Middle Permian fusulines from the Shirasaki Limestone in Yura Town, western part of the Kii Peninsula, Japan

Fumio KOBAYASHI *

*Suzukakedai 1-1-19, Sanda, Hyogo 669-1322, Japan

Abstract

Paleobiogeographically and biostratigraphically important fusulines occur in the Yura area, Southern Chichibu Terrane. Twenty-one species of fusulines and 17 species of non-fusuline foraminifers of the Middle Permian were distinguished in the Shirasaki Limestone, western end of the Yura area. They are illustrated to compare with fusulines previously figured from the limestone and to reinforce the foraminiferal information of the Southern Chichibu Terrane. Systematically described herein are 12 species of fusulines: Neofusulinella phairayensis, Parafusulina japonica, Parafusulina kinosakii, Parafusulina shimotsukensis, Parafusulina tochiyamensis, Pseudodoliolina ozawai, Verbeekina vebeeki, Neoschwagerina craticulifera, Yabeina higoensis, Yabeina katoi, Yabeina cf. omurensis, and Lepidolina? sp.

Key words: Middle Permian, fusulines, Shirasaki Limestone, Southern Chichibu Terrane

(Received: May 15, 2018 / Accepted: October 3, 2018/ Published: December 26, 2018)

Introduction

Stratigraphy and tectonic development of pre-Cretaceous rocks constructed until the 1970’s in the Yura area, Wakayama Prefecture (e.g. Tatebayashi, 1930; Saka, 1967), as well as those in other areas of Japan (e.g. Toriyama, 1963, 1967), were obliged to be changed and reconsidered on account of the age calibration of siliciclastic rocks determined by radiolarians introduced in the early 1980’s. According to Yao (1984), the accretionary complex of the Southern Chichibu Terrane in the Yura area consists of the Chuki Group (Lower Jurassic to Lower Cretaceous) divided into the Obiki, Yura, and Kamiya formations from north to south. The Obiki Formation is further subdivided into the Oshimayama, Banshoyama, and Tatego members. These stratigraphic units zonally arranging approximately in the east to west direction are clarified to be younger from north to south based on radiolarian biostratigraphy (Yao, 1984). Pre-Cretaceous limestone, basaltic rocks, and chert are intermingled within the Lower Jurassic to Lower Cretaceous siliciclastic rocks as a tectonic block. Yao (1984) showed that the Upper Paleozoic limestone blocks in the Yura area are restricted to the Tatego Member (Callovian-Tithonian) assignable to the Obiki Formation (lower Lower Jurassic to Tithonian). The Shirasaki Limestone, the largest limestone block in the Yura area, is remarkable in its occurrence of paleobiogeographically and biostratigraphically important fusulines, along with smaller limestone blocks exposed at Tatego and Kaimori (Fig.1). These fusulines are represented by Protriticites, Obsoletes, and Yabeina at Shirasaki, Akiyoshicha and Profusulinella at Kaimori, and Visean-Serpikhovian (Early Carboniferous) oostaffellins at Tatego, most of which were illustrated by Ishii (1985) without
description. Kobayashi (in press) systematically described these Carboniferous fusulines, except for Permian *Yabeina*, and discussed their paleobiogeographic and biostratigraphic implications.

This report illustrates 21 species of Middle Permian fusulines and 17 coeval species of non-fusuline foraminifers (Table 1), distinguished in seven samples (A-1, A-2, A-3, B-5, C-1, C-2, C-3), that were collected from the Shirasaki Limestone (Fig. 1). Sample C-3 is conglomeratic, Sample C-1 is somewhat conglomeratic, and other samples consist of bioclastic packstone/grainstone. Among 38 species of foraminifers, 12 fusulines are systematically described to compare with those illustrated by Ishii (1985) and to reinforce the foraminiferal information of the Southern Chichibu Terrane. The limestone outcrops, from which four samples (A-1, A-2, A-3, B-5) were obtained, are lost by the construction of a prefectural park at Shirasaki. Limestone thin sections of the foraminifers illustrated are stored in the collection of the Museum of Nature and Human Activities, Hyogo, Japan (Fumio Kobayashi Collection).

