UHR 19311-21b; Oblique parallel section, UHR 19311-2.*Locality*: 121.*Diagnosis*: Relatively thick cylindrical *Monodiexodina* with low, regularly and triangularly fluted septa, and dense axial fillings.*Description*: Shell is large cylindrical with gently curved axis of coiling and rounded pole regions. The shell possesses commonly eight to nine volutions, being at most eleven or more. The shell of nine to ten volutions is 14.0 to 15.0 mm long and 3.0 to 3.5 mm wide, with form ratio of 4.2 to 4.7.

Coiling of the shell is uniform. Its inner few volutions are ellipsoidal, then it gradually takes cylindrical shape. The height of volution from the first to the seventh volution in average of well oriented two axial sections is, 0.085, 0.100, 0.120, 0.170, 0.185, 0.215 and 0.240 mm, respectively.

Proloculus ranges 0.24 to 0.34 mm in outside diameter.

Spirotheca is composed of tectum and coarse alveoli, although usually recrystallized and difficult to determine. The thickness of the spirotheca gradually increases towards outer volutions; inner volutions, 15 to 30 microns and outer 35 to 55 microns. The thickness of the spirotheca beyond the eight volution is unable to measure owing to poor preservation of the shell at hand.

Septa are composed of tectum and lower thick layer. On account of absence of ideal sagittal sections, the number of the septa is not easily counted, but in the fourth to the sixth volution, 17 to 24 septa are counted. The septa are very regularly fluted at their lower portion throughout volutions. They show small triangular shape in section except axial regions where they are rather intensely fluted as to form cuniculi structure.

Dense and massive axial fillings are very well developed except for the first

few volutions where they are not always seen.

Chomata are absent even in inner volutions.

*Remarks:* The present form is characteristic in cylindrical shell with low, narrowly and regularly fluted septa and dense axial fillings. These diagnostic features make it possible to include the present form into genus *Monodiexodina*. It may be grouped in *Monodiexodina sutchanica* group. But it is safely discriminated from *Monodiexodina matsubaishi*, *Monodiexodina sutchanica* and *Monodiexodina shiptoni* in more thicker shell and nature of septal fluting.

It is similar to *Parafusulina* aff. *mccloudensis* from Kotsubosawa and Yokoteyama described in this article in possessing cylindrical shell. But the former has more elongate shell with less rapid expansion, well developed axial fillings and comparatively low and narrowly fluted septa than the latter.

*Parafusulina multiseptata* (SCHELLWIEN) differs from the present form in having fusiform to subcylindrical shell, different character of fluting, and less developed axial fillings.

*Parafusulina multiseptata crassispira* from Pamirs resembles the present form in cylindrical shell. The former, however, is readily distinguishable from the latter in absence of axial fillings, broadly, highly and irregularly fluted septa of the former.

The present species is also easily distinguished from *Parafusulina wordensis* because the latter has far larger shell than the former.

#### Genus *Chalaroschwagerina* SKINNER and WILDE, 1965

1965 *Chalaroschwagerina* SKINNER, & WILDE, p. 72.

1965 *Cuniculinella* SKINNER, & WILDE, p. 84.

*Type species:* *Chalaroschwagerina inflata* SKINNER and WILDE

*Generic diagnosis:* Shell is moderate to large in size, fusiform to subspherical with bluntly pointed poles. Compact juvenarium is absent and the shell is rather loosely coiled throughout the growth. Proloculus is moderate to large for the size of the shell. Spirotheca consists of tectum and keriotheca and relatively thick in outer volutions. Septa are intensely or irregularly fluted as to form cuniculi in some forms. Chomata are absent except for the first volution where rudimentary chomata are frequently observed. Phrenotheca usually well develops. Axial fillings are present in some forms but absent in other ones.

*Discussion:* Genus *Chalaroschwagerina* was newly established by SKINNER and WILDE (1965) with *Chalaroschwagerina inflata* SKINNER and WILDE as type species. This new genus is characteristic in possession of highly inflated fusiform shell with moderate to large proloculus, intensely fluted septa loosely coiled inner volutions.

SKINNER and WILDE (1965) at the same time proposed another new genus

*Cuniculinella* with *Cuniculinella tumida* SKINNER and WILDE as type species. This new genus, however, at a glance difficult to distinguish from *Chalaroschwagerina*. The difference between them lies only in the presence of cuniculi in the former. The author thinks that the presence of cuniculi in the former does not warrant enough for generic separation from the latter. Therefore the former should be suppressed into the latter.

Genus *Chalaroschwagerina* closely resembles genus *Schwagerina* and the morphological boundary between the two is gradational. The latter, however, differs from the former in possession of tightly coiled juvenarium and small proloculus.

*Pseudofusulina* is safely distinguishable from *Chalaroschwagerina* in more elongate shell with thinner spirotheca than the latter, though their morphological boundaries are successive.

A number of species herein included in genus *Chalaroschwagerina* were hitherto assigned to various genera, such as *Pseudofusulina*, *Schwagerina*, or even *Parafusulina* and *Chusenella*. So, their systematic positions have been fairly confused for a long while.

So far as examined, the species and forms shown below may be included in genus *Chalaroschwagerina* besides those assigned as *Chalaroschwagerina* and *Cuniculinella* by SKINNER and WILDE (1965, 1966).

*Pseudofusulina vulgaris* (SCHELLWIEN and DYHRENFURTH), *Psf. aculeata* LEVEN, *Psf. gallowayi* CHEN, *Psf. cushmani* CHEN, *Psf. kueichowensis* SHENG, *Psf. gujoensis* KANUMA, *Psf. hexagonaria* IGO, *Psf. valentinae* GROZDYLOVA and LEBEDEVA, *Psf. donganensis* (COLANI), *Psf. japonica* var. *hayasakai* LEE, *Psf. japonica* by LEE (1927), *Schwagerina ventricosa* SKINNER and WILDE, *Schw. mengi* CHEN, *Schw. uritensis* IGO, *Schw. okafujii* TORIYAMA, *Schw. hawkinsi* DUNBAR and SKINNER, *Schw. chiapasensis* THOMPSON and MILLER, *Schw. soluta* SKINNER and WILDE, *Schw. rotunda* SKINNER and WILDE, *Schw. turgida* SKINNER and WILDE, *Schw. ibukiensis* KOBAYASHI, *Schw.? hedbergi* THOMPSON and MILLER, *Schw. sp. A, B, D, E* by ROSS and SABINS (1966), *Chusenella globosa* (DEPRAT) by SAURIN (1965), *Triticites kueichihensis* CHEN, *Daixina? aff. versabilis* (BENSH) by SCHERBOVITCH (1969), *Parafusulina quasigruperaensis* SHENG, *Parafusulina zurumartensis* LEVEN, *Paraf. globosaeformis* LEVEN, *Paraf. incognita* LEVEN, *Paraf. tumida* LEVEN.

*Chalaroschwagerina* may have been derived from some forms of such *Daixina* as *Daixina pomposa* SHYOMINA from USSR in the lowest Permian or the uppermost Carboniferous. It evolved all through the lower Permian in parallel with *Schwagerina*, *Paraschwagerina* etc.

*Chalaroschwagerina vulgaris* (SCHELLWIEN and DYHRENFURTH)

Pl. 5, figs. 1, 2?, 3, 6-11

- 1909 *Fusulina vulgaris* SCHELLWIEN and DYHRENFURTH, pp. 163-164, figs. 1 & 2 (Fig. 1 is lectotype).
- 1909 *Fusulina vulgaris* var. *globosa* SCHELLWIEN and DYHRENFURTH, pl. 13, figs. 7 & 8; pl. 14, figs. 3-7.
- 1925 *Fusulina* (*Schellwienia*) *vulgaris*, OZAWA, pp. 23-24, pl. 7, fig. 3.
- 1925 *Schellwienia vulgaris* var. *globosa*, OZAWA, p. 24-25, pl. 7, figs. 1 & 2.
- ?1927 *Schellwienia vulgaris*, LEE, pp. 59-64, pl. 8, figs. 6-9, 11 & 12; pl. 9, fig. 9.
- 1927 *Schellwienia vulgaris* var. *globosa*, LEE, p. 67, pl. 9, fig. 12.
- 1934 *Pseudofusulina vulgaris*, CHEN, pp. 67-68, pl. 6, fig. 10.
- 1936 *Pseudofusulina vulgaris*, HUZIMOTO (=FUJIMOTO), pp. 75-77, pl. 11, figs. 1-7.
- 1936 *Pseudofusulina vulgaris*, var. *globosa*, HUZIMOTO (=FUJIMOTO), pp. 77-78, pl. 12, figs. 1-7; pl. 14, figs. 1 & 2.
- 1950 *Pseudofusulina vulgaris*, SAURIN, pp. 27-28, pl. 6, figs. 1, 2, & 9.
- 1955 *Pseudofusulina vulgaris*, MORIKAWA, pp. 89-90, figs. 1-5, 6?.
- 1958 *Pseudofusulina* (?) *isaensis* TORIYAMA, pp. 184-186, pl. 27, figs. 14-21.
- 1958 *Pseudofusulina vulgaris*, TORIYAMA, pp. 164-168, pl. 20, figs. 12-18; pl. 21, figs. 1-15.
- 1958 *Pseudofusulina vulgaris* var. *watanabei*, TORIYAMA, pp. 173-175, pl. 23, figs. 4-6.
- 1958 *Pseudofusulina vulgaris* var. *globosa*, TORIYAMA, pp. 168-170, pl. 21, figs. 16-18; pl. 22, figs. 1-7.
- 1958 *Pseudofusulina vulgaris* var. *megaspherica* TORIYAMA, pp. 170-172, pl. 22, figs. 8-17; pl. 23, figs. 1-3.
- 1958 *Pseudofusulina globosa* (DEPRAT) var. *exilis* TORIYAMA, pp. 175-178, pl. 23, figs. 7-16; pl. 24, figs. 1-20.
- 1958 *Pseudofusulina vulgaris* var. *pseudowatanabei*, KANUMA, pp. 77-78, pl. 8, fig. 4-8, 10 & 12.
- 1958 *Pseudofusulina vulgaris*, KANUMA, pp. 74-75, pl. 8, figs. 13 & 14.
- 1958 *Schwagerina vulgaris*, SAKAGAMI, pp. 83-84, pl. 2, figs. 10, 11 & 17.
- 1958 *Pseudofusulina vulgaris* var. *globosa*, SAKAGAMI, p. 85, pl. 2, fig. 12.
- 1959 *Pseudofusulina vulgaris* var. *globosa*, IGO, pp. 240-242, pl. 1, figs. 4-6; pl. 3, fig. 4.
- 1959 *Pseudofusulina vulgaris*, IGO, pp. 239-240, pl. 1, fig. 7.
- 1961 *Pseudofusulina globosa*, MORIKAWA and ISOMI, pp. 17-18, pl. 13, figs. 6-11.
- 1961 *Pseudofusulina vulgaris*, MORIKAWA and ISOMI, pp. 16-17, pl. 13, figs.



- 1-4.
- 1961 *Pseudofusulina vulgaris* var. *globosa*, KAWANO, pp. 94-96, pl. 6, fig. 20; pl. 7, figs. 1-12.
- 1961 *Pseudofusulina vulgaris* var. *megaspherica*, KAWANO, pp. 96-98, pl. 7, figs. 13-15; pl. 8, figs. 1-5.
- 1961 *Pseudofusulina vulgaris*, KAWANO, pp. 16-17, pl. 13, figs. 1-4.
- 1961 *Pseudofusulina* cf. *globosa* var. *exilis*, KAWANO, pp. 98-99, pl. 8, fig. 6.
- 1961 *Pseudofusulina vulgaris*, NOGAMI, pp. 210-211, pl. 9, figs. 1-3.
- 1961 *Pseudofusulina vulgaris globosa*, NOGAMI, pp. 212-213, pl. 9, figs. 4-7.
- 1961 *Pseudofusulina globosa exilis*, NOGAMI, pp. 214-215, pl. 9, figs. 10-13.
- 1962 *Pseudofusulina vulgaris watanabei*, ISHIZAKI, pp. 147-149, pl. 8, figs. 3?, 4 & 5?.
- 1962 *Pseudofusulina* aff. *vulgaris*, ISHIZAKI, pp. 146-147, pl. 8, fig. 7.
- 1963 *Pseudofusulina vulgaris*, SHENG, p. 192, figs. 6-8.
- 1963 *Pseudofusulina vulgaris* var. *globosa*, CHANG, pp. 216-217, pl. 9, fig. 4.
- 1965 *Pseudofusulina vulgaris vulgaris*, KANMERA and MIKAMI, pp. 295-297, pl. 51, figs. 1-3.
- 1965 *Pseudofusulina vulgaris*, KALMIKOVA, pp. 12-22, pl. 2, figs. 1-6.
- 1972 "*Pseudofusulina*" *vulgaris*, SUGIYAMA, text-fig. 3, figs. 1-4. (Only illustrations)
- Material*: UHR 19436-19437, 19590, 19595, 19610, 19628, 19632-19635, 19652-19655, and 19657-19659.
- Localities*: Locs. 8, 18, 38, 42-45, 62-66, 68-70, and 83-84.
- Lectotype*: TORIYAMA (1958, p. 167) chose SCHELLWIEN and DYHRENFURTH's (1909) fig. 2, on plate 14 as the lectotype of this species.
- Remarks*: KALMIKOVA (1965) restudied the topotype material of this species, and she discriminated two species, *Pseudofusulina vulgaris* and *Pseudofusulina globosa* as independent. However, their morphological boundaries are successive and intermediate forms are abundantly found in previously described forms. Consequently it is difficult to distinguish the both species with certainty. The author thinks that the differences in external shell shape typically observed in the topotype specimens do not warrant for specific separation. Further, they often occur together. Therefore the differences may be within specific variation, and they may be better treated as conspecific.

*Chalaroschwagerina setamaiensis* sp. nov.

Pl. 8, figs. 1-5

*Material*: UHR 19611-19613, 19618, 19621 (Holotype), 19641 and 19642.

*Localities*: Numerous specimens have been obtained from Kanokurayama area. Their localities are; Loc. 20, 21, 22, 27, 30, 51 and 52.

*Diagnosis:* A large *Chalaroschwagerina* with highly inflated shell, weakly concave mid-portion, and depressed lateral slopes, intensely, regularly and narrowly fluted thin septa, relatively thick spirotheca and moderately large proloculus.

*Descriptive remarks:* This new species is characteristic in highly vaulted shell with slightly concave mid-portion, and regularly and intensely fluted thin septa. The mature shell possessing 6 to 7 volutions attains as large as 11.0 mm in length, and 7.5 mm in width. The shell coils loose throughout growth. Proloculus is moderate in size and measures 300 to 350 microns in diameter. Spirotheca is coarsely alveolar. Its thickness in outermost few volutions is 130 to 150 microns. Septa are thin and intensely fluted. Septal fluting is narrow and sharply pointed in upper surface, and comparatively regularly fluted. Axial fillings are faintly developed in inner few volutions.

The present form is somewhat close to *Pseudofusulina* aff. *japonica*, described in this article in inflated fusiform shell. However, the former is provided with more highly vaulted shell with slightly concave mid-portion, and more intensely and steeply fluted septa than the latter.

It is also similar to some forms described as *Pseudofusulina* or *Parafusulina japonica*. Of these, LEE's (1927) form is apparently different from the original form described by GÜMBEL in possessing more highly inflated shell. The former seems to be better placed in *Chalaroschwagerina*. It is most close to the present Kitakami form in many respects, except for less inflated shell and less narrowly fluted septa of the former.

This form is similar to "*Pseudofusulina*" *krafftii* and its related species in external shell shape. The latter, however, contains in general less inflated shell with less intensely fluted septa than the former, although both are morphologically successive with each other.

No species of *Chalaroschwagerina* are known to coincide with the form herein treated. So the author proposes a new species for the present form, *Chalaroschwagerina setamaiensis*.

#### Genus *Schwagerina* MÖLLER, 1877

*Type species:* *Borelis princeps* EHRENBURG, 1842.

*Diagnosis:* Shell is medium to small in size, inflated fusiform to subcylindrical with sharp to bluntly pointed poles. Inner few volutions are comparatively tightly coiled. Proloculus is small. Expansion of the shell is gradual towards outward. Spirotheca is composed of tectum and coarse alveoli. Septa are intensely fluted throughout growth. Chomata are low, confined to the inner volutions.

*Remarks:* Genus *Schwagerina* is most close to *Paraschwagerina* among

related genera to it. However, the latter possesses large shell with distinct compact juvenarium and rapidly expanded mature stage. While in the former juvenarium is not distinct as that in the latter, and expansion of the shell of the former is rather gradual towards outwards.

In inflated shell form, genus *Schwagerina* somewhat resembles *Chalaroschwagerina*. But the latter almost entirely lacks compact juvenarium and possesses large proloculus, and loosely coiled inner volutions.

*Schwagerina* cf. *krotowi* (SCHELLWIEN)

Pl. 5, figs. 4 & 5?

*Compare with-*

- 1908 *Fusulina krotowi* SCHELLWIEN, pp. 190-192, pl. 20, figs. 1-7, 10.  
 1925 *Fusulina* (*Schellwienia*) *krotowi*, OZAWA, pp. 27-28, pl. 7, figs. 5 & 6.  
 1936 *Pseudofusulina krotowi*, HUZIMOTO (FUJIMOTO), pp. 82-84, pl. 15, figs. 1-5, 9-15.  
 1950 *Schwagerina krotowi*, SAURIN, p. 27, pl. 5, figs. 13, 16, 17.  
 1955 *Pseudofusulina krotowi*, MORIKAWA, p. 86, pl. 14, figs. 5, 6.  
 1958 *Schwagerina krotowi*, TORIYAMA, pp. 134-138, pl. 15, figs. 8-19.  
 1958 *Schwagerina krotowi*, KANMERA, pp. 193-194, pl. 24, fig. 20; pl. 35, figs. 13, 14.  
 1961 *Pseudofusulina krotowi*, MORIKAWA and ISOMI, p. 18, pl. 8, figs. 1-11.  
 1961 *Schwagerina krotowi*, KAWANO, pp. 84-85, pl. 4, fig. 28; pl. 5, figs. 1-4.  
 1962 *Schwagerina krotowi*, ROSS and DUNBAR, pp. 48-50, pl. 6, figs. 8-13.  
 1962 *Schwagerina krotowi*, ISHIZAKI, pp. 113-114, pl. 29, figs. 6-10.

*Material*: UHR 19654-3, 8, 13, UHR 19659-1 and 19590-9.

*Localities*: Loc. 8, 64 and 65.

*Description*: Shell is highly inflated with convex mid-portion and weakly concave lateral slopes. Mature shell possesses 5 to 7 volutions with length of 4.8 to 5.2 mm and width of 3.5 to 4.2 mm. Form ratio ranges 1.2 to 1.3. The shell expands relatively tight. Height of volution from the first to the fifth volution in average of 5 specimens is 0.155, 0.210, 0.268, 0.290 and 0.340 mm, respectively. Proloculus is medium in size. Its outside diameter measures 0.27 to 0.33 mm. Spirotheca is alveolar. It is gradually thickened towards outward; 0.027 in the first, 0.033 in the second, 0.04 in the third, 0.065 mm in the fourth volution in average of 5 specimens. Septa are highly and narrowly fluted throughout the shell. Septal fluting very often reaches the top of chamber. Number of the septa is counted 10, 20, 29, 27 and 34, from the first to the fifth volution in average of 3 specimens. Tunnel is low and small. Tunnel becomes narrower towards outer volutions. Tunnel angle from the first to the sixth volution in average of 2 specimens is, 20°, 21°, 17°, 16°, 12° and 8°.

respectively. Chomata are present only in the first volution. Phrenotheca is well developed.

*Remarks:* Although the original form of *Schwagerina krotowi* described by SCHELLWIEN (1908) possesses less inflated shell than the present Kitakami form, the latter seems very close to the former. It well coincides with MORIKAWA and ISOMI's *Pseudofusulina krotowi* from the East Lake Biwa, central Japan. Other *Schwagerina krotowi* described from Japan, Viet-Nam, and Greenland generally contains more elongate shell than the present form.

Generically, the present species may bridge genus *Schwagerina* and *Chalaroschwagerina*; the genus *Schwagerina* has more tightly coiled juverarium and to the contrary *Chalaroschwagerina* more loosely coiled one than the present species.

*Schwagerina acris* THOMPSON & WHEELER

Pl. 20, figs. 4, 9

1942 *Schwagerina pavillionensis* var. *acris* THOMPSON & WHEELER, p. 707, pl. 105, figs. 1 & 2.

1950 *Schwagerina acris* THOMPSON, WHEELER & DANNER, p. 56, pl. 8, figs. 11 & 12.

1954 *Schwagerina* aff. *acris*, KANMERA, p. 8, pl. 1, figs. 8-17; pl. 3, fig. 21.

1961 *Schwagerina* aff. *acris*, KAWANO, p. 88, pl. 5, figs. 13-15.

*Material:* Two axial sections, 3 sagittal sections and 2 tangential sections besides numerous ill-oriented sections are at hand; UHR 19330-3, UHR 19330-6, UHR 19330-4, UHR 19331-1, UHR 19332-4, UHR 19333-3 and others are included.

*Locality:* 151.

*Description:* Shell is medium in size, fusiform, and slightly concave lateral slopes with sharply pointed poles and almost straight axis of coiling. Mature shell possesses eight to nine volutions, but outer few volutions are missed without exception. An illustrated specimen of seven volutions (pl. 20, fig. 4) is 5.8 mm long and 3.1 mm wide with form ratio of 1.85.

Proloculus is spherical, medium in size and is estimated 0.19 to 0.25 mm in outside diameter.

In inner three or four volutions, the shell is tightly coiled, but beyond that it begins abruptly to be loosely coiled. The shell in the first volution is subspherical in shape but from the second it expands in poleward, making inflated fusiform with somewhat concave lateral portions. Height of volution in the typical illustrated specimen is 0.06 to 0.07 mm in the first to the fourth volution, 0.18 mm in the fifth, and over 0.30 mm beyond the sixth.

Form ratio of volution is rapidly expanded up to the third volution, then it

gradually decreases. The form ratio of the above referred specimen of half length to half width from the first to the seventh volution is estimated as follows; 1.2, 1.6, 2.5, 2.7, 2.4, 2.0 and 1.9, respectively.

Spirotheca is thick, coarsely alveolar in outer volutions, while in inner three or four volutions it is much thicker and fine keriothecal structure is detected, which is not always seen owing to ill-preservation of the spirotheca. The thickness of the spirotheca increases rapidly outwards. It measures from the first to the fifth volution in average of two specimens, 14.0, 22.3, 32.5, 45.0 and 61.3 microns respectively.

Septa are fluted highly and broadly, becoming more intense towards pole regions, where the top of folding crests almost touch the top of the chamber, on the contrary in mid-portion they are nearly straight. Number of the septa gradually increases until the fourth volution, but beyond that it suddenly increases. It is counted from the first to the sixth volution in a comparatively well preserved sagittal section, 11, 13, 15, 16, 24 and 29 respectively.

Dense axial fillings are remarkably present. They are strongly massive in pole regions of the second to the seventh volution, especially the third to the fifth.

Chomata are clearly present in the first two volutions, but then rudiment, diminishing thoroughly beyond the fourth.

Tunnel angle is  $17^{\circ}$  in the first,  $14^{\circ}$  in the second volution in the mentioned illustrated specimen.

*Remarks:* The present form is closely similar to *Schwagerina* aff. *acris* from the Kuma formation described by KANMERA in every respect. General shell shape, character of coiling, densely developed axial fillings, thickness of the spirotheca, number of the septa, and the diameter of proloculus of both forms are all quite identical with each other except for slightly inflated mid-portion of the Kitakami form.

*Schwagerina* aff. *acris* has been also described by KAWANO from Chugoku Massif, in 1961. His form is identical with Kitakami form as well as Kuma form.

The holotype specimen of *Schwagerina pavillionensis* var. *acris* THOMPSON & WHEELER, afterwards raised to a species, *Schwagerina acris* by the authors and DANNER, possesses quite identical characters with the Kitakami specimens as well as those of the Kuma and Chugoku Massif, in shell form, character of expansion, well developed axial fillings, form ratio, mode of development of the chomata, thickness of the spirotheca and septal counts, except for slightly tightly coiled inner volutions and larger proloculus of the former. According to these features, it may be fully possible to treat all above forms as a single species, although KANMERA once assigned the Kuma form as

*Schwagerina* aff. *acris* because of its incompleteness of sagittal sections at his disposal.

Genus *Pseudoschwagerina* DUNBAR and SKINNER, 1936

Type-species; *Schwagerina uddeni* BEEDE and KNIKER, 1924

*Pseudoschwagerina katoi* sp. nov.

Pl. 7, figs. 2?, 3-5

*Material studied*: UHR 196671 (Holotype), UHR 19672-19675.

*Diagnosis*: Highly vaulted fusiform shell with bluntly rounded poles, weakly concave lateral slopes, characteristically thick spirotheca in outer whorls, gently fluted septa in their lower margins, and large proloculus, and without distinct *Triticites*-like juvenarium.

*Description*: Shell is large, highly vaulted with bluntly pointed pole regions and slightly depressed lateral slopes. Mature shell possesses 5 to 6 volutions, being 11.0 to 12.0 mm long, and 5.4 to 6.8 mm wide with form ratio of 1.9 to 2.0. Compact juvenarium with chomata is almost completely absent, and the shell is subsphaerical with relatively loose coiling in inner volutions, then it is quickly expanded towards outward. But again it is slightly slowly expanded in the outer whorls, where the shell takes inflated fusiform with pointed poles. Height of volutions in the first volution is 100 to 150 microns, 300 to 400 microns in the second and 600 to 700 microns in the outer volutions.

Proloculus is large, 400 to 500 microns in outside diameter.

Spirotheca is fairly thick especially in outer whorls, and is composed of tectum and keriotheca. Increase in thickness of the spirotheca is remarkable; 20 to 30 microns in inner volutions, and 150 to 180 microns in the outermost volutions.

Septa are sparsely arranged, thin compared to the thick spirotheca, and fluted gently in their lower portions. Number of the septa is 10 in the first, 13 in the second and the third, 15 in the fourth volution in an illustrated specimen (pl. 7, fig. 2).

Chomata are absent except for small levee like ones on the proloculus.

*Remarks*: The present form is characteristic in possession of highly inflated fusiform shell with loose coiling throughout growth, moderately fluted septa, large proloculus, thick spirotheca in outer volutions, and absence of tightly coiled juvenile stage. From these diagnostic features this new species is readily included in either *miharanoensis* group or *Zellia* group proposed by HAYASAKA and KATŌ (1966). *Pseudoschwagerina miharanoensis* group is distinguishable from *Zellia* group mainly by vaulted shell without umbilical poles, fluted septa, and thin spirotheca compared to the latter.

In external shell shape, and fluted septa, the present new species may be grouped in *miharanoensis* group. On the other hand, however, the thick

spirotheca shows close affinity to *Zellia* group. Thus the form herein treated may stand morphologically between *miharanoensis* group and *Zellia* group.

KANOMATA and MIYAWAKI (1967) described a new species called *Paraschwagerina hosozawaensis* from Kesennuma, Southern Kitakami Mountains. Their new species should be transferred into *Pseudoschwagerina*, since it possesses large proloculus, and lacks compact juvenarium. It is grouped in *miharanoensis* group, though it contains more irregularly fluted septa than the typical species of *miharanoensis* group.

*Pseudoschwagerina convexa* THOMPSON from Wolfcampian formation resembles the present new species in shell shape. However, the latter provides more inflated shell with more loosely coiled immature stage, and less developed chomata than the former.

So far as the inflated fusiform shell is concerned, the present form is somewhat close to *Fusulina muongthensis* DEPRAT, the type species of *Parazellia* RAUSER-CHERNOUSOVA. The former, however, lacks compact juvenarium and consequently both are readily discriminated. Moreover, *Parazellia* as well as *Occidentschwagerina* M.-MACLAY, is considered to belong to *Pseudoschwagerina* s. str. group, as already advocated by some previous authors (ROSS, 1962; IGO, 1964; HAYASAKA and KATO, 1966).

This new species is named in honour of Prof. M. KATO who introduced the author into the study of palaeontology and always gave valuable instructions.

*Association:* This new species is associated with *Quasifusulina tenuissima*, and *Pseudofusulina* sp. sp. indet. *Locality:* Futamata, Yahagi-cho. Collected by Matajiro KATO. Unfortunately exact stratigraphical level is unknown, but probably lower Sakamotosawa series from its association.

