

# Early Permian (Sakmarian, Artinskian, Kungurian) foraminifers and Biostratigraphy of the Akiyoshi Limestone (Japan)

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## Abstract

Carboniferous and Permian carbonate sequences in Japan are most completely preserved in the Akiyoshi Limestone in the Akiyoshi Terrane (Permian accretionary complex), Southwest Japan. The studied Sakmarian to lower Kungurian sequence is biostratigraphically divided into six zones: *Globifusulina nux* Zone and *Globifusulina krotowi* Zone (Sakmarian), *Chalaroschwagerina vulgaris* Zone (lower to middle Artinskian), *Paraleeina magna* Zone (upper Artinskian), *Pamirina leveni* Zone (uppermost Artinskian), and *Misellina dyhrenfurthi* Zone (lower Kungurian) based on stratigraphic distribution and species composition of the fusuline faunas in Akiyoshi. These zones are compared and correlated to those in the Cisuralian stratotypes of the South Urals and Tethyan regions. Many fusuline species common in Akiyoshi and South Urals are discernible in the Sakmarian, and the Tethyan faunal elements become dominant in the Artinskian. Foraminifers consist of 117 species assignable to 53 genera in this study. Five fusuline species newly proposed are *Chenella rhomboides*, *Praemisellina minensis*, *Chalaroschwagerina compacta*, *Paraleeina cubiformis*, and *Paraleeina toriyamai*.

## Keywords

Fusulines, Sakmarian, Artinskian, lower Kungurian, Akiyoshi, Japan.

## 1. INTRODUCTION

The Akiyoshi Limestone is a Panthalassan-originated huge block in the Akiyoshi Terrane (Permian accretionary complex), Southwest Japan, along with Taishaku, Atetsu, and Omi limestones. It consists of basaltic rocks at the basal part and an overlying massive limestone succession, and is in fault contact with the surrounding non-calcareous rock units (Fig. 1). The limestone and surrounding non-calcareous formations (groups) are unconformably overlain by the post-accretional Mine Group (Upper Triassic) showing the molasses facies (Tokuyama, 1958; Kanmera *et al.*, 1990; Kobayashi, 2012).

The biostratigraphic zonation and correlations based on fusulines have been studied by many workers since Y. Ozawa (1925), and the taxonomy of fusulines and biostratigraphic subdivision of the Akiyoshi Limestone have been modified by later workers (Toriyama, 1958; M. Ota, 1977; Ueno, 1989, 1995; T. Ozawa & Kobayashi, 1990; Watanabe, 1991). Recently, Kobayashi (2017, 2019) reviewed and reconsidered the foraminiferal faunas and the biostratigraphic zonation from the Moscovian (middle Carboniferous) to Asselian (earliest Permian) and in the Guadalupian (Middle Permian). On

the other hand, many paleontologic and biostratigraphic problems have been remained uncertain or insufficient in most part of the Cisuralian (Sakmarian, Artinskian, and Kungurian), that is in the stratigraphic interval from the last occurrence of *Sphaeroschwagerina* to the first occurrence of *Misellina* in Akiyoshi as well as in other limestones of Japan.

As a continuation of the recent studies (Kobayashi, 2017, 2019; Kobayashi & Vachard, 2019), this paper presents the revised taxonomy of foraminiferal faunas and biostratigraphy of the Sakmarian to Kungurian in the Wakatakyama area of the Akiyoshi Plateau. They are summarized by (1) the Sakmarian to lower Kungurian is biostratigraphically divided into six: *Globifusulina nux* and *Globifusulina krotowi* zones (Sakmarian), *Chalaroschwagerina vulgaris* Zone (lower to middle Artinskian), *Paraleeina magna* Zone (upper Artinskian), *Pamirina leveni* Zone (uppermost Artinskian), and *Misellina dyhrenfurthi* Zone (lower Kungurian); (2) The stratigraphic interval correlatable to the Sakmarian in the Akiyoshi Limestone is newly defined biostratigraphically based on many species common to those established in the South Urals; and (3) Cisuralian fusuline faunas are more or less different among the limestone blocks accreted in the Permian, those done in the Jurassic, and the shelf

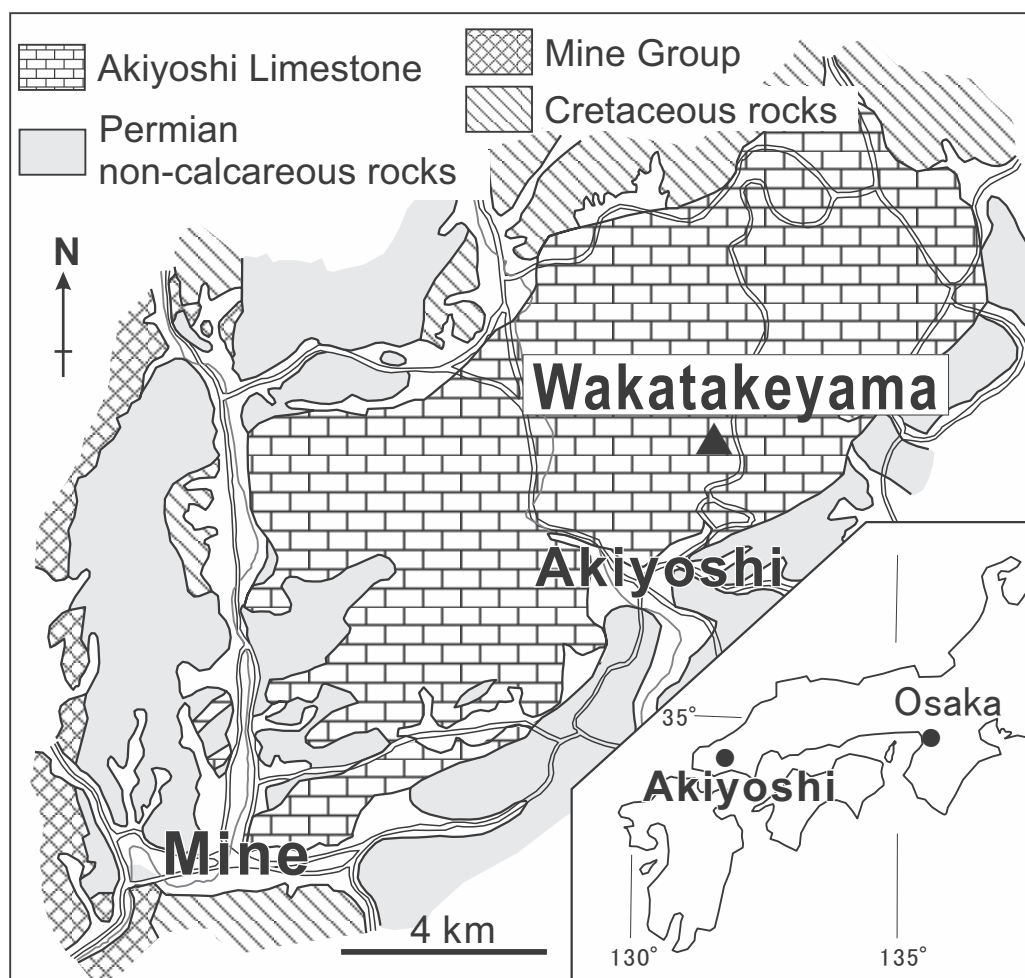


Fig. 1: Distribution of the Akiyoshi Limestone and surrounding rocks.

limestone with continental affinities in the Southern Kitakami Terrane. Among 117 species assignable to 53 genera, five species newly proposed in this paper are *Chenella rhomboides*, *Praemisellina minensis*, *Chalaroschwagerina compacta*, *Paraleeina cubiformis*, and *Paraleeina toriyamai*. In addition to them, many taxa are described and illustrated so as to compare to the coeval taxa reported in and outside Japan. Limestone samples and thin sections in the studied area are stored in the Museum of Nature and Human Activities, Hyogo, Japan (Fumio Kobayashi Collection, MNHAH).