**Systematic description**

Superfamily *Fusulinoidea* von Möller, 1878  
Family *Schubertellidae* Skinner, 1931  

**Genus Neofusulinella** Deprat, 1912  
*Type species:* *Neofusulinella lantenoisi* Deprat, 1913  

*Neofusulinella phairayensis* Colani, 1924  
Plate 1, Figures 40–43

*Neofusulinella phairayensis* Colani, 1924, p. 104, 105, pl. 16, figs. 1–5, 7–10, 12–16, 20–22; Y. Ozawa, 1927, p. 151, 152 (part), pl. 37, figs. 3b, 5, 6c; pl. 38, non. figs. 2a and 12 (=*Yangchienia compressa* Y. Ozawa, 1927), 7, 8, 11 (central part and both sides of 11=*Yangchienia compressa*); pl. 39, figs. 1, 2; pl. 44, fig. 6c, pl. 45, fig. 9; Kobayashi, 2011, p. 465, pl. 5, figs. 35–54.

**Remarks.—** Well-preserved specimens of *Neofusulinella* contained in Sample A-1 in association with *Parafusulina tochigiensis* Kobayashi, 2006a is apparently identified with *N. phairayensis* originally described by Colani (1924) from northern Vietnam in their size and mode of coiling of the test, wall structure, and development of chomata. They are distinguished from *N. giraudi* Deprat, 1915 contained in the same sample by their larger test and more numerous whorls. Some specimens named this species by Y. Ozawa (1927) from the Akasaka Limestone, originally assigned into *Fusulinella*, are...
Table 1. Middle Permian foraminifers distinguished in seven samples of the Shirasaki Limestone.

<table>
<thead>
<tr>
<th></th>
<th>A-1</th>
<th>A-2</th>
<th>A-3</th>
<th>B-5</th>
<th>C-1</th>
<th>C-2</th>
<th>C-3</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Kahlerina nautiloidea</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Rauserella</em> sp.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Codonofusiella?</em> sp. A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Codonofusiella?</em> sp. B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Dunbarula oviformis</em></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Dunbarula schubertellaeformis</em></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Neofusulinella giraudi</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Neofusulinella</em> sp.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td><em>Chusenella</em> sp.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Chusenella andersoni</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td><em>Parafusulina japonica</em></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Parafusulina kinosakii</em></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Parafusulina shimotsukensis</em></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Parafusulina tochigiensis</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td><em>Pseudodoliolina ozawai</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Verbeekina verbeekii</em></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Neoschwagerina craticulifera</em></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Yabeina higoensis</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td><em>Yabeina katoi</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td><em>Yabeina cf. omurensis</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td><em>Lepidolina?</em> sp.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td><em>Nodosinelloides</em> sp. A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td><em>Nodosinelloides</em> sp. B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Climacammina</em> sp.</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Deckerella</em> sp.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td><em>Endothyra</em> sp. A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Endothyra</em> sp. B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td><em>Tetrataxis</em> sp.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td><em>Paradagmaritopsis</em> sp.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Geinitzina postcarbonica</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td><em>Geinitzina</em> sp. A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td><em>Geinitzina</em> sp. B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td><em>Geinitzina?</em> sp.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td><em>Neodiscus</em> spp.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td><em>Frondina</em> sp.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td><em>Pachyphloia ovata</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td><em>Pachyphloia schwageri</em></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td><em>Pachyphloia?</em> sp.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

assignable to *Yangchienia compressa* (Y. Ozawa, 1927) as listed above.

Family Schwagerinidae Dunbar and Henbest, 1930
Genus *Parafusulina* Dunbar and Skinner, 1931
Type species: *Parafusulina wordensis* Dunbar and Skinner, 1931

*Parafusulina japonica* (Gümbel, 1874)
Plate 3, Figures 1–5, 7, 9, 11–13

*Fusulina japonica* Gümbel, 1874, p. 479; Schwager, 1883, p. 121–124, pl. 15, figs. 1–10; Deprat, 1914, p. 7–9, pl. 1, figs. 1–9.