### *Pseudoschwagerina schellwieni* HANZAWA

Pl. 11, figs. 1-3; pl. 12, fig. 9

- 1938 *Pseudoschwagerina schellwieni* HANZAWA, pp. 71-72, pl. 4, figs. 1-3.  
 1941 *Pseudoschwagerina schellwieni*, FUJIMOTO, p. 95, pl. 5, figs. 1-6.  
 1941 *Pseudoschwagerina schellwieni*, KAHLER and KAHLER, p. 94, pl. 11, figs. 3, 4.  
 1959 *Pseudoschwagerina* sp., IGO, p. 252, pl. 1, fig. 9.  
 1962 *Pseudoschwagerina schellwieni*, CHISAKA, pp. 535-536, pl. 1, figs. 3-6; pl. 2, fig. 1.  
 1963 *Pseudoschwagerina schellwieni*, CHANG, p. 215, pl. 8, fig. 4; pl. 9, fig. 11.  
 1964 *Pseudoschwagerina (Robustoschwagerina) schellwieni*, IGO, pp. 287-290, pl. 46, figs. 1, 2.  
 1965 *Pseudoschwagerina (Robustoschwagerina) schellwieni*, KANMERA and Mikami, pp. 284-285, pl. 46, figs. 2-5.

1965 *Robustoschwagerina schellwieni*, RAMOVŠ and KOCHANSKY-DEVIDE, p. 23, pl. 8, fig. 2.

1970 *Robustoschwagerina schellwieni*, KOCHANSKY-DEVIDE, pp. 206-207, pl. 14, fig. 1; pl. 16, figs. 1-5.

*Material*: UHR 19464, UHR 13152, and others.

*Lectotype*: KANMERA and MIKAMI chose fig. 1 on pl. 4 by HANZAWA (1938), as lectotype of this species.

*Remarks*: This species is characteristic in possession of two quite distinct growth stage; tightly coiled, *Triticites*-like juvenarium, and abruptly expanded mature stage. It is, of course, one of the representatives of *Robustoschwagerina* though the author did not treat it as independent subgenus here, as the morphological boundary among subgenera of *Pseudoschwagerina* s.l. is difficult to be determined.

*Occurrence*: The occurrence of this species is worthy of note. It is always found without association in limestones with micritic to microsparitic, and often muddy matrix, and the shell is not usually severely eroded.

Genus *Paraschwagerina* DUNBAR and SKINNER, 1936

Subgenus *Paraschwagerina* DUNBAR and SKINNER, 1936

*Type species*: *Paraschwagerina gigantea* (WHITE, 1932)

*Paraschwagerina (Paraschwagerina) sp.*

Pl. 9, fig. 6.

*Material*: UHR 19610-25 etc.

*Remarks*: Although no well oriented and well preserved specimens have been obtained, the present form is assignable to *Paraschwagerina (Paraschwagerina)* from all available informations. In shell form and nature of septal fluting, the present form is close to *Paraschwagerina gigantea* and *Paraschwagerina plena*. KANMERA and MIKAMI's (1965) *Paraschwagerina sp.* from the Southern Kitakami Mountains, is distinguishable from the present form in larger and more inflated shell with more rapid expansion, and more intensely and irregularly fluted septa than the latter. However, as the specimens at disposal are scanty in number and their orientation is not advisable to make more detailed comparison, single illustration is given for future investigation.

Subgenus *Acervoschwagerina* HANZAWA, 1949

*Paraschwagerina (Acervoschwagerina) cf. endoi* HANZAWA

Pl. 7, fig. 1

*Compare with-*

1949 *Paraschwagerina (Acervoschwagerina) endoi* HANZAWA, pp. 208-209, pl. 43, figs. 1-4.



1954 *Paraschwagerina (Acervoschwagerina) endoi*, THOMPSON, pl. 3, figs. 1-5, pl. 4, figs. 8-11.

1955 *Paraschwagerina (Acervoschwagerina) endoi*, MORIKAWA, pp. 78-79, pl. 5, figs. 1-4; pl. 8, fig. 7.

1959 *Acervoschwagerina endoi*, Основы Палеонтологии, pl. 9a, 95, 9b.

1961 *Paraschwagerina (Acervoschwagerina) endoi*, MORIKAWA and ISOMI, pp. 12-13, pl. 4, figs. 1-6.

*Descriptive remarks:* Single oblique section and another incomplete sections were found among numerous thin sections of fusulinids yielded in Kitakami deposited in our University. Unfortunately, as registration was incomplete, exact locality and stratigraphical position are unknown, though undoubtedly it was obtained from Setamai-Sakari district, Southern Kitakami Mountains.

The shell of 7 volutions attains over 13.5 mm in length and 8.0 mm in width, but correct external shell shape is unknown because of absence of axial sections at hand. Height of volution in juvenarium 50 to 120 microns, 900 to 1300 microns in the middle to the outer volution. Spirotheca is alveolar. Its thickness is up to 50 microns in juvenarium, and up to 150 microns in the outermost few volutions.

The present form is characteristic in tightly coiled juvenarium and abruptly expanded middle to mature stage with intensely and irregularly fluted septa. It is closely similar to *Paraschwagerina (Acervoschwagerina) endoi* originally described by HANZAWA (1949) from the central Japan in many respects. The species was also described by MORIKAWA (1955), and MORIKAWA and ISOMI (1961) from Shomaru Pass, Kwantō Mountains, central Japan, and East Lake Biwa, also central Japan, respectively. The Kitakami form especially closely resembles MORIKAWA's form from Shomaru Pass in shell shape and size, natures of coiling, mode of septal fluting. However, final specific assignment of the present form is retained as no sagittal and axial sections have been obtained as to make more precise comparison with each other.

*Paraschwagerina (Paraschwagerina) sp.* described by KANMERA and MIKAMI (1965) from the adjacent Sakamotosawa area differs from the present form in less irregularly fluted septa and less expanded shell of the former.

*Paraschwagerina oblonga* was first described by OZAWA from the Akiyoshi limestone, and subsequently from North China by LEE (1927). These forms somewhat resemble the present Kitakami form. But whole skeletal natures of OZAWA's form is hardly known to us, since his form was based on incomplete specimens. Chinese form differs from the Kitakami form in smaller and less rapidly expanded shell, with less irregular septal fluting. Previously described species of subgenus *Acervoschwagerina* are easily distinguishable from the

present form in shell shape and size mode of septal fluting, and nature of coiling.

It is safely discriminated from all species included in subgenus *Paraschwagerina* in large shell with irregularly fluted septa and abruptly and rapidly expanded shell in middle stage.

*Paraschwagerina (Acervoschwagerina) sp.*

Pl. 6, figs. 8, 9; pl. 9, figs. 4, 5

*Material:* UHR 19610-6, 8, 10, 14 & 20-24.

*Descriptive remarks:* This form is characterized by large inflated fusiform shell with tightly coiled juvenarium and abruptly expanded mature shell, very thin spirotheca, and intensely and irregularly fluted thin septa. Mature shell possessing 6 to 7 volutions attains 12 mm or more in length, and 6.0 to 5.0 mm in width. Height of volution in juvenarium is less than 60 microns, and 320 to 600 microns in mature stage. Spirotheca is very thin, faintly alveolar, gradually thickened outwards, and does not exceed 50 microns in the outermost volution in thickness. Septa are very thin, less than 20 microns in thickness, and irregularly and intensely fluted throughout growth. From the characteristics above described, the present form is included in subgenus *Acervoschwagerina*. All previously described species of *Acervoschwagerina* are readily discriminated from the present form in thin spirotheca and septa, mode of septal fluting, and nature of expansion of the shell. Therefore it may be a new species. But material at hand is more or less deformed, and no ideally cut sections have been obtained, the author will avoid to establish a new species at present. Association and localities are shown in table 3.

Genus *Pseudofusulina* DUNBAR and SKINNER, 1931

*Type species:* *Pseudofusulina huecoensis* DUNBAR and SKINNER, 1931.

*Diagnosis:* Shell is fusiform, moderate to large. The shell is coiled relatively loose all through the growth stage. Proloculus is moderate to large for the size of the shell. Spirotheca is alveolar, comparatively thick. Septa are intensely fluted. Cuniculi are commonly unobservable. Tunnel is singular. Chomata are developed only in inner few volutions.

*Remarks:* The author is of the opinion that "*Pseudofusulina*" *vulgaris* group, and "*Pseudofusulina*" *krafftii* group should be generically separated from *Pseudofusulina* s. str. group. Because the former two are apparently different mainly in shell shape from the latter. This difference may not be superficial, but is considered to be based on the difference in phylogeny of each stock. These stocks may have branched in the lowest Permian or the uppermost Carboniferous from various types of "*Triticites*".

"*Pseudofusulina*" *vulgaris* group is here treated as *Chararoschwagerina*. The author thinks that a new generic name should be given to "*Pseudofusulina*" *krafftii* group in future.

*Pseudofusulina* is distinguishable from *Parafusulina* in general in fusiform shell with more loosely coiled volutions, thicker spirotheca, and less intensely fluted septa.

*Pseudofusulina pseudoanderssoni* SHYOMINA

Pl. 4, figs. 14 & 15

1961 *Pseudofusulina pseudoanderssoni* SHYOMINA, pp. 56-57, pl. 2, figs. 11 & 12.

1961 *Pseudofusulina pseudoanderssoni* forma *latiterminosa* SHYOMINA, p. 57, pl. 2 figs. 13 & 14.

*Holotype*: A specimen illustrated in pl. 2, fig. 11, was designated as holotype of this species by SHYOMINA (1961).

*Material*: UHR 19591-1b, 19591-1a etc.

*Locality*: Loc. 19.

*Remarks*: This form possesses fusiform shell with pointed poles, rather intensely fluted septa, moderately large proloculus, relatively compact coiling throughout the shell, axial fillings, and faintly alveolar spirotheca. From these characteristics, the present form is included in genus *Pseudofusulina*.

It is identical with *Pseudofusulina pseudoanderssoni* SHYOMINA described from the upper Carboniferous *Schwagerina* horizon in the east of Moscow, USSR, in every respect. It may be one of the ancestors of genus *Pseudofusulina* s. str. from its stratigraphical and morphological evidences.

*Pseudofusulina fusiformis* (SCHELLWIEN & DYHRENFURTH)

Pl. 9, figs. 1-3; Pl. 11, fig. 4

1909 *Fusulina vulgaris* var. *fusiformis* SCHELLWIEN and DYHRENFURTH, pp. 165-168, pl. 15, figs. 1-4.

1927 *Fusulina* (*Schellwienia*) *valida* LEE, pp. 69-70, pl. 8, figs. 1-3 & 10.

1948 *Pseudofusulina fusiformis*, THOMPSON, pl. 12, fig. 3.

?1934 *Pseudofusulina tschernyschewi*, CHEN, pp. 52-54, pl. 3, fig. 5, pl. 6, fig. 2; pl. 7, figs. 13-15; pl. 10, figs. 1-11, 15, 17 & 19; pl. 14, figs. 5-10.

1955 *Pseudofusulina fusiformis*, MORIKAWA, pp. 98-99, pl. 13, figs. 1-7.

?1958 *Pseudofusulina vulgaris* var. *fusiformis*, KANUMA, pp. 75-76, pl. 7, figs. 7-11.

1959 *Pseudofusulina fusiformis*, IGO, pp. 246-247, pl. 3, fig. 5.

1959 *Pseudofusulina valida*, IGO, pp. 242-243, pl. 2, figs. 5 & 6.

1961 *Pseudofusulina fusiformis*, MORIKAWA & ISOMI, pp. 19-20, figs. 1-10; pl.

11, figs. 1-10; pl. 7, figs. 11 & 12; pl. 8, figs. 12 & 13, pl. 12, figs. 1-10; pl. 13, fig. 5.

?1961 *Pseudofusulina valida*, MORIKAWA & ISOMI, p. 13, pl. 6, fig. 16.

?1962 *Schwagerina fusiformis*, SUYARI, p. 26, pl. 8, figs. 7-9.

?1962 *Parafusulina fukasensis*, SUYARI, p. 28, pl. 9, figs. 1-4.

1965 *Pseudofusulina fusiformis*, KANMERA & MIKAMI, pp. 301-302, pl. 52, figs. 1-6.

*Remarks:* The present form is quite identical with *Pseudofusulina fusiformis*, restudied by KALMIKOVA (1965) on topotype material.

Compared to the original specimens of *Pseudofusulina tschernyschewi* from Timan, those of *Pseudofusulina fusiformis* possess thicker shell with thicker spirotheca, tightly coiled inner volutions with pointed poles, and smaller proloculus than the former. Upon the above mentioned features, these two species are readily distinguishable with each other.

CHEN (1934) described *Pseudofusulina tschernyschewi* from South China, which should be separated from *Pseudofusulina tschernyschewi* in that the former contains generally thicker shell throughout growth with loosely coiled inner volutions than the latter. In this connection, CHEN's (1934) form from South China is better transferred to *Pseudofusulina valida*.

*Pseudofusulina valida* is distinguished from typical *Pseudofusulina fusiformis* only in the thinner spirotheca of the former. However, hithertoknown *Pseudofusulina fusiformis* well shows that the wall thickness is variable from specimen to specimen. At this consequence, it makes us difficult to discern these two forms. Therefore the author treats the above two forms as conspecific with each other as NOGAMI (1961) has once advocated.

#### *Pseudofusulina* sp. A.

Pl. 4, figs. 4 & 5

1965 *Pseudofusulina* sp., KANMERA and MIKAMI, pp. 304-305, pl. 45, figs. 6-9; pl. 50, fig. 8.

*Material:* UHR 19590-4, UHR 19592-6b (both are illustrated) and others.

*Localities:* Loc. 8, 22 etc.

*Remarks:* This form is characteristic in elongate shell with large proloculus, rather irregularly fluted septa in lateral portions. It well coincides with *Pseudofusulina* sp. from Sakamotosawa, southern Kitakami Mountains, described by KANMERA and MIKAMI (1965). The former seems to possess smaller shell with smaller proloculus than the latter. The latter was produced from the uppermost Sakamotosawa series (upper subformation "Sd", by KANMERA and MIKAMI), but on the contrary the former was yielded from lower horizon.

KANMERA and MIKAMI suggested that their form described as *Pseudofusu-*

*lina* sp. might be a new species though they did not establish a new species because of insufficient material. The author's material is also too poor in number, in state of preservation and orientation for detailed observation and comparison.

*Pseudofusulina* sp. B

Pl. 1, figs. 12-18

*Compare with-*

1967 *Schwagerina* sp. B, Ross, p. 724, pl. 83, fig. 1; pl. 84, figs. 1-6.

1970 *Schwagerina rowetti* PETOCZ, pp. 50-53, pl. 2, figs. 19-27.

*Material studied:* UHR 19217-1, 2 3, 5, 6, 14a & 14b.

*Locality:* Northwest of Nakadaira, Yahagi-cho (Loc. 79), collected by Masaru TAKAIWA.

*Description:* Shell is moderate in size, fusiform with weakly concave midportion. Mature shell possesses 7 to 8 volutions, and 6.5 mm in length, 2.4 mm in width and gives form ratio of 2.7. The shell is comparatively tightly coiled assuming fusiform in shape in inner volutions but gradually loosely coiled towards outer volutions which take thick fusiform shell with slightly concave mid-portion.

Proloculus ranges from 170 to 210 microns in outside diameter.

Spirotheca is alveolar. Thickness of the spirotheca is 10 to 20 microns in the first two volutions, then rapidly increases in thickness up to the fifth volution, but nearly equal beyond it, being about 80 microns.

Septal fluting is intense. Septal folds are relatively narrow and high, often rectangular with rounded upper surface near to the ceiling of the chamber.

Number of the septa is counted 10 to 20 in inner volutions, and 25 to 30 in outer volutions.

Chomata are lacking, but instead pseudochomata are present in inner volutions. Tunnel is about one-half the height of the chamber.

Axial fillings infill the pole regions of inner three to four volutions.

*Remarks:* Ross (1967) described *Schwagerina* sp. B, to which the present form somewhat resembles, from Alaska. Compared to Ross' form the present one contains smaller proloculus, more loosely coiled inner volutions than the former. But still, in thickly fusiform shell with concave mid-portion, thin fusiform shell of immature stage nature of the septal fluting, both forms are considered to be closely allied with each other. The stratigraphic occurrence may suggest that the Kitakami form is an advanced form of the Alaska form.

Lately PETOCZ (1970) described a new species, *Schwagerina rowetti* from the lower Permian in the central Alaska range. The present form is quite similar to it in many respects except for well developed chomata of the former. Future

investigation on morphological relationships of these two forms is needed.

The present form, possessing thick fusiform shell with dense axial fillings and thick spirotheca may have given rise to one of "*Pseudofusulina*" *krafftii* group.

*Pseudofusulina* aff. *japonica* (GÜMBEL)

Pl. 3, figs. 3-6; pl. 10, fig. 4?

1965 *Pseudofusulina* sp. aff. *P. japonica*, KANMERA and MIKAMI, pp. 303-314, pl. 53, figs. 1-6.

*Localities*: Loc. 8, 14, 18, 19, 22, 24, 61, 74, and 84.

*Remarks*: A number of specimens at the author's hand are quite identical with *Pseudofusulina* sp. aff. *japonica* described by KANMERA and MIKAMI (1965) from the Sakamotosawa area in every respect. As stated by them, this form is not conspecific with *Pseudofusulina japonica* (GÜMBEL) because of having more inflated shell with thicker spirotheca throughout the shell of the former. An illustrated specimen (pl. 3, fig. 4) obtained from the middle Sakamotosawa series quite agrees with a KANMERA and MIKAMI's illustration in relatively small, inflated shell. They appear slightly different from the other specimens figured in the plate under the same name. The former may be one of the primitive forms of the latter.

The Sakamotosawa form was yielded from the upper Sakamotosawa series, whereas the present form stratigraphically falls down to the middle Sakamotosawa series, and extends upward as high as to the top of the Sakamotosawa series.

*Pseudofusulina*? *jenkinsi* THORSTEINSSON, 1960

Pl. 2, fig. 18

1960 *Schwagerina jenkinsi* THORSTEINSSON, p. 25, pl. 4, figs. 9-12; pl. 5, figs. 1-4.

1967 *Schwagerina jenkinsi*, ROSS, pp. 722-723, pl. 85, figs. 11-17; pl. 86, figs. 1-7.

*Material*: One axial section (UHR 19217-17a) and some ill-oriented specimens are available for study.

*Locality and Collector*: Loc. 79, collected by Masaru TAKAIWA.

*Description*: Shell is moderate in size, elongate fusiform with pointed poles. The illustrated specimen possesses 6 volutions and is estimated 10 mm long and 2.1 mm wide with form ratio of about 4.8.

Two distinct growth stages are observable; infant stage, possessing tightly coiled fusiform shell with sharply pointed poles, weakly developed axial fillings and thin spirotheca, adult stage has slender fusiform shell with loose coiling,

less pointed poles, irregularly and highly fluted septa, and coarsely alveolar spirotheca. Height of volution from the first to the sixth volution in the same illustrated specimen gives, 0.04, 0.07, 0.10, 0.17, 0.24, and 0.31 mm respectively.

Proloculus is small, measuring 140 microns in the same figured specimen.

Spirotheca is coarsely alveolar especially in mature stage. In inner volutions spirotheca is very thin, but abruptly thickened in the succeeding volutions. The thickness of the spirotheca from the first to the sixth volution is, 0.015, 0.02, 0.035, 0.055, 0.070 and 0.080 mm respectively.

Septa are thin, measure at most 20 microns in thickness, and highly and irregularly fluted throughout growth. The folding crest reaches the ceiling of the chamber. Cuniculi is absent. The number of the septa can not be counted owing to the absence of sagittal sections, but 18 to 22 septa are counted in the outermost few volutions in incomplete sections.

Rudimentary chomata (or pseudochomata) are present in immature stage.

Axial fillings are faintly developed in inner few volutions.

*Remarks:* This form well coincides with *Schwagerina jenkinsi* THORSTEINSSON from Grinnel Peninsula, Arctic Archipelago, and Alaska, North America, in every skeletal characteristics. Alaska form is associated with *Boultonia yukonensis* ROSS, and *Schwagerina hyperborea* (SALTER) from which the present Kitakami form is distinguished in containing smaller shell with fewer volutions, lower lateral slopes, thinner spirotheca, and comparatively loosely coiled outer volutions.

With regard to the generic assignment of this species, THORSTEINSSON's (1960) and ROSS' (1967) opinions are difficult to support. Because *Borelis princeps* EHRENBURG, 1842, being restudied by DUNBAR & SKINNER (1936), and now accepted as the type species of genus *Schwagerina* MÖLLER, 1877, contains inflated fusiform shell, which obviously differs from *Schwagerina jenkinsi* THORSTEINSSON that possesses elongate fusiform shell. Therefore this species should be separated from genus *Schwagerina*.

Whereas, in elongate shell with coarsely alveolar wall in outer volutions and intensely fluted septa without cuniculi, this species approaches genus *Pseudofusulina*. But the former is distinguished from the latter in possessing tightly coiled inner volutions, small proloculus and thin spirotheca in inner volutions. Future investigation on generic assignment of this species is, therefore, requested.

*Pseudofusulina* aff. "*Triticites*" *pseudosimplex* CHEN

Pl. 6, figs. 6, 7

1934 *Triticites pseudosimplex* CHEN, pp. 25-26, pl. 1, figs. 19 & 20.1961 "*Triticites*" *pseudosimplex*, NOGAMI, pp. 172-174, pl. 2, figs. 1-4.*Material*: UHR 19593-1 N ~3.*Locality*: 16.

*Description*: Shell is medium in size, cylindrical. Mature shell of  $6\frac{1}{2}$  to  $7\frac{1}{2}$  volutions is 6.7 to 8.6 mm long, 2.1 to 3.0 mm wide, with form ratio of 2.9 to 3.2. The shell coiled tightly and uniformly. Height of volution in an illustrated typical specimen is, 0.09 in the first, 0.10 in the second, 0.12 in the third, 0.17 in the fourth, 0.18 in the fifth, 0.205 in the six, and 0.22 mm in the seventh volution.

Proloculus is medium in size, measuring 0.27 to 0.33 mm.

Spirotheca is alveolar, being gradually thickened towards outward; 0.025 in the first, 0.055 to 0.060 in the forth, and 0.07 to 0.08 mm in the sixth volution.

Septa are weakly fluted in its lower margin, whereas almost plain in mid portion. Number of septa is counted as 12? in the second, 14 in the third and the fourth, 16 in the fifth, 17 in the sixth and 18 in the seventh volution.

Levee like chomata are found only in the first or feebly in the second volution.

*Remarks*: This form is in every point identical with *Triticites pseudosimplex* from China described by CHEN, and "*Triticites*" *pseudosimplex* described by NOGAMI (1961) from Atetsu plateau. Although original specimens are slightly tangentially cut, we can obtain the full specific informations through NOGAMI's specimens.

NOGAMI placed his specimens under *Triticites* with query and he also regarded this species as phylogenically transitional form between *Triticites* and *Parafusulina*. The author thinks that it should be better transferred to *Pseudofusulina* considering cylindrical shell with relatively large proloculus, loose coiling, thick spirotheca, and ill-development of chomata compared to *Triticites*.

*Occurrence*: This species is rarely found from locality 16 in a lower tributary of the Kanokurasawa being associated with "*Pseudofusulina*" *krafftii*, *Parafusulina motoyoshiensis*, *Misellina otakiensis*, *Schubertella* sp. and *Yatsenia kabayamaensis*.



*"Pseudofusulina" krafftii* (SCHELLWIEN and DYHRENFURTH)

Pl. 6, figs. 1-5

1970 *Pseudofusulina krafftii*, CHOI, pp. 337-339, pl. 10, fig. 4 (for further synonymy refer this article).

1971 *Pseudofusulina krafftii*, CHOI and FUJITA, pp. 371-372, pl. 1, figs. 6 & 7.

1972a *"Pseudofusulina" krafftii*, CHOI, pl. 2, figs. 4-6 (without description).

*Remarks:* This species is abundantly found from many localities and horizons ranging from the middle Sakamotosawa series to the lower Kanokura series.

As was stated in the foregoing pages, the author thinks *"Pseudofusulina" krafftii* group should be generically separated from genus *Pseudofusulina* s. str., because *Pseudofusulina huecoensis*, the type species of *Pseudofusulina*, is apparently different from *"Pseudofusulina" krafftii* in essential characteristics, i.e. shell form, nature of coiling, thickness of the spirotheca, and size of proloculus. *"Pseudofusulina" krafftii* group may compose a distinct phylogenetical stock independent from *Pseudofusulina* s. str. in the lower to the middle Permian.

Genus *Parafusulina* DUNBAR and SKINNER, 1931

*Type species:* *Parafusulina wordensis* DUNBAR and SKINNER, 1931.

*Parafusulina* aff. *mccloudensis* SKINNER and WILDE

Pl. 15, figs. 1-5; pl. 19, fig. 3

1956 *Parafusulina imlayi*, NODA, pp. 9-10, pl. 2, figs. 1 & 2.

*Compare with-*

1965 *Parafusulina mccloudensis* SKINNER & WILDE, pp. 90-91, pl. 60, figs. 6-11.

1966 *Schwagerina jeffordsi* SKINNER & WILDE, pp. 6-7, pl. 2, figs. 2-6; pl. 3, fig. 1

*Localities:* A number of specimens have been obtained from localities; 131(?), 132, 134, 144 & 156.

*Description:* Shell is large, cylindrical to subcylindrical, and possesses slightly concave lateral slopes with bluntly rounded poles and arcuate axis of coiling. Mature specimens possess ten or more volutions. The shell of nine volutions is estimated to be 14 to 21 mm long, and 4.0 to 5.0 mm wide, with variable form ratio of 2.8 to 5.3.

Expansion of the shell is rather small in inner two or three volutions, but comparatively rapid in succeeding few volutions. Beyond the sixth or the seventh volution it becomes nearly constant. The height of volution in an illustrated specimen (pl. 15, fig. 1) from the first to the eighth volution is, 0.14,

0.16, 0.16, 0.22, 0.22, 0.25, 0.27 and 0.26 mm respectively. In inner few volutions the shell is ellipsoidal, but towards outer it gradually takes subcylindrical shape. Form ratio of volution of the above referred illustrated specimen from the first to the eighth volution is 2.5, 3.4, 4.4, 4.5, 6.7, 6.0, 5.4 and 5.3, respectively.

Proloculus is spherical with outside diameter of 0.30 to 0.38 mm.

Spirotheca is composed of tectum and keriotheca. The spirotheca looks thickened by secondary mineralization, and it becomes thicker towards outward; inner few volutions 17.5 to 25.0 microns, and outer 25.0 to 60.0 microns or more.

Septa are regularly and narrowly fluted throughout the length of the shell as to make distinct cuniculi, but slightly gentle in mid-portion of the shell. The folding crests in cross section are commonly rounded or often pointed. The number of the septa gradually increases towards outer volutions; 10 to 19 from the first to the fifth volution, and 30 to 40 in mature stage.

Axial fillings are weakly present, being confined within narrow axial regions of the first to the third volution.

Chomata are not present throughout the shell.

*Remarks:* The present form is characteristic in possessing large subcylindrical shell with narrowly and regularly fluted septa and weak development of axial fillings.

This form somewhat resembles *Parafusulina?* sp. described by KANMERA from the Kuma formation in external shell shape, nature of coiling of the shell and the mode of development of axial fillings. The latter, however, possesses the shell with thinner spirotheca and septa. Moreover the nature of the septal fluting is obviously different with each other.

The present form is also similar to *Fusulina multiseptata* described by SCHELLWIEN in 1898 in general shell shape, character of fluting, mode of development of axial fillings. But the latter is distinguishable from the former in possessing smaller and shorter shell with fewer volutions, and more numerous septa than the former.

Recently LEVEN (1967) described *Parafusulina multiseptata* with two new subspecies from Pamirs, namely *Parafusulina multiseptata multiseptata* and *Parafusulina multiseptata crassispira*. At a glance, there exists close similarity between the Pamir and the present Kitakami form. But after a detailed comparison, Kitakami form reveals comparatively cylindrical, and regularly and narrowly fluted septa. Therefore these two forms are considered not conspecific.

The present form is distinguished from *Parafusulina tomuroensis* MORIKAWA and TAKAOKA, from Tomuro, Tochigi prefecture, in nature of

general shape and expansion of the shell, fluting of septa, and weak development of axial fillings.

*Parafusulina mizutanii* MORIKAWA, *Parafusulina undulata* CHEN, *Parafusulina subextensa* CHEN, and *Parafusulina rothi* DUNBAR & CONDRA somewhat resemble the present form. But all of these forms are readily distinguishable in many respects from the Kitakami form.