## 2. STRATIGRAPHY AND LIMESTONE LITHOLOGY

The limestone in the studied area is massive without showing any distinct stratification as well as in other areas of the Akiyoshi Limestone. Available key beds are not intercalated in the limestone sequence except for dark brown limestone layers with microcodium structure that are biostratigraphically confined to the middle to

upper part of the Kasimovian (Kobayashi, 2017). The limestone is cut by many faults with various degrees of displacement. Based on fusuline biostratigraphic reconfirmation of many samples, the limestone is complicatedly folded and faulted in the western part of the mapped area (Fig. 2). Moreover, the lateral tracing of some limestone beds with marked fusuline species reveals that it is apparently overturned at least in the middle part of the area. However, before the accretion of the Akiyoshi seamount, the limestone is supposed to be originally continuous and successive without any distinct stratigraphic breaks.

Cisuralian samples collected in the mapped area (Figs 2, 3) are highly fossiliferous and divided into several microfacies types (Fig. 4). Fusuline grainstone/packstone and algal foraminiferal grainstone/packstone are most prevailing in the Sakmarian and observed in several levels of the Artinskian. Various kinds of bioclasts such as foraminifers, algae, crinoids, ostracodes, bryozoans, sponges, pelecypods, gastropods, and corals are contained in them, and pelloid grains are characteristically present in some of them. Microbial limestone, micritic limestone,





Fig. 2: Geologic map showing the biostratigraphic subdivision of the Upper Carboniferous and Lower Permian (Moscovian to Kungurian), sample localities of the eastern part of the mapped area, and the location of four stratigraphic columns (A-B, C-D, E-F, and G-H). Details on them near Wakatakeyama are shown in Kobayashi (2017).

and pelloid limestone of several meters thick and poor in megafossils are intermittently intervened in fossiliferous limestones prolific in foraminifers. Oolitic limestone and boundstone/framestone are not conspicuous. On the other hand, the uppermost Artinskian and Kungurian limestones are generally more fine-grained, and dominated by bioclastic limestone poor in foraminifers and lime-mudstone/wackestone. Fusuline grainstone/packstone with prolific *Misellina* species found in the Kaerimizu area (Kobayashi, 2019) is accessory in the Kungurian limestone in the mapped area.

### 3. BIOSTRATIGRAPHY

Four stratigraphic columns, A-B, C-D, E-F, and G-H were prepared in the studied area (Figs 2, 5). More than 120 samples were collected along the four columnar sections. The Cisuralian is subdivided into eight fusuline zones. From lower to upper, they are *Sphaeroschwagerina fusiformis* Zone (P-1), *Alpinoschwagerina nagatoensis* Zone (P-2) corresponding to the *Pseudoschwagerina miharanoensis*-*Paraschwagerina akiyoshiensis* Zone

in Kobayashi (2017), *Globifusulina nux* Zone (P-3), *Globifusulina krotowi* Zone (P-4), *Chalaroschwagerina vulgaris* Zone (P-5), *Palaleeina magna* Zone (P-6), *Pamirina leveni* Zone (P-7), and *Misellina dyhrenfurthi* Zone (P-8). The *Globifusulina nux* and *Globifusulina krotowi* zones are first established in this study.

One-hundred and seventeen species belonging to 53 genera are distinguished in these biostratigraphic intervals from the P-3 to P-8 (Table 1). Forty-nine species contained in 28 samples from P-3 to P-5 and 57 species in 30 samples from P-6 to P-8 are shown in Table 2 and Table 3, respectively.

Before going into the *Globifusulina nux* Zone (P-3), the Asselian units (P-1 and P-2) are briefly summarized. Species composition of the Asselian samples C-37-C-40 (Fig. 5) is largely different from that of the Sakmarian ones. It is almost the same as that of the Wakatakeyama area described in detail by Kobayashi (2017) and is characterized by *Sphaeroschwagerina fusiformis* (Krotow, 1888), *Pseudoschwagerina muongthensis* (Deprat, 1915), and *Alpinoschwagerina nagatoensis* Kobayashi, 2017. Age-diagnostic fusuline species from the upper Gzhelian and Asselian (Fig. 6) do not extend





Fig. 3: Sample localities of the western part of the studied area.

upward to the Sakmarian. Taxonomic diversity of foraminifers is more variable in the upper Gzhelian and Asselian than in the Sakmarian. Among non-fusuline foraminifers, *Bradyina* common in the Moscovian to lower Asselian (Kobayashi & Vachard, 2019) almost disappears from P-3 upward.

### 3.1. *Globifusulina nux* Zone (P-3)

This zone is defined by the stratigraphic interval of the zonal species without association with *Globifusulina krotowi*. Other species characteristic in this zone are *Sakmarella paramölleri*, *S. sp.*, *Pseudochusenella alamellosa*, and *P. pointeli*. *Globifusulina nux* and the first three species extend upward to the P-4, and the

last species to P-5. *Schubertella* sp., *Staffella* sp. and *Climacammina gigas* are accessarily found in four samples (Table 2). This zone only discernible in the C-D section is fault bounded with the *Paraleeina magna* Zone (P-6). Thickness of this zone is estimated more than 28 m. Stratigraphic relationship between this zone and the upper Asselian (*Alpinoschagerina nagatoensis* Zone) is not ascertained in the mapped area.

### 3.2. *Globifusulina krotowi* Zone (P-4)

This zone is designated for 34 m thick limestone from the first occurrence of the zonal species to that of *Chalaroschwageria vulgaris*. Abundance and taxonomic diversity of both non-fusuline and fusuline foraminifers