*Fusulina (Schellwienia) japonica* (Gümbel), Y. Ozawa, 1927, p. 147–149, pl. 36, figs. 1–7, pl. 37,
fig. 7a.

non. *Schellwienia japonica* (Gümbel), Lee, 1927, p. 82, pl. 13, figs. 1–3. [= *Praeparafusulina pseudojaponica* (Dutkevich in Likharev, 1939)]

*Parafusulina japonica* (Gümbel), Morikawa, 1958, p. 112–114, pl. 19, figs. 1–7; Kobayashi, 2006a, p. 47, figs. 12.1–12.25; Kobayashi, 2011, p. 470, 471, pl. 15, figs. 9–15; pl. 16, figs. 1–27; Kobayashi, 2016, p. 403–405, figs. 4.1–4.49, 7.1–7.8, 8.1, 8.2.

non. *Parafusulina japonica* (Gümbel), Kalmykova, 1967, p. 206, 208, pl. 25, figs. 1–4. [= *Praeparafusulina pseudojaponica* (Dutkevich in Likharev, 1939)]

Remarks. —The first confirmation of the development of the Permian in Japan is based on the occurrence of this species from the Akasaka Limestone (Gümbel, 1874). Identification and generic assignment of this species have been considerably different among authors. For example, *Schellwienia japonica* described by Lee (1927) from North China was renamed as *Parafusulina pseudojaponica* by Dutkevich in Likharev (1939), and was later designated as the type species of *Praeparafusulina* established by Tumanskaya (1962). This species was separated from *Parafusulina* (*Parafusulina*) and reassigned to *Parafusulina* (*Skinnerella*) based on the mode of septal folding by Coogan (1960). Kobayashi (2016) revealed that the microspheric specimens of this species are much more typical of those of *Parafusulina* (*Parafusulina*) and *P. japonica* will be placed in the genus *Parafusulina* without generic and subgeneric subdivisions. Further morphologic and phylogenetic studies based especially on microspheric forms are needed in the “*Parafusulina*” and its allies of the Tethyan and Panthalassic regions.

Morphologic studies based on numerous specimens of *P. japonica* have been done in Kuzu (Kobayashi, 2006a, 2013), Akasaka (Kobayashi, 2011), and Tamanouchi (Kobayashi, 2016) materials. They show the broad intraspecific variations of this species. Ten specimens illustrated herein closely resemble specimens from Kuzu, Akasaka, and Tamanouchi in important test characters such as size and form of the test and proloculus, and mode of septal folding in the megalospheric forms of *P. japonica*. Microspheric forms of the species are very few and confined to two specimens of Tamanouchi (Kobayashi, 2016) and one abraded specimen from Kuzu (Kobayashi, 2006a).

*Parafusulina kinosakii* (Morikawa, 1958)

Plate 2, Figures 7, 10, 11

Schwagerina kinosakii Morikawa, 1958, p. 109, 110, pl. 16, figs. 1–10.

Schwagerina yabei (Hanzawa, 1942), Morikawa, 1958, p. 110, 111, pl. 15, fig. 9.

*Parafusulina kinosakii* (Morikawa), Kobayashi, 2011, p. 471, pl. 13, figs. 18–28.

Remarks.—Morikawa (1958) proposed this species from the Akasaka Limestone and distinguished it from *Parafusulina yabei*, first described from Kuzu by Hanzawa (1942), based on its ellipsoidal test. Both species are similar each other and might be conspecific as supposed by Igo (1964) and Kobayashi (2006a). Topotype specimens of *P. yabei* and *P. kinosakii* were reexamined by Kobayashi (2006a, 2013) and Kobayashi (2011), respectively. Although almost all specimens of the latter are incomplete due to the abrasion of outer test, they and the original specimens of Morikawa (1958) are different from *P. yabei* in their weaker septal folding in polar regions and weaker development of axial fillings. The present Shirasaki specimens are also distinguished from *P. yabei* and identified with *P. kinosakii* by these characters, though well-oriented specimens are few. This species is separated from Schwagerina and reassigned to *Parafusulina* by its more strongly folded septa throughout the test.