Lately, SKINNER & WILDE described a new species called *Parafusulina mccloudensis* from Northern California. The present form seems to be closely allied to it in general shell shape, septal fluting, mode of development of axial fillings. But the former generally contains the shell with notably curved axis of coiling than the latter. SKINNER & WILDE distinguished *Schwagerina jeffordsi* from *Parafusulina mccloudensis* because the latter provides chomata and no cuniculi. Nevertheless, the writer thinks it may be probable that these differences are all of intra-specific value.

M. NODA (1956) described *Parafusulina imlayi* yielded from Touman formation (Twuman series in the present terminology) developed in North Korea. His specimens, however, apparently differ from the original specimen of *Parafusulina imlayi* described from Sonora, Western Texas, by DUNBAR because of its less inflated shell with more rounded poles, instead it is conspecific with the present form in all available features.

***Parafusulina* cf. *multiseptata* (SCHELLWIEN)**

Pl. 10, figs. 1-3, 5

*Compare with-*

1898 *Fusulina multiseptata* SCHELLWIEN, pp. 247-248, pl. XVIII, figs. 1-4.

non. 1912 *Fusulina multiseptata*, DEPRAT, pp. 16-17, pl. IX, figs. 12-15.

1932 *Parafusulina multiseptata*, CHEN, pp. 86-87, pl. XI, figs. 2-4; pl. 12, figs. 2-4; pl. 13, figs. 1-6.

1965 *Pseudofusulina multiseptata*, RAMOVŠ and KOCHANSKY-DEVIDÉ, p. 16, pl. 6, fig. 1.

1967 *Parafusulina multiseptata multiseptata*, LEVEN, p. 162, pl. XVII, fig. 5; pl. XVIII, fig. 1.

1967 *Parafusulina multiseptata crassispira*, LEVEN, p. 162, pl. XVIII, figs. 3 & 5.

*Material:* UHR 19462, UHR 19621 and UHR 19615.

*Localities:* All specimens were obtained in Kanokurayama area. Loc. 24, 30 and 52.

*Description:* Shell is large fusiform with bluntly rounded pole regions. Mature shell possesses 7 to 8 volutions, and 12 to 15 mm long and 3.5 to 4.5 mm wide with form ratio of about 4.0.

The shell is coiled rather loosely and expands gradually. Height of volution from the first to the seventh volution in a sagittal section 0.13, 0.16, 0.20, 0.23, 0.29, 0.32, and 0.36 mm, respectively.

Proloculus is rather large for the size of the shell. Its outside diameter attains 0.45 mm.

Spirotheca is composed of tectum and coarse alveoli. It is gradually thickened towards outward; 0.020 to 0.025, in the first and 0.080 to 0.10 mm in the outermost volution.

Septa are numerous and intensely fluted especially in its lower portion as to form cuniculi. Their folding crest is rounded. The number of septa is counted in a typical sagittal section from the first to the sixth volution, 12, 24, 31, 31, 30 and 35, respectively.

Tunnel angle is not exactly measured, but may be 40° to 50° in the middle volutions of the shell.

Axial fillings seem to be almost lacking.

*Remarks:* The present form is identical with *Fusulina multiseptata* SCHELLWIEN in shell shape, size, expansion of the shell, thickness of the spirotheca. But unfortunately, no axial sections have been obtained in the former. Therefore inner natures of the former are not precisely known. So, the writer would like to reserve its final determination until more well preserved and well oriented specimens are gained.

*Fusulina multiseptata* by DEPRAT from Yun-nan is not conspecific with the original *Fusulina multiseptata* by SCHELLWIEN because the former possesses comparatively inflated fusiform shell with sharply pointed poles and distinct phrenotheca.

*Parafusulina* aff. *gigantea* obtained from the limestone pebble of the basal conglomerate of the Kanokura series at Kotsubosawa (Loc. 60), Yokotacho, Rikuzentakada City, and described in this article is somewhat similar to the present form. But the former has larger shell with more rapid expansion than the latter.

*Parafusulina* aff. *gigantea* (DEPRAT)

Pl. 13, figs. 1-3

*Compare with-*

1913 *Fusulina gigantea* DEPRAT, pp. 29-30, pl. 4, figs. 1-10.

1925 *Schellwienia gigantea*, OZAWA, pp. 32-33, pl. 4, fig. 9.

1935 *Pseudofusulina gigantea*, GUBLER, pp. 91-92, pl. 2, figs. 4, 5, 8 & 9; pl. 3, fig. 4.

1959 *Parafusulina gigantea*, TORIYAMA, and SUGI, pp. 19-21, figs. 1-5.

*Material:* UHR 19305-1 ~ 13.

*Locality:* Loc. 60.

*Remarks:* Gigantic specimens of *Parafusulina* are at hand. One of the largest specimen amongst them attains as large as 17 mm in length and 5.0 to 6.0 mm in width.

The present form is closely similar to *Fusulina gigantea* in large elongate fusiform shell with rapid expansion, rather strongly fluted septa as to form fine cuniculi, and thick spirotheca except for slightly smaller proloculus of the former. But unfortunately no specimens at the author's hand are sufficient enough to make more detailed comparison with it.

*Parafusulina motoyoshiensis* (MORIKAWA)

Pl. 4, figs. 1-3, 6?; pl. 10, fig. 6

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

1962 *Parafusulina granum-avenae*, CHISAKA, pp. 540, pl. 3, figs. 14-20; pl. 8, fig. 9?, 10 & 11.

1963 *Schwagerina nakazawae* NOGAMI pp. 63-64, pl. 3, figs. 13-17.

1970 *Parafusulina motoyoshiensis*, CHOI, pp. 340-341, pl. 9, figs. 1-12; pl. 12, figs. 1, 3, 5 & 7.

*Material:* UHR 19590-1, 2a, 2b, 2c, 2d, & 4, UHR 19593, UHR 19610, UHR 19618, and 19666 etc.

*Localities:* Locs. 8, 27, 16, 18 and 77.

*Description:* Shell is elongate fusiform, medium in size, with bluntly rounded poles. Mature shell of  $5\frac{1}{2}$  to 6 volutions is 9.8 to 11.0 mm long and about 2.0 mm wide with form ratio of 4.8 to 5.5.

The shell expands uniformly throughout growth. Height of volution is 0.05 to 0.06 mm in the first, 0.19 to 0.23 mm in the outermost volution.

Proloculus is rather large for the size of the shell. It ranges 0.3 to 0.45 mm in diameter.

Spirotheca is finely alveolar. Its thickness gradually increases towards outward; 0.010 mm in the first, 0.010 to 0.022 mm in the second, 0.020 to 0.040 in the third, 0.035 to 0.06 mm in the fourth, 0.04 to 0.09 mm in the outer volutions.

Septa are comparatively weakly but irregularly fluted; being confined within its lower portion. Number of septa in a sagittal section is counted as 7 in the first, 12 in the second, 15 in the third and 19 in the fourth volution.

Chomata are not found throughout volutions.

Tunnel is low and broad. The tunnel angle in an axial section in the second volution is measured as about  $45^\circ$ .

Axial fillings are weakly developed in narrow pole regions of inner few

volutions.

*Remarks:* The present form is closely similar to *Parafusulina motoyoshiensis* originally described by MORIKAWA (1960) from Iwaizaki, Southern Kitakami Mountains and recently by the author (1970b), in every respect. In general, however, the former provides less intensely fluted septa, thinner spirotheca and fewer volutions than the latter. Since the former yields from lower Permian, and the latter from the middle Permian, the former may be a direct ancestor of the latter.

CHISAKA's *Parafusulina granum-avenae* from the Maiya Town, Southern Kitakami Mountains may be identical with *Parafusulina motoyoshiensis*, though the former is more or less deformed and poorly preserved as to make more detailed comparison with the latter.

Quite recently DOUGLASS (1970) described *Monodiexodina kattaensis* from Southern Pakistan. He well demonstrated broad variation in shell form and size, proloculus diameter, and mode of septal fluting of the species. The present form appears very close to its thick form group. However, the former still contains in general more irregularly fluted septa than the latter, which definitely makes possible to distinguish the present form from the genus *Monodiexonina*.

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

*Type species:* *Chusenella ishanensis* HSÜ, 1942

*Generic diagnosis:* Shell is moderate in size inflated fusiform with sharply pointed poles and concave lateral portions. Inner volutions are tightly coiled, but outer ones are highly expanded. Spirotheca is composed of tectum and coarse alveoli. Septa are almost unfluted in inner few volutions, but intensely and comparatively regularly fluted in the outer volutions. Chomata are small, confined within juvenile stage. Chomata are feebly developed in inner volutions.

*Chusenella* sp.

Pl. 16, fig. 9

*Material:* UHR 19314-17 & 20.

*Locality:* 132.

*Remarks:* An axial section and a tangential section are at hand. From all available features, the present form is safely included in genus *Chusenella* above stated. Since material is too scanty and ill-preserved, detailed study on the present form is given to another occasion.

Family Verbeekinidae STAFF & WEDEKIND, 1910

Subfamily Verbeekiniinae 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 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.

*Pseudodoliolina gravitesta* KANMERA

Pl. 17, figs. 7 & 8; pl. 18, figs. 1-4

1954 *Pseudodoliolina pseudolepida gravitesta* KANMERA, pp. 12-14, pl. 2, figs. 1-6.

1954 *Pseudodoliolina* n. sp.?, KANMERA, pp. 14-15, pl. 2, figs. 7 & 8.

1954 *Verbeekina?* n. sp., KANMERA, pp. 15-16, pl. 2, fig. 9.

1956 *Misellina* sp. a, NODA, p. 12, pl. 3, figs. 4 & 5; pl. 4, fig. 1c.

1956 *Misellina* sp. b, NODA, pp. 12-13, pl. 1, figs. 11, 15b, 16; pl. 4, fig. 1a.

1960 *Pseudodoliolina pseudolepida gravitesta*, CHISAKA, p. 246, pl. 4, figs. 1-6.

1961 *Metadoliolina gravitesta*, ISHII & NOGAMI, pp. 163-164, pl. 25, figs. 1-4.

1962 *Pseudodoliolina pseudolepida gravitesta*, CHISAKA, pp. 545-546, p. 8, figs. 5 & 6.

1962 *Pseudodoliolina pseudolepida gravitesta*, SUYARI, pp. 32, pl. 12, figs. 8 & 9.

1963 *Pseudodoliolina pseudolepida*, HANZAWA & MURATA, p. 23, pl. 20, figs. 1-5.

*Lectotype:* KANMERA's (1954) pl. 2, fig. 1 was chosen by ISHII and NOGAMI (1961) as the lectotype.

*Localities:* 102, 104, 107, 112, 113, 131-135, 138, 141, 144, 153, and 156.

*Description:* Several well oriented, and numerous incomplete specimens have been obtained. Since all of them are more or less deformed and moreover missed especially in outer volutions, the following measurements are mainly based on some well oriented specimens which seem relatively free from deformation.

Shell is large cylindrical with rounded poles. Mature shell has 17 to 18 volutions with length of 10.6 to 16.4 mm and width of 5.4 to 6.2 mm, giving form ratio of 1.7 to 2.7.

Coiling of the shell is uniform throughout the shell. The shell is subspherical to ellipsoidal in inner few volutions, then gradually becomes cylindrical. Height of volution from the first to the sixteenth volution of well oriented three axial specimens is, 0.069, 0.079, 0.085, 0.090, 0.097, 0.121, 0.125, 0.137, 0.137, 0.160, 0.170, 0.185, 0.201, 0.230, 0.253, and 0.253 mm respectively in average. Form ratio of volution regularly increases from the first to the tenth volution, maintaining the same value from the tenth to the fourteenth, then decreases toward outermost volution. The typical two axial specimens give the form ratio from the first to the seventeenth volution in average, 1.15, 1.25, 1.40, 1.50, 1.60, 1.70, 1.75, 1.90, 1.95, 2.05, 2.05, 2.05, 2.05, 2.05, 2.00, 1.90 and 1.77, respectively.

Proloculus is small with the outside diameter of 0.16 to 0.29 mm.

Spirotheca is clearly differentiated throughout volutions, tectum, transparent layer, lower and upper tectoria. In some form fine alveolar structure is visible in outer volutions. Its thickness gradually increases towards outward, and measures from the first to the twelfth volution, 8, 9, 11, 13, 14, 16, 17, 17, 18, 20, 23, and 24 microns respectively.

Septa are straight, numerous. Their lower portion is remarkably thickened by dense material with the consequence of forming pendant-club shape. Septal counts of volution is not strictly known on account of the absence of ideal sagittal sections. But it gradually increases towards outer volutions; 10 to 20 in inner, and up to 50 or more in outermost few volutions.

Parachomata are distinct, broadly based and narrowly spaced. They are  $\frac{1}{2}$  to  $\frac{1}{4}$  the height of the chamber in inner few volutions where the shell is subspherical to ellipsoidal, gradually becoming coarsely spaced. In shape they are triangular, and low and small, but become narrowly pointed in outer volutions.

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

*Remarks:* The present thick cylindrical specimens are quite identical in essential characters with *Pseudodoliolina pseudolepida gravitesta* KANMERA, although the latter seemingly possesses smaller shell, fewer volutions, which may be caused by missing of outer few volutions.

From Maiya district in the Kitakami Mountains, CHISAKA described *Pseudodoliolina pseudolepida gravitesta* in 1962. Though his specimens are too much deformed to make detailed comparison with mine, all available features safely reveal close relation between them.

Recently SOSNINA (1965) examined abundant material from the Shihote-Aline where DUTKEVICH reported *Doliolina lettensis* (SCHUBERT), and she, correcting the previous description, proposed a new species, *Metadoliolina dutkevitchi*. She also tried to divide it into two groups; one of them



comparatively large cylindrical shell with loose coiling, and the other slender elongate shell with tight coiling. The present form, however, obviously differs from the Sihote Aline form in shell shape, expansion of the shell, development of parachomata, and the structure of the spirotheca.

*Pseudodoliolina kanokuraensis* sp. nov.

Pl. 17, figs. 1-5

*Material:* UHR 19282-1 ~ 45 and others.

*Localities:* 102 and 113.

*Specific diagnosis:* Very close to *Pseudodoliolina gravitesta*, but is prominent in possessing especially well developed bar-like parachomata in outer few volutions.

*Description:* Shell is medium in size, fusiform to ellipsoidal with nearly straight axis of coiling, and bluntly rounded poles. Mature shell possesses fifteen or more volutions. Outer four to six volutions are completely or partly missed. Shell size is estimated to attain in fifteen volution of well preserved two specimens, 7.4 to 9.2 mm in length and 4.2 to 4.9 mm in width with form ratio of 1.76 to 2.0.

The shell is spherical to subspherical in inner three to four volutions, then gradually expanding towards poles. It is ellipsoidal in median stage and attains fusiform to ellipsoidal in the tenth to the eleventh volution. Form ratio of volution of half length to radius vector from the first to the eleventh volution is, 1.13, 1.28, 1.39, 1.47, 1.52, 1.63, 1.79, 1.90, 2.02, 2.12 and 2.13 respectively in average of five specimens. Expansion in width is slow and regular in inner to medial volutions. On the contrary in the ninth to the eleventh volution, the shell abruptly expanded. Average height of volution from the first to the twelfth volution in six specimens, 0.053, 0.07, 0.08, 0.87, 0.10, 0.11, 0.125, 0.138, 0.144, 0.172, 0.18, and 0.20 mm, respectively.

Proloculus is spherical and measured 0.22 to 0.26 mm in outside diameter.

Spirotheca is differentiated into tectum, diaphanotheca in which alveolar structure is partly observed, and lower tectorium. The tectum is coated with dense dark layer continuous with parachomata. Thickness of the spirotheca is nearly uniform in all stages but slightly increases towards outer volutions; 7.5 to 10 microns in inner, and 10 to 12.5 microns in outer volutions.

Development of parachomata is distinctly divided into two stages. The parachomata in younger stage of inner eight to ten volutions is rectangular shaped in which they are comparatively broad and rounded in their surface. The parachomata of later stage are really strange. They are very thin, bar-like shape and reach the top of the chamber. The bar-like parachomata first appear being restricted within midportion of the shell. In most case, outer volutions

where the bar-like parachomata developed are disappeared caused by erosion.

Septa are straight and their number in each volution is counted from the first to the ninth volution, 9, 10, 14, 17, 18, 18, 21, 22, and 23, respectively in average. In every specimen number of the septa always slightly decreases in the fifth or the sixth than the proceeding volution.

*Remarks:* This new species is characteristic by the development of slender bar-like parachomata in outer volutions. The observed fact of thinning out of parachomata can never be caused by ill-preservation. Because their development is so regular and they always appear suddenly from the ninth to the eleventh volution, and never seen in younger stage. Furthermore, this nature of the parachomata well agrees with the general evolutionary trend of parachomata in genus *Pseudodoliolina*.

***Pseudodoliolina elongata* CHOI**

Pl. 17, fig. 6

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

1970b *Pseudodoliolina elongata* CHOI, pp. 347-348, pl. 14, figs. 1-6.

*Material:* UHR 19282-1 and others.

*Locality:* 102.

*Remarks:* This species is typical in its large elongate cylindrical shell with thin and slightly rugose spirotheca. Outer volutions of an illustrated axial section is thoroughly missing.

Subfamily Neoschwagerininae DUNBAR & CONDRA, 1928

Genus *Colania* LEE, 1933, emend. OZAWA, 1970

*Type-species:* *Colania kwangsiana* LEE, 1933, pl. 9, fig. 3.

*Generic diagnosis:* Shell is large elongate to inflated fusiform with bluntly rounded poles. Proloculus is comparatively large. Spirotheca is thin, composed of tectum and keriotheca. Regularly and broadly spaced, thin transverse septula occur throughout the shell. In the highly specialized forms, at most two sets of secondary transverse septula occur in the outermost volutions. Axial septula are well developed throughout the length of the shell; 8-51. Foramina are numerous.

*Remarks:* The Genus *Colania* was first established by J. S. LEE (1934), *Colania kwangsiana* (pl. 4, fig. 3) as the type. The figured specimen as *Colania kwangsiana*, however, was slightly obliquely cut unfortunately and its description seems to have been somewhat insufficient and inadequate. Therefore genus *Colania* has been long unknown about its true nature, and it has been placed as being synonymous with *Lepidolina* (M. L. THOMPSON, 1948, with query; D. M. RAUSER-CHERNOUSOVA and A. V. FURSHENKO in ОСНОВЫ

Палеонтологии, in 1959 also with query; M. L. THOMPSON in *Treatise*, 1964), *Yabeina* (C. O. DUNBAR & J. SKINNER, 1937; C. O. DUNBAR & L. HENBEST, 1942; S. HANZAWA & M. MURATA, 1963), or *Neoschwagerina* (J. C. SHENG, 1963). But A. D. MIKLUHO-MACLAY, (1963) regarded *Clania* to be valid placing stress on the nature of the septa and septula from inner towards outer volutions as originally stated by LEE (1933), although he considered that *Colania* possesses closer characteristics to *Lepidolina* rather than to *Yabeina*. SHENG (1963), redescribed the type species of the genus *Colania* with a number of good illustrations, although he transferred the genus *Colania* into the genus *Neoschwagerina*. Through SHENG's illustrations and description, the morphological characteristics of *Neoschwagerina kwangsiana* became to be more well understood in detail.

On the other hand, genus *Gifuella* was established by HONJO in 1959, *Gifuella gifuensis* as the type species. As to the characteristic feature of this genus, he especially placed stress on rather broadly spaced and ill-developed nature of primary and secondary transverse septula. MINATO and HONJO (1959) studied nature of axial septula of the genus *Gifuella* more in detail, and definitely distinguished this genus from both *Minoella* HONJO, and *Neoschwagerina* YABE in this concern. Phylogenetical position of the genus *Gifuella* was later on further discussed by HASEGAWA (1965). In a brief review of the previously proposed species belonging to either *Yabeina* or *Lepidolina*, he concluded that two bioseries among the higher forms of Neoschwagerinids to be distinguishable as *Neoschwagerina-Yabeina* bioseries, and *Gifuella*-*"Lepidolina"* bioseries, although this view is slightly different from the phylogenetic trees compiled by MINATO and HONJO (1959).

HASEGAWA also considered *Colania* as synonymous with *Gifuella* and employed the latter name for this group. This opinion was supported by T. OZAWA (1970), though he used the former name because of priority.

Indeed, one may notice close similarity between *"Neoschwagerina" kwangsiana* and *Gifuella douvillei* by SHENG's paper. Notwithstanding of this, MINATO and HONJO (1965) studied the nature of transverse septula of *"N."* *kwangsiana* through photographs of plesiotype specimen sent by SHENG to them. According to them, changing nature of transverse septula from the inner towards the outer volutions, and the similarity between *Gifuella* and *Colania kwangsiana* in the mature stage may be only superficial. They also held a view, *Colania kwangsiana* might be an advanced form from *Neoschwagerina craticulifera* either in form of shell or nature of septula. They accordingly regarded that LEE's genus *Colania* was still valid.

However, the author is now inclined to HASEGAWA and OZAWA's opinion to regard *Gifuella* as synonymous with *Colania*. Since the latter has priority, to

employ the latter name is considered to be most reasonable.

*Colania kotsuboensis* sp. nov.

Pl. 16, figs. 1, 6, 7 & 10

*Material:* UHR 19313, UHR 19316, UHR 19321, UHR 19324 and UHR 19327.

*Localities:* 108, 131-134, 136, 138, 141.

*Description:* Shell is fusiform with bluntly pointed poles. Actual shell size of full grown shell is unknown owing to missing of outer volutions. But ordinarily 14 to 15 volutions are detectable, and about 10.0 to 11.0 mm long and 4.5 to 5.3 mm wide, giving form ratio of 1.8 to 2.5.

The shell in inner few volutions is ellipsoidal, then assuming fusiform towards outward. Expansion of the shell is slow and uniform. The average height of volution from the first to the thirteenth volution in average of eight specimens is 0.061, 0.078, 0.100, 0.108, 0.125, 0.136, 0.142, 0.160, 0.185, 0.194, 0.215, 0.220, and 0.230 mm respectively.

Proloculus is rather small. It is usually 0.25 to 0.26 mm, and at most 0.45 mm in diameter.

Spirotheca is very thin and composed of tectum and lower thin layer. On account of ill-preservation of the shell, the structure of the lower thin layer is not clearly ascertained. Thickness of the spirotheca does not exceed 20 microns throughout the shell.

Septa are numerous, being thickened at their lower portion by secondary deposits. Poor preservation and abundance of axial septula prevent counting the number of them. But the number of septa in an relatively well preserved parallel section may give the count, 12, 15, 18, 18 and 20 respectively, from the fifth or the sixth to the ninth or the tenth volution.

Axial septula initially occur from the third to the fourth volution. Two to three long or small of them are developed in the middle stage, and five to six in outer stage between each adjacent septum.

Slender primary transverse septula are well developed throughout the growth of the shell. They are regularly spaced, like those of *Lepidolina*. Secondary transverse septula appear first from the sixth or the seventh volution. In outer volutions two sets of them are observable (pl. 3, fig. 10).

Foramina are minute, distributed near the base of the septa.

*Remarks:* The present form closely resembles the elongate form of *Colania douvillei* especially in the characteristics of the inner volutions. The former, however, possesses more evolved natures than the latter in the outer volutions; well developed axial and secondary transverse septula as well as large shell of the former. From these facts with geological evidences, the present form may

be one of the specialized form of *Colania douvillei*, and may be branched in the early stage of the latter.

The present form is, on the other hand, discriminated from genus *Lepidolina* by less developed characteristics of axial and transverse septula, and smaller proloculus than the latter, although the former possesses the closest features to the latter amongst forms of previously described *Colania douvillei*.

*Neoschwagerina okuboi* MORIKAWA and SUZUKI (= *Colania douvillei*) from Akasaka limestone is also readily distinguishable from the Kitakami form in more inflated shell with less developed axial and secondary transverse septula of the former.

Lately, SKINNER and WILDE, (1966) described some new species of *Yabeina* from Pacific Northeast and Alaska. Among them *Yabeina gracilis* and *Yabeina cylindrica* from Marble Canyon limestone have close similarity to the present form in essential features. However, the former two species have smaller and tightly coiled shell with more narrowly distributed transverse septula than the latter.

So far as the author awares no previously described species of highly specialized Neoschwagerinids is identical with the present form. Therefore, he proposes a new species, *Colania kotsuboensis* for the present form, designating pl. 16, fig. 6 as holotype.

#### Genus *Lepidolina* LEE, 1933

*Type species: Neoschwagerina (Sumatrina) multiseptata* DEPRAT, 1912.

*Remarks:* Generic contention of genus *Lepidolina* LEE has long been in confusion. Not a few authors regarded it as synonymous with *Yabeina*, because the nature of the septa and septula in the former is merely the extreme thinness of them as compared to the latter genus. Whereas some authors treated *Lepidolina* as independent from *Yabeina* mainly stressing on its phylogenetical position.

Y. HASEGAWA (1965) recognized two main bioseries; *Minoella-Neoschwagerina-Yabeina* bioseries and the other, *Minoella-Gifuella*-*"Lepidolina"* bioseries. This was followed by T. OZAWA (1970) who discussed the phylogeny of subfamily Neoschwagerininae and discriminated two main stocks, *Maklaya-Neoschwagerina-Yabeina* stock and *Cancellina-Colania-Lepidolina* stock. HASEGAWA and OZAWA's opinions appear to be reasonable. The author thinks, in addition, that the former series may be originated directly from *Misellina claudiae*, while the latter from some form such as *Misellina ovalis* (CHOI, 1972b). Besides, the above mentioned two bioseries are also geographically and faunistically distinguishable with each other as have been already stated by some authors (K. KANMERA, 1968; T. OZAWA, 1970; CHOI, 1972c). Although

YAMAGIWA and SAKA (1972) discovered the association of *Lepidolina multiseptata*, *Lepidolina kumaensis* and *Yabeina* aff. *globosa* in the Shima peninsula, southwest Japan, which is quite exceptional. *Lepidolina multiseptata*-*Lepidolina kumaensis* fauna are geographically confined within eastern Tethys Sea region viz. New Zealand, South east Asia South China, and East Asia. Especially, the latter fauna is restricted within Japan, North Korea, and Ussuri territory. While *Yabeina globosa* fauna is found throughout the Tethys Sea region and North America.

Compiled phylogeny of *Lepidolina* is shown in fig. 11.

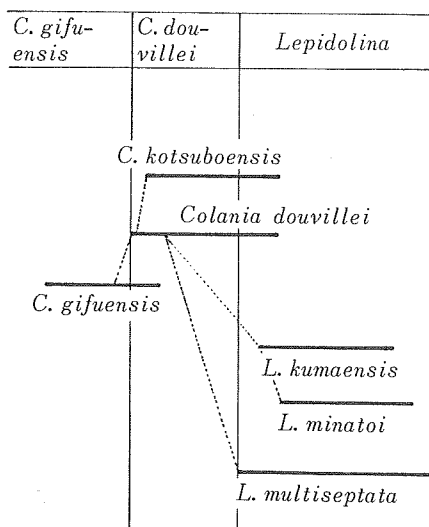


Fig. 11. Phylogeny of *Colania* and *Lepidolina*.

***Lepidolina multiseptata* (DEPRAT)**

Pl. 16, figs. 8, 11, pl. 20, figs. 1, 2, 7, 8, 10

1925a *Neoschwagerina* (*Yabeina*) *shiraiwensis* OZAWA, pl. 3, figs. 8; pl. 4, figs. 1-3.

1925b *Yabeina shiraiwensis*, OZAWA, pp. 63-64, pl. 2, figs. 2b, 5c, 7b; pl. 10, figs. 1, 2.

1935 *Neoschwagerina megaspherica* var. *gigantea* GUBLER, pp. 116-118, pl. 3, figs. 6, 8, 10?.

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 gubleri* KANMERA, pp. 19-21, pl. 4, figs. 1-13.

1954 *Yabeina yasubaensis*, KANMERA, pp. 18-19, pl. 2, figs. 10-13; pl. 5, figs. 14-19.

