Permian fusulinaceans from the Akuda and Horikoshitoge Formations, Hachiman town, Gifu Prefecture, Central Japan

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Received 18 May 1996; Revised manuscript accepted 15 August 1996

Abstract. Thirty-seven species belonging to 16 genera of fusulinaceans are discriminated from the Akuda and Horikoshitoge Formations, exposed in Hachiman town, Gifu Prefecture, Central Japan. Among them, the following six species are newly proposed: Sphaerulina akudensis, Durbarula uenoi, Schwagerina shukae, S. kanumai, Pseudofusulina minoiensis, and P. miyamensis. This fusulinacean fauna is similar in composition to that described from the Nyukawa Group exposed about 80 km northeast of the present area, and indicates the Yakhtashian to Kuberganian of the standard stratigraphic scheme of the Tethyan Province.

Key words: Akuda Formation, fusulinaceans, Horikoshitoge Formation, Mino Terrane, Permian

Introduction

The study area is located in Hachiman town, Gifu Prefecture, Central Japan. This area belongs to the northern part of the Mino Terrane of the Inner Zone of Southwest Japan, and is underlain by Jurassic clastic sedimentary rocks. The strata consist of turbidites and olistostromes that commonly include allochthonous blocks of chert, limestone, and greenstone of various age, shape, and size. The chert blocks yield Triassic conodonts and radiolarians. The limestone blocks are commonly fossiliferous and yield calcareous algae, fusulinaceans, and conodonts that suggest an Early to Middle Permian age.

Kanuma (1958a, b, 1959, 1960) extensively studied this area and divided the strata into four formations, namely, the Akuda, Kuchibara, Kayukawa, and Shimadani Formations in ascending order. The Akuda and Kuchibara Formations consist mainly of white to pale gray massive limestone and black bedded limestone, respectively. The Kayukawa Formation consists mainly of clastic sedimentary rocks. The Shimadani Formation is composed of bedded chert. Kanuma (1958a, b) described late Early Permian fusulinaceans collected from the limestone of the Akuda Formation.

Subsequently, Yoshida (1972) studied the structural geology of this area and analyzed some complicated folding structures. I restudied this area and discovered many Triassic conodonts from cherts of the Kayukawa and Kuchibara Formations (H. Igo, 1979) and provided new information concerning the geologic age of these formations. Furthermore, I confirmed that the cherts are allochthonous blocks or sheets embedded in both formations.

Wakita (1984) made regional mapping in the Hachiman area and pointed out that Jurassic clastic sedimentary rocks are extensively distributed in this area, intercalating allochthonous blocks of various kinds of sedimentary rocks. Moreover, these blocks show various sizes and ages. He subdivided the Jurassic rocks into five such units, the Nabigawa, Kodaragawa, Kajika, Furumichi, and Samondake Formations. Concerning the limestone of the Akuda Formation, he showed that it is a huge allochthonous block embedded in the Nabigawa Formation and it is designated as the Akuda Block.

I continued investigation of this area and reported a mixed conodont fauna preserved within fissure filling deposits in the limestone of the Akuda Block (H. Igo, 1989). Furthermore, I discussed the origin of this mixing related with the sedimentary environment of the Akuda Limestone. Recently, Horibo (1990) documented the petrography of limestones which belong to the Akuda and Horikoshitoge Formations, and discussed their depositional environments.

During my consecutive field survey in the Hachiman area, I have collected many limestone samples from the Akuda and Horikoshitoge Formations in which abundant fusulinaceans are contained. Paleontological study of the samples elucidates that the fusulinaceans are similar to hitherto described species from allochthonous limestones embedded in the accreted Jurassic sedimentary rocks in the Mino Terrane, Central Japan. The purpose of the present paper is to describe the fusulinaceans in these two formations and to discuss the age and similarities of the fauna with that reported from other allochthonous limestones in the Mino Terrane. I discriminate a total of 37 species of...
fusulinaceans belonging to 16 genera in this study, among which six species are new to science and four species left in open nomenclature.

Geologic setting

The Akuda Block of Wakita (1984) is an informally designated rock unit of limestone previously treated as a formation, the Akuda Formation (Kanuma, 1958, etc.; Hh. Igo, 1989). Recently, Horibo (1990) restudied Wakita's Akuda Block based on the limestone petrography and analysis of biofacies. He subdivided the Akuda Block into the Akuda (s.s) and Horikoshitoge (newly designated) Formations by their lithic characters. Furthermore, Horibo showed that these formations are almost coeval but that the former was deposited in lagoons or sand bars while the latter accumulated in the marginal part of the bank. The two formations are now in fault contact.

In the present study, I follow Horibo's newly proposed definition of the Akuda and Horikoshitoge Formations. The Akuda Formation constitutes the main part of the Akuda Block, which is about 1.7 km in width and 12 km in lateral extent. It strikes E–W and dips 80° to 90° S or N. According to my observations, the Akuda Formation consists mainly of white to pale gray massive and thick-bedded limestones including limestone conglomerate and calcarenite, and variegated greenstones and volcanioclastics. The total thickness of this formation was estimated to be 550 m by Hh. Igo (1989) and 500 m by Horibo (1990). The Akuda is well exposed along the roadcut from Nishi-Akuda to Akuda-
Kuchi (Sections B, C, E) and north of the Horikoshi Pass (Section A). Limestones in the Sections B and E are mostly pale gray to white and massive. Limestones along the Section C (B-17, B-11) are bedded and mostly dark gray with brownish tints.

Intercalations of limestone conglomerate (Horibo's limestone-breccia) are characteristic lithofacies of the Akuda Formation. This conglomerate consists of various-sized angular clasts of limestone and dolostone cemented with ill-sorted lime mud, lime sand, and red hematitic clay. The other type of conglomerate is volcanic conglomerate exposed along the roadcut at Nishi-Akuda (R-1). Limestone clasts of the conglomerate are commonly rounded and of boulder size cemented with variegated tuff.

The Horikoshitoge Formation at Higashi-Akuda consists mainly of gray to dark gray bioclastic bedded limestone, and attains a thickness of about 200 m. Along the Section D, limestones (B-37 to B-46) show typical lithology of the Horikoshitoge and their microfacies are lime mud/wackestone. These limestones yield abundant fusulinaceans.

**Fusulinaceans from the Akuda and Horikoshitoge Formations**

Volcanic conglomerate crops out at Nishi-Akuda (R-1) and abundantly includes limestone clasts containing well-preserved fusulinaceans. This conglomerate is assumed to be equivalent with limestone-breccia in the upper part of the Column B (Section 71) of Horibo (1990). This breccia occupies the upper part of the middle division of the Akuda Formation. The following fusulinaceans are discriminated from R-1: *Pseudoreichelina* sp., *Pamirina* (Levenella) *leveni* Kobayashi, P. (L.) *evoluta* Sheng and Sun, *Nankinella* sp., N. aff. *kotakiensis* (Fujimoto and Kawada), *Sphaerulinia akudensis* Hh. Igo sp. nov., *Schubertella pseudobosca* Chen, *Neofusulinella giraudi* Deprat, *Schwagerina shukaoae* Hh. Igo sp. nov., *S. higashidaniensis* Hy. Igo, *S. kanumai* Hh. Igo sp. nov., *Pseudofusulinina minoenesis* Hh. Igo sp. nov., *P. regularis* (Schellwien), *P. houziguanica* Sheng, and P. sp. Massive limestone (R-2) situated about 30 m above R-1 yields *P. regularis* (Schellwien) and *Chalaroschwagerina aff. chinensis* (Chen). A single species, *S. kwangchiensi* Chen, was obtained from R-3 situated about 60 m below R-1.

Although the actual stratigraphic position is uncertain, I collected some samples from limestones exposed south of the Horikoshi Pass (A-1, A-2). These samples may repre-
sent the lower part of the Akuda Formation and contain *Pseudofusulina norikurensis* Hy. Igo and *P. paratschernychewi* Kanuma. Collections were also made along the roadcut (Section A) north of the Horikoshi Pass. Limestones situated in the lower part of this section (A-21, A-22) yield *Neofusulina tantenoi* Deprat, *Minijapanella* (M.) *elagata* Fujimoto and Kanuma, *Dunbarula uenoi* H. Igo sp. nov., *Pseudofusulina horadaniensis* Hy. Igo, *Makaya pamirica* (Leven), *M. sarabuniensis* Kammera and Toriyama, and *Armenia* sp.

Limestone samples were collected along the Section B, about 300 m north of the above-mentioned localities. They are at levels B-2, B-3, and B-4 and yield *Schwagerina shukoaee* H. Igo sp. nov., *Acervoschwagerina fusiformis* Kanuma, and others. Massive limestone in the lower part of the Section C (B-1) includes *Parafusulina? sublineata* Hy. Igo and thickly bedded limestone in the upper part of this section yields *Parafusulina sotonensis* Igo and others (B-11).