*Parafusulina shimotsukensis* Kobayashi, 2006a

Plate 2, Figures 6, 9


Remarks.—This species proposed by Kobayashi (2006a) from the Nabeyama Formation of Kuzu shows extremely broad intraspecific variations in many test characters as illustrated by numerous individuals in Kobayashi (2013) from six stratigraphic levels of the formation. The Shirasaki specimens, all of which are incomplete and/or abraded, appear to be allied to *Parafusulina yabei* rather than to *P. shimotsukensis*. However, smaller appearance of the test is apparently due to the incompleteness of the test. Outer whorls of the latter species are more rapidly expanding than those of the former.
Parafusulina tochigiensis Kobayashi, 2006a
Plate 2, Figures 1, 5, 8

Parafusulina kaerimizensis (Y. Ozawa, 1925), Yao et al., 1970, pl. 2, fig. 1 (=Ishii, 1985, fig. 17.3); Ishii, 1985, pl. 2, fig. 1.
Parafusulina tochigiensis Kobayashi, 2006a, p. 51, figs. 11.1–11.20; Kobayashi, 2011, p. 473, 474, pl. 14, figs. 1–10; pl. 15, fig. 4.

Remarks.—Kobayashi (2006a) considered that this species proposed from the Nabeyama Formation belongs to the Parafusulina japonica group and is the direct descendant of P. kuzuensis Chisaka and Fuse, 1973. P. kuzuensis was considered to be a junior synonym of P. tomeganensis Morikawa, 1958, based on the reexamination of the topotypes of the latter from the Akasaka Limestone (Kobayashi, 2011). P. tochigiensis is characterized by elongate fusiform to subcylindrical test with small proloculus for large test, strongly folded septa, and not well-developed cuniculi for the genus.

The Shirasaki specimens closely resemble the types from the Nabeyama Formation showing broad intraspecific variations in many test characters (Kobayashi, 2006a, 2013) and apparently identified with the species. Two specimens illustrated from the Shirasaki Limestone by Yao et al. (1970) and Ishii (1985) are reassigned to P. tochigiensis because of many test characters common to those of P. tochigiensis. They are not identified with P. kaerimizensis, very characteristic in the Akiyoshi Terrane, in their larger test and proloculus, and much more loosely coiled inner few whorls than those of the topotypes of the Akiyoshi Limestone.

Pseudodoliolina ozawai Yabe and Hanzawa, 1932
Plate 2, Figures 12–14

Remarks.—As reviewed by Kobayashi (2011, p. 477, 478), Thompson and Foster (1937) made clear the generic diagnosis of Pseudodoliolina and taxonomic independency of Pseudodoliolina ozawai which were uncertain in Yabe and Hanzawa (1932). On the other hand, strict distinction of P. ozawai from its similar species, such as P. oliviformis Thompson, Wheeler, and Danner, 1950 proposed from the Twin Lakes area, Washington and P. chinghaiensis Sheng, 1958 from Qinghai, is not easy on account of their many similarities of test characters. Similarly, it is also uneasy to separate from incomplete forms of P. pseudolepida (Deprat, 1912).

Two specimens illustrated in Pl. 2, figs. 12, 13 in association with Neoschwagerina craticulifera (Schwager, 1883) are closely similar to the types of P. ozawai from the Akasaka Limestone. On the other hand, one illustrated in Pl. 1, fig. 14 in association with Yabeina higoensis Kobayashi, 2001 might be distinguished from P. ozawai by having more elongate test and slenderer parachomata. However, it is provisionally included in P. ozawai because of insufficient specimens in the Shirasaki materials.

Verbeekina verbeeki (Geinitz, 1876)
Plate 3, Figures 6, 8, 10, 14

Remarks.—The specimen illustrated in Pl. 3, fig. 10 from sample C-1 has thinner wall and septa in outer whorls, and more weakly developed parachomata than other three from sample A-1. However, these four specimens are assumed to be conspecific and identified with Verbeekina verbeeki, taking different degree of abrasion of outer test of the present materials, and broad morphologic variations of the mode of test expansion, thickness of wall, and development of parachomata of this species described from the Akasaka Limestone (Kobayashi, 2011) into account.
Family Neoschwagerinidae Dunbar and Condra, 1927  
Subfamily Neoschwagerininae Dunbar and Condra, 1927  
Genus Neoschwagerina Yabe, 1903  
Type species: Neoschwagerina craticulifera Schwager, 1883