- 1956 *Yabeina*? sp., NODA, pl. 4, fig. 4.  
1956 *Yabeina* cf. *shiraiwensis*, NODA, pl. 4, figs. 2, 3, 5-7.  
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 gubleri*, NOGAMI, pp. 103-104, pl. 1, figs. 5, 6.  
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 yasubaensis*, NOGAMI, pp. 102-103, pl. 1, fig. 8.  
1958 *Yabeina shiraiwensis*, MORIKAWA et al., p. 89, pl. 6, figs. 9, 10.  
1960 *Yabeina gubleri*, CHISAKA, pp. 250-251, pl. 6, figs. 1-4; pl. 7, figs. 1-6; pl. 8, figs. 1-5.  
1960 *Yabeina shiraiwensis*, CHISAKA, pp. 248-249, pl. 5, figs. 1-10; pl. 6, fig. 5?  
1960 *Yabeina shiraiwensis*, MORIKAWA, pp. 296-297, pl. 53, figs. 1-9.  
1961 *Yabeina shiraiwensis*, NOGAMI, pp. 186-190, pl. 6, figs. 1-8.  
1962 *Yabeina shiraiwensis*, ISHII and NOGAMI, pp. 63-66, pls. 1, 2.  
1962 *Yabeina shiraiwensis*, CHISAKA, pp. 546-547, pl. 8, fig. 7.  
1964 *Yabeina multiseptata gigantea*, ISHII and NOGAMI, pp. 20-22, pl. 4, figs. 4-7.  
1964 *Yabeina multiseptata shiraiwensis*, ISHII and NOGAMI, pl. 5, figs. 1-3.  
1967 *Yabeina kesenensis* KANOMATA and CHISAKA, p. 410, pl. 1, figs. 16, 18, 19, 21; pl. 2, figs. 1-10, 13, 14, 15.  
1967 *Yabeina shiraiwensis*, KANOMATA and CHISAKA, p. 410, pl. 1, figs. 1-13, 17-20.  
1970b *Yabeina (Lepidolina) multiseptata shiraiwensis*, CHOI, pp. 350-351, pl. 13, fig. 8, pl. 15, figs. 4-6.  
1971 *Lepidolina multiseptata gigantea*, YAMAGIWA, IWAHASHI and HABUCHI, pp. 55-56, pl. 1, fig. 1.  
1971 *Lepidolina multiseptata shiraiwensis*, YAMAGIWA, IWAHASHI and HABUCHI, pp. 56-57, pl. 1, fig. 2.  
1972 *Lepidolina multiseptata gigantea*, YAMAGIWA and SAKA, pp. 265-266, pl. 31, fig. 1.  
1972 *Lepidolina multiseptata multiseptata*, YAMAGIWA and SAKA, pp. 266-267, pl. 31, fig. 2.  
Material: UHR 19281-19283, 19285-19288, 19290-19294, 19296, 19300, 19302, 19323-19325, 19326-19327 and 19330-19338.  
Localities: 101-103, 105-115, 117, 120, 136, 140-142, 143, 144, and 151.

*Remarks:* *Lepidolina multiseptata gigantea* and *Lepidolina multiseptata shiraiwensis* are much resembled with each other. Although the typical form of the former at the author's disposal possesses less inflated shell with thinner spirotheca, well developed septula and larger proloculus than the latter, to distinguish both subspecies at a glance is difficult. Considering the association of them, the author is inclined to think that they may be better treated as mere varieties not dividing them into subspecies.

*Occurrence:* This species is quite abundant in the upper Permian limestones in the present district. It is associated with almost every species of upper Permian fusulinids.

As to the relation to limestone lithology, severely eroded shells of *Lepidolina multiseptata*, especially *Lepidolina multiseptata shiraiwensis*, are frequently embedded in sparitic matrix with abundant crinoid, bryozoa, and algal fragments. These are not observable in limestones bearing *Lepidolina kumaensis*, *Lepidolina minatoi* or *Pseudodoliolina* which possess elongate cylindrical shell.

*Lepidolina kumaensis* KANMERA

Pl. 19, fig. 4

*Synonym:* See the author's previous paper (1970a), adding the following, 1956 *Lepidolina* sp. NODA, pp. 15-16, pl. 4, fig. 8; pl. 5, fig. 6, and 1972 *Lepidolina kumaensis*, YAMAGIWA, and SAKA, pp. 267-278, pl. 31, fig. 3.

*Material:* UHR 19284.

*Remarks:* Some subcylindrical specimens, which are safely discriminated from *Lepidolina minatoi* by smaller and slightly more inflated shell with less rapid expansion of the former, are found amongst vast number of thin sections at my hand. They coincide with *Lepidolina kumaensis* from their all available features.

*Lepidolina minatoi* nom. nov.

Pl. 16, figs. 2 & 3; pl. 19, figs. 1 & 2

1954 *Lepidolina?* *gigantea* TORIYAMA, pp. 179-182, pl. 24.

non 1935 *Neoschwagerina megasherica* var. *gigantea* GUBLER, pp. 116-118, pl. 3, figs. 6, 8 & 10?.

*Material:* UHR 19281, UHR 19285, UHR 19302, UHR 19322, UHR 19339, UHR 19340, UHR 19343.

*Lectotype:* A specimen illustrated in pl. 24 by TORIYAMA 1954 is here chosen as lectotype of this species.

*Localities:* 101, 105, 120, 139, 152, 153 & 156.

*Derivation of specific name:* This gigantic new species is named in honour of Professor M. MINATO who first found this species in Kattisawa, Sumita-cho



(town), Setamai.

*Description:* Shell is extraordinary large, elongate cylindrical with rounded poles. It seems to be difficult to determine the exact external shell size on account of missing of outer volutions of the specimens at my disposal. But it is estimated to be 20 to 30 mm in length and 4.8 to 7.0 mm in width in most cases. The largest specimen at my hand obtained from loc. 139 at least attains as large as 52 mm in length and probably 12 to 13 mm in width. Mature shell possesses at least 16 volutions and may reach 21 volutions or more. The shell expands slowly and uniformly. Height of volution in the first two volutions is 0.10 mm and about 0.22 mm in the seventh to the thirteenth volution in a well preserved holotype specimen (pl. 19, fig. 1).

Proloculus is large, measures at most 0.6 mm in diameter.

Structure of the spirotheca is not clearly observed because of ill-preservation of specimens, but it seems to be composed of tectum and lower homogeneous layer which in some part shows faint alveolar structure. Thickness of the spirotheca is nearly equal throughout the shell; 0.10 to 0.15 mm.

Regularly spaced thin and slender transverse septula are developed in all volutions, being combined with parachomata. Secondary transverse septula occur from the fifth or the sixth volution.

Septa and axial septula are numerous. Eight to nine axial septula are present between adjacent septa in outer volutions.

Foramina are small and circular in shape, and developed at the lower part of the septa.

*Remarks:* This species is particularly characterized by large elongate cylindrical shell. No previous Neoschwagerinids have been known until present as large as the largest specimen (pl. 16, figs. 2 & 3) at my disposal.

This species is closely similar to *Lepidolina kumaensis* in elongate cylindrical shell shape, nature of septula and large proloculus. The former, however, possesses far larger elongated cylindrical shell with more rapid expansion for corresponding volutions, and with slightly large proloculus than the latter.

M. MINATO found a gigantic fusulinid from Kattisawa, Setamai, Sumita-cho (town), Iwate prefecture and later R. TORIYAMA (1954) described this specimen under the name of *Lepidolina? gigantea*. This species has been referred again by M. MINATO and S. HONJO (1959) especially on its spirothecal structure. The illustrated specimen by TORIYAMA in 1954 as *Lepidolina? gigantea* is identical with the present form in large shell with numerous volutions and nature of septula although the former is too poorly oriented and ill-preserved as to prevent more detailed comparison with the latter. The

specific name of *gigantea* is, however, not suitable to use for it. Because GUBLER in 1935 established *Neoschwagerina megaspherica* var. *gigantea* which is transferred to *Lepidolina multiseptata gigantea* in the present authors' sense. Therefore *Lepidolina? gigantea* TORIYAMA, is treated as secondary homonym of *Lepidolina multiseptata gigantea* (GUBLER). The new name is accordingly needed for TORIYAMA's form and the present form as well. The author proposes *Lepidolina minatoi* for this species, choosing a specimen illustrated by TORIYAMA in his pl. 24 in 1954, as lectotype.

*Occurrence:* This species is always found in micritic to microsparitic limestone which is often muddy. Associations are *Lepidolina multiseptata*, *Pseudodoliolina gravitesta*, *Kahlerina pachytheca*, *Nankinella* sp. B (?), and *Waagenophyllum* (*Waagenophyllum*) *virgalense*. But the density of fossils is sparse. And frequently found with phaceloid coral above mentioned which is almost completely preserved its original corallite arrangements. Therefore *Lepidolina minatoi* may have best adapted in gentle, and probably slightly deep, muddy environment.

### III. FUSULINID ZONATION

Figure 12 shows the composite stratigraphical ranges of each species discriminated in the Setamai-Yahagi district, with those found in Imo area previously described by the author (1970b).

Two major faunal assemblages are to be recognized among them. One is marked by the abundant occurrence of Schwagerinidae including such genera as *Pseudofusulina*, *Parafusulina*, *Nagatoella*, *Paraschwagerina* and *Pseudoschwagerina*. The other is characteristic in production of advanced representatives of Verbeekinidae of such genera as *Lepidolina*, *Pseudodoliolina*, and abundant species of Staffellidae, Ozawainellidae, and Schubertellidae, with some species of *Parafusulina*, *Monodiexodina* and *Chusenella*.

The former assemblage is known to occur in the Sakamotosawa series, while the latter from the Kanokura series in geological succession.

#### 1. Zonation of the Sakamotosawa series.

The Sakamotosawa series was divided into two stages, Kawaguchi stage (*Pseudoschwagerina* zone) and Kabayama stage ("*Parafusulina*" zone), in ascending order by MINATO et. al. (1954). The boundary between these two stages was determined as the stratigraphical upper limit of *Pseudoschwagerina* by them.

However, it has become evident that the stratigraphical range of *Pseudoschwagerina schellwieni* extends as high as to the uppermost Sakamotosawa series. Therefore, other criteria should be employed in subdividing the

Sakamotosawa series.

Later in 1964, MINATO, KATO and HASEGAWA (1964) redefined the Kawaguchi stage as *Pseudoschwagerina* zone, and the Kabayama stage as *Pseudofusulina* zone.

The Sakamotosawa series may be divided into two major lithologic cycles, and lateral change of lithofacies becomes gradually conspicuous towards upward in the upper cycle. Further, the lower cycle is characterized by *Ferganites langsonensis*, *Triticites*, and *Schwagerina* cf. *krotowi*; whereas the upper cycle by *Pseudofusulina fusiformis*, *Pseudofusulina ambigua* and others. Therefore, to place the boundary between the Kawaguchi and the Kabayama stage at the top of the lower cycle, namely at the top of *Ferganites langsonensis*-*Schwagerina* cf. *krotowi* subzone herein defined seems to be quite reasonable in the Southern Kitakami Mountains.

The basal part of the Sakamotosawa series is almost thoroughly barren in limy facies, and is predominated by sandy and slaty lithofacies with basal conglomerate and graphite beds. Therefore no fusulinid fossils are known to occur in it except for an indeterminable species of *Pseudoschwagerina* from the basal conglomerate of the Sakamotosawa series at Amakaze, Setamai district collected by MINATO (MINATO et al., 1954), though the author could not examine the material.

Throughout the thick limestone facies of the Sakamotosawa series, the following characteristic species are yielded; *Nagatoella minatoi*, *Pseudoschwagerina schellwieni*, *Chalaroschwagerina vulgaris*, *Pseudofusulina* aff. *japonica*, *Parafusulina motoyoshiensis*, *Misellina otakiensis*, and "*Pseudofusulina*" *krafftii*.

Considering available diagnostic species which show relatively short stratigraphical ranges, three zones with three subzones as shown in table 1 are discriminated in the Sakamotosawa series.

1) *Pseudoschwagerina schellwieni* zone.

Although this species ranges up to the uppermost Sakamotosawa series, it alone represents the basal part of the fusulinid zone in the present area. To be noted is that *Pseudoschwagerina schellwieni* is almost always found without any associated forms in slaty limestone with micritic to microsparitic matrix. The fact is also well observable in other districts in the Kitakami Mountains.

2) *Chalaroschwagerina vulgaris* zone.

This zone ranges from the upper Kawaguchi stage to the lower Kabayama stage, and is marked by *Chalaroschwagerina vulgaris*.

The lower part of this zone, herein named as *Ferganites langsonensis*-

Table 1. Fusulinid zones in the Setamai-Yahagi district, Southern Kitakami Mountains.

| Sakamotosawa series | Kanokura series |                                                                            |
|---------------------|-----------------|----------------------------------------------------------------------------|
|                     | Iwazaki stage   |                                                                            |
| Sakamotosawa series | Kattisawa stage | <i>Lepidolina multisepiata</i> zone                                        |
|                     |                 | <i>Lepidorina minatoi</i> -<br><i>Lepidolina kumaensis</i><br>subzone      |
|                     | Kattisawa stage | <i>Colania kotsuboensis</i> zone                                           |
|                     |                 | <i>Monodiexodina matsubaishi</i> zone                                      |
|                     | Kabayama stage  | <i>Pseudofusulina fusiformis</i> zone                                      |
|                     |                 | <i>Pseudofusulina ambigua</i> subzone                                      |
| Sakamotosawa series | Kabayama stage  | <i>Chalaroschwagerina setamaiensis</i> subzone                             |
|                     |                 | <i>Chalaroschwagerina vulgaris</i> zone                                    |
|                     | Kawaguchi stage | <i>Ferganites langsonensis</i> -<br><i>Schwagerina cf. krotowi</i> subzone |
| Sakamotosawa series | Kawaguchi stage | <i>Pseudoschwagerina schellwieni</i> zone.                                 |
|                     |                 |                                                                            |

*Schwagerina* cf. *krotowi* subzone contains these two species abundantly together with *Triticites* sp. A and B, *Nipponitella explicata*, *Nagatoella ikenoensis*, *Pseudofusulina? jenkinsi*, *Pseudofusulina Pseudoanderssoni*, *Pseudofusulina* sp. A, *Pseudofusulina* sp. B, *Minojapanella elongata*, and *Schubertella irumensis*.

Besides, *Misellina otakiensis*, *Nagatoella minatoi*, *Pseudofusulina* aff. *japonica*, *Parafusulina motoyoshiensis*, and *Toriyamaia laxiseptata*, *Pseudofusulina? krafftii*, *Paraschwagerina (Acervoschwagerina)* sp., all of which range upwards, and also occur frequently. The yield of primitive form of *Misellina claudiae*, although rare, is worthy of note in consideration of phylogeny of *Misellina caludiae* lineage (CHOI, 1972b).

The lower portion of the Kabayama stage which corresponds to the upper part of the *Chalaroschwagerina vulgaris* zone, shows a transitional faunal assemblage from that of *Ferganites langsonensis-Schwagerina* cf. *krotowi* subzone, to that of *Pseudofusulina fusiformis* subzone. So, some species disappear and some newly appear in this epoch. *Schwagerina* aff. *compacta*, *Pseudofusulina* aff. *pseudosimplex*, and indeterminate species of *Staffella* are restricted in the upper part of this zone. *Paraschwagerina (Acervoschwagerina)* sp., *Chalaroschwagerina vulgaris*, and *Toriyamaia laxiseptata* diminish in the upper limit of this zone. On the contrally, *Paraschwagerina (Paraschwagerina)* sp. and *Pseudofusulina fusiformis* which is questionably assigned, newly appear from the uppermost part of the zone. *Monodiexodina matsubaishi?* is rarely found in this horizon as well as in the uppermost part of *Ferganites langsonensis-Schwagerina* cf. *krotowi* subzone.

### 3) *Pseudofusulina fusiformis* zone.

This zone is quite characteristic in the occurrence of *Pseudofusulina fusiformis*, *Pseudofusulina ambigua*, *Pseudofusulina tschernyschewi*, *Chalaroschwagerina setamaiensis*, *Parafusulina* cf. *multiseptata*, *Parafusulina* aff. *gigantea*, *Monodiexodina kattaensis* and *Paraschwagerina (Acervoschwagerina)* cf. *endoi*. All of these species are restricted within this zone, and constitute a distinct faunal assemblage, represented by *Pseudofusulina fusiformis*. In places the upper part of this zone is eroded by pre-Kanokura upheaval.

## 2. Zonation of the Kanokura series.

From the fusulinid assemblage in the present district, the Kanokura series is divided into three zones; *Monodiexodina matsubaishi* zone, *Colania kotsuboensis* zone, and *Lepidolina multiseptata* zone, in ascending order.

Lithologically, great change is observable between the *Colania kotsuboensis* zone and the *Lepidolina multiseptata* zone in this district.

The Kanokura series has been divided into two stages, the Kattisawa and the Iwaizaki stage in ascending order. The type area of the Kattisawa stage, first introduced by MINATO (1944) involves the *Monodiexodina matsubaishi* zone and the *Colania kotsuboensis* zone. However, the type Iwaizaki stage (MINATO, 1944), represented typically by limestone facies, also corresponds to the *Colania kotsuboensis* and to the base of the *Lepidolina multiseptata* zone of the present district. Therefore the designation of the Kattisawa stage and the Iwaizaki stage has been in confusion.

On the basis of the apparent lithological and fusulinid faunal changes between the *Colania kotsuboensis* zone and the *Lepidolina multiseptata* zone, the author considers that the *Monodiexodina matsubaishi* and the *Colania kotsuboensis* zone should be treated as the Kattisawa stage, and *Lepidolina multiseptata* zone as the Iwaizaki stage.

1) *Monodiexodina matsubaishi* zone.

Lower to middle part of the Kattisawa stage is especially well observable in the Kanokura, Imo, and Iwaizaki areas. These areas are dominated by sandy and limy facies, and linearly traceable from north to south, and is now interpreted to have been resulted from the banks in the Permian sedimentary basin in those days. This zone yields mainly genera *Parafusulina*, *Chusenella*, and *Monodiexodina*. The occurrence of *Cancellina* from the lower part of it is significant in correlation. *Yangchienia kwangsiensis* from the basal part of this zone is also interesting, because it has been found from the *Cancellina* subzone of the Maokou limestone (CHEN, 1956; SHENG, 1963) in South China. *Parafusulina motoyoshiensis*, *Chusenella pseudocrassa*, *Codonofusiella explicata* and *Monodiexodina matsubaishi* occur throughout this zone.

2) *Colania kotsuboensis* zone.

This zone is typically developed in the Kotsubosawa area and the Imo area. It is correlated to the *Neoschwagerina margaritae-Colania douvillei* zone outside the Kitakami Mountains. This zone contains *Colania kotsuboensis*, *Pseudodoliolina gravitesta*, *Pseudodoliolina elongata*, *Kahlerina pachytheca* and *Parafusulina* aff. *mccloudensis* and *Chusenella* spp. Of them, *Colania kotsuboensis* is most characteristic, and is employed for the name of zone. But the faunal assemblage of this zone laterally changes remarkably, being related to the change of lithofacies. *Pseudodoliolina elongata* is typical in Imo, whereas an indeterminable species of *Parafusulina* is exclusively found in Yokoteyama area. *Pseudofusulina paramotohashii* etc. are rich in the Iwaizaki limestone.

### 3) *Lepidolina multiseptata* zone.

Throughout the Iwaizaki stage *Lepidolina multiseptata* is especially abundant and it definitely characterizes the fusulinid fauna of the Iwaizaki stage in the district now in concern. Other associated fusulinids are *Lepidolina kumaensis*, *Lepidolina minatoi*, *Pseudodoliolina gravitesta* and *Kahlerina*.

Of these forms, *Lepidolina kumaensis*, and *Lepidolina minatoi* nom. nov. characterize the lower to middle portion of the Iwaizaki stage, except for the base of it. Thus *Lepidolina minatoi*-*Lepidolina kumaensis* subzone is here proposed. To be worthy of note is that the first appearance of *Lepidolina kumaensis* and *Lepidolina minatoi* is slightly younger than that of *Lepidolina multiseptata*.

The uppermost fusulinid zone is represented by such small fusulinid foraminifera as *Codonofusiella explicata* which shows very broad stratigraphical range, *Nankinella* sp. A, and *Kahlerina* sp. as well as such large fusulinids, *Lepidolina multiseptata* and *Schwagerina acris*. None of species of *Reichelina* or *Palaeofusulina* has been found in the upper Permian in the present district.

## IV. CORRELATION

### I) Japan

#### 1. Southern Kitakami Mountains.

##### (1) Sakamotosawa area.

Sakamotosawa area is located adjacent to Setamai district. There the lower Permian formation is typically exposed, which has been repeatedly studied by many previous investigators. Of them, KANMERA and MIKAMI (1965) studied in detail the fusulinid fauna of the Sakamotosawa formation, and established the fusulinid zonation shown in correlation table.

The earliest part of the Permian fusulinid zones in the Setamai district called here as *Pseudoschwagerina schellwieni* zone may be roughly correlatable with *Zellia nunosei* zone in the type Sakamotosawa formation from the view points of the lithological succession and fusulinid association in both districts. It is worthy of note that no specimen of *Zellia nunosei* is found in the setamai district, though it abundantly occurs in the Sakamotosawa area.

The lower part of *Chalaroschwagerina vulgaris* zone, *Ferganites langsonensis*-*Schwagerina* cf. *krotowi* in the Setamai district, is equivalent to *Nipponitella explicata*-*Monodiexodina* (*Ferganites*) *langsonensis* zone of the KANMERA and MIKAMI's zonation.

This zone commonly produces *Ferganites langsonensis* and *Nipponitella explicata* in both districts. In addition, the Setamai district produces *Triticites* sp. A and B, *Schwagerina* cf. *krotowi*, *Pseudofusulina*? *jenkinsi*, *Pseudofusulina*

Kubergandian

| Pamir<br>(Leven,<br>1967) | S. China<br>(Sheng, 1963) | Pamirian | Lopingian | Kyushu<br>(Kanmera,1954,1955,1958;<br>Nakazawa & Kanmera,              | Akiyoshi<br>(Hasegawa,1963) )                           | Atetsu<br>(Nogami,1961) )                 | Akasaka<br>(Honjo,1959) )                                  | Ibukiyama<br>(Kobayashi,1957)          | Kitakami                                 |                                      |                                      |                                         | NorthKorea<br>(Radkevitch et.al.1970)                                                 | Shihote-Aline<br>(Sosnina,1960) | Alaska<br>(Petocz,1970)                    | YukonTerritory<br>(Ross,1967)           |                                         |
|---------------------------|---------------------------|----------|-----------|------------------------------------------------------------------------|---------------------------------------------------------|-------------------------------------------|------------------------------------------------------------|----------------------------------------|------------------------------------------|--------------------------------------|--------------------------------------|-----------------------------------------|---------------------------------------------------------------------------------------|---------------------------------|--------------------------------------------|-----------------------------------------|-----------------------------------------|
|                           |                           |          |           | <i>Reichelina<br/>changsinensis-<br/>Palaeofusuling<br/>simplicata</i> | <i>Lep. toriyamai-<br/>Lep. shiraiwensis</i>            | <i>Lepidolina shiraiwensis</i>            | <i>Yabeina shiraiwensis</i>                                | <i>Yabeina globosa</i>                 | <i>Yabeina cf. katoi</i>                 | <i>Lep. multiseptata</i>             | <i>Lep. kumaensis</i>                | <i>Lep. minatoi-<br/>Lep. kumaensis</i> | <i>Sakamotosawa<br/>(Kanmera&amp;Mikami,1965)</i>                                     | Song Sang<br>series             | <i>Colaniella<br/>parva</i> zone           |                                         |                                         |
|                           |                           |          |           |                                                                        |                                                         |                                           |                                                            |                                        |                                          |                                      |                                      |                                         |                                                                                       |                                 |                                            |                                         |                                         |
| Murgabian                 | Maokouan                  |          |           | <i>Neoschwagerina<br/>margaritae</i>                                   | <i>Gifuella douvillei</i>                               | <i>Neoschwagerina<br/>douvillei</i>       | <i>Gifuella douvillei</i>                                  | <i>Neoschwagerina<br/>margaritae</i>   | <i>Pseudofusulina<br/>paramotohashii</i> | <i>Colania kotsuboensis</i>          | <i>Monodiexodina<br/>matsubaishi</i> | Jeokdong<br>series                      | <i>Monodiexodina<br/>sutchanica-<br/>Misellina<br/>dutkevitchi</i><br>zone            |                                 |                                            |                                         |                                         |
|                           |                           |          |           | <i>Verbeekina verbeeki</i>                                             | <i>Neoschw. margaritae</i>                              |                                           |                                                            |                                        |                                          |                                      |                                      |                                         |                                                                                       |                                 |                                            |                                         |                                         |
|                           |                           |          |           | <i>Neoschw. craticulifera</i>                                          | <i>Verbeekina heimi</i>                                 |                                           | <i>Neoschwagerina<br/>craticulifera</i>                    |                                        |                                          |                                      |                                      |                                         |                                                                                       |                                 |                                            | <i>Neoschwagerina<br/>craticulifera</i> | <i>Neoschwagerina<br/>craticulifera</i> |
| Artinskian                | Chihstian                 |          |           | <i>Neoschw. simplex</i>                                                | <i>Paraf. kaerimizensis</i>                             | <i>Paraf. kaerimizensis</i>               | <i>Pseudodoliolina ozawai</i>                              | <i>Parafusulina sapperi</i>            | <i>Monodiexodina<br/>matsubaishi</i>     | <i>Monodiexodina<br/>matsubaishi</i> | <i>Pst. fusiformis</i>               | Kojeol<br>series                        | <i>Misellina<br/>claudiae-<br/>Cancellina<br/>primigena</i><br>zone                   | F                               | <i>Schw. rainyensis</i> zone               |                                         |                                         |
|                           |                           |          |           | <i>Minoella nipponica</i>                                              | <i>Paraf. granum-avenae</i>                             | <i>Chalaroschw. setamaiensis</i>          | <i>Psf. fusiformis</i>                                     | <i>Nagatoella minatoi</i>              |                                          |                                      |                                      |                                         |                                                                                       |                                 | E                                          |                                         | <i>Schw. sp. C</i> zone                 |
|                           |                           |          |           | <i>Pseudoschwagerina<br/>minatoi</i>                                   | <i>Pseudofusulina<br/>vulgaris</i>                      | <i>Pseudofusulina<br/>vulgaris</i>        | <i>Acervoschwagerina<br/>cf. kagemoriensis</i>             | <i>Chalaroschwagerina<br/>vulgaris</i> |                                          |                                      |                                      |                                         |                                                                                       |                                 | <i>Psf. vulgaris</i>                       |                                         | <i>Psf. krafftii</i>                    |
| Sakmarian                 | Mapiingian                |          |           | <i>Pseudoschwagerina<br/>morikawai</i>                                 | <i>Pss. muongthensis</i>                                | <i>Pseudoschwagerina<br/>subsphaerica</i> | <i>Nipponitella explicata-<br/>Mon. lang-<br/>sonensis</i> | <i>Rugosofusulina<br/>alpina</i>       | <i>Pseudoschwagerina<br/>schellwieni</i> | <i>Zellia nunosei</i>                |                                      |                                         | <i>Pseudofusulina<br/>vulgaris-<br/>Schwagerina<br/>sphaerica var.<br/>gigas</i> zone | C                               | <i>Eoparafusulina<br/>mendenhalli</i> zone | <i>Schw. jenkinsi</i><br>assemblage     |                                         |
|                           |                           |          |           | <i>Triticites simplex</i>                                              | <i>Quasifusulina longissi-<br/>ma- "Pss." nakazawai</i> | <i>Pseudofusulinella<br/>sp. A</i> zone   | <i>Schw. whartoni</i><br>zone                              | <i>Schw. sp. B</i> ass.                |                                          |                                      |                                      |                                         |                                                                                       |                                 |                                            |                                         |                                         |
|                           |                           |          |           | A                                                                      | <i>Pseudofusulinella<br/>sp. A</i> zone                 | <i>Eaparafusulina<br/>yukonensis</i> ass. |                                                            |                                        |                                          |                                      |                                      |                                         |                                                                                       |                                 |                                            |                                         |                                         |

Table 2. Correlation of fusulinid zones in the Setamai-Yahagi district with other Permian sequences in Japan and its neighbouring districts.



*pseudoanderssoni*, and *Nagatoella ikenoensis*. All of these species are characteristic in the Setamai district now in concern, but conversely they are thoroughly lacking in the Sakamotosawa area so far as known. Instead of this, the latter produces some species of *Rugosofusulina*, none of which is found in the Setamai-Yahagi district.

Furthermore, the stratigraphical ranges of *Nagatoella minatoi*, "*Pseudofusulina*" *krafftii*, *Pseudofusulina* aff. *japonica*, *Toriyamaia laxiseptata*, *Chalaroschwagerina vulgaris*, all of which are fusulinid elements of the upper subformation in the type Sakamotosawa area, extend down to the *Ferganites langsonensis*-*Schwagerina* cf. *krotowi* subzone in the Setamai-Yahagi district.