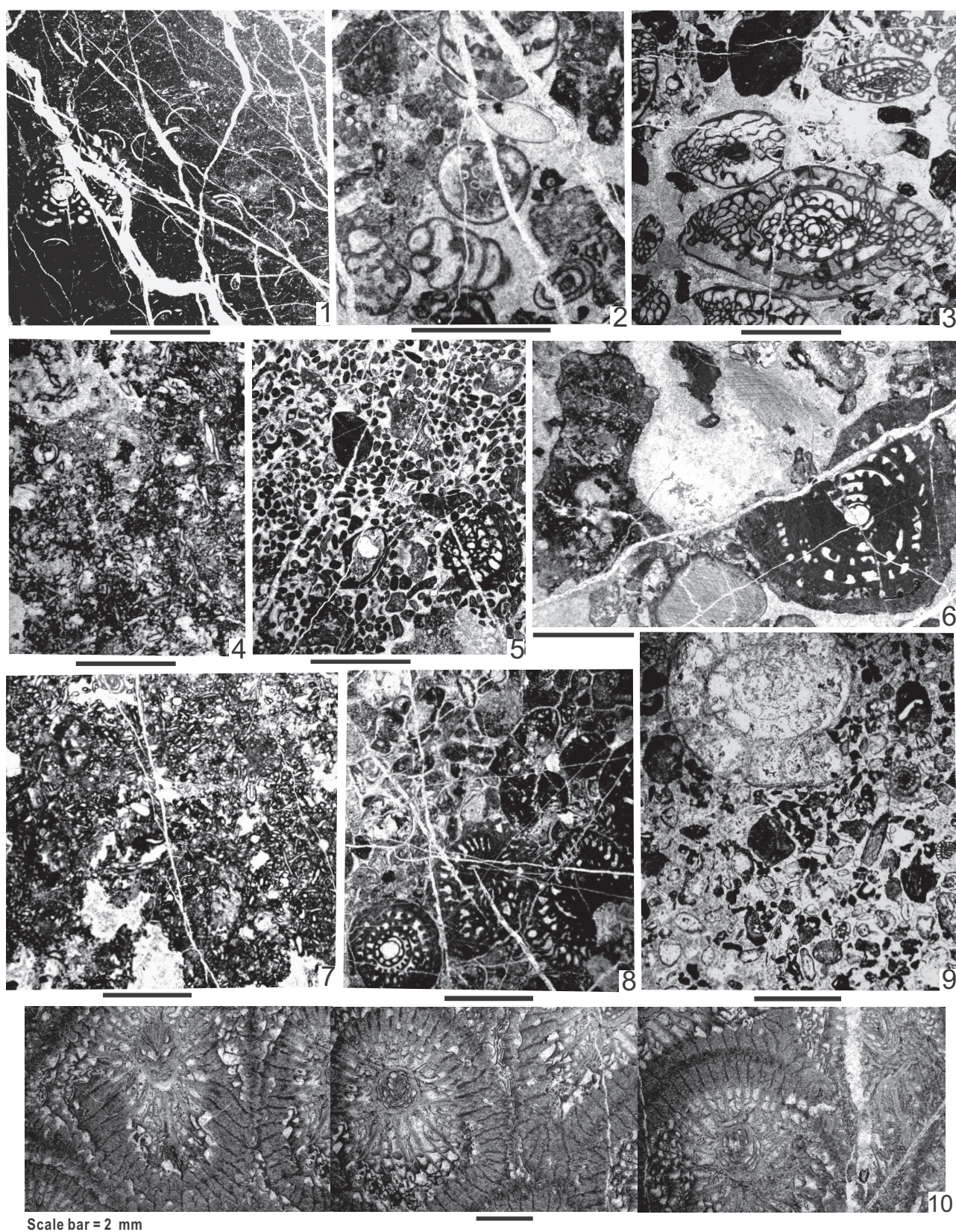


Fig. 4: Limestone lithology of Cisuralian samples in the mapped area, 1: lime-mudstone with many thin-shelled bivalves, B-495 (P-6); 2: algal foraminiferal grainstone/packstone, B-540 (P-7); 3: fusuline grainstone, C-76 (P-5); 4: algal packstone, C-55 (P-4); 5: bioclastic pelloid grainstone, B-544 (P-6); 6: conglomeratic bioclastic grainstone, B-441 (P-6); 7: phylloid algal framestone, C-54 (P-6); 8: bioclastic packstone/grainstone, B-416 (P-6); 9: algal bioclastic grainstone, C-59 (P-4); 10: rugose coral boundstone, B-355 (P-2).



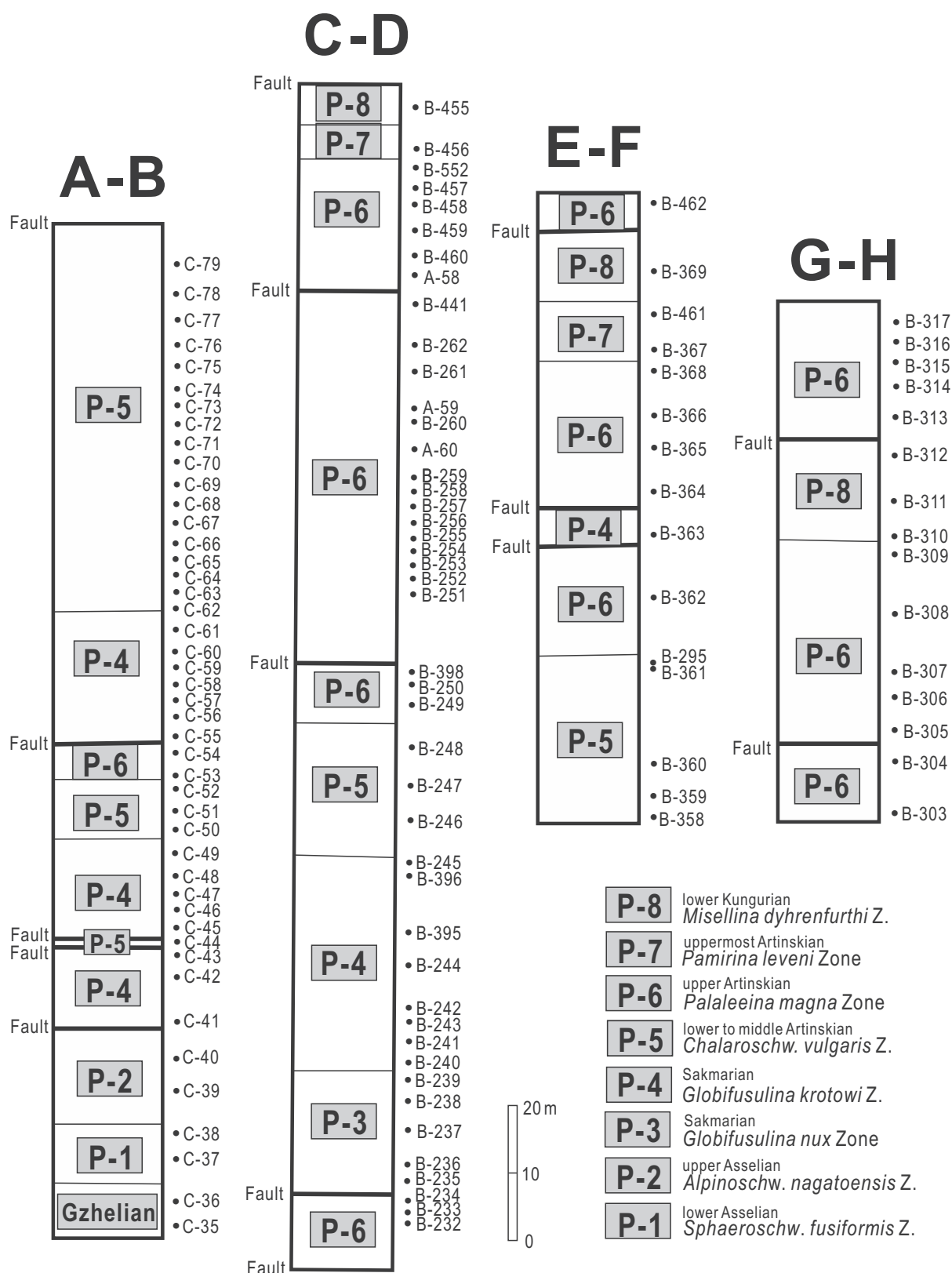


Fig. 5: Four stratigraphic columns in the mapped area showing the positions of samples and the foraminiferal biostratigraphy.

Table 1: Foraminifers distinguished in the P-3 (*Globifusulina nux*) to the P-8 (*Misellina dyhrenfurthi*) zones in the mapped area.