Neoschwagerina craticulifera (Schwager, 1883)  
Plate 4, Figures 1–15

Schwagerina craticulifera Schwager, 1883, p. 140, pl. 18, figs. 15–25.  
Neoschwagerina craticulifera (Schwager), Yabe, 1906, p. 2, pl. 1, fig. 3; Ishii, 1985, pl. 1, fig. 10; Kobayashi, 2011, p. 518, 520, pl. 33, figs. 1–18; pl. 37, figs. 4–6.  
Neoschwagerina (Neoschwagerina) craticulifera (Schwager), Y. Ozawa, 1927, p. 154–156, pl. 40, figs. 1–7, 10, 11a.  
Neoschwagerina minoensis Y. Ozawa, 1927, Ishii, 1985, pl. 1, fig. 7.  
Maklaya sp., Ishii, 1985, pl. 1, fig. 9.

Remarks.—Many species or subspecies identified with Neoschwagerina craticulifera were described by many workers. Those examples in the Akasaka Limestone were discussed by Kobayashi (2011). Fifteen specimens illustrated herein from the Shirasaki Limestone are all identified with N. craticulifera. Smaller appearance of the test in many specimens is due to the abrasion of outer test in the Shirasaki materials. This species is distinguished from N. colaniae Y. Ozawa, 1927 in its smaller test, fewer number of whorls, and absence or fewer number of secondary transverse septula between adjacent primary transverse septula in outer whorls. N. minoensis illustrated by Ishii (1985) from the Shirasaki Limestone should be undoubtedly transferred to this species (see topotype specimens of N. minoensis described by Kobayashi, 2011 from the Akasaka Limestone). Maklaya sp. illustrated by Ishii (1985) is almost the same as the specimen named N. craticulifera, both of which are from the Shirasaki Limestone. It has more developed primary transverse septula than typical Maklaya.

Genus Yabeina Deprat, 1914  
Type species: Neoschwagerina (Yabeina) inouyei Deprat, 1914 [=Yabeina globosa (Yabe, 1906)]

Yabeina higoensis Kobayashi, 2001  
Plate 4, Figures 16–21, 23

Yabeina globosa (Yabe, 1906), Ishii, 1985, pl. 1, fig. 1.  
Yabeina ozawai (Honjo, 1959), Ishii, 1985, pl. 1, fig. 6.  
Yabeina higoensis Kobayashi, 2001, p. 72, figs. 6.4, 6.8; pl. 5, figs. 1–9; Kobayashi, 2006c, p. 189, figs. 6.1–6.17.

Remarks.—The Shirasaki specimens identified with Yabeina higoensis, proposed on the basis of materials from the Kuma Formation by Kobayashi (2001) and Kaize, Saku Basin by Kobayashi (2001, 2006c), are distinguished from Y. globosa and Y. katoi (Y. Ozawa, 1927) by their diagnostic features of smaller height of the whorl in middle and late stages. They are also different from most of other species of Yabeina in their well development of secondary transverse septula and axial septula in comparison with a relatively small test. Based on these features of this species, the Shirasaki specimens identified with Y. globosa and Y. ozawai by Ishii (1985) are attributed to Y. higoensis. Smaller appearance of the latter than the former in Ishii (1985) is certainly due to the absence of a few or more outer whors.

Yabeina katoi (Y. Ozawa, 1927)  
Plate 4, Figure 26

Neoschwagerina katoi Y. Ozawa, 1927, p. 159, pl. 41, figs. 1, 10; pl. 42, fig. 3; pl. 43, figs. 1a, 2a, 3, 5, 6.  
Yabeina aff. globosa (Yabe, 1906), Yao et al., 1970, pl. 2, fig. 3 (=Yabeina globosa in Ishii, 1985, fig. 17.1).  
? Yabeina katoi (Y. Ozawa), Ishii, 1985, pl. 1, fig. 2.  
Yabeina katoi (Y. Ozawa), Kobayashi, 2011, p. 528, 530, 532, pl. 42, figs. 1–4; pl. 43, figs. 1–5.