A single species, *Pseudofusulina krafftii* (Schellwien), was collected from a white massive limestone exposed at OHT-4, upstream of the Otome-tani Valley, north of Nishi-Akuda.


As already mentioned, the Akuda and Horikoshitoge Formations are a huge allochthonous block embedded in Jurassic rocks, and the detailed internal structure of this block is unclear. I measured several sections to collect fusulinaceans, but these specimens do not provide enough biostratigraphic value, and even the local correlation among measured sections is difficult. Fusulinaceans discriminated in this study, however, indicate that the formations are almost coeval as already pointed out by Horibo (1990).

The present fusulinacean fauna is characterized by species of *Pseudofusulina* with a large cylindrical shell, thick spherithec, and dense axial filling. Characteristic *Schwagerina* species with a fusiform shell of medium size, thin spherithec, and delicate septa are also important representatives. A similar schwagerinid but with an elongate shell identified to *Parafusulina* with reservations, is also characteristic. Although its occurrence is rare, the presence of *Acervoschwagerina* in this fauna is noteworthy. The fauna also contains *Neofusulina*, *Sphaerulina*, *Schubertella*, *Minijapanella*, *Nankinella*, and other small fusulinaceans. The mentioned faunal characters are common features in the fauna reported from the upper Lower Permian (Yakhtashian) of the Tethyan Realm. The present fauna excludes typical *Parafusulina* species except for *Parafusulina sotonensis* and species of *Misellina*, which are good indicators of the Bolorian, are also lacking.

In the Section A, limestones of two different levels yield two species of *Makaya*, and an unidentified species of *Armenia* in association with *Neofusulina* and others. These levels may occupy higher levels than those of the aforementioned species and are correlated with the middle Middle Permian (Kubergandan).

The Jurassic accreted terrane, the Mino Terrane, in Central Japan commonly includes various sized Upper Paleozoic limestones. Previous to our recognition of accreted terrane schemes, these limestones had long been considered to be autochthonous strata which were deposited in the shallow carbonate shelf, bank, reef, and other marine geosynclinal environments. Fusulinaceans of these limestones were studied by many specialists in the Lake Biwa area (Morikawa and Isomi, 1961), Akasaka Limestone (Ozawa, 1927, Morikawa, 1956, etc.), Ibuki Limestone (Kobayashi, 1957), Yoganayama Limestone (Sashida, 1980), Hachimana area (Kanuma, 1958a, etc.), Nyukawa Group (Hy. Igo, 1964, etc.), Shiraume Limestone (Cho and Fujita, 1970), and others. There are other fusulinacean-bearing limestones in the Mino Terrane of Central Japan such as the Fujiwaradake, Ryozen, and Funafuseyama Limestones. Fusulinaceans contained in these limestones have not been fully studied, but the present fauna is similar to the fauna described from the Shiroi, Kono, and lower Sote Formations of the Nyukawa Group (Hy. Igo, 1964, 1965) exposed about 60 km northeast of the present area.

**Systematic paleontology**

Order Foraminiferida Eichwald, 1830
Suborder Fusulinina Wedekind, 1937
Superfamily Fusulinacea von Möller, 1878
Family Staffellidae Mikulcsno-Maklay, 1949
Genus *Pseudoreichelina* Leven, 1970

**Type species.—** *Pseudoreichelina darvasica* Leven, 1970

*Pseudoreichelina* sp.

Figures 10-15—20

**Materials.—** Axial section, TGUFU 1086; tangential sections, TGUFU 1084, 1085, 1087, 1089; sagittal section, TGUFU 1088.

**Remarks.—** The present specimens are mostly recrystallized and the spherithec structure and other specific characters are obliterated. The shape of septa in the last uncoiled volution of the specimens indicates assignment to the genus *Pseudoreichelina*.

**Occurrence.—** All specimens collected from R-1 in Section E of Nishi-Akuda.


**Type species.—** *Pamirina darvasica* Leven, 1970
Subgenus Levenia Ueno, 1991
Subgenus *Levenella* Ueno, 1994
Type species.—Pamirina leveni Kobayashi, 1977

**Pamirina (Levenella) leveni** Kobayashi, 1977

Figures 11-20–31

*Pamirina leveni* Kobayashi, 1977, p. 11-14, pl. 1, figs. 13-38.


**Materials.**—Axial sections, TGUFU 1110, 1111, 1112, 1113, 1114, 1115, 1116, 1117, 1120, 1121; sagittal sections, TGUFU 1118, 1119.

**Remarks.**—Ueno (1991) proposed the subgenus *Levenella*, which is characterized by a finer alveolar keriotheca than that of *Pamirina*. Subsequently, Ueno (1994) revised the genus name *Levenella* to *Levenella*. The Akuda specimen quite agree with the original ones described by Kobayashi (1977) from the Hanagiri Limestone and Otaki, Saitama Prefecture, Central Japan.

**Occurrence.**—All specimens collected from R-1 in Section E of Nishi-Akuda.

**Pamirina (Levenella) evoluta**

Sheng and Sun, 1975

Figures 11-32–34

*Pamirina ? evoluta* Sheng and Sun, 1975, p. 46, pl. 1, fig. 15.


**Materials.**—Axial sections, TGUFU 1122, 1123, 1124.

**Remarks.**—Recently, this species has been fully described by Ueno (1991) on the materials from the Akiyoshi Limestone Group. It has a larger proloculus than *P. (L.) leveni*. The specimens referable to this species are very rare in my collections.

**Occurrence.**—TGUFU 1122 from B-47 in Section D near Higashi-Akuda; TGUFU 1123, 1124 from R-1 in Section E of Nishi-Akuda.

Family Staffellidae MIklukho-Maklay, 1949

Genus *Nankinella* Lee, 1934

**Type species.**—Staffella discoides Lee, 1931

**Nankinella** sp.

Figure 11-16

**Material.**—Tangential section, TGUFU 1106.

**Remarks.**—The present specimen is completely recrystallized and the inner structure of the shell is obscure, but the angular periphery and umbilicated axial areas indicate assignment to the genus *Nankinella*.

**Occurrence.**—One specimen from R-1 in Section E of Nishi-Akuda.

**Nankinella aff. kotakiensis**

(Fujimoto and Kawada, 1953)

Figures 11-17–19

**Compare.**—Hayasakainia kotakiensis Fujimoto and Kawada, 1953, p. 119-121, figs. 1-10; Hy Igo, 1956a, p. 172, 173, pl. 27, figs. 1, 6, 12-16.

**Materials.**—Axial sections, TGUFU 1107, 1108, 1109.

**Description.**—Shell very small, discoidal, subspherical with somewhat broadly rounded periphery. Mature shell consists of seven to eight volutions. In two specimens, axial length 1.83 to 1.86 mm, median width 1.83 to 1.86 mm, and form ratio 0.716 to 0.749.

Shell mostly recrystallized. Inner four volutions discoidal and planispiral having slightly angular periphery. Spirotheca thin, consisting of a tectum and recrystallized translucent layer. Proloculus very small and spherical. Chomata present in inner three to four volutions.

**Remarks.**—The present specimens closely resemble the type specimens of *Nankinella kotakiensis*, but the former differs from the latter in more angular periphery in inner volutions. *Nankinella orientalis* MIklukho-Maklay resembles the present specimens but differs from the latter in fewer volutions. *Nankinella inflata* (Colani) also resembles the present specimens but the latter has a large shell and more angular periphery in inner volutions.

**Occurrence.**—All specimens from R-1 in Section E.

**Genus Sphaerulina** Lee, 1933

**Type species.**—Sphaerulina crassispira Lee, 1933

**Sphaerulina akudensis** H. Igo sp. nov.

Figures 11-9–14

**Materials.**—Axial section of holotype, TGUFU 1095; axial section of paratype, TGUFU 1104; tangential sections, TGUFU 1100, 1101; sagittal sections, TGUFU 1112, 1103.

**Diagnosis.**—Small *Sphaerulina* with an inflated oval shell, thick wall, fewer volutions, and unfulted septa.

**Description.**—Shell small, discoidal, and subspherical with slightly umbilicated axial regions and rounded periphery. Mature shell having six volutions, 1.03 mm in axial length, 1.40 mm in median width, and form ratio 0.736 in holotype.

Inner two volutions tightly coiled and have narrowly rounded periphery. Outer volutions expand rather rapidly. Radius vectors of holotype in first to sixth volutions 0.08, 0.15, 0.25, 0.38, 0.53, and 0.73 mm respectively. Proloculus very small, spherical, and having external diameter of 0.075 mm in holotype.