| Non-fusuline foraminifers                                      | Schwagrinitid fusulines                                           | Fusulines except for schwagerininitids                  |
|----------------------------------------------------------------|-------------------------------------------------------------------|---------------------------------------------------------|
| <i>Pseudolangella</i> ? sp.                                    | <i>Globifusulina krotowi</i> (Schellwien, 1908)                   | <i>Pamirina leveni</i> Kobayashi, 1977                  |
| <i>Calcitornella</i> sp.                                       | <i>Globifusulina nux</i> (Schellwien, 1908)                       | <i>Zarodella zhamoidai</i> Sosnina, 1981                |
| <i>Cornuspira</i> ? sp.                                        | <i>Sakmarella paramöller</i> (Rauzer-Chernousova, 1938)           | <i>Praemisellina minensis</i> n. sp.                    |
| <i>Spireitlina conspecta</i> (Reitlinger, 1950)                | <i>Sakmarella</i> sp.                                             | <i>Praemisellina</i> cf. <i>minensis</i> n. sp.         |
| <i>Spireitlina</i> sp.                                         | <i>Verneuilites abnormis</i> (Rauzer-Chernousova, 1940)           | <i>Palaeostaffella yobarensis</i> (Y. Ozawa, 1925)      |
| <i>Globivalvulina laxa</i> Lin, Li & Sun, 1990                 | <i>Verneuilites urdalensis</i> (Rauzer-Chernousova, 1940)         | <i>Palaeostaffella akudensis</i> (Hh. Igo, 1966)        |
| <i>Globivalvulina</i> sp. A                                    | <i>Verneuilites</i> ? sp.                                         | <i>Palaeostaffella subquadrata</i> Kobayashi, 2019      |
| <i>Globivalvulina</i> sp. B                                    | <i>Pseudochusenella pointeli</i> (Rauz.-Chern., 1940)             | <i>Chenella mathildae</i> (Dutkevich, 1934)             |
| <i>Tetrataxis conica</i> Ehrenberg, 1854                       | <i>Pseudochu. alamellosa</i> (Rauzer-Chernousova, 1949b)          | <i>Chenella rhomboides</i> n. sp.                       |
| <i>Tetrataxis postminima</i> Potievskaya, 1962                 | <i>Rugosochusenella</i> sp.                                       | <i>Chenella</i> sp.                                     |
| <i>Tetrataxis</i> cf. <i>paraconica</i> Reitlinger, 1950       | <i>Biwaella</i> sp.                                               | <i>Nankinella</i> cf. <i>nagatoensis</i> Toriyama, 1958 |
| <i>Tetrataxis</i> spp.                                         | <i>Darvasites</i> sp.                                             | <i>Nankinella</i> ? sp.                                 |
| <i>Polytaxis</i> sp.                                           | <i>Darvasites</i> ? <i>ingavati</i> Hy. Igo, Ueno & Sashida, 1993 | <i>Staffella</i> sp.                                    |
| <i>Textularia longissima</i> Reitlinger, 1950                  | <i>Darvasites</i> ? cf. <i>beitepensis</i> Leven, 1995            | <i>Staffella</i> ? sp.                                  |
| <i>Deckerella</i> aff. <i>elegans artiensis</i> Morozova, 1949 | <i>Eoparafusulina</i> cf. <i>ellipsoidalis</i> (Toriyama, 1958)   | <i>Pseudoreichelina darvasica</i> Leven, 1970           |
| <i>Climacammina fragilis</i> Reitlinger, 1950                  | <i>Praeskinnerella cushmani</i> (Chen, 1934)                      | <i>Pseudoreichelina obiniouensis</i> (Leven, 1970)      |
| <i>Climacammina gigas</i> Suleimanov, 1949                     | <i>Paraschwagerina fax</i> (Thompson & Wheeler, 1946)             | <i>Pseudoreichelina discoidea</i> Ueno, 1992            |
| <i>Climacammina</i> sp. A                                      | <i>Likharevites tinvenkiangi</i> (Lee, 1927)                      | <i>Pseudoreichelina endothyroidea</i> Ueno, 1992        |
| <i>Climacammina</i> spp.                                       | <i>Likharevites</i> sp. A                                         | <i>Pseudoreichelina</i> sp. A                           |
| Palaeotextulariidae gen. and sp. indet.                        | <i>Likharevites</i> sp. B                                         | <i>Pseudoreichelina</i> sp. B                           |
| <i>Bradyina</i> sp.                                            | <i>Likharevites</i> sp. C                                         | <i>Toriyamaia laxiseptata</i> Kanmera, 1956             |
| <i>Endothyra irregularis</i> Reitlinger, 1950                  | <i>Leeina asiatica</i> (Kalmykova, 1967)                          | <i>Schubertina</i> sp.                                  |
| <i>Endothyra</i> sp.                                           | <i>Leeina chihsiaensis</i> (Lee, 1931)                            | <i>Schubertella kingi</i> Dunbar & Skinner, 1937        |
| <i>Agathammina ampla</i> Lin, 1984                             | <i>Leeina callosa</i> (Rauzer-Chernousova, 1940)                  | <i>Schubertella melonica</i> Dunbar & Skinner, 1937     |
| <i>Agathammina asymmetrica</i> , Han, 1982                     | <i>Leeina krafftii</i> (Schellwien & Dyhrenfurth, 1909)           | <i>Schubertella exilis</i> Suleimanov, 1949             |
| <i>Agathammina</i> sp. A                                       | <i>Leeina</i> sp.                                                 | <i>Schubertella</i> sp.                                 |
| <i>Agathammina</i> sp. B                                       | <i>Pseudofusulina dzamantalensis</i> (Leven, 1967)                | <i>Mesoschubertella</i> sp.                             |
| <i>Agathammina</i> spp.                                        | <i>Pseudofusulina norikurensis</i> Hy. Igo, 1959                  | <i>Misellina dyhrenfurthi</i> (Dutkevich, 1939 )        |
| <i>Hemigordius discoides</i> Lin, Li & Sun, 1990               | <i>Pseudofusulina</i> cf. <i>nalivkini</i> Leven, 1967            | <i>Misellina parvicostata</i> (Deprat, 1915)            |
| <i>Hemigordius rotundus</i> Wang, 1982                         | <i>Pseudofusulina</i> sp.                                         |                                                         |
| <i>Hemigordius</i> sp.                                         | <i>Pseudofusulina</i> ? cf. <i>pavlovi</i> Leven, 1967            |                                                         |
| <i>Hemigordiopsis</i> ? sp.                                    | <i>Chusenella</i> ? sp.                                           |                                                         |
| <i>Neohemigord.</i> aff. <i>japonicus</i> (Y. Ozawa, 1925)     | <i>Chalaroschwagerina compacta</i> n. sp.                         |                                                         |
| <i>Neohemigordius</i> ? sp. A                                  | <i>Chalaroschw. vulgaris</i> (Schellw. & Dyhr., 1909)             |                                                         |
| <i>Neohemigordius</i> ? sp. B                                  | <i>Chalaroschw. globosa</i> (Schellw. & Dyhr., 1909)              |                                                         |
| <i>Hemigordiellina</i> ? sp.                                   | <i>Chalaroschw. pulchra</i> Skinner & Wilde, 1965                 |                                                         |
| <i>Glomomidiella vulgaris</i> (Lipina, 1949)                   | <i>Chalaroschwagerina</i> sp. A                                   |                                                         |
| Hemigordiopsidae gen. and sp. indet.                           | <i>Chalaroschwagerina</i> spp.                                    |                                                         |
| <i>Geinitzina</i> spp.                                         | <i>Paraleeina magna</i> (Toriyama, 1958)                          |                                                         |
| <i>Pachyphloia</i> ? sp.                                       | <i>Paraleeina cubiformis</i> n. sp.                               |                                                         |
| <i>Nodosinelloides</i> sp.                                     | <i>Paraleeina toriyamai</i> n. sp.                                |                                                         |
| <i>Turrispiroides multivolutus</i> (Reitlinger, 1950)          | <i>Paraleeina</i> sp.                                             |                                                         |
| <i>Protonodosaria</i> sp.                                      | <i>Parafusulina solidissima</i> Rauzer-Chernousova, 1949b         |                                                         |
|                                                                | <i>Parafusulina</i> sp.                                           |                                                         |
| 43 species belonging to 23 genera                              | 44 species belonging to 17 genera                                 | 29 species belonging to 13 genera                       |