As well as in the Sakamotosawa area, the Setamai district yields *Pseudofusulina fusiformis*, *Pseudofusulina ambigua*, "*Pseudofusulina*" *krafftii* and *Schwagerina*? aff. *compacta* in the upper Kabayama stage, herein defined as *Pseudofusulina fusiformis* zone.

The zone plentifully contains the following species, all of which are not mentioned by KANMERA and MIKAMI in the Sakamotosawa area; *Chalaroschwagerina setamaiensis*, *Monodiexodina kattaensis*, *Paraschwagerina* (*Acervoschwagerina*) sp., *Paraschwagerina* (*Acervoschwagerina*) cf. *endoi*, *Pseudofusulina tschernyschewi* (previously described as *Pseudofusulina* sp. from Imo by the author (CHOI, 1970b)), *Parafusulina* cf. *multiseptata*, *Nankinella* sp. C, *Eoverbeekina* sp., and *Misellina claudiae*.

To sum up the above description, the fusulinid zonation established by KANMERA and MIKAMI in the type Sakamotosawa area is principally applicable to that of the Setamai-Yahagi district. However, the investigated area by them is comparatively narrow to define the exact stratigraphical range of each fusulinid species. Therefore the majority of fusulinids range actually downward or upward than in a study by KANMERA and MIKAMI

## (2) Iwaizaki

MORIKAWA (1960) described the fusulinid fauna of the Iwaizaki limestone, Southern Kitakami Mountains. He discriminated the three zonules in the limestone in descending order; *Yabeina shiraiwensis*, *Pseudofusulina paramotohashii*, *Parafusulina matsubaishi* zonules.

The author (CHOI, 1970a) reported the occurrence of *Lepidolina kumaensis*, with *Codonofusuiella inuboensis*, *Dunbarula kitakamaiensis*, *Rauserella pachytheca*, *Pseudofusulina chihshiaensis*, and *Nankinella* sp., in a lens of slaty limestone of the uppermost fusulinid horizon in the area.

OZAWA, who reexamined the author's material from the Iwaizaki, recently informed the author the occurrence of *Lepidolina multiseptata* though quite few in number and ill-oriented, together with *Lepidolina kumaensis*. The

author also found that this was in reality.

Therefore fusulinid zone of the Iwaizaki limestone is as a whole tabulated as is shown in correlation table (Table 2).

The fusulinid zones established in the Iwaizaki quite agree with those in the present area. Especially the combination of *Lepidolina multiseptata* and *Verbeekina verbeeki* in the Iwaizaki is quite identical with that of the Imo (CHOI, 1970b). Moreover, none of *Verbeekina* occurs from the equivalent horizon in the Setamai and its adjacent districts although investigated in detail.

## 2. Ibukiyama limestone

Fusulinids of the Ibukiyama limestone, in the central Japan, were studied by KOBAYASHI (1957), who established the fusulinid zones shown in correlation table.

Among species reported from the *Pseudoschwagerina* zone in the Ibukiyama, *Pseudofusulina vulgaris* commonly occurs in the Kitakami Mountains. KOBAYASHI listed in his fig. 2, *Misellina* sp., stratigraphically ranging from the upper part of *Acervoschwagerina* subzone to the lower part of the *Pseudofusulina ambigua* subzone. It may be one of the most primitive *Misellina*, probably identifiable to *Misellina otakiensis*.

Although comparable species in both districts are merely *Charaloschwagerina vulgaris* and probably *Misellina* sp., *Acervoschwagerina* subzone in the Ibukiyama limestone may be correlatable with the lower part of the *Chalaroschwagerina vulgaris* zone or *Ferganites langsonensis-Schwagerina* cf. *krotowi* subzone in the Kitakami Mountains.

This may be supported by the fact that *Schwagerina krotowi*, *Nagatoella ikenoensis*, and *Misellina ibukiensis*, all of which were yielded from *Ferganites langsonensis-Schwagerina* cf. *krotowi* subzone in the present district, were described by MORIKAWA and ISOMI (1961) from the Early Permian in the East of Lake Biwa, adjacent to Ibukiyama.

The upper part of the *Pseudofusulina ambigua* zone in the Ibukiyama yielding *Pseudofusulina ambigua*, *Pseudofusulina aganoensis*, and *Misellina* cf. *claudiae*, may be equivalent to *Pseudofusulina fusiformis* zone in the present district.

No common species except for *Verbeekina verbeeki* occur in the middle to the upper Permian in the Ibukiyama and the Kitakami.

## 3. Atetsu Plateau

Permian succession is well established in the Atetsu limestone Plateau, S. W. Japan. NOGAMI (1963) discriminated the five fusulinid zones with eight subzones in the limestone as shown in correlation table. Correlation of the

Atetsu Plateau with the Setamai district is comparatively easy, because of the similarity of ranges of fusulinids in both districts.

The whole *Pseudofusulina vulgaris* zone of NOGAMI is almost completely correlatable with *Chalaroschwagerina vulgaris* zone in the present area from the association of *Chalaroschwagerina vulgaris* and *Pseudofusulina* aff. "*Triticites*" *pseudosimplex* in both places, and the lower part of the zone in the former is correlatable with the *Ferganites langsonensis*-*Schwagerina* cf. *krotowi* subzone in the latter, which is induced from the first appearance of *Chalaroschwagerina vulgaris*.

Undoubtedly *Pseudofusulina krafftii magna* subzone of the Atetsu is correlated with *Pseudofusulina fusiformis* zone of the Kitakami, though stratigraphical positions of *Pseudofusulina* aff. *fusiformis*, and *Schwagerina* sp. D (= *Pseudofusulina ambigua*) seem somewhat lower than those in the latter district.

The boundary between *Parafusulina kaerimizensis* and underlying *Pseudofusulina krafftii magna* subzone in the Atetsu may be geologically comparable with the base of the Kanokura series, represented by the basal conglomerate in the Kitakami Mountains.

*Monodiexodina matsubaishi* zone in the Kitakami is correlated with the *Parafusulina kaerimizensis* subzone and *Neoschwagerina craticulifera* subzone in the Atetsu plateau. Likewise, *Neoschwagerina margaritae* and *Neoschwagerina douvillei* subzone of the latter coincides with the *Colania kotsuboensis* zone of the former from the occurrence of *Pseudodoliolina elongata*, and stratigraphical relationship with the base of the *Lepidolina multiseptata* zone in both districts.

The extensive range of *Yabeina shiraiwensis* (*Lepidolina multiseptata*) in the latter is also similar to that of the former. The similarity of fusulinid fauna throughout the Permian between them is worthy of note.

#### 4. Akiyoshi

Permian fusulinids and biostratigraphy of the Akiyoshi limestone have been repeatedly studied by many investigators (OZAWA, 1925; HANZAWA, 1941; TORIYAMA, 1958; HASEGAWA, 1963; MURATA, 1961). Fusulinid zone established by them are fundamentally the same, though minor differences are present according to investigators. Since the Permian fusulinid fauna of the Akiyoshi limestone is quite identical with that of the Atetsu Plateau except that of the lowest Permian, more detailed remarks on correlation with the Kitakami are omitted here.

## 5. Yayamadake limestone

The upper Carboniferous to the lower Permian is well developed in the Yayamadake limestone, Kyushu. Fusulinid biostratigraphy of the limestone was studied in detail by KANMERA (1954, 1955, 1958).

The fusulinid zones of the lower Permian was named by KANMERA (1958) as *Pseudoschwagerina* zone with *Pseudoschwagerina morikawai* subzone and *Pseudoschwagerina minatoi* subzone in ascending order.

Although comparable form is merely *Schwagerina krotowi* between the Yayamadake and the Kitakami, *Pseudoschwagerina minatoi* subzone of the former may be correlatable with *Ferganites langsonensis-Schwagerina* cf. *krotowi* subzone. *Pseudoschwagerina morikawai* zone in the former may be lacking in the latter, owing to the difference of lithofacies which is non-calcareous in the latter district.

## 6. Kozaki formation

Kozaki formation is also one of the representatives of the Japanese middle Permian. KANMERA (1963) discriminated *Misellina claudiae*, *Neoschwagerina simplex*, *Neoschwagerina craticulifera*, *Neoschwagerina margaritae*, and *Yabeina globosa* zones in ascending order in the Kozaki formation. It may be safely correlated with the Kitakami middle Permian as is shown in table 2.

## 7. Kuma formation and Maizuru group

The upper Permian formations are well developed in Maizuru zone, S. W. Japan, and Kuma, Kyushu, as well as in the Setamai district of the Kitakami. Not only faunistically but also lithologically, these places are closely similar with one another, and they have been collectively called as the Kuma type fauna or the Kuma type formation.

Fusulinids of the Kuma formation were studied by KANMERA (1954), and those of the Maizuru group was by NOGAMI (1958). Following is a list of common fusulinid species among them.

$$\left. \begin{array}{l} Yabeina yasubaensis \\ Yabeina gubleri \end{array} \right\} = Lepidolina multiseptata = \left\{ \begin{array}{l} Yabeina yasubaensis \\ Yabeina gubleri \end{array} \right.$$

$$\left. \begin{array}{l} Lepidolina kumaensis \\ Lepidolina toriyamai \end{array} \right\} = Lepidolina kumaensis = \left\{ \begin{array}{l} Lep. kumaensis \\ Lep. toriyamai \\ Lep. toriyamai maizuruensis \end{array} \right.$$

$$\left. \begin{array}{l} Pseudodoliolina pseudolepida \\ Pseudodoliolina n. sp. \\ Verbeekina? sp. \end{array} \right\} = Psdd. gravitesta$$

|                                                   |                                                |
|---------------------------------------------------|------------------------------------------------|
| <i>Schwagerina pseudocrassa</i>                   | = <i>Chusenella pseudocrassa</i>               |
| <i>Schw. aff. acris</i>                           | = <i>Schw. acris</i>                           |
| <i>Parafusulina?</i> sp.                          | = <i>Parafusulina</i> aff. <i>mccloudensis</i> |
| <i>Dunbarula?</i> sp.                             | = <i>Dunbarula kitakamiensis</i>               |
| <i>Nankinella</i> sp. A = <i>Nankinella</i> sp. A |                                                |

|                                   |          |                                 |
|-----------------------------------|----------|---------------------------------|
| Kuma formation<br>(KANMERA, 1954) | Kitakami | Maizuru group<br>(NOGAMI, 1958) |
|-----------------------------------|----------|---------------------------------|

Recently KANMERA found *Reichelina changhsingensis*, *Palaeofusulina simplicata* and *Nankinella* spp. in the dolomitic limestone of the Kamura and Tsukumi formation, the uppermost Permian, in Kyushu immediately below the lower Triassic. Thus the upper Permian fusulinid zones of Japan was defined as *Yabeina globosa-Lepidolina multiseptata* zone, *Lepidolina kumaensis* zone, and *Reichelina changhsingensis-Palaeofusulina simplicata* zone in ascending order (NAKAZAWA and KANMERA, 1971).

However, any reliable data concerning the highest fusulinid horizon have not been obtained in the Kitakami Mountains. Whether *Reichelina changhsingensis-Palaeofusulina simplicata* zone in Kyushu corresponds to the highest fusulinid horizon yielding *Lepidolina multiseptata*, *Schwagerina acris*, *Codonofusiella explicata*, *Nankinella* sp. A and *Kahlerina pachythea* (?) or to the Toyoma series represented by *Bellerophon* or *Enphemitopsis* in the Kitakami, can not be concluded at this time. Because no comparable fusulinid species of *Reichelina* or *Paleofusulina* without the association of Neoschwagerinace, have been yet discovered in the upper Permian of the Kitakami Mountains.

## II) Outside Japan

### 1. North Korea and Shihote-Aline

Upper Permian formations called as Twuman system containing fusulinid fossils are well developed along the Twuman River, in North Korea. Special attention should be paid to the close similarity of upper Permian fusulinid fauna as well as lithofacies between the Kitakami and North Korea. The Twuman system is divided into Kojeol series (mainly lower Permian), Jeokdong series (middle to upper Permian with abundant fossils) which corresponds to the whole Kanokura series in the present area from fossil evidences, and Song Sang series (upper Permian) in ascending order. (RADKEVITCH, A. A. et. al., 1966).

Fossils including fusulinids from Sambong district, along the Twuman River, were described by NODA (1956). The following fusulinid species are identical with the Kitakami forms.

| Kitakami                                     | North Korea (NODA, 1956)                                           |
|----------------------------------------------|--------------------------------------------------------------------|
| <i>Parafusulina</i> aff. <i>mccloudensis</i> | = <i>Parafusulina</i> <i>imlay</i>                                 |
| <i>Pseudodoliolina</i> <i>gravitesta</i>     | = { <i>Misellina</i> sp. a<br><i>Misellina</i> sp. b               |
| <i>Lepidolina</i> <i>multiseptata</i>        | = { <i>Yabeina</i> cf. <i>shiraiwensis</i><br><i>Yabeina</i> ? sp. |
| <i>Lepidolina</i> <i>kumaensis</i>           | = <i>Lepidolina</i> sp.                                            |

Correlation of both districts is shown in table 2.

Fusulinid fauna of the Shihote Aline and Ussuri Territory were studied by YELISEYEVA (1959), SOSNINA (1960, 1965), MIKLUHO-MACLAY, (1957) and others. The affinity of the fossil assemblages of both districts above mentioned to that of the Kitakami Mountains is also worthy of note. *Monodiexodina sutchanica* from the former two districts is biologically closely related to *Monodiexodina matsubaishi* from the present district. *Lepidolina ussurica* from the former is also identical with *Lepidolina kumaensis* from the latter.

SOSNINA (1960) discriminated the following six biozones in the Permian of Shihote-Aline in ascending order; *Pseudofusulina vulgaris* and *Schwagerina sphaerica* var. *gigas* zone, *Misellina claudiae* and *Cancellina primigena* zone, *Mododiexodina sutchanica* and *Misellina* (= *Pseudodoliolina*) *dutkevitchi* zone, *Misellina* (= *Pseudodoliolina*) *lepida* and *Lepidolina ornata* zone, and *Colaniella parva* zone. These zones are roughly correlatable with those of the Kitakami Mountains shown in table 2.

## 2. Boreal Sea Provinces

Of interest is that the lower Permian fusulinid fauna of the present district includes that of the Boreal sea province.

Lower Permian fusulinids of Alaska and Yukon Territory were studied by ROSS (1967) and PETOCZ (1970). They established some assemblage zones ranging from Asselian to Artinskian. These districts are quite characteristic in abundant production of *Eoparafusulina* (= *Ferganites*) and "Schwagerina" represented by *Schwagerina jenkinsi* or *Schwagerina hyperborea*. These fauna are also well traced in the lower Permian not only of Alaska but also of other districts within Boreal Province; Grinnel Peninsula, Greenland, and Spitzbergen.

ROSS' (1967) *Schwagerina jenkinsi* assemblage zone in Alaska is possible to be correlatable with *Ferganites langsonensis*-*Schwagerina* cf. *krotowi* subzone in Kitakami because of association of *Pseudofusulina*? (*Schwagerina* by ROSS) *jenkinsi* in both places. Consequently, ROSS' *Eoparafusulina*

*yukonensis* and *Schwagerina* sp. B assemblage zones may be stratigraphically equivalent to the lowest Sakamotosawa series, where limy facies is lacking, and *Pseudoschwagerina schellwieni* zone in the Kitakami Mountains.

Assemblage zone C in central Alaska (PETOCZ, 1970) involving *Schwagerina rowetti* which is biologically closely related to *Pseudofusulina* sp. B in the present paper may correspond to *Ferganites langsonensis*-*Schwagerina* cf. *krotowi* subzone in Kitakami. Therefore, assemblage zones A and B of the former are correlatable to *Pseudoschwagerina schellwieni* zone and lowest Sakamotosawa series with no fusulinids of the latter.

## V. COLLECTING LOCALITIES

Collecting localities are indicated in figs. 2 and 3. Their stratigraphical positions are shown in figs. 4-9. Localities younger than numeral 100 except for 61, 81 and 82 mean the occurrences from the Sakamotosawa series, and over 100 and 61, 81 & 82 are of the Kanokura series. But locs. 158 & 159 are from the Toyoma series and no fusulinid fossils, but pelecypods, brachiopods, and cephalopods were obtained. At all localities fusulinids are found from limestone exposures, and pebbles or limy matrices in conglomerate except for locs. 158 and 159.

### 1. Setamai district

Locs: 1-52, and 101-122 are the Kabayamasawa, the Kanokurasawa, and the Kattisawa areas, Setamai, Sumita-cho.

Locs. 1-6; Along the course of the Kabayamasawa.

Loc. 1; The uppermost course of the Kabayamasawa, elevation 460 m.

Loc. 2; 350 m lower course from the loc. 1.

Loc. 3; Near the junction of the Kabayamasawa and the Motoiwasawa.

Loc. 4; The uppermost course of the Daikokudo, a small tributary of the Kabayamasawa. 390 m high above the sea level, about 500 m north of Hill 598 m.

Loc. 5; Middle course of the Obatakesawa, a small tributary of the Kabayamasawa.

Loc. 6; Near the summit of the Umemoriyama (463 m in height).

Locs. 7-14; Along the valley of the Kanokurasawa.

Loc. 7; At a road cutting, about 70 m north of the Moriaibashi (bridge).

Loc. 8; About 120 m north west of the Moriai-bashi, at the junction of the Kattisawa and the Kanokurasawa.

Loc. 9; 250 m west of the mouth of the Kanokurasawa.

- Loc. 10; An outcrop by road, 420 m west of the Moriai-bashi.
- Loc. 11; About 100 m upper course of Loc. 10.
- Loc. 12; At 200 m upper course of loc. 11.
- Locs. 13 & 14; Just below the basal conglomerate of the Kanokura series, about 400 m west of the loc. 12.
- Locs. 15-18; Southern slope of the Kanokurasawa.
- Loc. 15; 110 m east of loc. 13.
- Loc. 16; Steeply inclined cliff, 220 m above the sea level.
- Loc. 17; Ridge of elevation 200 m.
- Loc. 18; A little north of the ridge, 230 m high above the sea level.
- Locs. 19-23, 27, 51 & 52; Along the Budosawa, a small tributary of the Kattisawa.
- Loc. 24; Middle course of Ogayo, a small tributary of the Kattisawa.
- Locs. 25-33, and 122; Along the course of the Shimoyashikisawa, an upper tributary of the Kattisawa.
- Locs. 34-50 and 120, The upper course of the Kattisawa, south of the Kanokurayama.
- Locs. 101-108, Northern slope of the Kanokurayama.
- Loc. 109; 100 m north from the mouth of the Ohune, a tributary of the Kanokurasawa.
- Loc. 110; An outcrop 130 m west from the mouth of the Kozirosawa, a small tributary of the Kanokurasawa.
- Loc. 111; At elevation 350 m, steep south slope 200 m south from the mouth of the Kozirosawa.
- Loc. 112; Middle course of the Ohune
- Loc. 113; Near the upper course of the Onida, a tributary of the Kanokurasawa. Elevation 500 m.
- Locs. 114 & 115; Southern slope of the Budoyama (556 m height), both are about 300 m height above the sea level.
- Loc. 116; Middle course of the Tonokibora, a small tributary of the Kattisawa. Elevation 350 m.
- Loc. 119; A ridge, 900 m east of the summit of the Kanokurayama. Elevation 680 m.
- Locs. 117 & 118; Eastern slope of the Kanokurayama, about 1300 m, and 1100 m east of the summit of the Kanokurayama, respectively.
- Loc. 121; River bank, about 80 m southwest from the junction of the Kattisawa and the Shimoyashikisawa.
- Loc. 122 Western side of the Shimoyashikisawa, 250 m high above the sea level.



## 2. Yahagi district

Locs. 60-61, and 130-144 are the upper course of the Kotsubosawa, Yokota-cho, Rikuzentakada city.

Locs. 62-75; Aibata, a small tributary of the Yukisawa. Elevation for loc. 62, 180 m; loc. 72, 270 m; loc. 73, 320 m. Locs. 74 & 75 are on ridge, about 400 m high above the sea level.

Locs. 76-77, and 151, Lower course of the Yamagoyasawa, a tributary of the Yukisawa, Yahagi-cho.

Loc. 78; East of the Suwa shrine, Yahagi-cho.

Loc. 80; Along the railway, Ohunatoline, 500 m north of the Kamishishiori station.

Loc. 81-84; West of the Shishiori river, 1500-2100 m south of the Kamishishiori station.

Loc. 152; At ridge 700 m east of the summit of the Matsukurayama, Yahagi-cho.

Locs. 153; Hill side, about 370 m north from the junction of the Matsukurasawa and the Yahagi river.

Locs. 154-155; Along the uphill road of the Nokkoe saka (pass).

Loc. 156, At a ridge, 420 m southwest of the summit of the Yokoteyama, Yahagi-cho.

## 3. Karakuwa district

Loc. 157; Dairiseki kaigan (Marble coast), Kowaragi, Karakuwa-cho, Motoyoshi-gun (county).

Loc. 158; A cliff in the ground of Kowaragi elementary school, Karakuwa.

Loc. 159; Sea coast, 350 m east of Tadakoshi, Karakuwa.

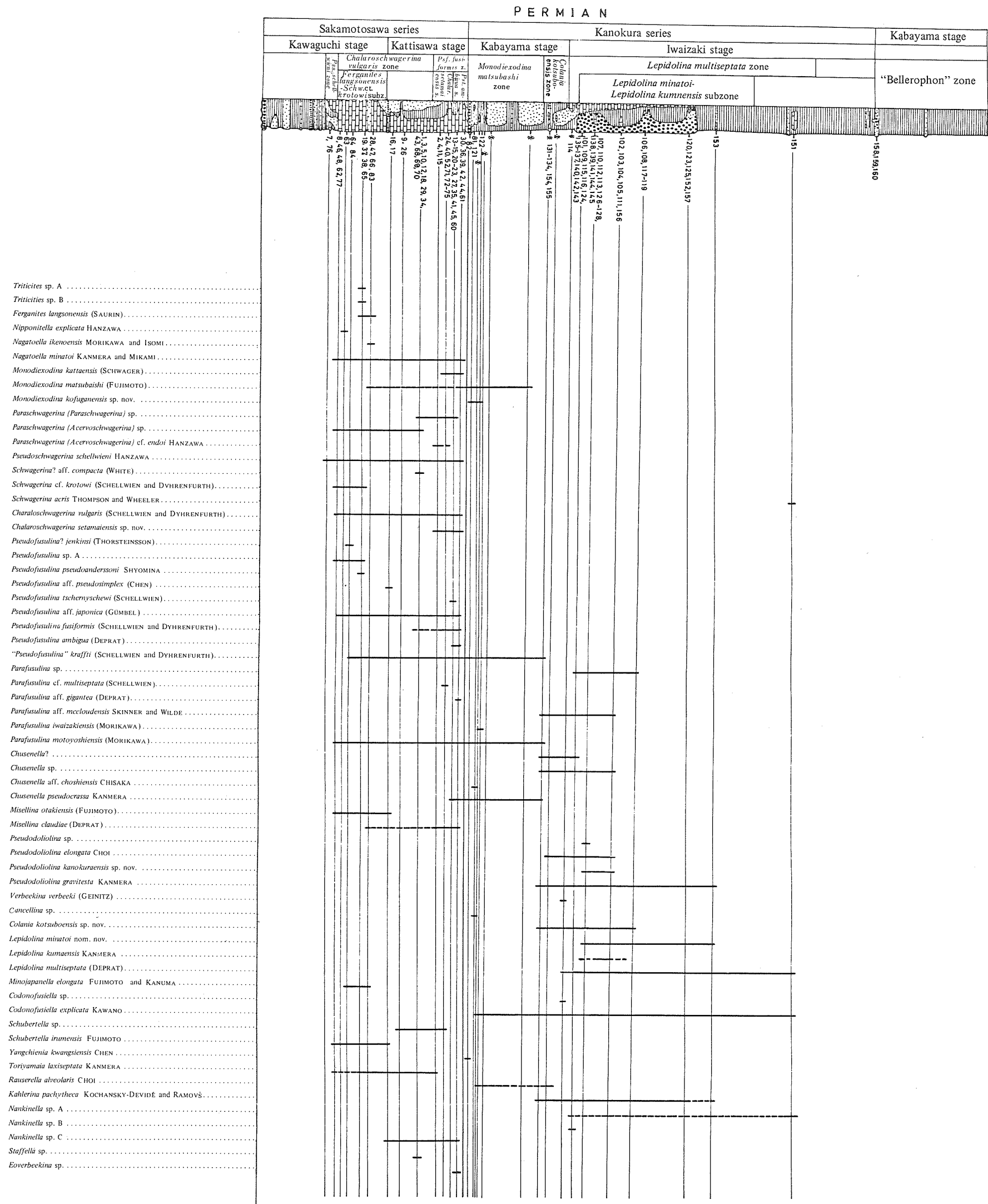
*Postscript:* After the manuscript went to press, the author came to notice the followings articles on fusulinids.

KALMYKOVA (Вопросы Микропаеонтологии, vol. 15, pp. 51-58, 1972) newly established a genus, *Praemisellina* with *Praemisellina georgii* KALMYKOVA (= *Staffella dagmarae* DUTKEVITCH) as type species from Sakmarian in the western Ural. As she considered, *Praemisellina* might be a primitive form of *Misellina*. But it seems to the present author to be quite identical with *Misellina otakiensis* str. in every feature. Therefore the KALMYKOVA's new genus is synonymous with *Misellina* defined by the author in a previous article (CHOI, 1972b). However the problem that one of the original paratype specimens of *Staffella dagmarae* DUTKEVITCH (pl. 3, fig. 12, 1934) appears to possess mineralized shell which is commonly observed in subfamily Staffellinae still remains unsolved. If this phenomenon is usually the case in DUTKEVITCH

form, *Praemisellina* should be separated from *Misellina* and is better transferred to Staffellinae, and may be regarded as the most primitive form of *Eoverbeekina*.

KOCHANSKY-DEVIDÉ (*Bull. Sci.*, sec. A, vol. 14, no. 9-10, pp. 297-298, 1969) proposed *Paratriticites* as a new genus. According to her description and illustrations, *Paratriticites* is provided with elongate fusiform shell with relatively large proloculus, loosely coiled inner volutions, and fluted septa with cuniculi in outer volutions. But the author thinks that the presence of cuniculi in *Paratriticites* is not sufficient enough for generic separation from *Pseudofusulina*, so the former is better suppressed into the latter. The former is considered one of the primitive forms of *Pseudofusulina*.

Fig. 12. Composite stratigraphical ranges of fusulinid fossils yielded in the Setamai-Yahagi district. \* indicates the horizons in Imo (Choi, 1970b).