Spirotheca rather thick compared with shell size. It consists of a tectum and recrystallized dark calcite layer. In siprotheca of outer volutions except last volution appears a diaphanotheca-like transparent layer. Septa rather thick, plane, and having a lighter calcite layer than that of siprotheca. Chomata low, small, and asymmetrical.
### Table 1. Measurements of Sphaerulina akudensis Hh. Igo sp. nov. (in mm)

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<th>F.R.</th>
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<td>1</td>
<td>TGUFU1099</td>
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<td>TGUFU1100</td>
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<th>Thickness of spirotheca</th>
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**Remarks.**—This new species resembles a species hitherto described as *Pamirina*, but the former has a larger shell and thicker spirotheca than the latter. Recently, Hy. Igo et al. (1993) described *Sphaerulina cf. croatica* Kochansky-Devidé from the Wang Saphung Formation of northeastern Thailand. The Thai species resembles *S. akudensis* but has an inflated shell and distinct chomata.

**Etymology.**—This species name is derived from a local name of Hechimian town.

**Occurrence.**—All specimens from R-1 in Section E.

**Family Schubertellidae Skinner, 1931**
**Subfamily Schubertellinae Skinner, 1931**
**Genus Schubertella Staff and Wedekind, 1910**

**Type species.**—*Schubertella transitoria* Staff and Wedekind, 1910

**Schubertella pseudoobscura** Chen, 1934

*Figure 11-15*

*Schubertella pseudoobscura* Chen, 1934, p. 16, 17, pl. 1, figs. 1, 2; Lin, 1984, p. 153, pl. 8, figs. 25, 26.

**Material.**—Axial sections, TGUFU 1105.

**Description.**—Shell small and almost spherical with slightly umbilicated axial regions. This specimen has four volutions, 0.53 mm in axial length, 0.54 mm in width, and form ratio 0.98. Inner first to second volutions planispiral and coiling at a right angle to axis of outer volutions. Inner two volutions tightly and last one loosely coiled. Proloculus small, spherical, its outside diameter 0.05 mm. Spirotheca thin and composed of a single structureless layer. Chomata low, asymetrically developed in third volution.

**Remarks.**—This specimen resembles the type species but the former is larger than the latter.

**Occurrence.**—One specimen from R-1 in Section E.

**Genus Neofusulinella Deprat, 1912**

**Type species.**—*Neofusulinella praecursor* Deprat, 1912

**Neofusulinella giraudi** Deprat, 1915

*Figures 11-1-4*

*Neofusulinella giraudi* Deprat, 1915, p. 11, pl. 1, figs. 6–11; Ozawa, 1927, p. 38, figs. 3–6, 16 c, pl. 39, figs. 4–6.

**Schubertella giraudi** (Deprat). Sheng, 1963, p. 34, 158, 159, pl. 4, figs. 1–9; Kobayashi, 1957, p. 263, 264, pl. 1, figs. 1–5; Kammera, 1963, p. 88, 89, pl. 12, figs. 8–12; Hy. Igo, 1967, pl. 7, figs. 7, 8; Sashida, 1980, p. 300–302, pl. 34, figs. 7–9; Wang et al., 1981, p. 19, pl. 15, figs. 1–5; Sun et al., 1983, p. 17, pl. 3, fig. 5; Wang and Tang, 1986, pl. 1, figs. 6, 8; Xiao et al., 1986, pl. 73, pl. 1, figs. 10, 15, 24, 25; Zhou, 1991, pl. 2, figs. 13, 14.

**Mesoschubertella giraudi** (Deprat). Xia, 1994, pl. 18, fig. 6.

**Materials.**—Axial sections, TGUFU 1090, 1092; slightly oblique axial sections, TGUFU 1091, 1093.

**Remarks.**—This species resembles *Neofusulinella praecursor* but is easily distinguished from the latter in that its shell is not elongated. Sheng (1963) transferred this species to the genus *Schubertella* based on the general shape, form ratio, and development of chomata. I assign this species to *Neofusulinella* for several reasons. The size of shell in *Schubertella* is smaller than that of *Neofusulinella*. The early stage of *Schubertella* has sharply changed axis of coiling relative to later ones. Chomata of *Neofusulinella* are asymmetrical and highly elongate while *Schubertella* has asymmetrical massive chomata.

**Occurrence.**—TGUFU 1090 from R-1 in Section E; TGUFU 1091 from B-47; TGUFU 1092,1093 from B-48 in Section D near Higashi-Akuda.

**Neofusulinella lantenoisi** Deprat, 1913

*Figures 11–5–8*

*Neofusulinella praecursor* Deprat, 1913, p. 41, 42, pl. 7, figs. 23–25; Thompson and Foster, 1937, p. 131, 132, pl. 24, figs. 1–4; Pitsakpaivan, 1965, p. 24–26, pl. 1, fig. 16; Leven, 1967, p. 126.
pl. 1, figs. 9, 10; Toriyama et al., 1969, p. 28-31, pl. 3, fig. 23, pl. 4, figs. 1-15; Xiao et al., 1986, p. 75, pl. 1, figs. 11, 16.

**Materials.**—Slightly oblique axial section, TGUFU 1095; axial sections, TGUFU 1096, 1097, 1098.

**Description.**—Shell small to medium in size and thickly fusiform with straight axis of coiling and bluntly pointed poles. Mature shell having six volutions, 1.50 to 1.67 mm in axial length, 0.67 to 0.93 mm in width, and form ratio 1.8 to 2.2.

Proloculus small and spherical with outside diameter of 0.04 to 0.05 mm. Inner two volutions planispirally coiled and make a right angle with axis of outer volutions. Spirotheca thin, consists of a tectum, dispanothece and, lower thicker layer. Septa thin, numerous, and plane. Chomata developed in third to last volutions, low, massive, and asymmetrical. Septal pore distinct in almost all volutions except for the inner two volutions.

**Remarks.**—Recently, Li (1985) proposed a new genus *Multiavella* with the holotype *M. guangxiensis* from the Lower Permian at Chongzuo, Guangxi, South China. *Multiavella* may be a synonym of *Neofusulina*.

Toriyama et al. (1969) described this species from the Khao Phlong Phrabs section, Changwat Saraburi, central Thailand and discussed the taxonomic status, validity, and the phylogeny of *Neofusulina*.

Recently, Zhou and Sheng (1993) restudied Permian stallidids and proposed a new concept of classification in these subfamilies. They attributed the genera *Loella*, *Hacella*, *Sphaerulina* (in part), and *Caspiella* (in part) to the genus *Neofusulina*.

**Occurrence.**—TGUFU 1095, 1097, 1098 from A-22 in Section A; TGUFU 1096 from A-21 in the same section.

Subfamily Biwaellinae Davydov, 1984
Genus *Toriyamaia* Kanamera, 1956

**Type species.**—*Toriyamaia laxisepta* Kanamera, 1956

*Toriyamaia laxisepta* Kanamera, 1956

*Figures* 10-4, 5

*Toriyamaia laxisepta* Kanamera, 1956, p. 252-255, pl. 36, figs. 1-14; Sheng, 1963, p. 33, 34, 157, pl. 4, figs. 36, 37; Kanamera, 1963, p. 87-88, pl. 11, figs. 1-4, pl. 19, figs. 8, 9; Kanamera and Mikami, 1965, p. 277-279, pl. 46, figs. 9, 10; Choi, 1973, p. 20, pl. 2, figs. 8-10; Ozawa, 1975, pl. 7, fig. 18; Lin et al., 1977, p. 19, pl. 3, fig. 17; Kahler and Kahler, 1979, p. 226, 227, pl. 4, fig. 7; Zhou et al., 1987, pl. 2, fig. 7; Ueno, 1992, p. 1276-1279, figs. 4-1-7.

**Materials.**—Tangential sections, TGUFU 1073, 1074.

**Remarks.**—The present specimens closely resemble Kanamera’s original ones described from the Kozaki Formation, Kyushu, Japan.

**Occurrence.**—All specimens from B-48 in Section D.

Family Boultoniidae Skinner and Wilde, 1954
Genus *Minojapanella* Fujimoto and Kanuma, 1953
Subgenus *Minojapanella* Fujimoto and Kanuma, 1953

**Type species.**—*Minojapanella elongata* Fujimoto and Kanuma, 1953

*Minojapanella (M.) elongata* Fujimoto and Kanuma, 1953

Figs. 11-37, 38

*Minojapanella elongata* Fujimoto and Kanuma, 1953, p. 152, pl. 19, figs. 1-11; Thompson, 1954, pl. 2, figs. 1-5 (2-3, 5); same as pl. 19, figs. 10, 11 of Fujimoto and Kanuma, 1953, p. 152); Monikawa and Isomi, 1961, p. 7, pl. 2, figs. 10-15; Choi, 1973, p. 14, 15, pl. 1, figs. 8-11; Xiao et al., 1986, p. 77, pl. 1, figs. 26, 29; Ozawa and Kobayashi, 1990, pl. 8, fig. 7; Xia, 1994, pl. 18, fig. 20.