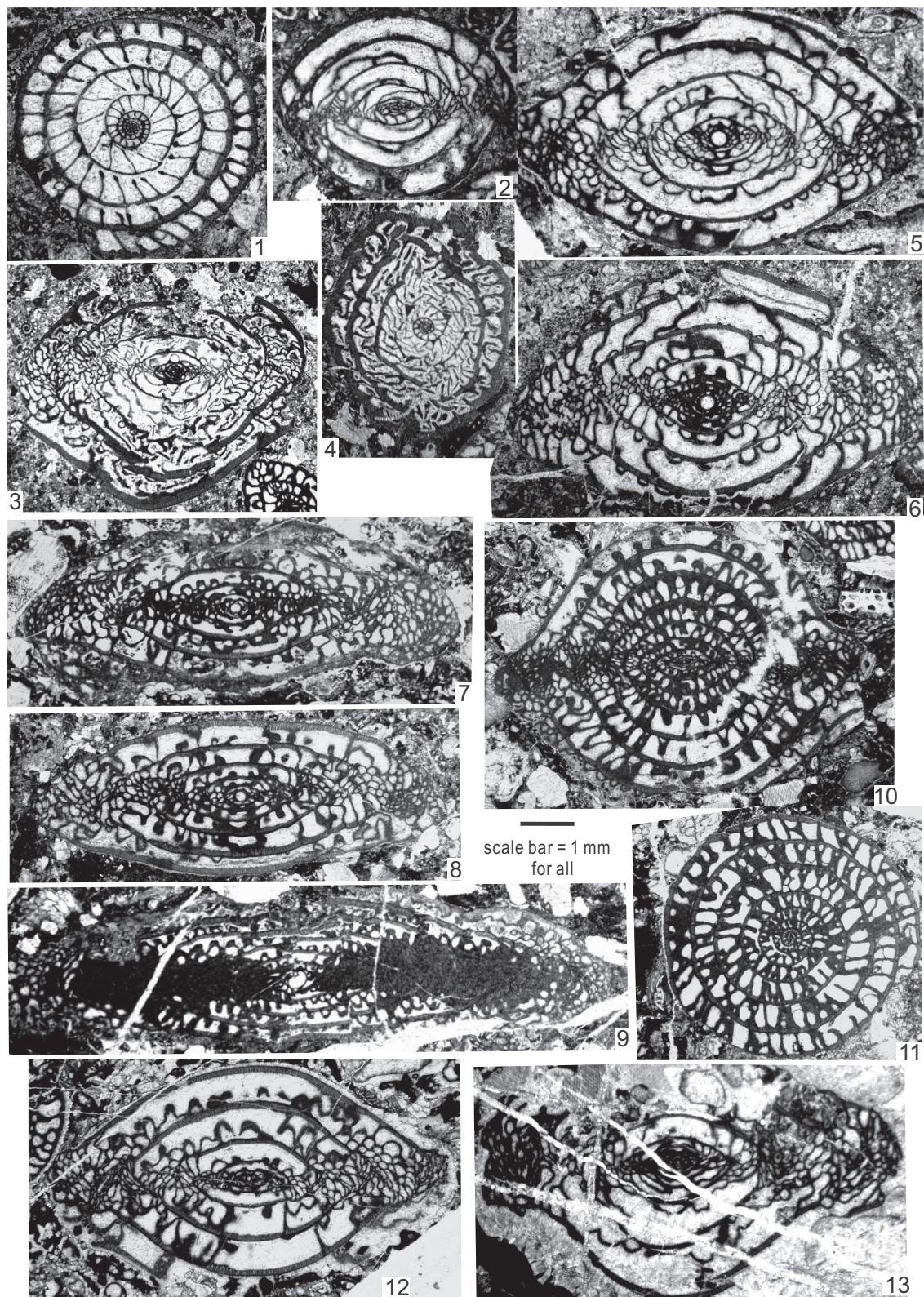


Fig. 6: Some late Gzhelian and Asselian fusulines in the mapped area. 1-2: *Sphaeroschwagerina fusiformis* (Krotow, 1888), 1: D2-060433, 2 D2-060429, both from C-37 (P-1). 3-4: *Alpinoschwagerina nagatoensis* Kobayashi, 2017, 3: D2-062515, C-249 (P-2); 4: D2-061257, C-117 (P-2). 5-6: *Pseudoschwagerina muongthensis* (Deprat, 1915), 5: D2-057425, B-226 (P-1); 6: D2-060381, C-33 (P-1). 7: *Daixina fecunda* (Shamov & Shcherbovich, 1949), D2-057461, B-228 (P-1). 8: *Jigulites horridus* (Kanmera, 1958), B-282 (upper Gzhelian). 9: *Pseudofusulina parasolida* Bensh, 1962, D2-060341, C-31 (P-2). 10-11: *Schwagerina watanabei* Kobayashi, 2017, 10: D2-058433, 11: D2-058455, both from B-290 (P-2). 12: *Carbonoschwagerina morikawai* (Hy. Igo, 1957), B-266 (upper Gzhelian). 13: *Carbonoschwagerina minatoi* (Kanmera, 1958), C-316 (upper Gzhelian).



Table 2: Occurrence of foraminifers from the P-3 (*Globifusulina nux*) to the P-5 (*Chalaroschwagerina vulgaris*) zones in the selected samples, and the number of thin sections in each sample.