Remarks.—The specimen obtained only from sample C-3, though incomplete and abraded, should be separated from Yabeina higoensis by its larger chamber height of outer whors. It is identified with Y. katoi in its thin wall, and slender primary and secondary transverse septula. The specimen, named Y. aff. globosa by Yao et al. (1970) and renamed Y. globosa by Ishii (1985), is reassigned to Y. katoi by these morphologies characteristic in Y. katoi, as clearly exemplified in the topotypes of the Akasaka Limestone (Kobayashi, 2011). Precise identification with this species in the Shirasaki specimen by Ishii (1985, pl. 1, fig. 2) is uneasy on account of its abrasion of outer whors.
Yabeina cf. omurensis Yamagiwa and Ishii, 1958
Plate 4, Figures 22, 24

Compare to:
Yabeina omurensis Yamagiwa and Ishii, 1958, p. 62, 64, pl. 4, figs. 1–8; Ishii, 1985, pl. 1, fig. 5.

Remarks.—Although exact test size is unknown due to the abrasion of outer whorls, two illustrated specimens are compared to Yabeina omurensis first described by Yamagiwa and Ishii (1958) from the Shima Peninsula, Mie Prefecture and later by Ishii (1985) from the Shirasaki Limestone. They are more similar to the Ishii’s (1985) specimen in their thinner wall and septa, and slenderer primary transverse septula than those of the original ones from the Shima Peninsula. Relatively poor development of secondary transverse septula and axial septula for a species of Yabeina is common in these Shima and Shirasaki materials.

Subfamily Lepidolininace Miiklukho-Maklay, 1958
Genus Lepidolina Lee, 1933 emend. T. Ozawa, 1970
Type species: Neoschwagerina (Sumatrina) multiseptata
Deprat, 1912

Lepidolina? sp.
Plate 4, Figure 25

Remarks.—Relatively large neoschwagerinids, though exact test size is unknown on account of the section far apart from the center, were rarely recognized in sample C-3. Yabeina higoensis, Pseudodoliolina ozawai, Chusenella sp., Codonofusiella? sp. A, Kahlerina nautilioidea Sosnina, 1968, and others are also contained in this conglomeratic limestone. The illustrated specimen is characterized by elongate fusiform test with thin wall and well-developed, slender secondary transverse septula. By these morphologic characters and incompleteness of the test, it is questionably assigned to Lepidolina.

References

Chisaka, T. and Fuse, M. (1973) Parafusulina (Parafusulina) kuzuensis n. sp. from the Yamasuge Limestone Member in the vicinity of Kuzu Town, Tochigi Prefecture, Japan. Bulletin of the Faculty of Education, Chiba University, 22, 180–188.


Honjo, S. (1959) Neoschwagerinids from the Akasaka Limestone (a paleontological study of the Akasaka Limestone, 1st report). Journal of the Faculty of Science, Hokkaido University, Ser. 4, 10, 111–161.


Ozawa, Y. (1925) Paleontological and stratigraphical studies on the Permo-Carboniferous limestone of Nagato, Part 2, Paleontology. *Journal of the College of Science*, Imperial University of Tokyo, 45, 1–90.

Ozawa, Y. (1927) Stratigraphical studies on the fusulina limestone of Akasaka, Province of Mino. *Journal of the Faculty of Science*, Imperial University of Tokyo, Sec. 2, 121–146.


Staff, H. von. (1909) Beiträge zur Kenntnis der Fusuliniden.
Neues Jahrbuch für Mineralogie, Geologie und Paläontologie, Beilagebände, 27, 461–508.


Yabe, H. (1906) A contribution to the genus Fusulina, with notes on Fusulina limestone from Korea. Journal of College of Science, Imperial University of Tokyo, 21, 1–36.


Plate 1.