**Materials.**—Oblique section, TGUFU 1127; sagittal section, TGUFU 1128.

**Remarks.**—The present specimens coincide with the type specimens which were described from a limestone near Hachiman town, Gifu county, Gifu Prefecture, Central Japan. Fujimoto and Kanuma (1953) did not designate any holotype in their paper, but Thompson (1954) subsequently designated as the holotype the specimen illustrated by Fujimoto and Kanuma in pl. 19, figs. 1a-c; this specimen is in fact the lectotype, not the holotype (Kahler and Kahler 1966, p. 245). The actual locality of the type specimens was not mentioned in the original paper. Recently, I examined the type specimen; and confirmed that the lectotype occurred in a limestone exposed at Houshimaru, Wara village, Gifu Prefecture.

**Occurrence.**—TGUFU 1127 from A-22; TGUFU 1128 from A-21 in Section A.

**Genus** Dunbarula Ciry, 1948

**Type species.**—*Dunbarula mathieui* Ciry, 1948

*Dunbarula ueno* Hh. Igo sp. nov.

*Figures* 11-35, 36

**Materials.**—Axial section of holotype, TGUFU 1125; axial section of paratype, TGUFU 1126.

**Diagnosis.**—Elongate *Dunbarula* with a thin wall, and septa only fluted in polar regions.

**Description.**—Shell small, elongate cylindrical in shape and having a gently bent axis of coiling and broadly rounded polar ends. Juvenile volutions tightly coiled but shell loosely coiled in last volution. Inner first to second volutions at a large angle of coiling to the outer ones. Shell of holotype consists of 5 volutions, 2.13 mm in axial length, 0.43 mm in width, with a form ratio of 4.95. Proloculus small and spheroidal, its outside diameter 0.02 mm in holotype. Radius vectors of first to fifth volutions in holotype 0.04, 0.05, 0.07, 0.12, and 0.20 mm, respectively.

Spiral thin and composed of a tectum and less dense layer. Thickness of spiral layer of first to fifth volutions of
holotype 0.010, 0.012, 0.025, 0.027, and 0.020 mm, respectively. Septa numerous and strongly fluted in polar regions. Septal pores present near polar regions.

Chomata small and developed in second to fourth volutions.

Remarks.—Skinner and Wilde (1967) redescribed topotypes of Dunbarula mathiei Ciry from Tunisia. Dunbarula mathiei has broad variations in shape, ranging from ellipsoidal through thickly to slender subcytwindrical. The present new species has a characteristic elongate shell. Other biocharacters show that the species is assignable to the genus Dunbarula.

Etymology.—This species name is dedicated to Dr. Kazumi Ueno, Assistant Professor of the Institute of Geoscience, University of Tsukuba, for his active research on fusulinaceans.

Occurrence.—All specimens from A-22 in Section A.

Family Schwagerinidae Dunbar and Henbest, 1930
Subfamily Schwagerininae Dunbar and Henbest, 1930
Genus Schwagerina Möller, 1877

Type species.—Borelis princeps Ehrenberg, 1842

Schwagerina shukoae Hh. Igo sp. nov.

Figures 9-5-7

Materials.—Tangential section of immature specimen, TGUFU 1059; axial section of holotype, TGUFU 1060; slightly tangential axial section of paratype, TGUFU 1061.

Diagnosis.—Small Schwagerina with an inflated fusiform shell, small proloculus, regularly fluted septa, and without axial fillings.

Description.—Shell medium in size, tightly coiled, fusiform with an inflated median part and broadly rounded poles. In holotype, axial length 6.98 mm, median width 2.90 mm, and form ratio 2.39. Mature shells consist of 6 volutions.

Spirotheca thin, consists of a tectum and fine alveolar kerotheca. Proloculus small, spherical, with an outside diameter of about 0.02 mm. Septa numerous, highly and regularly fluted throughout shell. Septal folds regular in shape with broadly rounded crest.

Chomata lacking except for poor development on the surface of proloculus. Tunnel single, low, and narrow.

Remarks.—The present new species is characterized by an inflated fusiform shell and regularly fluted septa.

Hy. Igo (1984) measured Schwagerina hishadienseis from the Shiroy Formation of the Nyukawa Group. He illustrated one axial and one tangential sections and two sagittal sections. The specimen questionably identified by him (pl. 104, fig. 2) probably falls within the present new species.

Etymology.—This species name is dedicated to Dr. Shuko Adachi, Assistant Professor of the Institute of Geoscience, University of Tsukuba, for her active research on Carboniferous to Triassic foraminifers.

Occurrence.—Holotype TGUFU 1060 and tangential section TGUFU 1059 from R-1 in Section E; paratype TGUFU 1061 from B-2 in Section B near Akuda-Kuchi.

Schwagerina murai Morikawa, 1955

Figure 5-4


Material.—Axial section of mature specimen, TGUFU 1003.

Description.—Shell large, elongate fusiform with bluntly rounded poles. Equatorial part of shell somewhat constricted. This specimen has 6 volutions, and is 9.06 mm in axial length and 2.73 mm in median width, with a form ratio of 3.32. Radius vectors in first to sixth volutions 0.03, 0.48, 0.67, 0.78, 1.17, and 1.47 mm, respectively.

Spirotheca thick, consists of a thin tectum and coarse kerotheca. Thickness of spirotheca in sixth whorl 0.13 mm. Proloculus large, spherical, its outside diameter is 0.42 mm. Septa strongly and regularly fluted throughout shell. Heavy secondary deposition fills in tunnel area and polar regions.

Table 2. Measurements of Schwagerina shukoae Hh. Igo sp. nov. (in mm)

<table>
<thead>
<tr>
<th>Reg. no.</th>
<th>Fig.</th>
<th>L</th>
<th>W</th>
<th>F.R.</th>
<th>D.P.</th>
<th>Radius vector</th>
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<th>Thickness of spirotheca</th>
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Figure 5. 1-3. Pseudofusulina norikurensis Hy. Igo, 1: axial section, TGUFU 1000, 2: slightly oblique axial section, TGUFU 1001, 3: axial section of immature specimen, TGUFU 1002. 4. Schwagerina murai Morikawa, axial section, TGUFU 1003. 5-8. Pseudofusulina paraschemyschewi Kanuma, 5-7: axial sections, TGUFU 1004, 1005, 1006, 8: axial section of immature specimen, TGUFU 1007. 9-11. Pseudofusulina hordaniensis Hy. Igo, axial sections, TGUFU 1008, 1009, 1010. All figures ×10.
Permian fusulinaceans from Central Japan
except for outermost whorl. Tunnel low and narrow. Chomata almost absent.

Remarks.—This species resembles *Pseudofusulina fusiformis* (Schellwien) in many respects, but the former differs from the latter in having heavy secondary deposition.

This species was described from the lower Soto Formation of the Nyukawa Group by Hy. Igo (1966). The present specimen is very similar to Igo's Soto specimen. This species also resembles *Pseudofusulina krafti* (Schellwien), but the former is distinguishable from the latter in its elongate shell, pointed polar ends, and thin spirotheca.

**Occurrence.**—From B-44 in Section D.

Schwagerina kwangchiensis Chen, 1956

**Figures** 8-7—9


Materials.—Slightly oblique axial sections, TGUFU 1043, 1045; axial section, TGUFU 1044.

Description.—Shell medium in size, elongate fusiform to subcylindrical, more or less tightly coiled and having broadly rounded poles. Mature shell with seven volutions, 7.66 mm in length, 2.06 mm in median width, with a form ratio of 3.72.

Proloculus very small, spherical, 0.12 to 0.22 mm in outside diameter. Spirotheca thin, consists of a tectum and kerotheca with fine alveoli. Septa numerous, strongly and regularly fluted throughout shell. Septal folds regularly shaped and closely spaced.

Axial filling very weak in polar regions of younger volutions. Chomata almost lacking and tunnel indistinct.

Remarks.—The present species resembles *Pseudofusulina regularis* (Schellwien), but the former has a smaller proloculus. It also resembles *Pseudofusulina ambiguia* (Deprat), but is distinguished from the latter in larger size of shell and proloculus.

The present species was originally described from the Wuhsueh Limestone in Hupeh, China, by Chen (1956). The limestone equivalent with the Maokou Limestone is exposed in southwestern China.

**Occurrence.**—All specimens from R-3 in Section E.

Schwagerina higashidaniensis Hy. Igo, 1964

**Figures** 8-16, 17


Materials.—Axial sections, TGUFU 1052, 1053.

Description.—Shell medium-sized, elongate fusiform to subcylindrical with broadly rounded poles and straight axis of coiling. Mature shell has five to six volutions and 6.32 to 8.00 mm in axial length, 1.53 to 1.83 mm in median width, with a form ratio of 2.27 to 3.45. Inner second to third volutions tightly coiled with sharply pointed poles. Outer fourth to fifth volutions increase in height rather rapidly. Proloculus small, spherical, its outside diameter being 0.16 to 0.17 mm. Spirotheca thin, consists of a tectum and kerotheca with very fine alveoli. Septa numerous, thin, strongly and irregularly fluted. Phrenotheca absent in present specimens. Tunnel singular, low, and indistinct in outer volutions. Chomata present in first to second volutions but lacking outer volutions.