|                                                 | P-3   |       |       |       | P-4   |       |       |       |       |      |      | P-5  |      |       |       |       |       |       |       |       |      |                 |      |      |      |      |      |      |  |
|-------------------------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|------|------|------|------|-------|-------|-------|-------|-------|-------|-------|------|-----------------|------|------|------|------|------|------|--|
|                                                 | B-235 | B-237 | B-238 | B-239 | B-240 | B-242 | B-243 | B-244 | B-363 | C-55 | C-56 | C-59 | C-60 | B-104 | B-105 | B-273 | B-300 | B-511 | B-557 | B-558 | C-44 | C-51            | C-62 | C-64 | C-69 | C-70 | C-71 | C-75 |  |
| <i>Nodosinelloides</i> sp.                      |       |       |       |       |       |       |       |       |       | X    |      |      |      |       |       |       |       |       |       |       |      |                 |      |      |      |      |      |      |  |
| <i>Turrispiroides multivolutus</i>              |       |       |       |       |       |       |       |       |       |      |      | x    |      |       |       |       |       |       |       |       |      |                 | X    |      |      |      |      |      |  |
| <i>Spireitlina conspecta</i>                    |       |       |       |       |       |       |       |       |       |      |      |      |      |       |       |       |       |       |       |       |      | X               | x    |      |      |      |      |      |  |
| <i>Spireitlina</i> sp.                          |       |       |       |       |       |       |       |       |       |      |      |      |      |       |       |       |       |       |       |       |      |                 | x    |      |      |      |      |      |  |
| <i>Deckerella</i> aff. <i>elegans artiensis</i> |       |       |       |       |       |       |       |       |       | x    |      |      |      |       |       |       |       |       |       |       |      |                 |      |      |      |      |      |      |  |
| <i>Climacammina gigas</i>                       | x     |       |       |       |       |       | X     |       |       |      |      |      |      |       |       |       |       |       |       |       | X    |                 | x    |      |      |      | x    |      |  |
| <i>Climacammina</i> sp. A                       |       |       |       |       |       |       |       |       |       |      |      |      |      |       |       |       |       |       | x     |       |      |                 |      | X    |      | x    |      |      |  |
| <i>Climacammina</i> spp.                        |       |       |       |       |       |       |       |       |       | X    |      |      |      |       |       |       |       |       |       |       |      | x               | x    |      |      | x    |      | x    |  |
| <i>Globivalvulina</i> sp. B                     |       |       |       |       |       |       | x     |       |       |      |      |      |      |       |       |       |       |       |       |       |      |                 |      |      |      |      |      |      |  |
| <i>Tetrataxis</i> cf. <i>paraconica</i>         |       |       |       |       |       |       |       |       |       |      |      |      |      |       |       |       |       |       |       |       |      |                 |      |      |      |      |      | x    |  |
| <i>Endothyra</i> sp.                            |       |       |       |       |       |       |       |       | x     |      |      |      |      |       |       |       |       |       |       |       |      |                 |      |      |      |      |      |      |  |
| <i>Endothyra irregularis</i>                    |       |       |       |       |       |       |       |       |       |      |      |      |      |       |       |       |       |       |       |       |      |                 |      |      |      |      |      | X    |  |
| <i>Hemigordius discoides</i>                    |       |       |       |       |       |       |       |       |       |      |      | X    |      |       |       |       |       |       |       |       |      |                 |      |      |      |      |      |      |  |
| <i>Glomomidiella vulgaris</i>                   |       |       |       |       |       |       |       |       |       | X    |      |      |      |       |       |       |       |       |       |       |      |                 |      |      |      |      |      |      |  |
| <i>Hemigordiellina</i> sp.                      |       |       |       |       |       |       |       |       |       | X    |      |      |      |       |       |       |       |       |       |       |      |                 |      |      |      |      |      |      |  |
| <i>Praemisellina minensis</i> n. sp.            |       |       |       |       | x     |       |       |       | x     | X    |      |      |      |       |       |       |       |       |       |       |      | X: illustrated  |      |      |      |      |      | x:   |  |
| <i>Praemisellina</i> cf. <i>minensis</i>        |       |       |       |       |       |       |       |       | x     |      |      |      |      |       |       |       |       |       |       |       |      | not illustrated |      |      |      |      |      |      |  |
| <i>Palaeostaffella yobarensis</i>               |       |       |       |       |       |       |       |       | X     |      |      | x    |      |       |       |       | x     |       |       |       |      |                 |      |      |      |      |      |      |  |
| <i>Nankinella</i> cf. <i>nagatoensis</i>        |       |       |       |       |       |       | X     |       |       | x    |      | x    |      |       |       |       |       |       |       |       |      | x               |      |      |      |      |      |      |  |
| <i>Staffella</i> sp.                            | x     |       |       |       |       |       | x     |       |       |      |      | X    |      |       |       |       | x     |       |       |       |      |                 |      |      |      |      |      |      |  |
| <i>Pseudoreichelina endothyroidea</i>           |       |       |       |       |       |       |       |       |       |      |      |      |      |       |       |       |       |       |       |       |      | X               |      |      |      |      |      |      |  |
| <i>Schubertina</i> sp.                          |       |       |       |       |       |       | X     |       |       |      |      |      |      |       |       |       |       |       |       |       |      |                 |      |      |      |      |      |      |  |
| <i>Schubertella</i> sp.                         | x     | x     | X     | x     |       |       | X     | X     |       |      |      | x    |      |       |       |       |       |       |       |       |      |                 |      |      | x    |      |      | x    |  |
| <i>Schubertella kingi</i>                       |       |       |       |       |       |       |       |       | X     |      |      |      |      |       |       |       |       |       |       |       |      |                 |      |      |      | x    | X    |      |  |
| <i>Schubertella exilis</i>                      |       |       |       |       |       | X     |       |       |       |      |      |      | X    |       |       |       |       | x     |       |       |      |                 |      | X    |      | x    |      |      |  |
| <i>Schubertella melonica</i>                    |       |       |       |       |       |       |       |       |       |      |      |      | x    |       |       |       |       |       |       |       |      |                 |      | x    | x    |      |      |      |  |
| <i>Globifusulina nux</i>                        | X     | x     | X     | X     | X     | X     |       |       |       |      |      | X    |      |       |       |       |       |       |       |       |      |                 |      |      |      |      |      |      |  |
| <i>Globifusulina krotowi</i>                    |       |       |       |       | X     | x     | X     |       | X     | X    | X    | x    |      |       |       |       |       |       |       |       |      |                 |      |      |      |      |      |      |  |
| <i>Sakmarella paramölleri</i>                   | X     |       |       |       | X     |       |       | X     |       | X    |      |      |      |       |       |       |       |       |       |       |      |                 |      |      |      |      |      |      |  |
| <i>Sakmarella</i> sp.                           | X     |       |       |       | X     |       |       | X     |       |      |      |      |      |       |       |       |       |       |       |       |      |                 |      |      |      |      |      |      |  |
| <i>Verneuilites urdalensis</i>                  |       |       |       |       |       |       | X     | X     |       |      |      |      |      |       |       |       |       |       |       |       |      |                 |      |      |      |      |      |      |  |
| <i>Verneuilites abnormis</i>                    |       |       |       |       |       |       | X     | X     |       | X    |      | X    |      |       |       |       |       |       |       |       |      |                 |      |      |      |      |      |      |  |
| <i>Pseudochus. pointeli</i>                     | X     |       |       |       | X     |       | X     |       |       |      |      |      |      |       |       |       |       |       |       |       |      |                 |      |      |      |      |      |      |  |
| <i>Pseudochusenella alamellosa</i>              |       | X     |       | X     | X     |       |       |       |       |      |      |      | X    |       |       |       |       |       |       |       |      |                 |      |      |      |      |      |      |  |
| <i>Biwaella</i> sp.                             |       |       |       |       |       |       |       | x     | X     | X    | x    |      |      | x     | x     | x     |       | x     | X     |       |      |                 |      | x    | X    | X    | x    |      |  |
| <i>Praeskinnerella cushmani</i>                 |       |       |       |       |       |       |       |       |       |      |      |      |      |       | X     | X     |       |       | x     |       | X    |                 | x    | x    |      | X    | X    | x    |  |
| <i>Leeina asiatica</i>                          |       |       |       |       |       |       |       |       |       |      |      |      |      |       |       | X     |       |       |       |       |      |                 |      |      |      |      | X    |      |  |
| <i>Leeina chihhsiaensis</i>                     |       |       |       |       |       |       |       |       |       |      |      |      |      |       |       |       |       |       | X     |       |      |                 |      |      |      |      |      |      |  |
| <i>Leeina callosa</i>                           |       |       |       |       |       |       | X     |       | X     |      | X    |      |      |       |       |       |       |       |       |       |      |                 |      |      |      |      |      |      |  |
| <i>Eoparafusulina</i> cf. <i>ellipsoidalis</i>  |       |       |       |       |       |       |       |       |       |      |      |      |      |       |       | X     |       |       |       |       |      |                 |      |      | X    |      |      |      |  |
| <i>Paraschwagerina fax</i>                      |       |       |       |       |       |       |       |       |       |      |      |      |      | X     |       | x     |       |       | X     | X     |      |                 |      |      |      | X    | X    |      |  |
| <i>Likharevites tinvenkiangi</i>                |       |       |       |       |       |       |       |       |       |      |      |      |      |       |       |       |       |       | X     | X     |      |                 |      |      | X    |      |      |      |  |
| <i>Likharevites</i> sp. A                       |       |       |       |       |       |       |       |       |       |      |      |      |      |       |       |       |       |       | x     |       |      |                 |      |      |      |      | X    | X    |  |
| <i>Likharevites</i> sp. C                       |       |       |       |       |       |       |       |       |       |      |      |      |      |       |       |       |       |       |       |       |      |                 |      |      |      |      |      | X    |  |
| <i>Chalaroschwagerina vulgaris</i>              |       |       |       |       |       |       |       |       |       |      |      |      |      | x     |       | X     |       | X     |       | X     | X    | x               |      |      | X    | X    | X    | X    |  |
| <i>Chalaraoschwagerina globosa</i>              |       |       |       |       |       |       |       |       |       |      |      |      |      | X     |       | X     |       |       | X     | X     |      |                 |      | X    | X    | X    |      | X    |  |
| <i>Chalaroschwagerina compacta</i> n. sp.       |       |       |       |       |       |       |       |       |       |      |      |      |      | X     |       |       | X     |       | X     | X     |      | X               | X    |      |      |      |      |      |  |
| <i>Chalaroschwagerina pulchra</i>               |       |       |       |       |       |       |       |       |       |      |      |      |      | x     | X     |       |       |       |       |       | x    |                 |      |      |      |      |      |      |  |
| <i>Chalaroschwagerina</i> sp. A                 |       |       |       |       |       |       |       |       |       |      |      |      |      | X     | X     |       |       |       | X     | x     |      |                 |      |      |      |      |      | X    |  |
| Number of thin sections                         | 32    | 8     | 15    | 16    | 44    | 14    | 17    | 35    | 21    | 38   | 14   | 33   | 8    | 36    | 50    | 57    | 17    | 16    | 41    | 17    | 29   | 14              | 21   | 14   | 11   | 14   | 18   | 28   |  |

increase in this zone (Table 2). Besides *Globifusulina krotowi*, *Verneuilites urdalensis*, *V. abnormis*, *V.?* sp., and *Leeina callosa* are found restrictedly in this zone. *Pseudochusenella pointeli* is characteristic in the P-3 and P-4. *Praemisellina* and *Palaeostaffella* first appear in this zone in the Akiyoshi Limestone. On the other hand, species assignable to *Paraschwagerina* and *Likharevites*, common and age-diagnostic in the Asselian and Artinskian zones, have not been detected in this zone as well as in *Globifusulina nux* Zone (P-3).