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(Manuscript received April 1, 1972)

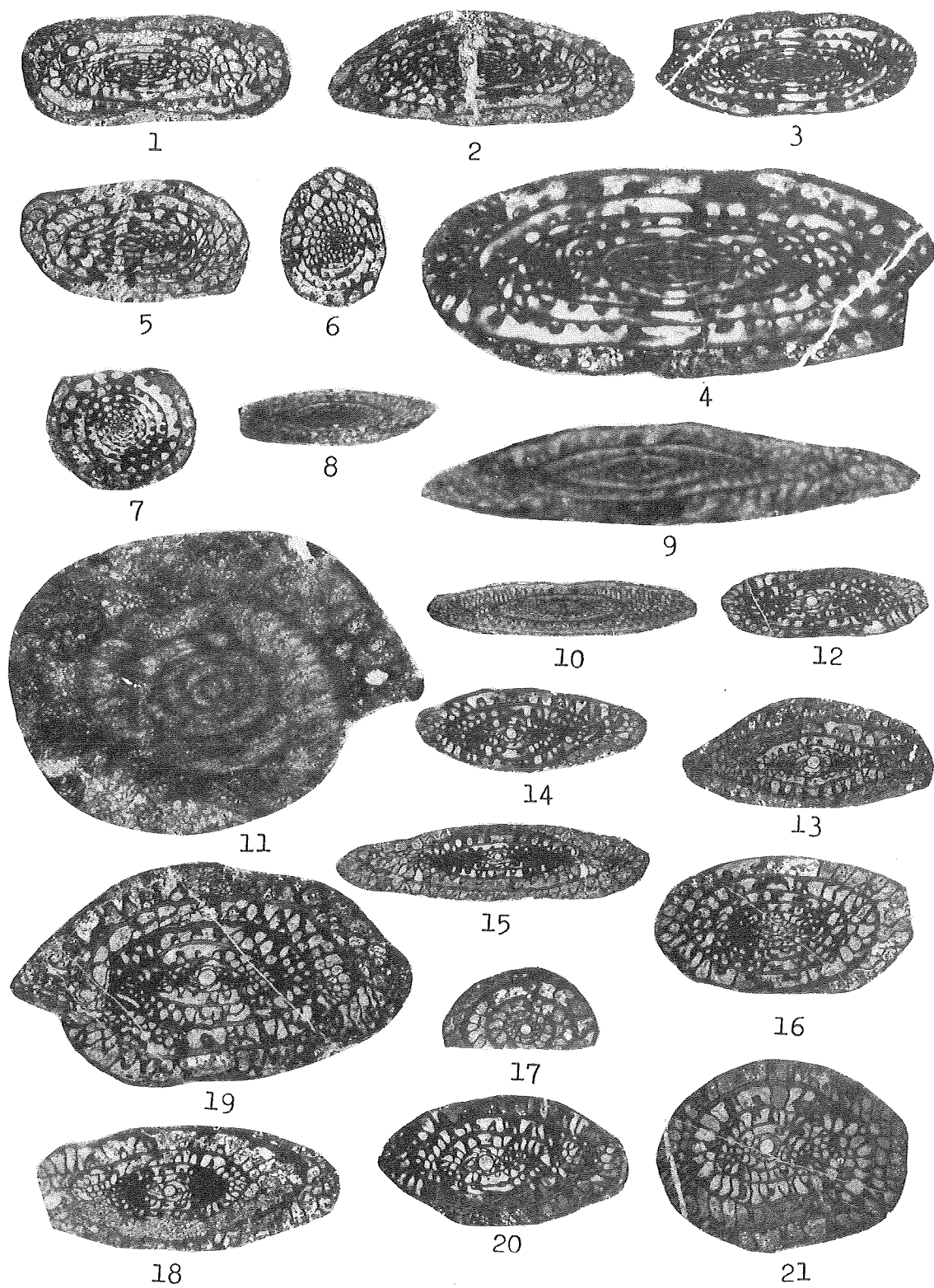


PLATES 1 ~ 20 AND EXPLANATION.

**Explanation of plate 1**

Figs. 1-3, 5-7, and 12-21 are  $\times 10$ . Figs. 4, 8 and 10 are  $\times 20$ . Fig. 9 is  $\times 50$ , and fig. 11 is  $\times 100$ .

- Nagatoella ikenoensis* MORIKAWA and ISOMI ..... 28  
 Figs. 1-5: Tangential sections. 1; UHR 19217-9a, 2; UHR 19217-11a, 3; UHR 19217-10, 4; Enlarged photograph of fig. 3, 5 UHR 19217-9b.  
 Fig. 6: Oblique parallel section. UHR 19217-4.  
 Fig. 7: Sagittal section. UHR 19217-13.  
 (See also pl. 2, fig. 15)
- Minojapanella elongata* FUJIMOTO and KANUMA ..... 14  
 Figs. 8-10: Tangential sections. 8; UHR 19217-15b, 9; UHR 19217-16b, 10; UHR 19217-13.  
 Fig. 11: Sagittal section. UHR 19217-8b.
- Pseudofusulina* sp. B ..... 48  
 Figs. 12-16 & 18: Axial sections. 12; Slightly obliquely cut. UHR 19217-1, 13; UHR 19217-6, 14; UHR 19217-3, 15; UHR 19217-2, 16; Obliquely cut axial section. UHR 19217-11b, 18, UHR 19217-14.  
 Fig. 17: Sagittal section. UHR 19217-17b.
- Chalaroschwagerina* sp  
 This species was obtained in association with forms illustrated in this plate. Since material was scanty in number, only illustrations are given.  
 Fig. 19: Axial section. UHR 19217-15c.  
 Fig. 20: Axial section. UHR 19217-9b.  
 Fig. 21: Diagonal sagittal section. UHR 19217-18.
- (All specimens were yielded from loc. 79, collected by Masaru TAKAIWA )

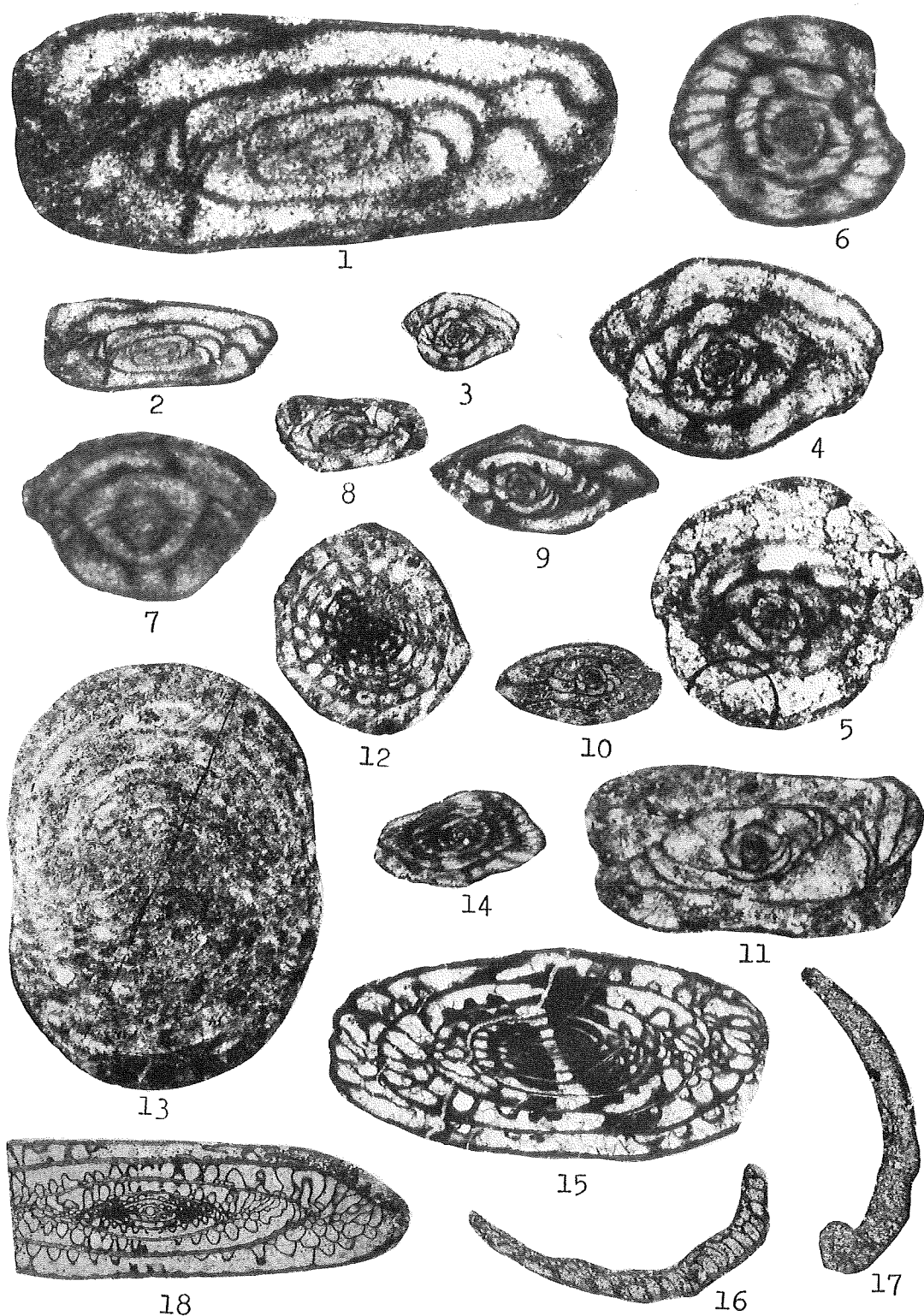


## Explanation of plate 2

Figs. 1, 4-7 are  $\times 50$ ; figs. 2, 3, 8, 9, 11 & 13-15 are  $\times 20$ ; figs. 10 & 16-18 are  $\times 10$ .

|                                                                                                 |    |
|-------------------------------------------------------------------------------------------------|----|
| <i>Rauserella?</i> sp. ....                                                                     | 2  |
| Fig. 2: Deep tangential section. UHR 19590-3b. Fig. 1 is an enlarged figure of fig. 2. (Loc. 8) |    |
| <i>Schubertella irumensis</i> (FUJIMOTO) ....                                                   | 15 |
| Fig. 3: Axial section. UHR 19590-36. Fig. 4 is enlargement of fig. 3. (Loc. 8)                  |    |
| Fig. 5: Axial section UHR 19590-10. (Loc. 8)                                                    |    |
| Fig. 6: Deep parallel section. UHR 19592-1c. (Loc. 22)                                          |    |
| Fig. 7: Tangential section. UHR 19592-1b. (Loc. 22)                                             |    |
| <i>Toriyamaia laxiseptata</i> KANMERA ....                                                      | 20 |
| Fig. 8: Tangential section. UHR 19592-2b. (Loc. 22)                                             |    |
| Fig. 9: Axial section. UHR 19592-7b. (Loc. 22)                                                  |    |
| Fig. 10: Axial section. UHR 19461-2. (Loc. 4)                                                   |    |
| Fig. 11: Axial section. UHR 19462. (Loc. 4)                                                     |    |
| <i>Eoverbeekina</i> sp. ....                                                                    | 17 |
| Fig. 12: Deep parallel section. UHR 19307-1. (Loc. 61)                                          |    |
| Fig. 13: Tangential section. UHR 19307-2. (Loc. 61)                                             |    |
| <i>Yangchienia kwangsiensis</i> CHEN ....                                                       | 15 |
| Fig. 14: Axial section. UHR 19434. (Loc. 81) Outermost volution is missing.                     |    |
| <i>Nipponitella explicata</i> HANZAWA ....                                                      | 29 |
| Fig. 16: A part of flared portion. UHR 19212. (Loc. Futamata, Yahagi)                           |    |
| Fig. 17: Tangential section. UHR 19210. (Loc. Futamata, Yahagi)                                 |    |
| (See also pl. 3, fig. 2)                                                                        |    |
| <i>Pseudofusulina? jenkinsi</i> THORSTEINSSON ....                                              | 49 |
| Fig. 18: Axial section. UHR 19217-17a. (Loc. 79)                                                |    |
| <i>Nagatoella ikenoensis</i> MORIKAWA and ISOMI ....                                            | 28 |
| Fig. 15: Tangential section. UHR 19463a. (Loc. Komata, Sumita-cho)                              |    |
| (See also pl. 1, figs. 1-7)                                                                     |    |

(Figs. 10 and 11 were collected by Hiroshi SUTOMI, fig. 16-18 by Masaru TAKAIWA, fig. 14 by Fumio SUDO, fig. 15 is unknown. Others were by the author)



**Explanation of plate 3**

All figures are ten times natural size.

|                                                                             |    |
|-----------------------------------------------------------------------------|----|
| <i>Monodiexodina kattaensis</i> (SCHWAGER) .....                            | 31 |
| Fig. 1: Tangential section. UHR 19610-6b. (Loc. 18)                         |    |
| <i>Nipponitella explicata</i> HANZAWA .....                                 | 29 |
| Fig. 2: Sagittal section. UHR 19638-1. (Loc. 48)                            |    |
| (See also pl. 2, figs. 16 & 17)                                             |    |
| <i>Pseudofusulina</i> aff. <i>japonica</i> (GÜMBEL) .....                   | 49 |
| Fig. 3: A deformed axial section. UHR 19610-15. (Loc. 18)                   |    |
| Fig. 4: Axial section. UHR 19590-8b. (Loc. 8)                               |    |
| Fig. 5: A depressed axial section. UHR 19659-3a. (Loc. 70)                  |    |
| Fig. 6: Slightly diagonally cut tangential section. UHR 19610-13. (Loc. 18) |    |
| (See also pl. 10, fig. 4)                                                   |    |

(Permian fusulinids from the Setamai-Yahagi district, Southern Kitakami Mountains.)

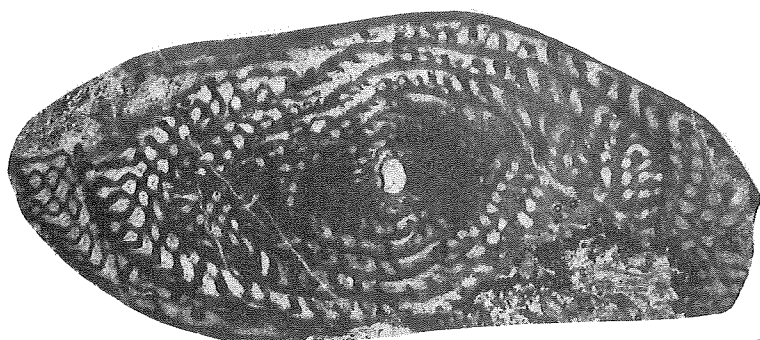




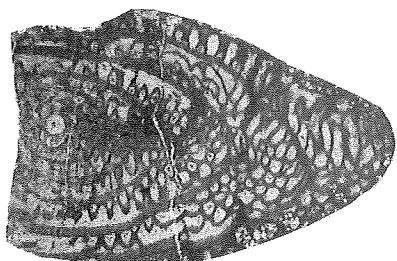
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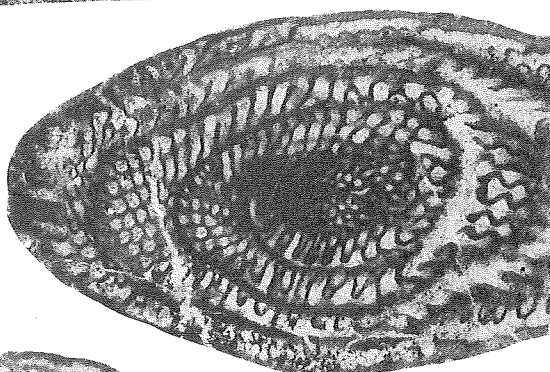
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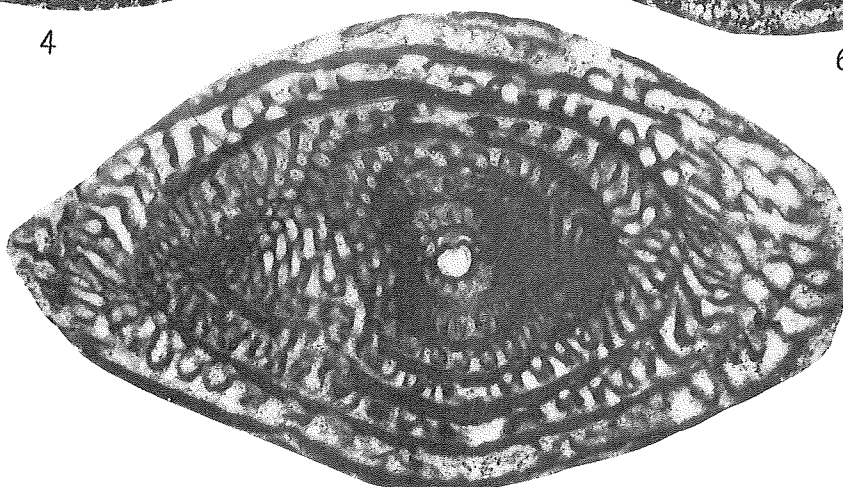
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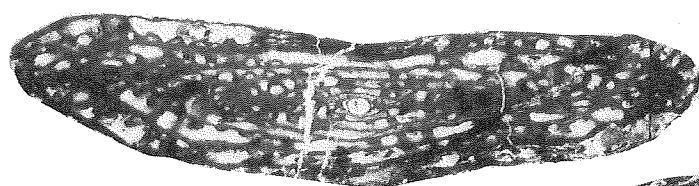
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# Explanation of plate 4

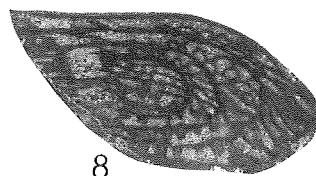
All figures are ten times natural size.

|                                                                    |    |
|--------------------------------------------------------------------|----|
| <i>Parafusulina motoyoshiensis</i> (MORIKAWA) .....                | 56 |
| Fig. 1: Axial section. UHR 19590-2d. (Loc. 8)                      |    |
| Fig. 2: A deformed axial section. UHR 19590-2e. (Loc. 8)           |    |
| Fig. 3: A deformed axial section. UHR 19590-3. (Loc. 8)            |    |
| ?Fig. 6: Axial section. UHR 19592-12. (Loc. 22)                    |    |
| (See also pl. 10, fig. 6)                                          |    |
| <i>Ferganites langsonensis</i> (SAURIN) .....                      | 25 |
| Fig. 7: Tangential section. UHR 19591-1c. (Loc. 19)                |    |
| Fig. 8: Tangential section. UHR 19595-4a. (Loc. 64)                |    |
| <i>Triticites</i> sp. A .....                                      | 21 |
| Fig. 12: Tangential section. UHR 19592-10a. (Loc. 22)              |    |
| Fig. 13: Tangential section. UHR 19592-10b. (Loc. 22)              |    |
| (See also pl. 7, fig. 7)                                           |    |
| <i>Triticites</i> sp. B .....                                      | 21 |
| Fig. 9: Deformed axial section. UHR 19592-7a. (Loc. 22)            |    |
| Fig. 10: Inner volutions of axial section. UHR 19592-7c. (Loc. 22) |    |
| Fig. 11: Axial section. UHR 19592-6c. (Loc. 22)                    |    |
| <i>Pseudofusulina pseudoanderssoni</i> SHYOMINA .....              | 46 |
| Fig. 14: Tangential section. UHR 19591-1b. (Loc. 19)               |    |
| Fig. 15: Tangential section. UHR 19591-1a. (Loc. 19)               |    |
| <i>Pseudofusulina</i> sp. A .....                                  | 47 |
| Fig. 4: Axial section. UHR 19590-4. (Loc. 8)                       |    |
| Fig. 5: Slightly deformed axial section. UHR 19592-6b. (Loc. 22)   |    |

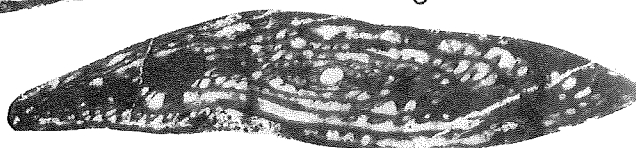
(All specimens were yielded in the Setamai-Yahagi district, Southern Kitakami Mountains, collected by the author)



1



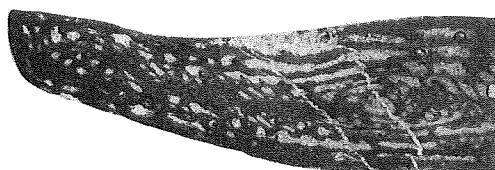
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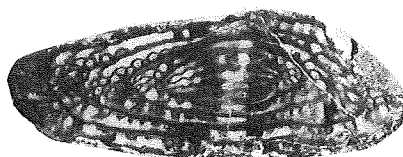
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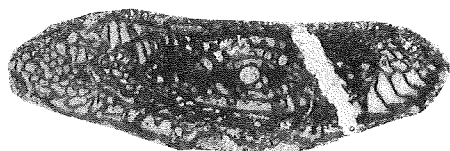
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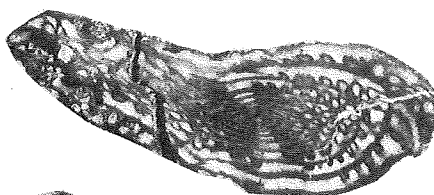
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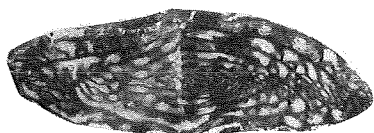
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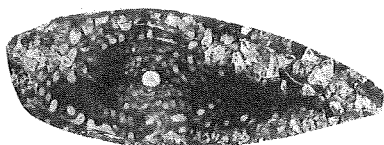
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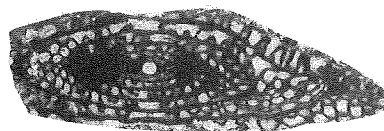
13



11



14



15

# Explanation of plate 5

All figures are ten times natural size.

## *Chalaroschwagerina vulgaris* (SCHELLWIEN and DYHRENFURTH ) ..... 35

Fig. 1: Sagittal section. UHR 19595-14. (Loc. 64)

?Fig. 2: Tangential axial section. UHR 19590-9a. (Loc. 8)

Fig. 3: Axial section. UHR 19593-9. (Loc. 16)

Fig. 6: Axial section. UHR 19595-11. (Loc. 64)

Fig. 7: Axial section UHR 19595-22. (Loc. 64)

Fig. 8: Sagittal section. UHR 19595-4. (Loc. 64)

Fig. 9: A deformed tangential section. UHR 19602-1. (Loc. 9)

Fig. 10: Axial section. UHR 19654-14. (Loc. 65)

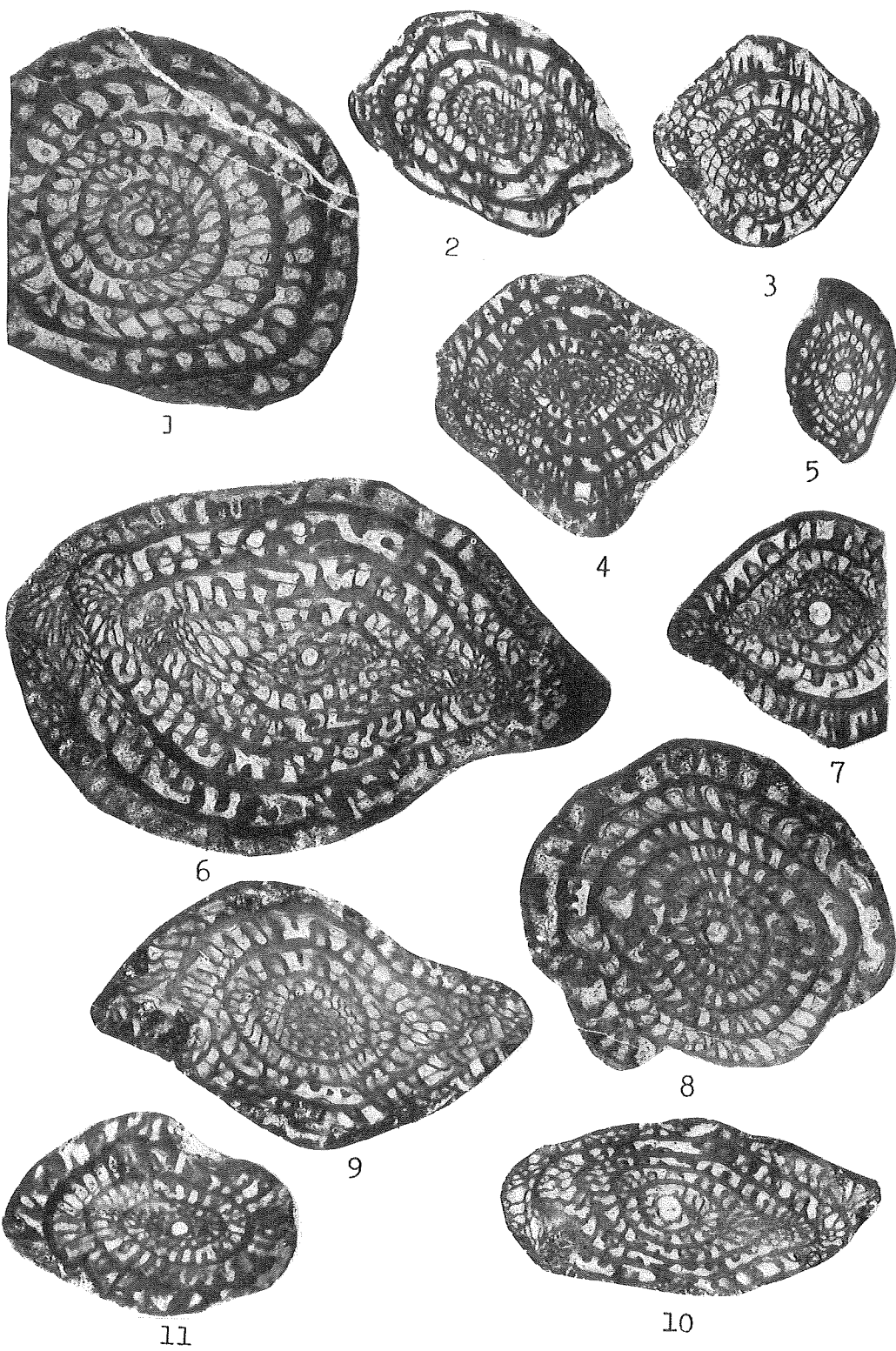
Fig. 11: Sagittal section. UHR 19595-5. (Loc. 64)

## *Schwagerina* cf. *krotowi* (SCHELLWIEN and DYHRENFURTH ) ..... 38

Fig. 4: Axial section. UHR 19593-3. (Loc. 16)

Fig. 5: Sagittal section. Outer volutions are missing. UHR 19590-9b. (Loc. 8)

(All specimens are from Setamai-Yahagi district, Southern Kitakami Mountains. Collected by the author.)

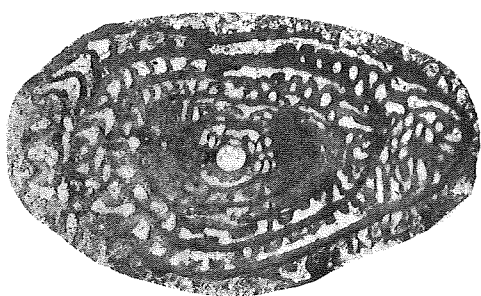


## Explanation of plate 6

All figures are ten times natural size.

|                                                                         |    |
|-------------------------------------------------------------------------|----|
| <i>"Pseudofusulina" krafftii</i> (SCHELLWIEN and DYHRENFURTH) .....     | 52 |
| Fig. 1: Axial section. UHR 19606-1a. (Loc. 13)                          |    |
| Fig. 2: Axial section. UHR 19606-3. (Loc. 13)                           |    |
| Fig. 3: Slightly deformed axial section. UHR 19640. (Loc. 50)           |    |
| Fig. 4: Parallel section. UHR 19606-1b. (Loc. 13)                       |    |
| Fig. 5: Tangential section. UHR 19539-4. (Loc. 16)                      |    |
| <i>Pseudofusulina</i> aff. <i>"Triticites" pseudosimplex</i> CHEN ..... | 51 |
| Fig. 6: Axial section. UHR 19539-1. (Loc. 16)                           |    |
| Fig. 7: Axial section. UHR 19539-2. (Loc. 16)                           |    |
| <i>Paraschwagerina</i> ( <i>Acervoschwagerina</i> ) sp. ....            | 45 |
| Fig. 8: Tangential section. UHR 19610-8. (Loc. 18)                      |    |
| Fig. 9: Depressed axial section. UHR 19610-22. (Loc. 18)                |    |
| (See also plate 9, figs. 4 & 5)                                         |    |

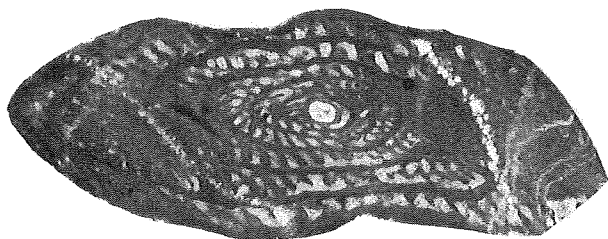
(All specimens were obtained from Setamai-Yahagi district, Southern Kitakami Mountains.  
Collected by the author.)