Fig. 1. *Nodosinelloides* sp. A. D2-036789, Sample C-3.
Fig. 2. *Nodosinelloides* sp. B. D2-036667, Sample A-2.
Fig. 3. *Pachyphloia?* sp. D2-036650, Sample A-1.
Figs. 4–6. *Pachyphloia ovata* Lange, 1925. 4: D2-036653, 5: D2-036626, 6: D2-036650; all Sample A-1.
Fig. 13. *Frondina?* sp. D2-036770, Sample C-2.
Fig. 14. *Deckerella?* sp. D2-036659, Sample A-2.
Fig. 15. *Climacammina?* sp. D2-036629, Sample A-1.
Fig. 16. *Geinitzina?* sp. A. D2-036787, Sample C-3.
Fig. 17. *Paradagmaritopsis* sp. D2-036645, Sample A-1.
Fig. 18. *Tetrataxis?* sp. D2-036645, Sample A-1.
Fig. 22. *Geinitzina?* sp. B. D2-036631, Sample A-1.
Fig. 23. *Endothyra?* sp. B. D2-036627, Sample A-1.
Fig. 24. *Geinitzina postcarbonica* Spandel, 1901. D2-036662, Sample A-2.
Fig. 25. *Rauserella?* sp. D2-036781, Sample C-3.
Figs. 26–33. *Neodiscus* spp. 26: D2-036769, 27: D2-036768, 28: D2-036766, 29, 30: D2-036773, 31: D2-036771, 32: D2-036781, 32, 33: Sample C-1, others: Sample C-2.
Figs. 34–36. *Kahlerina nautiloidea* Sosnina, 1968. 34: D2-036781, Sample C-3; 35: D2-036765, Sample C-1; 36: D2-036787, Sample C-3.
Fig. 37. *Codonofusiella?* sp. A. D2-06778, Sample C-3.
Figs. 44, 45, 47, 49, 51. *Dunbarula oviformis* Kobayashi, 2006b. 44, 45: D2-036629, 47: D2-036636, 49: D2-036640, 51: D2-036636; all Sample C-1.
Figs. 46, 48. *Dunbarula schubertellaeformis* Sheng, 1958. 46: D2-036787, Sample C-3; 48: D2-036763, Sample C-1.
Fig. 50. *Codonofusiella?* sp. B. D2-036669, Sample C-2.
Scale bar shows 0.5 mm.

Plate 2.

Fig. 1, 5, 8. *Parafusulina tochigiensis* Kobayashi, 2006a. 1: D2-036618, 5: D2-036634, 8: D2-036625; all Sample A-1.
Figs. 2, 3. *Chusenella?* sp. 2: D2-036788, 3: D2-036778; both Sample C-3.
Fig. 4. *Chusenella andersoni* (Thompson, Wheeler and Danner, 1950). D2-036760, Sample A-1.
Scale bar shows 2 mm.

Plate 3.

Figs. 6, 8, 10, 14. *Verbeekina verbeeki* (Geinitz, 1876). 6: D2-036620, 8: D2-036638, 10: D2-036763, 14: D2-036650; 10: Sample C-1, others: Sample A-1.
Scale bar shows 1 mm.

Plate 4.

Figs. 22, 24. *Yabeina cf. omurensis* Yamagiwa and Ishii, 1958. 22: D2-036763, 24: D2-036753; both Sample C-1.
Fig. 25. *Lepidolina?* sp. D2-036780, Sample C-3.
Fig. 26. *Yabeina katoi* (Y. Ozawa, 1927). D2-036790, Sample C-3.
Scale bar shows 1 mm.
Plate 2.
Plate 3.
Plate 4.
紀伊半島西部由良町白崎石灰岩のペルム紀中期フズリナ類

小 林 文 夫

紀伊半島西部、和歌山県由良町西端に分布する南部秩父テレーンの異地性岩体、白崎石灰岩は古生物地理・生層序的見地から重要なフズリナ類を産する。白崎石灰岩のペルム紀中期フズリナ情報を充実させるため、識別されたフズリナ類21種のうち12種を記載し、それらとこれまでに図示された同時期のフズリナ類と比較・検討した。記載した12種はNeofusulinella phairayensis, Parafusulina japonica, Parafusulina kinosakii, Parafusulina shimotsukensis, Parafusulina tochigiensis, Pseudodoliolina ozawai, Verbeekina verbeeki, Neoschwagerina craticulifera, Yabeina higoensis, Yabeina katoi, Yabeina cf. omurensisとLepidolina? sp.である。

（2018年5月15日受付, 2018年10月3日受理, 2018年12月26日発行）