### 3.3. *Chalaroschwagerina vulgaris* Zone (P-5)

This zone is defined as the total stratigraphic range of the zonal species. Conformable relation of this zone with the lower P-4 and the upper P-6 zones is confirmed in the A-B and C-D sections. Thickness of this zone exceeds more than 60 m in the upper part of the A-B section. Faunal composition of schwagerinids is largely different between the P-4 and P-5 zones. Schwagerinid genera such as *Globifusulina*, *Sakmarella*, and *Verneuilites* disappear in this zone. The zonal species and its allies (*Chalaroschwagerina globosa*, *C. sp. A*, *C. compacta*, and *C. pulchra*) are very common to common and exclusively occur in this zone. Other fusulines restricted to this zone are *Paraschwagerina fax*, *Leeina chihshiaensis*, *Leeina asiatica*, and *Likharevites* sp. A. *Likharevites tinvenkiangi* and *Praeskinnerella cushmani* are almost confined to this zone. *Pseudochusenella pointeli* is only found at loc. B-105 in association with *Chalaroschwagerina* sp. A in this zone. Non-fusuline foraminifers and staffellids are very rare or absent in limestones crowded with *Chalaroschwagerina*. *Pseudofusulina* sp. occurs in the uppermost part of this zone (B-295). However, schwagerinids apparently assignable to *Pseudofusulina* are sporadic and not discernible in most samples in this zone. Thus, differences of faunal composition in this zone from that in the P-3 and P-4 are exceedingly remarkable especially in schwagerinids.

### 3.4. *Paraleeina magna* Zone (P-6)

This zone of about 60 m thick is defined by the stratigraphic interval of *Paraleeina magna*. Two new species of *Paraleeina* (*P. cubiformis* and *P. toriyamai*), *Leeina krafftii*, *Pseudofusulina norikurensis*, *P. dzmantalsensis*, *P. cf. nalivekini*, *P.?* cf. *pavlovi*, *Parafusulina solidissima*, and *Parafusulina* sp. also occur in many samples of different stratigraphic levels (Table 3). All species of *Chalaroschwagerina* disappear in this zone. *Likharevites tinvenkiangi*, *L. sp. B*, and *Toriyamaia laxiseptata* are also characteristic in this zone, though not common and restricted to a few samples. *Praeskinnerella cushmani* rarely occurs in B-234 and *Chusenella?* sp. rarely in B-303.

This zone corresponds to the acme zone of *Praemisellina*, *Palaeostaffella*, *Chenella*, and *Pseudoreichelina* in the Akiyoshi Limestone. Non-fusuline foraminifers become more dominant in this zone than in the underlying zones. They are more prolific and more diversified than fusulines in some samples represented by B-261 containing *Agathammina asymmetrica*, *A. ampla*, *Hemigordius* sp., and many others (Table 3).

### 3.5. *Pamirina leveni* Zone (P-7)

This zone is defined by thin stratigraphic interval (about 5 to 10 m thick) yielding *Pamirina leveni*. It is narrowly developed in the northern part of the mapped area crossing the C-D and E-F sections (Fig. 2). Discriminated species except *Pamirina leveni* are confined to *Schubertina* sp., *Zarodella zhmoidai*, *Globivalvulina* sp. A, *Agathammina ampla*, and *A. sp.* in sample B-367, and *Paraleeina* sp., *Agathammina ampla*, and *A. sp.* in sample B-461. *Leeina?* sp., *Palaeostaffella yobarensis*, *Chenella* sp., *Staffella?* sp. and *Globivalvulina* sp. A are associated with *Pamirina* possibly identical with *P. leveni* in sample B-456. The occurrence of *Cuniculinella vulgarisiformis* (Morikawa, 1952), *Palaeostaffella subquadrata*, and *Schubertella melonica* is confirmed in the *Pamirina leveni* Zone of the Kaerimizu area (Kobayashi, 2019). However, these fusulines were not found out in the P-7 of the mapped area.

### 3.6. *Misellina dyhrenfurthi* Zone (P-8)

This zone conformably overlying P-7 measures more than 15 m thick and is defined by the total range of *Misellina dyhrenfurthi*. The lower boundary is not exactly determined on account of some meters thick stratigraphic interval barren in both *Pamirina* and *Misellina* in the mapped area, as well as in the Kaerimizu area. The uppermost part of this zone is in fault contact with the *Paraleeina magna* Zone (P-6) in the mapped area (Fig. 2). Diversities of foraminifers are low in this zone like in the P-7 (Table 3). Fusulines confined to this zone are *Misellina dyhrenfurthi* and *M. parvicostata* in addition to few indetermined staffellids and schubertellids. The first and second species coexist in sample B-369. *Palaeostaffella subquadrata* and *Spireitlina conspecta* are commoner in the P-6 and the P-5, respectively. Both abundance and diversity of foraminifers are lower in this zone of the mapped area than in the *Misellina dyhrenfurthi* Zone of the Kaerimizu area (Kobayashi, 2019). *Toriyamaia laxiseptata*, *Schubertella melonica*, *Nankinella nagatoensis*, and *Palaeostaffella akudensis* occur in the *Misellina dyhrenfurthi* Zone of the Kaerimizu area (Kobayashi, 2019). In the mapped area, however, these schubertellids, ozawainellids, and staffellids occur in the P-6, but they are absent both in the P-7 and P-8.

Table 3: Occurrence of foraminifers from the P-6 (*Paraleeina magna*) to the P-8 (*Misellina dyhrenfurthi*) zones in the selected samples, and the number of thin sections in each sample.