Remarks.—The present specimens coincide with Igo's holotype described from the Siroi Formation, Nyukawa Group. The present species is easily distinguishable from some species of the genus *Paraschwagerina*. The former has irregular septal fluting, but the latter has regular septal fluting. The former has extraordinarily thin spirotheca and septa.

**Occurrence.**—All specimens from R-1 in Section E.

Schwagerina kanumai Hh. Igo sp. nov.

**Figures** 9-1—4

Materials.—Axial section of holotype, TGUFU 1055; axial section of paratypes, TGUFU 1056, 1057, 1058.

Diagnosis.—Small Schwagerina with an inflated fusiform shell, small proloculus, and thin spirotheca. Septa regularly fluted. Axial filling lacking.

Description.—Shell medium in size, inflated fusiform, and biconical in shape. It has more or less acutely pointed poles and a straight axis of coiling. Mature shell consists of 6 volutions. Axial length 7.86 mm, median width 3.33 mm, and form ratio 2.36 in holotype.

Inner three volutions tightly coiled and outer three volutions increasing rather rapidly in height. Proloculus small, spherical, its outside diameter 0.23 mm in holotype.

Spirotheca thin and composed of a tectum and fine alveolar keriotheca. Thickness of spirotheca of each volution in holotype 0.03, 0.03, 0.03, 0.05, 0.06, and 0.08 mm, respectively. Septa very thin, regularly and intensely fluted. Septal folds across almost entire chamber in outer volutions.

Phrenotheca weak and rarely observed. Chomata almost lacking except for rudimentary ones on the surface of proloculus and first volution.

Remarks.—The present new species is quite similar to *Schwagerina ? annamitica* (Deprat), which was described from the Shiroi Formation, Nyukawa Group by Hy. Igo (1964). The former is distinguished from the latter in highly fluted septa.

Etymology.—This species name is dedicated to Dr. Mosaburo Kanuma, Professor Emeritus of the Department of Astronomy and Earth Sciences, Tokyo Gakugei University. He contributed to early studies of geology and fusulinaceans in the Hachimana area.

**Occurrence.**—All specimens from R-1 in Section E.
Table 3. Measurements of Schwagerina kanumai Hlg. Igo sp. nov. (in mm)

<table>
<thead>
<tr>
<th>Reg. no.</th>
<th>Fig.</th>
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Thickness of spirotheca

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Genus *Parafusulina* Dunbar and Skinner, 1931

Type species.—*Parafusulina wordensis* Dunbar and Skinner, 1931

*Parafusulina ? sublineata* Hy. Igo, 1965

Figures 9–15

*Parafusulina sublineata* Hy. Igo, 1965, p. 221, 222, pl. 30, figs. 1-3, pl. 32, figs. 1, 2.

Materials.—Axial sections, TGUFU 1063, 1065, 1066, 1068; slightly oblique axial sections, TGUFU 1062, 1064, 1069; tangential section, TGUFU 1067.

Description.—Shell large, highly elongate subcylindrical, having a slightly straight median part, irregularly undulated lateral slope, and truncated poles. Axis of coiling slightly bent. Mature shell consists of eight volutions. Axial length 7.33 to 12.00 mm, median width 1.64 to 3.2 mm, and form ratio 3.75 to 4.39.

First to third volutions tightly coiled, outer ones rapidly increase in height. Proloculus small, its outside diameter is 0.17 to 0.23 mm. Spirotheca thin, consists of a thin tectum and keriotheca but spirotheca of inner volutions recrystallized. Septa numerous, highly fluted throughout shell.

Septal folds form rounded crests, commonly extend across entire chamber. Phrenotheca almost absent. Vestigial chomata present in first to second volutions but lacking in outer ones. Axial filling almost lacking.

Remarks.—The present specimens agree closely with Hy. Igo's holotype specimen described from the Sote Formation, Nyukawa Group.

The Akuda specimens are larger than those of the Sote specimens. I could not obtain any complete specimens.

The holotype is also a broken specimen.

Occurrence.—All specimens from B-17 in Section D near Higashi-Akuda.

*Parafusulina setensis* Hy. Igo, 1967

Figure 10-6

*Parafusulina kawai* Morikawa setensis Hy. Igo, 1967, p. 12, pl. 8, figs. 1-6.

Material.—Slightly oblique axial section, TGUFU 1075.

Description.—Shell large, elongate fusiform with more or less inflated median part and bluntly rounded poles. Present specimen consists of five volutions. Axial length 9.06 mm, median width 2.93 mm, and form ratio 3.08. Shell tightly coiled with a straight axis of coiling. Proloculus spherical with an outside diameter of 0.31 mm.

Spirotheca recrystallized, but probably composed of a tectum and keriotheca. Septa regularly fluted and septal loops with bluntly rounded to angular crest. Chomata lacking. Tunnel single narrow.

Axial filling weakly developed in polar regions of younger volutions.

Remarks.—The present specimen is weekly recrystallized, so that I could not determine detailed spirothecal structure. The Akuda specimen has less dense axial filling than that of Hy. Igo's holotype from the Sote Formation, Nyukawa Group.

Occurrence.—From B-11 in Section D.

Genus *Pseudofusulina* Dunbar and Skinner, 1931

Type species.—*Pseudofusulina huecoensis* Dunbar and Skinner, 1931

Pseudofusulina norikurensis Hy. Igo, 1959

Figures 5-1-3

Pseudofusulina kraftti (Schellwien) norikurensis Hy. Igo, 1959, p. 244, 245, pl. 2, figs. 1-3; Sashida, 1983, p. 286-289, pl. 34, figs. 3-4.

Pseudofusulina norikurensis Hy. Igo. Morikawa and Isomi, 1961, p. 21, pl. 15, figs. 1-4; pl. 16, figs. 1-7.

Materials.—Axial sections, TGUFU 1000, 1002; slightly oblique axial section, TGUFU 1001.

Description.—Shell large, inflated fusiform with broadly rounded poles. Mature shell consists of 8 to 9 volutions. Axial length 8.79 to 10.32 mm, median width 4.33 to 5.13 mm, and form ratio 2.01 to 2.03. Radius vectors in first to eighth volutions 0.40, 0.63, 0.83, 1.17, 1.53, 1.90, 2.30, and 2.76 mm, respectively.

Proloculus large, spherical with outside diameter of 0.50 to 0.57 mm. Spirotheca thick, consists of a thin distinct tectum and very coarse kerotheca. Outer kerotheca thin and 1/4 of whole thickness of kerotheca. Septa numerous, relatively intensely and regularly fluted along axial regions.

Cuniculi well developed in lower volutions. Phreotheca poorly developed in lower part of chamber. Axial filling well developed in polar regions of inner five volutions. Tunnel low and narrow. Chomata lacking throughout shell.

Remarks.—This species resembles Parafusulina japonica (Gümbel), but differs from the latter in having an inflated shell with broadly rounded poles. This species was originally proposed by Hy. Igo (1959) as a subspecies of Pseudofusulina kraftti, but Morikawa and Isomi (1961) raised it to species level. I consider that this species is closely related to Parafusulina japonica in septal fluting and axial filling.

Occurrence.—TGUFU 1000, 1001 from A-1 south of the Horikoshi Pass; TGUFU 1002 from B-47 in Section D.

Pseudofusulina paratschernyschewi Kanuma, 1959

Figures 5-5-8

Pseudofusulina paratschernyschewi Kanuma, 1959, p. 67, 68, p. 6, figs. 4-7.

Materials.—Axial sections, TGUFU 1004, 1005, 1006, 1007.

Description.—Shell large and fusiform with almost straight axis of coiling and narrowly rounded poles. It is rather loosely coiled. Mature shell of 5 to 6 volutions 8.33 mm in axial length, and 3.40 mm in median width, giving a form ratio of 2.48. Radius vectors in first to sixth volutions, 0.47, 0.67, 0.93, 1.23, and 1.60 mm, respectively.

Proloculus relatively large, spherical to subspherical, with an outside diameter of 0.58 mm in mature shell. Spirotheca thick, consists of a thin tectum and coarse kerotheca.

Average thickness of spirotheca in first to last volutions in mature shell 0.05, 0.05, 0.10, 0.11, and 0.15 mm, respectively. Septa numerous, rather regularly fluted nearly from pole to pole. Septal folds narrow, generally high, and commonly attain top of volutions. Cuniculi developed in outer volutions. Tunnel low and relatively narrow. Chomata almost lacking. Axial filling poorly developed in polar region of first to fourth volutions. Phreotheca not present.