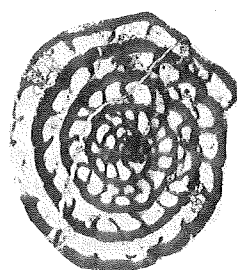
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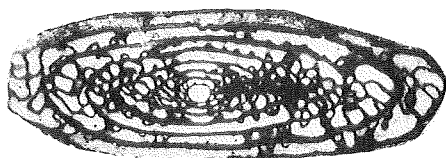
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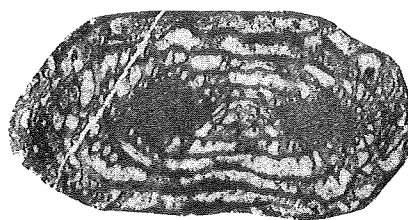
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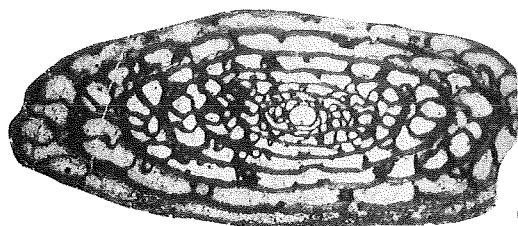
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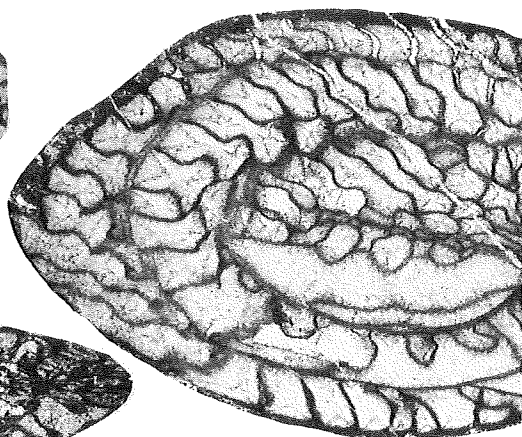
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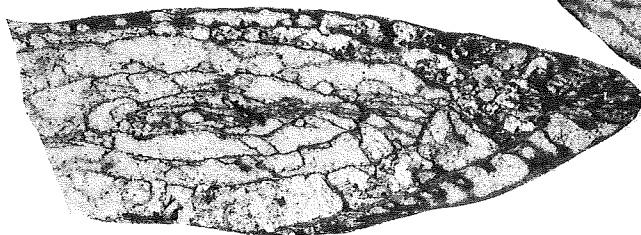
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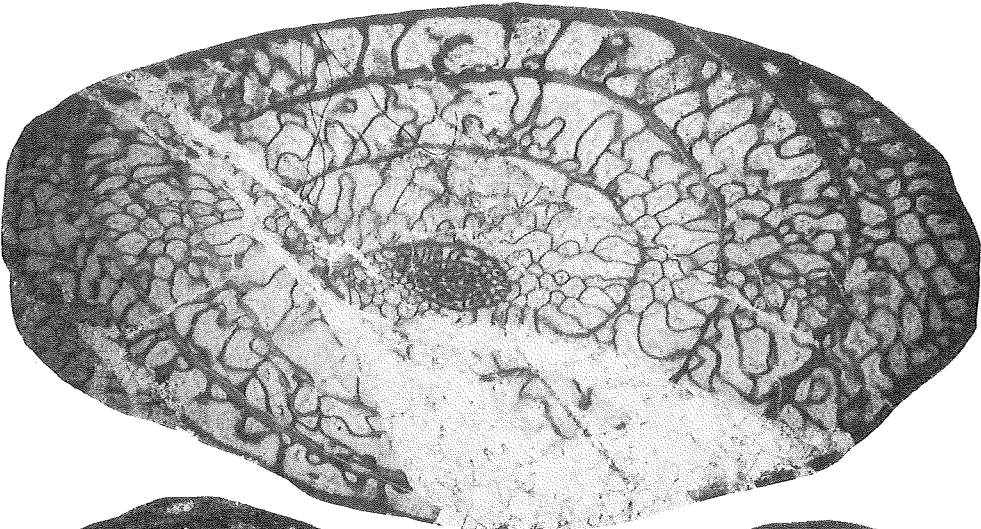
9

## Explanation of plate 7

All figures are ten times natural size.

- Paraschwagerina* (*Acervoschwagerina*) cf. *endoi* HANZAWA . . . . . 43  
 Fig. 1: Diagonally cut axial section. UHR 19676. Exact locality is unknown, but undoubtedly from somewhere in Setamai district.
- Pseudoschwagerina katoi* CHOI, sp. nov. . . . . 41  
 ?Fig. 2: Sagittal section. UHR 19675.  
 Fig. 3: Axial section. Outer shell is missing. UHR 19671.  
 Fig. 4: Axial section of holotype. UHR 19672.  
 Fig. 5: Oblique axial section. UHR 19673.  
 (Figs. 2-5 were yielded in Futamata, Yahagi-cho, Collector; Matajiro KATO ?)
- Nagatoella minatoi* KANMERA and MIKAMI . . . . . 29  
 Fig. 6: Sagittal section. UHR 19606-1c. (Loc. 13)  
 (See also pl. 12, fig. 1-8)
- Ferganites langsonensis* (SAURIN) . . . . . 25  
 Fig. 7: Tangential section. UHR 19592. (Loc. 22)  
 (See also plate 4, figs. 7 and 8)
- (All specimens are from Setamai-Yahagi district, Southern Kitakami Mountains.)

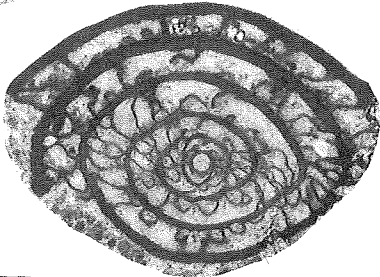




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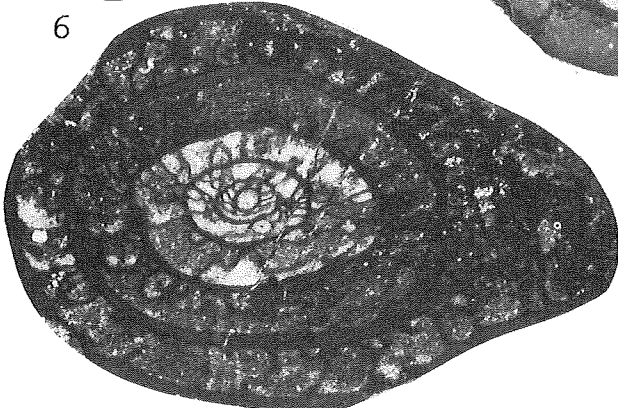
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**Explanation of plate 8**

All figures are ten times natural size.

*Chalartoschwagerina setamaiensis* CHOI sp. nov. . . . . 36

Fig. 1: Tangential section. UHR 19611-12. (Loc. 21)

Fig. 2: Tangential section. UHR 19611-11. (Loc. 21)

Fig. 3: Tangential section. UHR 19611-13. (Loc. 21)

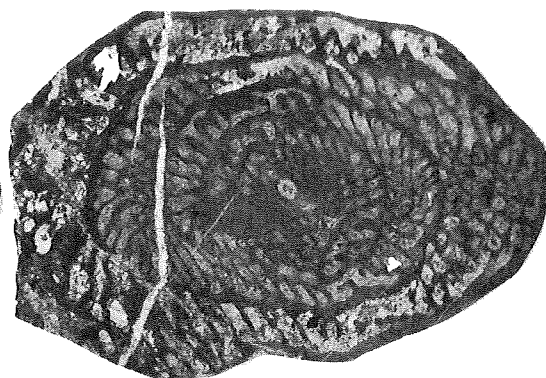
Fig. 4: A little obliquely cut axial section. Holotype. UHR 19621. (Loc. 30)

Fig. 5: Sagittal section. UHR 19592-13. (Loc. 22)

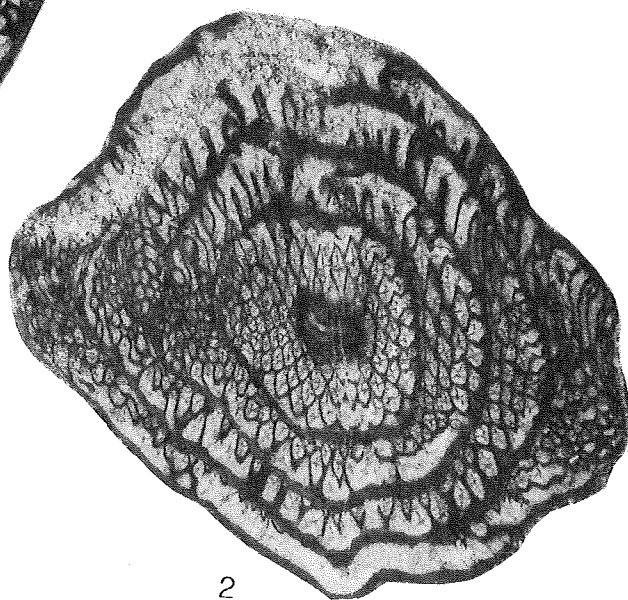
(Specimens were obtained from Setamai-Yahagi district, Southern Kitakami Mountains, collected by the author)



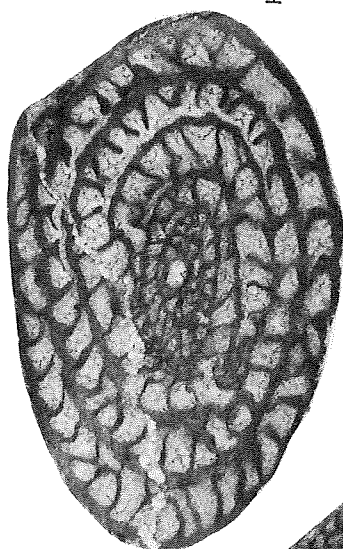
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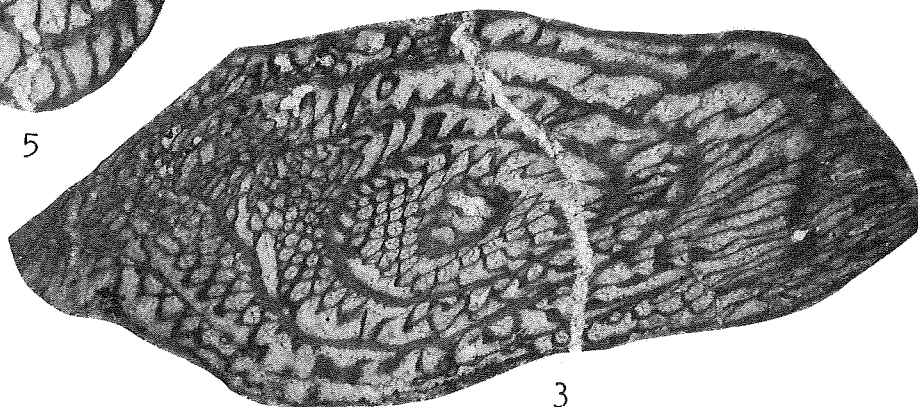
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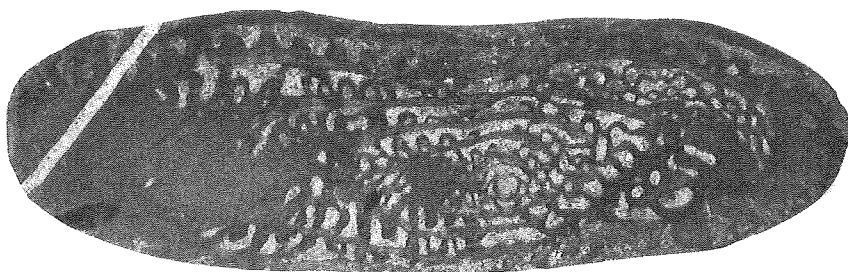
3

**Explanation of plate 9**

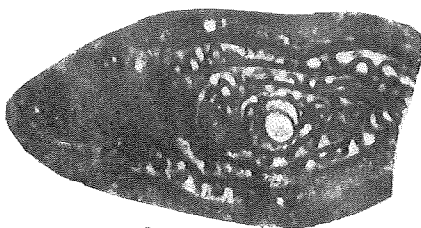
All figures are  $\times 10$ .

|                                                                            |    |
|----------------------------------------------------------------------------|----|
| <i>Pseudofusulina fusiformis</i> (SCHELLWIEN and DYHRENFURTH) .....        | 46 |
| Fig. 1: Axial section. UHR 19305-1f. (Loc. 61)                             |    |
| Fig. 2: Axial section of inner volutions. UHR 19305-2. (Loc. 61)           |    |
| Fig. 3: Axial section. Outer shell is missing. UHR 19305-3. (Loc. 61)      |    |
| <i>Paraschwagerina</i> ( <i>Acervoschwagerina</i> ) sp. ....               | 45 |
| Fig. 4: Oblique tangential section. UHR 19610-6a. (Loc. 18)                |    |
| Fig. 5: Oblique tangential section. UHR 19610-14. (Loc. 18)                |    |
| (See also pl. 6, figs. 8, 9)                                               |    |
| <i>Paraschwagerina</i> ( <i>Paraschwagerina</i> ) sp. ....                 | 43 |
| Fig. 6: A little obliquely cut tangential section. UHR 19610-25. (Loc. 18) |    |

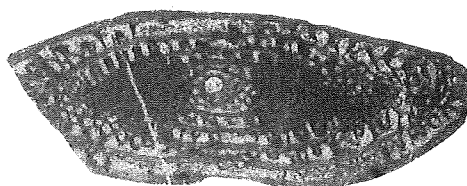
(All specimens are from Setamai-Yahagi district, Southern Kitakami Mountains. Collector; the author).



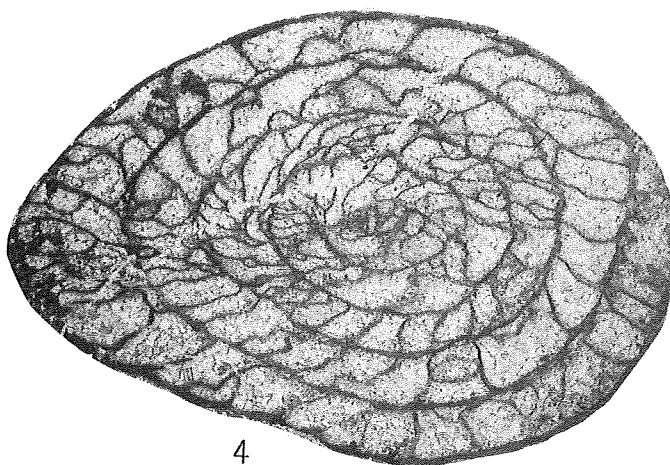
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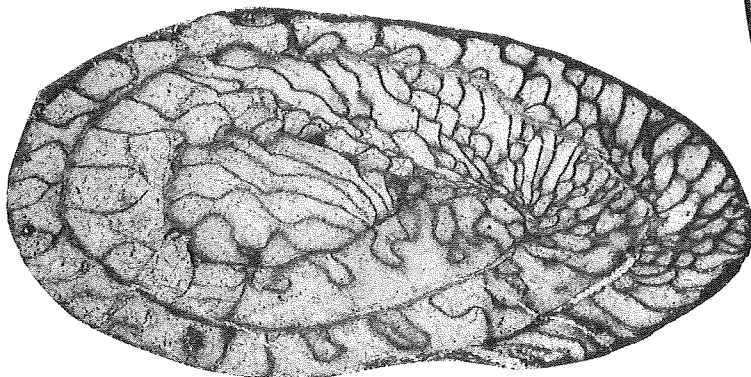
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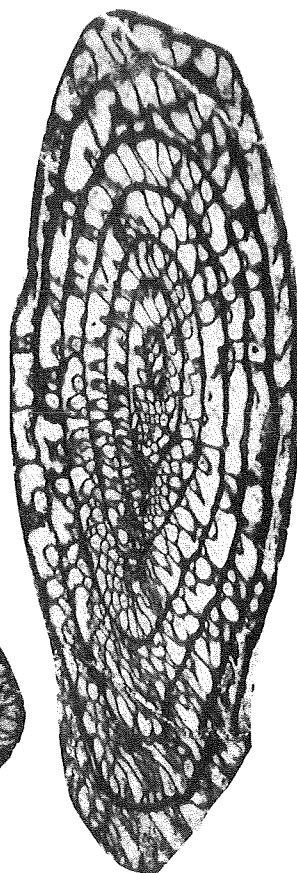
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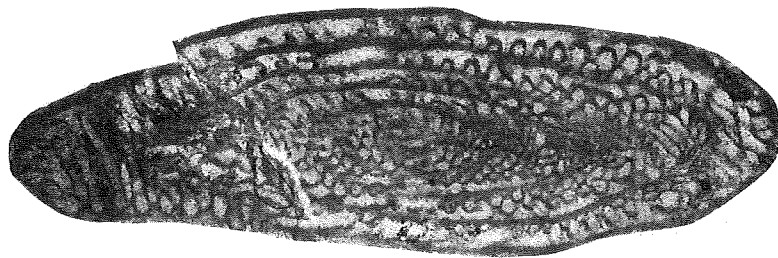
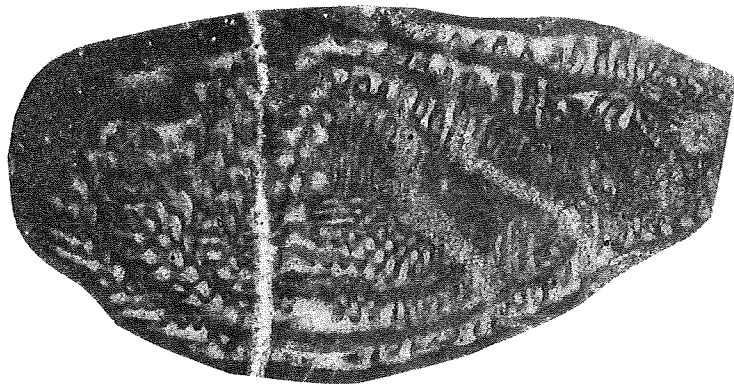
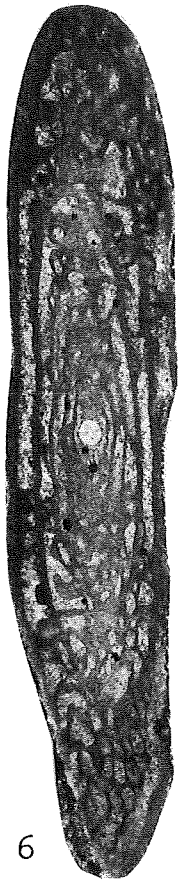
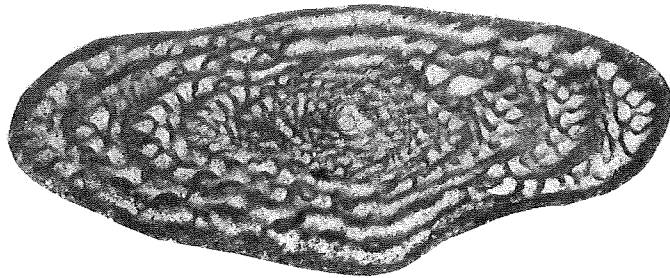
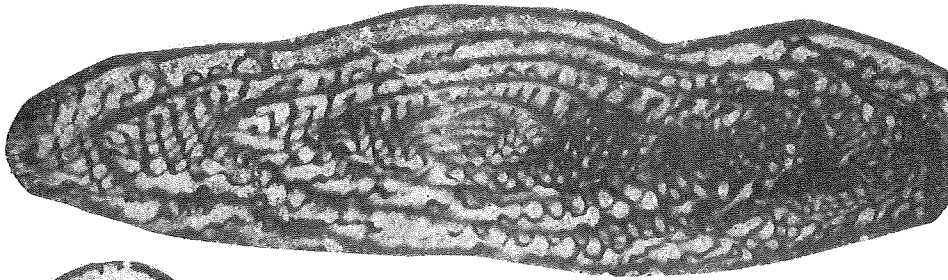
6

## Explanation of plate 10

All figures are ten times natural size.

|                                                                                               |    |
|-----------------------------------------------------------------------------------------------|----|
| <i>Parafusulina</i> cf. <i>multiseptata</i> (SCHELLWIEN) .....                                | 54 |
| Fig. 1: Tangential section. UHR 19615-3a.                                                     |    |
| Fig. 2: Sagittal section. UHR 19615-3b.                                                       |    |
| Fig. 3: Oblique section. UHR 19615-3c.                                                        |    |
| Fig. 5: Tangential section. UHR 19615-4.                                                      |    |
| <i>Parafusulina</i> <i>motoyoshiensis</i> (MORIKAWA) .....                                    | 56 |
| Fig. 6: Axial section. UHR 19666-1. (Loc. 77)                                                 |    |
| (See also pl. 4, figs. 1-3 & 6)                                                               |    |
| ? <i>Pseudofusulina</i> aff. <i>japonica</i> (GÜMBEL) .....                                   | 49 |
| Fig. 4: Excentric axial section. Slightly depressed and expansion appears rapid. UHR 19615-2. |    |

(All specimens are from loc. 24, unless otherwise stated. Collector; the author.)



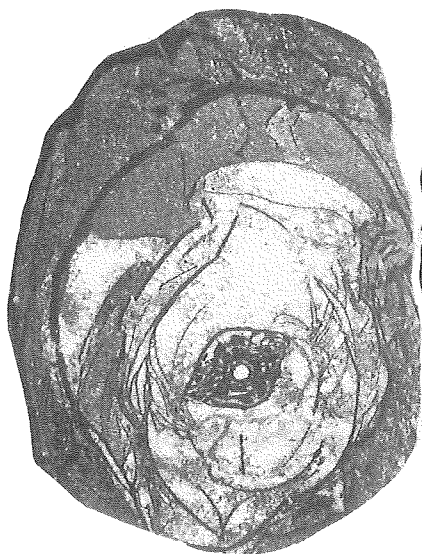


# Explanation of plate 11

All figures are ten times natural size.

- Pseudoschwagerina shellwieni* HANZAWA ..... 42
- Fig. 1: Axial section. Outer volutions are thoroughly destroyed. Note *Triticites* like infant stage. Loc. Futamata, Yahagi-cho, Collector; Matajiro KATO
- Fig. 2: Tangential section. Locality and horizon are exactly unknown, but somewhere in Kotsubosawa. Collected by Masao MINATO.
- Fig. 3: Sagittal section. UHR 19665-4. (Loc. 76). Collected by the author.  
(See also pl. 12, fig. 9)
- Pseudofusulina fusiformis* (SCHELLWIEN and DYHRENFURTH) ..... 46
- Fig. 4: Axial section. Collected by Yoichi AMANO (=HIRATA) at Yukisawa.  
(See also pl. 9, figs. 1-3)
- (All specimens are from Setamai-Yahagi district, Southern Kitakami Mountains.)





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## Explanation of plate 12

All figures are ten times natural size.

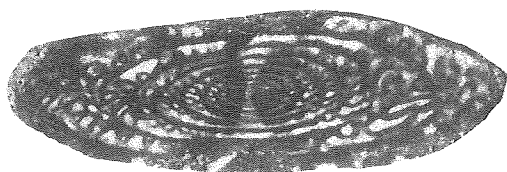
*Nagatoella minatoi* KANMERA and MIKAMI, ..... 29

- Fig. 1: Deep tangential section. UHR 19306-3a. (Loc. 61)  
 Fig. 2: Axial section. Outer volutions are missing. UHR 19306-3b. (Loc. 61)  
 Fig. 3: Axial section. UHR 19590-2. (Loc. 8)  
 Fig. 4: Tangential section. UHR 19590-8a. (Loc. 8)  
 Fig. 5: Tangential section. UHR 19606-2. (Loc. 13)  
 Fig. 6: Oblique axial section. UHR 19306-3c. (Loc. 61)  
 Fig. 7: Slightly excentric axial section. UHR 19306-4. (Loc. 61)  
 Fig. 8: Oblique section. UHR 19606-1a. (Loc. 13)  
 (See also pl. 7, fig. 6)

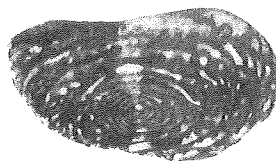
*Pseudoschwagerina schellwieni* HANZAWA, ..... 42

- Fig. 9: Weakly deformed axial section. (Loc. Kotsubosawa)  
 (See also pl. 11, figs. 1-3)

(All specimens except for fig. 9 are collected by the author in the Setamai-Yahagi district. Fig. 9 is by Masao MINATO)



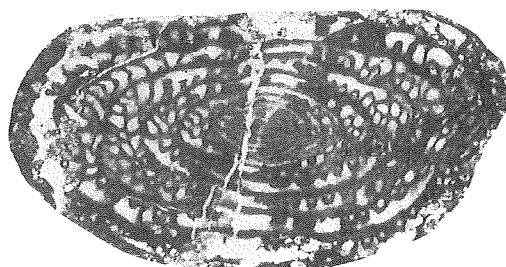
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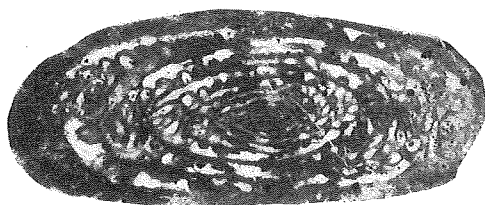
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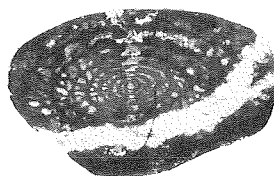
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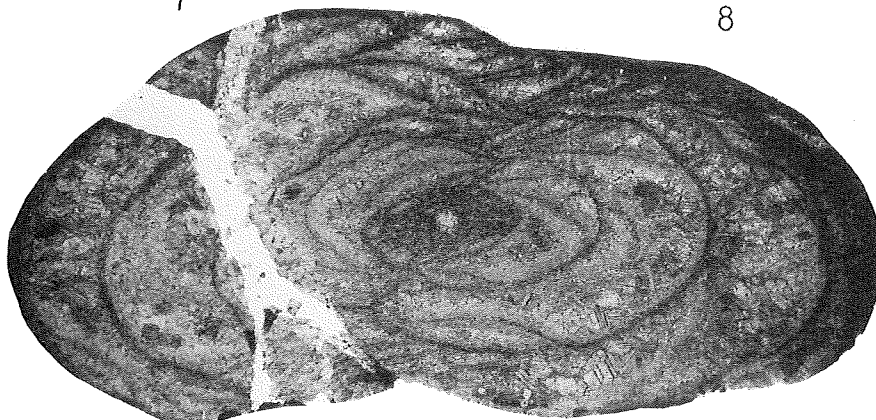
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## Explanation of plate 13

All figures are  $\times 10$ . Loc. 61.

*Parafusulina* aff. *gigantea* (DEPRAT) ..... 55

Fig. 1: Tangential section. UHR 19305-10a.

Fig. 2: Sagittal section and a part of tangential section. Note the pronounced development of cuniculi. UHR 19305-10b.

Fig. 3: Sagittal section. UHR 19305-9.

*Pseudofusulina* aff. *japonica* (GÜMBEL) ..... 49

Fig. 4: Axial section, showing broadly and roundly fluted septa. UHR 19305-11.

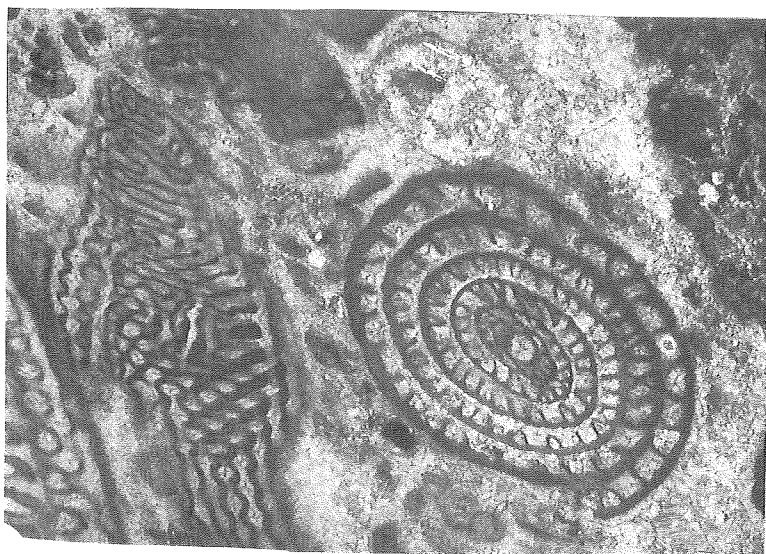
Fig. 5: Axial section showing narrowly fluted septa. UHR 19307-5.

Fig. 6: Axial section. UHR 19305-1a.

(Permian fusulinids from the Setamai-Yahagi district, Southern Kitakami Mountains.)



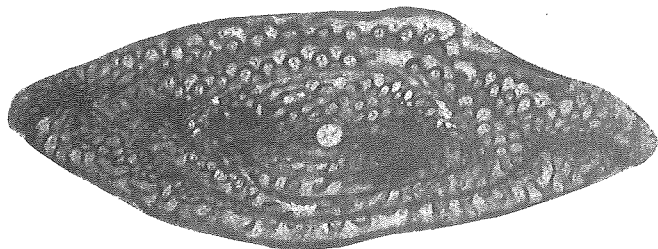
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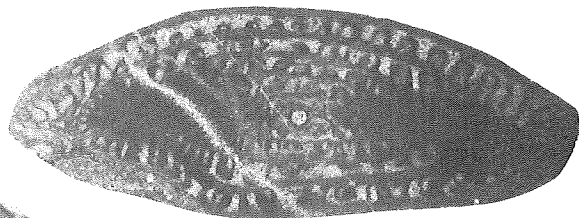
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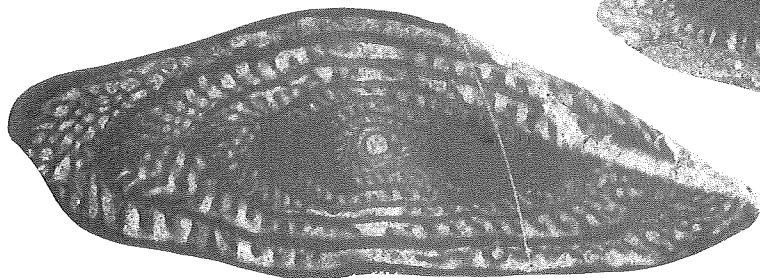
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## Explanation of plate 14

All figures are  $\times 10$ .