Remarks.—This species was first described by Kanuma (1959). He mentioned that this species accords closely with Parafusulina japonica (Gümbel) described by Chen (1934). He considered that Chen's P. japonica is related to Pseudofusulina tschernyschewi (Schellwien).

This species resembles P. tschernyschewi, but the former has a larger proloculus. This species also resembles Parafusulina japonica, but differs from the latter in having dense axial fillings and thick spirotheca.

Occurrence.—TGUFU 1004 from B-42; TGUFU 1005, 1006 from B-47; TGUFU 1007 from A-1 south of the Horikoshi Pass.

Pseudofusulina horadaniensis Hy. Igo, 1964

Figures 5-9-11


Materials.—Axial sections, TGUFU 1008, 1009, 1010.

Description.—Shell large, cylindrical to elongate fusiform, and having straight median portion and truncated poles. Outline of shell elongate subhexagonal in axial section. Axial length 7.13 to 8.59 mm, median width 2.73 to 3.33 mm, and form ratio 2.10 to 2.58 in mature shells. Mature shell consists of six to seven volutions.

Radius vectors in first to seventh volution 0.33, 0.48, 0.66, 0.87, 1.13, 1.47, and 1.80 mm, respectively. Shell tightly coiled in first to third volutions.

Proloculus relatively large, spherical, with outside diameter of 0.40 to 0.43 mm. Spirotheca thick, consists of a thin tectum and coarse kerotheca with rather coarse alveoli. Thickness of spirotheca in first to sixth volutions 0.03, 0.05, 0.06, 0.08, 0.11, and 0.13 mm, respectively.

Septa numerous and intensely fluted. Septal folds about 1/2 as high as chamber. Phreotheca absent. Tunnel single, low, and narrow. Chomata lacking. Axial filling strong and massive in polar regions. Outer one or two volutions lack axial filling.

Remarks.—This species closely resembles Pseudofusulina kraftti but differs from the latter in having pointed truncate poles and massive axial fillings. This species resembles in many respects Parafusulina postkraftti Leven (1967) described...
from the Pamirs but the latter has a large shell, intensely fluted septa, and well developed phrenotheca.

Occurrence. — TGUFU 1008 from B-48; TGUFU 1010 from B-44 in Section D; TGUFU 1009 from A-2 south of the Horikoshi Pass.

_Pseudofusulina isomie_ Hy. Igo, 1965

Figures 6–7

_Pseudofusulina isomie_ Hy. Igo, 1965, p. 219, 220, pl. 29, fig. 6, pl. 30, figs. 5, 6, pl. 31, figs. 6, 7.

Materials. — Axial section of mature specimens, TGUFU 1011, 1013, 1014, 1015, 1017; axial section of immature specimen, TGUFU 1016; sagittal section of mature specimen, TGUFU 1012.

Description. — Shell large, cylindrical to elongate fusiform, and having slightly concave median part and bluntly rounded poles. Axial radius 8.91 to 11.79 mm, median width 3.40 to 4.33 mm, and form ratio 2.45 to 3.00 in mature specimens. Mature shell has six to seven volutions.

Radius vectors in first to seventh volutions in largest specimen (TGUFU 1011) 0.33, 0.47, 0.73, 1.00, 1.37, and 1.73 mm, respectively. Shell rather tightly coiled in first to third volutions and having a straight axis of coiling. Proloculus large, spherical with an outside diameter of 0.37 to 0.73 mm. Spireotheca thick, consists of a tectum and relatively coarse alveolar keriotheca. Upper keriotheal layer thin, 1/4 of whole thickness of keriotheca. Septa numerous, intensely fluted throughout length of shell and commonly extend across entire chamber. Fluting regular in median part of shell. Phrenotheca almost absent. Chomata lacking, tunnel low and narrow. Axial filling weekly developed in axial region of inner volutions.

Remarks. — In the Akuda specimens, axial filling is weaker than in the holotype from the Sote Formation. However, shape of shell and septal fluting are exactly the same in these specimens.

The Akuda specimens resemble _Pari fusulina japonica_ (Gümbel) which was illustrated by Toriyama (1975, pl. 5, figs. 48; pl. 6, figs. 1-8) but the latter specimens have an elongate fusiform shell and intense septal fluting.

This species closely resembles _Schwagerina toyamaensis_ Suyari (1962). It differs from the latter in smaller proloculus, intense septal fluting, and thick spirothecae.

Occurrence. — TGUFU 1011 from B-37; TGUFU 1013, 1014, 1016 from B-42; TGUFU 1012, 1015, 1017 from B-47 in Section D.

_Pseudofusulina krafti_ (Schellwien, 1909)

Figure 6-10

Fusulina krafti Schellwien, 1909, p. 169, pl. 16, figs. 1-9.

Schellwienia krafti (Schellwien). Ozawa, 1925, p. 25-27, pl. 6, fig. 7, pl. 7, fig. 4; Ozawa, 1927, p. 147, fig. 5.

_Pseudofusulina krafti_ (Schellwien). Fujimoto, 1936, p. 80, 81, pl. 14, figs. 3-8; Morikawa, 1955, p. 94, 95, pl. 7, figs. 15-17; Kanuma, 1959, p. 70, 71, pl. 7, figs. 1-3, 6; Morikawa and Isomi, 1961, p. 20, 21, pl. 14, figs. 1-10, pl. 15, fig. 5, pl. 6; Sheng, 1963, p. 65, pl. 16, figs. 16-18; Chang, 1963, p. 206, pl. 4, fig. 11; Kalmykova, 1967, p. 183, 184, pl. 10, figs. 1-4; Leven, 1967, p. 146, 147, pl. 10, figs. 5, 6; Choi, 1970, p. 371, 372, pl. 1, figs. 6, 7; Choi, 1973, p. 52, pl. 6, figs. 1-5; Shishida, 1980, p. 296-298, pl. 34, figs. 3, 4; Xia, 1994, pl. 15, fig. 5.

Figure 9. 1-4. Schwagerina kanumai Hh. Igo sp. nov., 1: axial section of holotype, TGUFU 1055, 2-4: axial sections of paratypes, TGUFU 1056, 1057, 1058. 5-7. Schwagerina shikokuensis Igo sp. nov., 5: tangential section of immature specimen, TGUFU 1059, 6: axial section of holotype, TGUFU 1060, 7: slightly tangential section of paratype, TGUFU 1061. 8-15. Parafusulina sublineata Hy. Igo, 8, 10, 15: slightly oblique axial sections, TGUFU 1062, 1064, 1069, 9, 11, 12, 14: axial sections, TGUFU 1063, 1065, 1066, 1068, 13: tangential section, TGUFU 1067. All figures ×10.
Pseudofusulina krafftii (Scheilwien). Kanmera and Mikami, 1965, p. 299-301, pl. 44, fig. 7.
Pseudofusulina krafftii (Scheilwien) forma A. Nogami, 1961, p. 217-219, pl. 10, figs. 5-8.

Material.—Axial section, TGUFU 1020.

Description.—Shell large, cylindrical to subcylindrical with broadly rounded poles. Mature shell has six to seven involutions. Axial length 10.66 mm and median width 4.33 mm, giving form ratio of 2.46. Shell tightly coiled in the first to third involutions and having a weekly bent axis of coiling. Radius vectors in first to sixth involutions 0.27, 0.38, 0.58, 0.90, 1.33, and 1.73 mm, respectively.

Proloculus large, spherical, with outside diameter of 0.37 mm. Spirotheca thick, consists of a tectum and coarse alveolar keriotheca. Septa numerous, intensely fluted near axis of coiling, most septal loops reach ceiling of chambers. Chomata poorly developed in first to second involutions. Tunnel single, low, and wide. Axial fillings developed in polar regions.

Remarks.—In the Akuda specimen, the spirotheca varies in thickness even in the same involution. This well known species has broad variations in shell shape, septal fluting, size of shell, degree of axial filling, and other features. Many previous authors have already pointed out these variations.

Occurrence.—From OHT-4 at Otoshime-Tani.

Pseudofusulina minoensis Hh. Igo sp. nov.

Figures 7-1-9

Materials.—Axial section of holotype, TGUFU 1022; axial sections of paratypes, TGUFU 1021, 1023; axial sections of immature specimens, TGUFU 1025, 1026, 1027, 1028, 1029; sagittal section of mature specimen, TGUFU 1024.

Diagnosis.—Large Pseudofusulina with an elongate cylindrical shell and large proloculus. Septa regularly fluted.

Description.—Shell large, elongate subcylindrical to elongate fusiform, with a slightly flat median part and bluntly rounded poles. Axial length 11.32 to 10.52 mm, median width 3.33 to 2.73 mm, and form ratio 4.00 to 3.85 in mature specimens.

Shell rather tightly coiled in first to third involutions and

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Table 4. Measurements of Pseudofusulina minoensis Hh. Igo sp. nov. (in mm)

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<th>Reg. no.</th>
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Thickness of spirotheca

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having a straight or slightly curved axis of coiling. Proloculus large, spherical, with an outside diameter of 0.53 to 0.26 mm.

Spirotheca thick, consists of a tectum and coarse alveolar keriotheca. Thickness of spirotheca in first to fifth tourlutions of holotype 0.03, 0.03, 0.04, 0.03, and 0.09 mm, respectively. Surface of tectum regularly undulated.

Septa numerous, more or less regularly fluted, and most septal loops reach up to about 2/3 height of chamber. Phrenotheca present in outer volutions. Chomata lacking except for very poor development in first to second volutions. Tunnel singular, low, and narrow. Axial filling weekly developed in inner volutions.

Remarks.—This species very closely resembles Pseudofusulina granumavenae (Roemer) in many points. The former can be distinguished from the latter, however, in having fewer volutions and weak septal fluting.

Etymology.—This species name is derived from the ancient province name of Gifu Prefecture.

Occurrence.—Collected from R-1 in Section E of Nishi-Akuda.

Pseudofusulina miyamensis Hh. Igo sp. nov.

Figures 7-10-11

Materials.—Axial section of holotype, TGUFO 1031; axial section of paratype, TGUFO 1030.

Diagnosis.—Small Pseudofusulina with an elongate fusiform shell and thin spirotheca, and proloculus rather large compared with shell size.

Description.—Shell small, elongate fusiform with bluntly rounded poles and a straight axis of coiling. Axial length 5.68 and 5.86 mm, median width 1.53 and 1.57 mm, form ratio 3.83 and 3.61. Shell tightly coiled in first to third volutions. Radius vectors in first to fifth volutions of holotype 0.27, 0.40, 0.53, 0.73, and 0.87 mm, respectively. Proloculus large compared with shell size. Spirotheca thin, consists of a tectum and fine alveolar keriotheca. Thickness of spirotheca in first to fifth volutions of holotype 0.02, 0.03, 0.04, 0.06, and 0.05 mm, respectively. Septa regularly fluted, most loops reach to ceiling of chamber. Chomata lacking, but rudimentary ones observed on first volution. Tunnel singular and low. Axial filling very weekly developed in inner volutions.

Remarks.—This species resembles Pseudofusulina minoensis Hh. Igo, but the former has a smaller shell than the latter.

Etymology.—This species name is derived from the name of a village in the studied area.

Occurrence.—From R-1 in Section E of Nishi-Akuda.

Pseudofusulina fusiformis (Schellwien, 1909)

Figures 8-1, 2

Fusulina vulgaris var. fusiformis Schellwien, 1909, p. 165-168, pl. 15, figs. 1-4.

Pseudofusulina vulgaris var. fusiformis (Schellwien). Kanuma, 1959, p. 75, 76, figs. 7-11.

Pseudofusulina fusiformis (Schellwien). Thompson, 1948, pl. 12, fig. 3 (same as pl. 15, fig. 2 of Schellwien, 1909, p. 165-168; Monikawa, 1955, p. 98, 99, pl. 13, figs. 1-7; Hy. Igo, 1959, p. 246, 247, pl. 3, fig. 5; Monikawa and Isomi, 1961, p. 19, 20, pl. 7, figs. 11, 12, pl. 8, figs. 12, 13, pl. 10, figs. 1-10, pl. 11, figs. 1-10,

Table 5. Measurements of Pseudofusulina miyamensis Hh. Igo sp. nov. (in mm)

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Spirotheca thick, composed of a tectum and alveolar keriotheca. Septa fluted rather regularly, most septal loops attain a height about 2/3 that of the chamber. Chomata poorly developed in first to second involutions. Tunnel singular, rather low, and narrow.

Remarks.—The present specimens are similar to Schellwien's original specimens. This species described by Kammera (1958) from the Hayama Limestone is very similar to the Akuda specimens.

Hy. Igo (1972) described this species from North Thailand and discussed biocaracters and synonymous specimens of previous papers.

Occurrence.—TGUFO 1039, 1041 from B-47 and R-2 near Hiigashi- and Nishi-Akuda; TGUFO 1040, 1042 from R-1 in Section E near Nishi-Akuda.

**Pseudofusulina houziguanica** Sheng, 1963

Figures 8-10–13

Pseudofusulina houziguanica Sheng, 1963, p. 67, 193, 194, pl. 16, figs. 11–14; Wang et al., 1981, p. 36, pl. 3, figs. 6, 7; Zhang and Dong, 1986, p. 100, pl. 14, fig. 7; Sun and Zhang, 1988, pl. 1, figs. 5, 14.

Pseudofusulina cf. houziguanica Sheng, Xiao, Wang, Zhang, and Dong, 1986, p. 100, pl. 10, fig. 17; Ueno, 1992, figs. 4, 5, 3, 4; Xiao, 1994, pl. 16, fig. 18.

Materials.—Axial sections, TGUFO 1046, 1047, 1048, 1049. Description.—Shell medium in size, rather tightly coiled, inflated fusiform or elliptical, having straight median portion and broadly rounded poles. Mature shell consists of 5 to 6 involutions. Axial length 4.06 to 5.00 mm, median width 2.20 to 2.46 mm, and form ratio 1.65 to 2.20.

Spirotheca rather thick compared with shell size and consists of a tectum and relatively coarse keriotheca. Septa numerous and regularly fluted throughout their length. Septal loops almost reach upper part of chamber.

Proloculus spherical or nearly rectangular, large compared with their shell size, thin-walled, and external diameter 0.37 to 0.50 mm. Axial fillings rather heavy except central part of shell. Chomata lacking except for very poorly developed ones on surface of proloculus. Tunnel indistinct.

Remarks.—The present species is closely related to *Para-fusulina funafusensis* Matsumura described from the Funafusayama Limestone of the northern Mino Terrane. *Para-fusulina funafusensis* is probably a junior synonym of the present species.

Occurrence.—All specimens from R-1 in Section E of Nishi-Akuda.

**Pseudofusulina krotowi** (Schellwien, 1908)

Figures 8-14, 15

Fusulina krotowi Schellwien, 1908, p. 190–192, pl. 20, figs. 1-10. Schellwienia krotowi (Schellwien). Ozawa, 1925, p. 27, 28, pl. 7, figs. 5, 6.

Pseudofusulina krotowi (Schellwien). Fujimoto, 1936, p. 82-84, pl. 15, figs. 1, 5, 9-15; Rauer-Chernousova, 1938, p. 143, 144, pl. 9, figs. 2, 8, 14, 5, 6; Monikawa, 1955, p. 86, pl. 14, figs. 5, 6; Kanuma, 1959, p. 78, 79, pl. 8, figs. 1-3; Monikawa and

Materials.—Axial sections of mature specimens, TGUFO 1039, 1041; slightly oblique axial sections, TGUFO 1040, 1042. Description.—Shell moderate in size, elongate fusiform with a straight axis of coiling, having slightly inflated median part and bluntly pointed poles. Mature shell composed of five to six involutions. Axial length 5.26 to 6.18 mm, median width 2.20 to 2.60 mm, and form ratio 2.38 to 2.39. Proloculus moderate in size, spherical, 0.33 to 0.28 mm in its outside diameter. First volution subspherical in shape.
Isomi, 1961, p. 18, 19, pl. 8, figs. 1–11.
Schwagerina krotowi (Schellwien). Kanmera, 1958, p. 193, 194, pl. 24, fig. 20; pl. 35, figs. 13, 14; Toriyama, 1958, p. 134–138, pl. 15, figs. 8–19; Kawano, 1961, p. 84, 85, pl. 4, fig. 28; pl. 5, figs. 1–4; Ishizaki, 1962, p. 113, 114, pl. 29, figs. 6–10.

**Materials.**—Axial sections, TGUFU 1050, 1051.

**Remarks.**—The present specimens closely resemble Schellwien’s original ones. This species was described from a limestone of the Okumyogata Formation about 15 km north of Hachimin town by Kanuma (1959).

**Occurrence.**—TGUFU 1049, 1050 from B–46 and B–48 in Section D near Higashi-Akuda.

**Pseudofusulina** sp.

Figures 7–12–16

**Materials.**—Axial sections of mature specimens, TGUFU 1033, 1034; axial sections of immature specimens, TGUFU 1032, 1035, 1036.

**Description.**—Shell medium in size, elongate fusiform, having somewhat bluntly rounded poles. Mature shell consists of four volutions. Axial length 7.60 to 8.59 mm, median width 2.26 to 2.73 mm, and form ratio 2.78 to 3.60 in mature specimens. Proloculus large, spherical, with outside diameter of 0.46 to 0.58 mm.


**Remarks.**—This species closely resembles *Pseudofusulina minoisens* Hh. Igo sp. nov., but has slightly stronger axial filling and septal fluting than in the latter.