Figs. 1-6 are from loc. 121, and fig. 7 is from loc. 133.

*Monodiexodina kofuganensis* CHOI, sp. nov. . . . . 32

Fig. 1: Axial section. UHR 19311-6.

Fig. 2: Weakly deformed axial section. UHR 19311-21a. Holotype.

Fig. 3: Tangential section. Attention to the low and very narrowly fluted septa. UHR 19311-7.

Fig. 4: Parallel section. UHR 19311-2.

Fig. 5: Tangential section. UHR 19311-19.

*Monodiexodina matsubaishi* (FUJIMOTO) . . . . . 32

Fig. 6: Axial section. UHR 19311-17.

*Chusenella?* sp

Fig. 7: Oblique tangential section. UHR 19315-1.

(Permian fusulinids from the Setamai-Yahagi district, Southern Kitakami Mountains.)





# Explanation of plate 15

All figures are  $\times 10$ .

*Parafusulina* aff. *mccloudensis* SKINNER & WILDE ..... 52

Fig. 1: Axial section of a typical specimen. UHR 19314-47. (Loc. 132)

Fig. 2: Tangential section. UHR 19343-10. (Loc. 156)

Fig. 3: Tangential section showing the arcuate axis of coiling. UHR 19314-27. (Loc. 132)

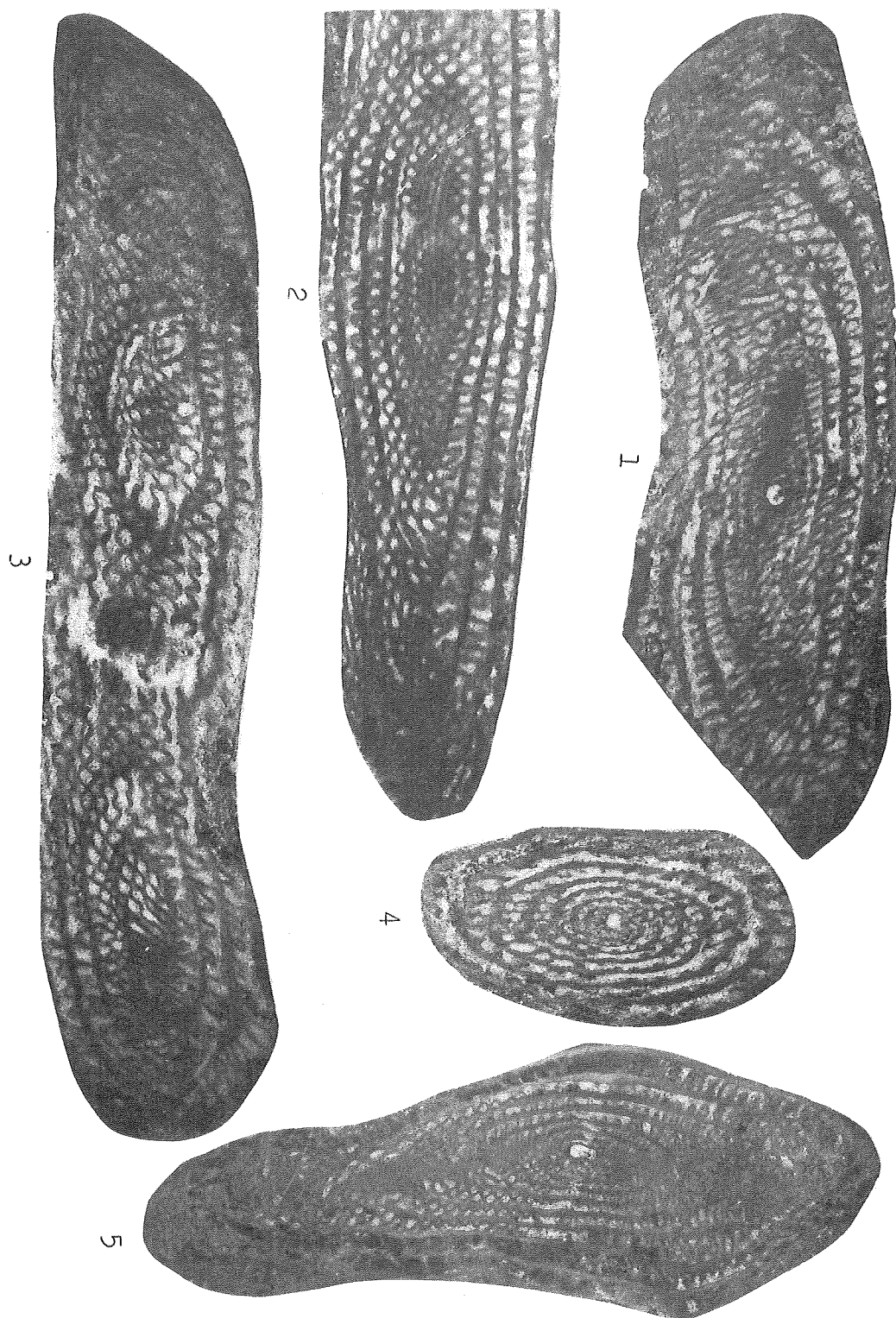
Fig. 4: Sagittal section. UHR 19314-48. (Loc. 132)

Fig. 5: Axial section. UHR 19343-6. (Loc. 156)

(See also pl. 19, fig. 3)

(Permian fusulinids from the Setamai-Yahagi district, Southern Kitakami Mountains.)

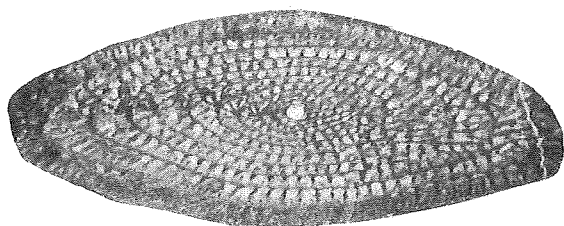




## Explanation of plate 16

- Colania kotsuboensis* CHOI, sp. nov. . . . . 63  
 Fig. 1: Axial section showing inner volutions. Paratype. UHR19315-1.  $\times 10$ . (Loc. 133)  
 Fig. 6: Axial section of holotype. Note the development of secondary transverse septula: UHR 19315-2.  $\times 10$ . (Loc. 133)  
 Fig. 7: Sagittal section. UHR 19313-15.  $\times 10$ . (Loc. 131)  
 Fig. 10: A part of paratype axial section, illustration the development of primary and secondary transverse septula. UHR 19314.  $\times 10$ . (Loc. 132)
- Lepidolina minatoi* CHOI, nom. nov. . . . . 67  
 Fig. 2: Paratype specimen of natural size. The largest specimen among Neoschwagerinids known to date. Fig. 3 is twice the size of fig. 2. (Loc. 139)
- Lepidolina multiseptata* (DEPRAT). . . . . 65  
 Fig. 8: Sagittal section of a specimen grouped in *Lepidolina multiseptata shiraiwensis*. UHR 19291-2.  $\times 10$ . (Loc. 109)  
 Fig. 11: Axial section. A specimen close to *Lepidolina multiseptata gigantea* group. UHR 19323.  $\times 10$ . (Loc. 140)
- Chusenella* sp. . . . . 57  
 Fig. 9: Axial section. UHR 19314-20.  $\times 10$ . (Loc. 132)
- Codonofusiella explicata* (KAWANO) . . . . . 14  
 Fig. 12: Parallel section. UHR 19333-7.  $\times 20$ . (Loc. 151)
- Kahlerina pachythea* KOCHANSKY-DEVIDÉ and RAMOVŠ . . . . . 19  
 Fig. 4 & 5: Axial section. 4; UHR 19282-6, 5; UHR 19282-31.  $\times 10$ . (Loc. 102) See also pl. 20, fig. 6.

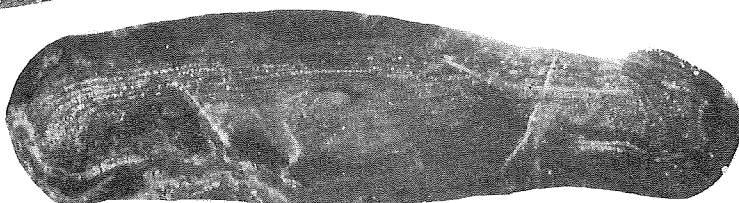
(All specimens were obtained from Setamai-Yahagi district, Southern Kitakami Mountains.)



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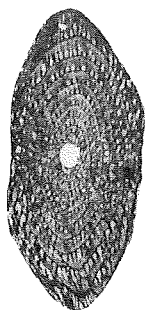
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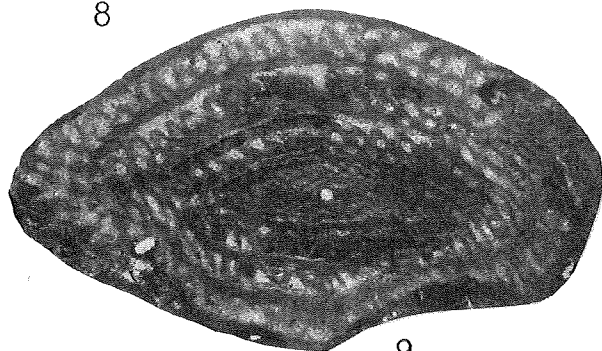
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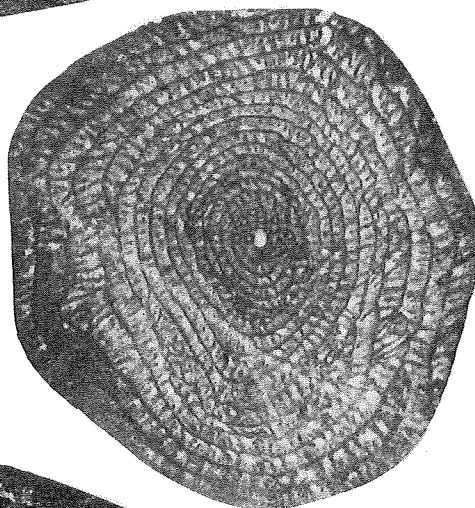
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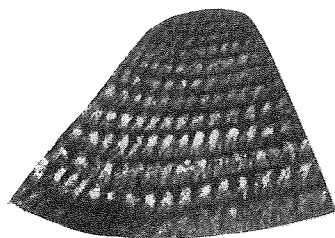
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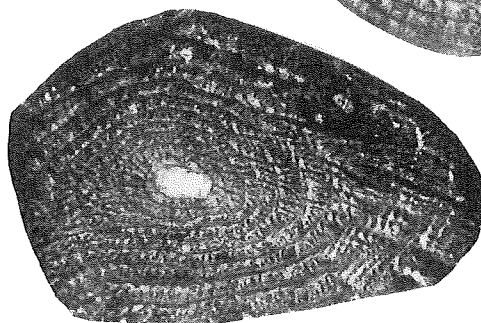
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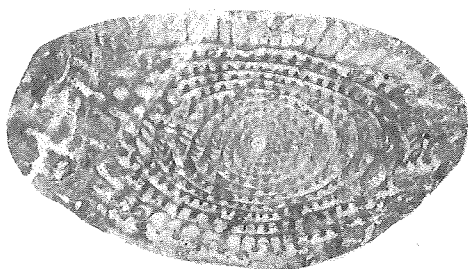


12

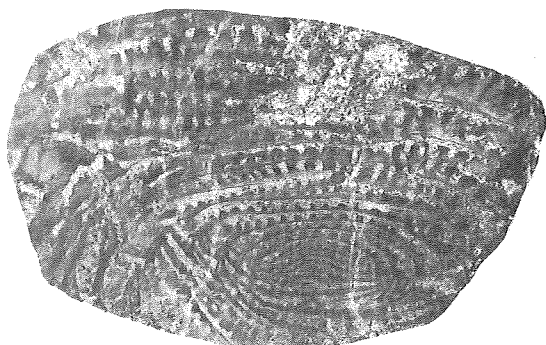
## Explanation of plate 17

All figures are  $\times 10$ .

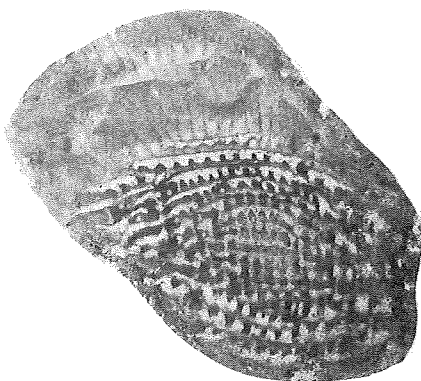
- Pseudodoliolina kanokuraensis* CHOI, sp. nov. .... 60
- Fig. 1: Axial section of holotype showing abruptly thinned out and elongated parachomata in the outer volutions. UHR 19282-32. (Loc. 102)
- Fig. 2: Tangential section. Outer volutions are almost missed. UHR 19282-29. (Loc. 102)
- Fig. 3: A part of tangential section showing bar-like chomata in outer volutions. UHR 19282-28. (Loc. 102)
- Fig. 4: Sagittal section. UHR 19282-20. (Loc. 102)
- Fig. 5: Axial section of inner volutions. UHR 19282-3. (Loc. 102)
- Pseudodoliolina elongata* CHOI .... 61
- Fig. 6: Axial section. Outer volutions are missed. Note the rugose spirotheca. UHR 19282-1. (Loc. 102)
- Pseudodoliolina gravitesta* KANMERA .... 58
- Fig. 7: Parallel section. UHR 19343-12. (Loc. 156)
- Fig. 8: Axial section. UHR 19343-4. (Loc. 156)
- (See also pl. 18, figs. 1-4)
- (Permian fusulinids from the Setamai-Yahagi district, Southern Kitakami Mountains.)



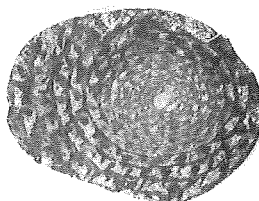
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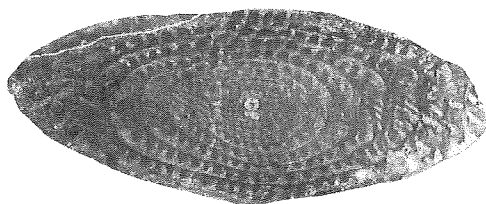
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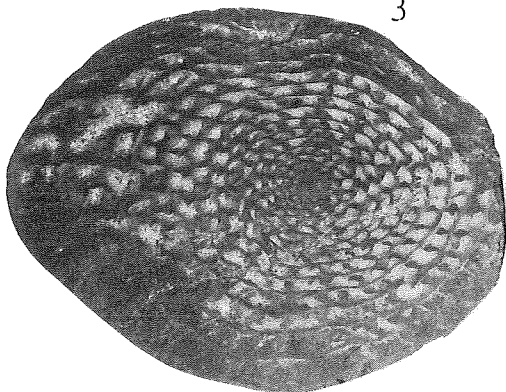
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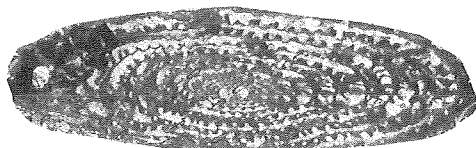
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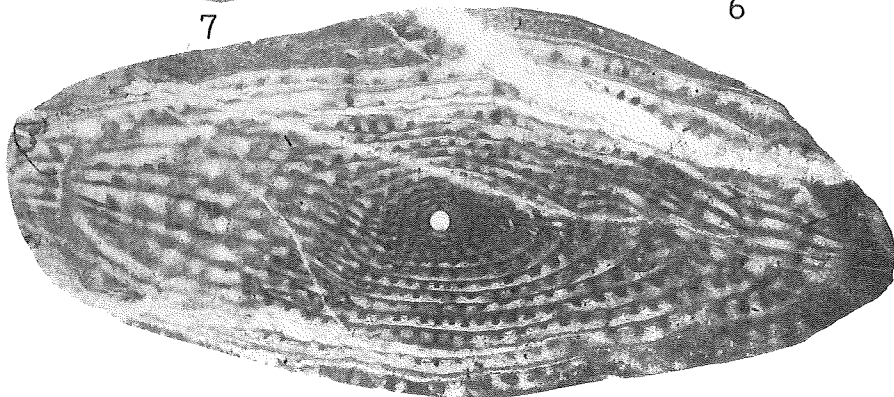
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**Explanation of plate 18**

All figures except for fig. 5 are  $\times 10$ . Fig. 5 is  $\times 20$ .

*Pseudodoliolina gravitesta* KANMERA ..... 58

Fig. 1: Axial section. Chomata are poorly developed in the outer volutions. UHR 19314-50. (Loc. 132)

Fig. 2: Axial section. UHR 19314-15. (Loc. 132)

Fig. 3: Axial section. UHR 19321-1. (Loc. 138)

Fig. 4: Tangential section of a severely pressed specimen which has tremendously well developed parachomata. Note the variation in the mode of development of parachomata in *Pseudodoliolina gravitesta*. UHR 19321-2. (Loc. 138)

(See also pl. 17, figs. 7 & 8)

*Pseudodoliolina* sp

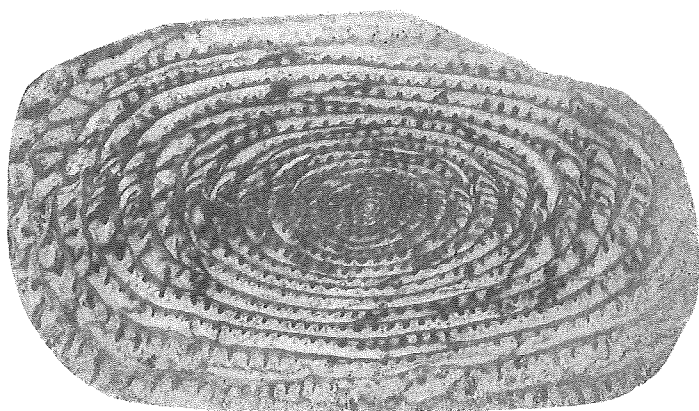
Fig. 5: A part of tangential section showing thin spirotheca with slight rugosity and poorly developed parachomata. This specimen may be related to *Pseudodoliolina elongata*. UHR 19324. (Loc. 141)

?*Nankinella* sp. A ..... 17

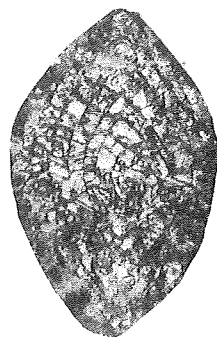
Fig. 6: Tangential section. UHR 19323-2. (Loc. 140) See also pl. 20, fig. 3.

(Permian fusulinids from the Setamai-Yahagi district, Southern Kitakami Mountains.)

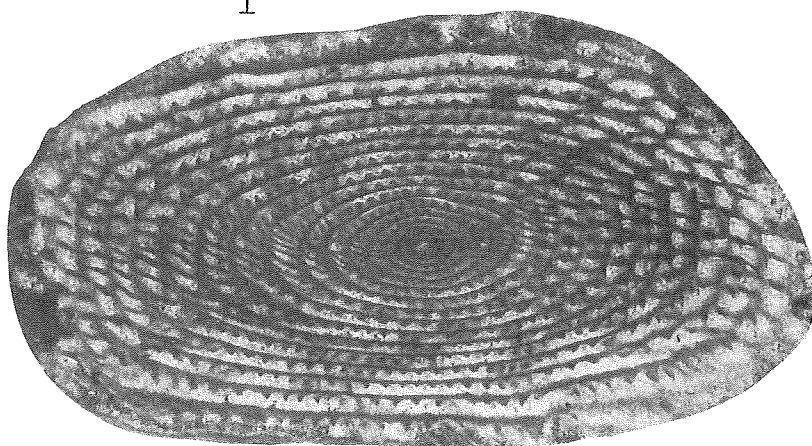




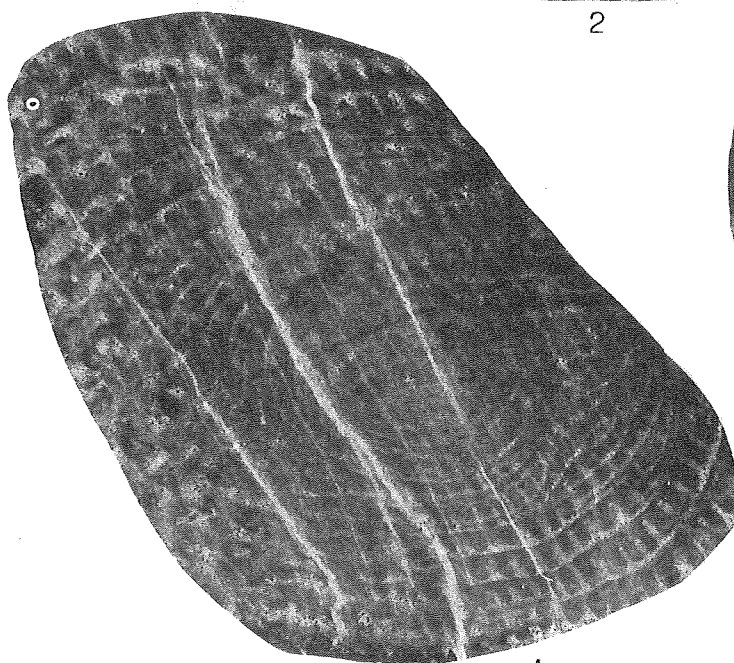
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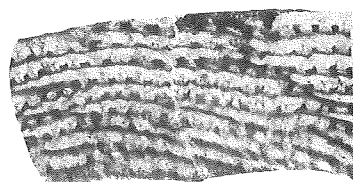
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# Explanation of plate 19

All figures are  $\times 10$ .

|                                                                                        |    |
|----------------------------------------------------------------------------------------|----|
| <i>Lepidolina minatoi</i> CHOI, nom. nov. ....                                         | 67 |
| Fig. 1: Holotype. Axial section. UHR 19343-6. (Loc. 156)                               |    |
| Fig. 2: Tangential axial section. UHR 19343-15. (Loc. 156)                             |    |
| <i>Lepidolina kumaensis</i> KANMERA ....                                               | 67 |
| Fig. 4: A part of axial section. UHR 19284-1. (Loc. 104)                               |    |
| <i>Parafusulina</i> aff. <i>mccloudensis</i> SKINNER and WILDE ....                    | 52 |
| Fig. 3: Axial section, showing largely curved axis of coiling. UHR 19314-2. (Loc. 132) |    |
| See also pl. 15, figs. 1-5.                                                            |    |

(All specimens were collected by the author from the Setamai-Yahagi district, Southern Kitakami Mountains.)

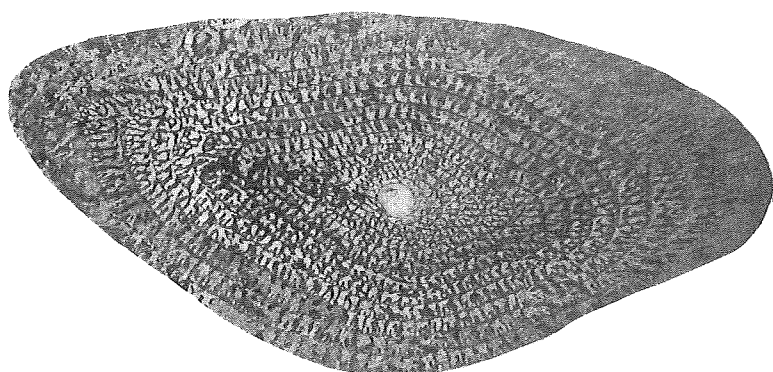




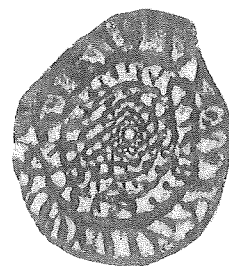
### Explanation of plate 20

All figures except for figs. 3 & 5 are  $\times 10$ . Figs. 3 & 5 are  $\times 20$ .

- Lepidolina multiseptata* (DEPRAT) . . . . . 65  
 Figs. 1 & 2: Axial sections. 1; UHR 19336-7, 2; UHR 19331-5. Both are from loc. 151.  
 Figs. 7 & 8: Sagittal sections. Fig. 7 is slightly deformed. 7; UHR 19332-2, 8; UHR 19330-2. (Loc. 151)  
 Fig. 10: Deformed axial section. Transverse septula are poorly developed. UHR 19291-1. (Loc. 109)
- Schwagerina acris* THOMPSON and WHEELER . . . . . 39  
 Fig. 4: Axial section. UHR 19330-1. (Loc. 151)  
 Fig. 9: Sagittal section. UHR 19333-3. (Loc. 151)
- Nankinella* sp. A . . . . . 17  
 Fig. 3: Axial section. UHR 19330-7. (Loc. 151) See also pl. 18, fig. 6.
- Nankinella* sp. B  
 Fig. 5: Deep tangential section. UHR 19323-1. (Loc. 140)
- Kahlerina pachythea* KOCHANSKY-DEVIDÉ and RAMOVŠ . . . . . 19  
 Fig. 6: Axial section. UHR 19315-1. (Loc. 133) See also pl. 16, figs. 4 & 5.
- (Permian fusulinids from Setamai-Yahagi district, Southern Kitakami Mountains. All specimens were collected by the author)



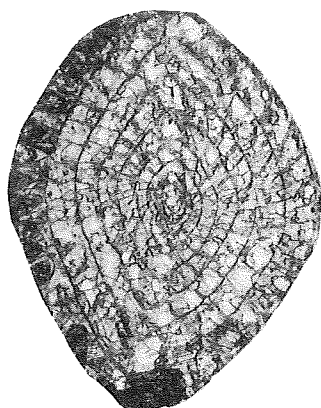
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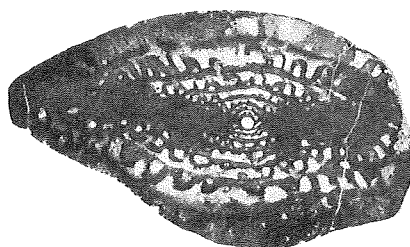
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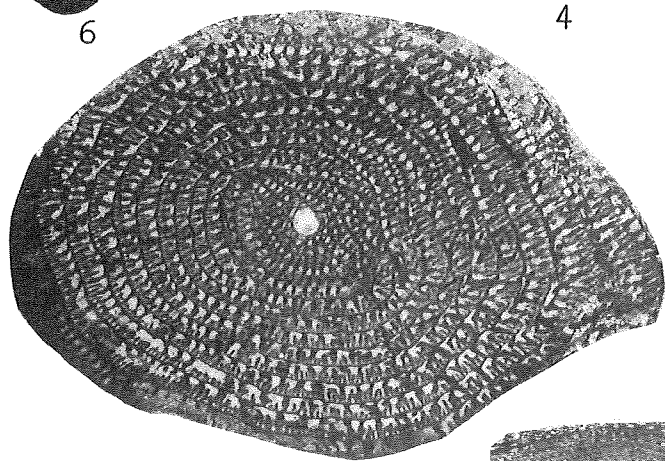
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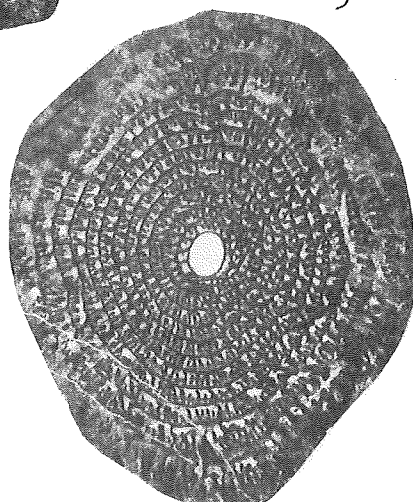
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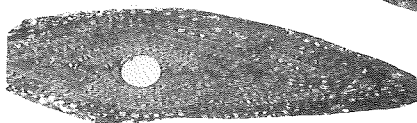
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