**Occurrence.**—All specimens from R–1 in Section E of Nishi-Akuda.

Subfamily Pseudoschwagerininae Chang, 1963
Genus *Acervoschwagerina* Hanzawa, 1949

**Type species.**—*Paraschwagerina* (Acervoschwagerina) endoi Hanzawa, 1949

**Acervoschwagerina fujimotoi** Kanuma, 1959

Figures 10–1–3

*Acervoschwagerina fujimotoi* Kanuma, 1958, p. 62, 63, pl. 4, figs. 6–8; Ishii, 1964, p. 125, pl. 1, figs. 1, 2.

**Materials.**—Oblique sections, TGUFU 1070, 1071; slightly oblique axial section, TGUFU 1072.

**Description.**—Shell very large, elongate fusiform, and having inflated median part and broadly or narrowly rounded poles. Inner three or four volutions very tightly coiled, height suddenly increases in outer volutions.

Axial length of present specimens more than 15.98 mm and median width 6.00 mm or more. Proloculus spherical, small, and its outside diameter 0.27 to 0.47 mm. Spirotheca very thin and consists of a tectum and keriotheca. Septa numerous and thin, fluting irregular throughout shell. Chomata poorly developed in first to second volutions.

**Remarks.**—The present specimens are deformed by compaction of sediments and the height of the outer volutions has consequently been lowered.

**Occurrence.**—TGUFU 1070 from B–2; TGUFU 1071 from B–3; TGUFU 1072 from B–4 in Section C near Akuda-kuchi.

Genus *Chalaroschwagerina* Skinner and Wilde, 1965

**Type species.**—*Chalaroschwagerina inflata* Skinner and Wilde, 1965

**Chalaroschwagerina aff. chinensis** (Chen, 1956)

Figures 8–18

**Compare.**—*Schwagerina chinensis* Chen, 1956, p. 6, 35, pl. 5, fig. 10.

**Materials.**—Axial section of mature specimen, TGUFU 1054.

**Description.**—Shell large, highly inflated fusiform with rounded or elongate node-like poles and a rounded median part. Present specimen consists of six volutions. Axial length 9.32 mm, median width 5.06 mm, and form ratio 1.84. Inner volutions not so tightly coiled. Proloculus moderate in size, spherical, with an external diameter of 0.27 mm.

Spirotheca consists of a tectum and rather fine alveolar keriotheca. Thickness of spong sector with a maximum thickness of 0.08 mm. Septa numerous, moderately flattened throughout shell. Septal folds with bluntly pointed crests or obtuse crests extend almost halfway up the chamber. Phrenotheca weakly developed in median part of outer volutions. Chomata and axial filling lacking.

**Remarks.**—The present specimen closely resembles *Schwagerina chinensis*, which was described from Hupeh Province by Chen (1956). However, the former differs from the latter in the shape of septal fluting. The present specimen is similar to some species described as *Paraschwagerina*, but has a larger proloculus, more loosely coiled inner volutions, and regularly fluted septa.

**Occurrence.**—From R–2 in Section E of Nishi-Akuda.

Family Neoschwagerinidae Dunbar and Condra, 1927
Subfamily Neoschwagerininae Dunbar and Condra, 1927
Genus *Maklaya* Kanmera and Toriyama, 1968

**Type species.**—*Cancellina pamirica* Leven, 1967

**Maklaya pamirica** (Leven, 1967)

Figures 10–7–10

*Cancellina pamirica* Leven, 1967, p. 186, 187, pl. 32, figs. 1, 3; Sun and Zhang, 1988, pl. 4, fig. 21.

**Maklaya pamirica** (Leven). Kanmera and Toriyama, 1968, p. 34–37, pl. 4, figs. 1–16; Kahler and Kahler, 1979, p. 249, 250, pl. 8, fig. 6; Ishibashi, 1984, p. 222, 223, pl. 31, fig. 16; Yang, 1985, pl. 2, fig. 3; Ozawa and Kobayashi, 1990, pl. 9, figs. 10, 11; Fan et al., 1990, pl. 7, figs. 18, 27; Ueno, 1991, p. 994.
Hisaharu Igo

995, figs. 9-5-10.

Materials.—Axial sections, TGUFU 1076, 1077, 1078, 1079.

Description.—Shell medium in size, subospherical with broadly rounded poles. Mature specimens consist of 9 to 10 volutions. Axial length 2.10 to 2.56 mm, median width 1.83 to 2.33 mm, and form ratio 1.10 to 1.30. Proloculus minute, spherical, with an external diameter of 0.06 to 0.08 mm.

Spirotheca rather thick compared with shell size and composed of a tectum and alveolar keriotheca. Thickness of spirotheca in first to tenth volutions of mature specimen 0.005, 0.008, 0.020, 0.030, 0.050, 0.050, 0.050, 0.070, and 0.070 mm, respectively. Short, broad, and fan-shaped primary transverse septula well developed in fourth or succeeding volutions. Septa thick and unfluted throughout shell. Parachomata nearly triangular in axial section, first appearing in third volution. No axial septula present.

Remarks.—Recently, this species was described from the Akuyoshi Limestone by Ueno (1991). The Akuda specimens closely resemble the Akuyoshi specimens.

Occurrence.—TGUFU 1076, 1077, 1078 from A-21; TGUFU 1079 from A-22 in Section A near the Horikoshi Pass.

Maklaya saraburiensis Kanmera and Toriyama, 1988

Figures 10-11, 12


Neoschwagerina saraburiensis (Kanmera and Toriyama). Han, 1985, p. 685, pl. 2, figs. 14, 15.

Materials.—Axial sections of mature specimens, TGUFU 1080, 1081.

Description.—Shell small, subospherical with bluntly pointed poles. Mature specimens having seven and nine volutions, 1.33 and 1.86 mm in axial length, 1.27 and 1.57 mm in median width, and 1.18 and 1.44 in form ratio respectively. Inner two volutions planispiral with a short axis of coiling. Proloculus small, spherical, 0.06 mm in outside diameter. Spirotheca composed of a tectum and alveolar keriotheca. Thickness of spirotheca of first to seventh volutions of Figure 10-11, 0.007, 0.007, 0.012, 0.025, 0.030, 0.050, and 0.060 mm, respectively. Short and low primary transverse septula first appear in fourth volution. Parachomata observed in third or succeeding volutions. No axial septula present.

Remarks.—This species is distinguished from Maklaya pamirica (Leven) by a larger shell and greater numbers of volutions. The Akuda specimens closely resemble the type specimen, which was described from the Rat Buri Limestone in the Khao Phloeng Phrab area, central Thailand.

Occurrence.—TGUFU 1080, 1081 from A-22 in Section A near the Horikoshi Pass.

Family Verbeekinidae Staff and Wedekind, 1910
Subfamily Verbeekininae Staff and Wedekind, 1910
Genus Armenina Miklukho-Maklay, 1955

Type species.—Armenina karinae Miklukho-Maklay, 1955

Armenina sp.

Figures 10-13, 14

Materials.—Axial sections of mature specimens, TGUFU 1082, 1083.

Description.—Shell small, subospherical with rounded polar regions. Mature specimens having eight to nine volutions, 1.67 to 1.76 mm in axial length, 1.33 to 1.40 mm in median width, and form ratio 1.26 to 1.76. Inner 1/2 volutions planispiral, with a short axis of coiling and having a right angle to outer volutions. Inner three to four volutions tightly coiled and outer ones loosely coiled. Radius vectors of first to eighth volutions of axial section (Figure 10-13) 0.08, 0.11, 0.16, 0.25, 0.34, 0.45, 0.60, and 0.76 mm, respectively.

Proloculus small, spherical, and 0.05 mm in outside diameter. Spirotheca very thin for the genus, composed of a tectum and fine alveolar keriotheca except for the inner first to second volutions, which are a dense single layer. Thickness of spirotheca of first to ninth volutions (Figure 10-14) 0.007, 0.013, 0.013, 0.013, 0.010, 0.020, 0.030, 0.030, and 0.030 mm, respectively.

Parachomata small, low, narrow, and reach about 1/4 or 1/3 of chamber height. They appear in third volution. No axial septula present.

Remarks.—This species closely resembles Verbeekina (Armenina) priscia Toriyama and Kanmera, but differs from the latter in having a larger shell and rudimental parachomata.

Occurrence.—From A-21 in Section A near the Horikoshi Pass.

Repository: All specimens described in this paper are deposited in the Department of Astronomy and Earth Sciences, Tokyo Gakugei University with the prefix TGUFU.

Acknowledgments

I would like to acknowledge Professor Hisayoshi Igo of the Institute of Geoscience, University of Tsukuba for his critical reading of an early version of the manuscript and providing useful information on fusulinaceans in the Mino Terrane. I thank Drs. Katsumi Ueno and Shuko Adachi of the same university for their valuable discussion and help in photographing specimens. I also thank Mr. Junichi Yamamoto, a teacher of Sannou Elementary School in Tokyo. He collaborated with me in the field and prepared many thin sections when he was a student of our university.

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