|                                                 | P-6  |      |      |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |      |       |       |       | P-7   |       |       | P-8   |   |  |
|-------------------------------------------------|------|------|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|------|-------|-------|-------|-------|-------|-------|-------|---|--|
|                                                 | A-58 | A-59 | A-60 | B-232 | B-234 | B-249 | B-251 | B-252 | B-253 | B-254 | B-259 | B-261 | B-307 | B-308 | B-368 | B-404 | B-414 | B-460 | B-489 | B-542 | B-544 | B-552 | C-54 | B-367 | B-456 | B-461 | B-311 | B-312 | B-369 | B-455 |   |  |
| <i>Pseudolangella?</i> sp.                      |      |      |      |       |       |       |       |       |       |       | X     |       |       |       |       |       |       |       |       |       |       |       |      |       |       |       |       |       |       |       |   |  |
| <i>Spireitlina conspecta</i>                    |      |      |      |       |       |       |       |       |       |       |       | X     |       | X     |       |       |       |       |       |       |       |       |      |       |       |       |       | X     |       |       |   |  |
| <i>Textularia longissima</i>                    |      |      |      | X     |       |       |       |       |       |       |       |       |       | X     |       |       |       |       |       |       |       |       |      |       |       |       |       |       |       |       |   |  |
| <i>Deckerella</i> aff. <i>elegans artiensis</i> |      |      |      |       | X     |       |       |       |       |       |       |       |       | X     |       |       |       |       | X     |       |       |       |      |       |       |       |       |       |       |       |   |  |
| <i>Climacammina fragilis</i>                    |      |      |      |       |       |       |       |       |       |       |       |       |       | X     |       |       |       |       |       |       |       | X     |      |       |       |       |       |       |       |       |   |  |
| <i>Globivalvulina laxa</i>                      |      |      |      | X     |       |       |       |       |       | X     |       | X     |       | X     |       |       |       |       |       |       |       | X     |      | X     |       |       |       |       |       |       |   |  |
| <i>Globivalvulina</i> sp. A                     |      |      |      |       |       |       |       |       |       |       | X     |       |       |       |       |       | X     |       |       |       |       | X     | X    |       | X     |       |       |       |       |       |   |  |
| <i>Globivalvulina</i> sp. B                     |      |      |      |       |       |       |       |       | X     |       |       | X     |       |       |       | X     |       |       |       |       |       |       |      |       |       |       |       |       |       | X     |   |  |
| <i>Tetrataxis conica</i>                        |      |      |      |       |       |       |       |       |       |       |       | X     |       |       |       |       |       |       |       |       |       |       |      |       |       |       |       |       |       | X     |   |  |
| <i>Endothyra irregularis</i>                    |      |      |      |       |       |       | X     |       |       |       |       | X     |       |       |       |       |       |       |       |       |       |       |      |       |       |       |       |       |       |       |   |  |
| <i>Glomomidiella vulgaris</i>                   |      |      | X    |       |       |       |       |       |       |       |       | X     |       |       |       | X     |       | X     |       |       |       | X     |      |       |       |       |       |       | X     |       |   |  |
| <i>Agathammina ampla</i>                        |      |      |      |       |       |       |       |       |       |       |       | X     |       |       |       |       |       |       |       |       |       |       |      | X     |       |       |       |       |       |       |   |  |
| <i>Agathammina asymmetrica</i>                  |      |      |      |       |       |       |       |       |       |       |       | X     |       |       |       |       |       |       |       |       |       | X     |      |       | X     |       |       |       |       |       |   |  |
| <i>Agathammina</i> spp.                         |      |      |      |       |       |       |       |       |       |       |       | X     |       |       |       |       |       |       |       |       |       | X     |      |       | X     |       |       |       | X     |       | X |  |
| <i>Hemigordius rotundatus</i>                   | X    |      |      |       |       | X     |       |       |       |       |       | X     |       |       |       |       | X     |       |       |       |       |       |      |       |       |       |       |       |       |       | X |  |
| <i>Hemigordius</i> sp.                          |      |      |      |       | X     |       |       |       |       | X     |       | X     |       |       |       |       |       |       |       |       |       |       |      |       |       |       |       |       |       |       |   |  |
| <i>Neohemigordius</i> aff. <i>japonicus</i>     |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       | X     |       |       |      |       |       |       |       |       |       |       |   |  |
| <i>Neohemigordius?</i> sp. A                    |      |      | X    |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |      |       |       |       |       |       |       |       |   |  |
| <i>Neohemigordius?</i> sp. B                    |      |      |      |       |       |       |       |       |       |       | X     |       |       |       |       |       |       |       |       |       |       |       |      |       |       |       |       |       |       |       |   |  |
| <i>Hemigordiopsis?</i> sp.                      |      |      |      |       |       |       |       |       |       |       |       | X     |       |       |       |       |       |       |       |       |       |       |      |       |       |       |       |       |       |       |   |  |
| <i>Pachyphloia?</i> sp.                         | X    |      |      | X     |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |      |       |       |       |       |       |       |       |   |  |
| <i>Praemisellina minensis</i> n. sp.            |      |      |      |       |       |       |       |       |       | X     |       |       |       |       |       |       |       |       |       |       |       | X     |      |       |       |       |       |       |       |       |   |  |
| <i>Praemisellina</i> cf. <i>minensis</i>        |      |      |      | X     |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |      |       |       |       |       |       |       |       |   |  |
| <i>Palaeostaffella subquadrata</i>              |      |      |      |       |       |       |       |       |       |       | X     |       |       |       |       |       |       | X     |       |       |       |       |      |       |       |       |       | X     |       |       |   |  |
| <i>Palaeostaffella akudensis</i>                |      |      |      |       | X     |       | X     |       |       |       |       |       |       |       |       |       |       | X     |       | X     |       | X     |      |       |       |       |       |       |       |       |   |  |
| <i>Palaeostaffella yobarensis</i>               |      |      |      | X     |       |       | X     |       | X     | X     | X     | X     | X     | X     | X     | X     | X     | X     | X     | X     | X     | X     |      |       | X     |       |       |       |       |       |   |  |
| <i>Chenella mathildae</i>                       |      |      |      |       |       |       |       |       |       |       |       | X     |       |       |       |       | X     |       |       |       |       |       |      |       |       |       |       |       |       |       |   |  |
| <i>Chenella rhomboides</i> n. sp.               |      |      | X    | X     | X     | X     | X     | X     | X     | X     | X     | X     | X     | X     | X     | X     | X     | X     | X     | X     | X     | X     |      |       |       |       |       |       |       |       |   |  |
| <i>Nankinella</i> cf. <i>nagatoensis</i>        |      |      |      |       |       | X     |       | X     | X     | X     | X     | X     |       |       | X     |       | X     |       | X     |       |       |       |      |       |       |       |       |       |       |       |   |  |
| <i>Staffella</i> sp.                            |      |      |      |       |       |       |       |       | X     |       | X     |       |       |       |       |       |       |       |       |       |       | X     |      |       |       |       |       |       |       |       |   |  |
| <i>Pseudoreichelina darvasica</i>               |      |      |      |       |       | X     |       | X     | X     | X     |       | X     |       |       |       | X     |       |       |       |       |       |       |      |       |       |       |       |       |       |       |   |  |
| <i>Pseudoreichelina obiniouensis</i>            |      |      |      |       |       |       |       | X     |       | X     |       |       |       |       |       |       |       |       |       |       |       |       |      |       |       |       |       |       |       |       |   |  |
| <i>Pseudoreichelina discoidea</i>               |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       | X     |      |       |       |       |       |       |       |       |   |  |
| <i>Zarodella zhmoidai</i>                       |      |      |      |       |       |       | X     |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |      | X     |       | X     |       |       |       |       |   |  |
| <i>Toriyamaia laxiseptata</i>                   |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |       | X     |       | X     |       | X     |       |      |       |       |       |       |       |       |       |   |  |
| <i>Pamirina leveni</i>                          |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |      | X     | X     | X     |       |       |       |       |   |  |
| <i>Misellina dyhrenfurthi</i>                   |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |      |       |       |       |       |       | X     | X     | X |  |
| <i>Misellina parvicostata</i>                   |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |      |       |       |       |       |       | X     |       |   |  |
| <i>Schubertella kingi</i>                       |      |      | X    |       |       |       |       |       |       | X     |       |       |       |       |       | X     |       |       |       |       |       |       |      |       |       |       |       |       |       |       |   |  |
| <i>Schubertella exilis</i>                      |      |      |      |       |       |       |       |       |       |       |       |       |       | X     |       |       |       |       |       |       |       | X     |      |       |       |       |       |       |       |       |   |  |
| <i>Schubertella melonica</i>                    |      |      |      | X     |       |       | X     |       |       |       |       |       |       | X     |       |       |       |       |       |       |       |       |      |       |       |       |       |       |       |       |   |  |
| <i>Biwaella</i> sp.                             |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       | X     |       |       | X     |      |       |       |       |       |       |       |       |   |  |
| <i>Praeskinnerella cushmani</i>                 |      |      |      | X     |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |      |       |       |       |       |       |       |       |   |  |
| <i>Pseudochusenella</i> sp.                     |      |      |      |       |       | X     |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |      |       |       |       |       |       |       |       |   |  |
| <i>Likharevites tinvenkiangi</i>                |      |      |      |       |       |       |       |       |       |       |       |       | X     |       |       |       |       |       |       |       |       |       |      |       |       |       |       |       |       |       |   |  |
| <i>Likharevites</i> sp. B                       |      |      |      |       |       |       | X     |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |      |       |       |       |       |       |       |       |   |  |
| <i>Leeina krafftii</i>                          | X    | X    | X    | X     | X     |       |       |       |       | X     |       | X     |       |       |       | X     |       |       |       |       |       |       |      |       |       |       |       |       |       |       |   |  |
| <i>Pseudofusulina dzamantalensis</i>            |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       | X     |       |       |       |       |       |       |      |       |       |       |       |       |       |       |   |  |
| <i>Pseudof. norikurensis</i>                    | X    |      |      |       |       |       |       |       |       |       |       | X     |       |       |       | X     |       | X     |       |       |       |       |      |       |       |       |       |       |       |       |   |  |
| <i>Pseudofusulina</i> cf. <i>nalivkini</i>      |      |      |      |       | X     |       |       |       |       |       |       | X     |       |       |       |       |       |       |       |       |       |       |      |       |       |       |       |       |       |       |   |  |
| <i>Pseudof.?</i> cf. <i>pavlovi</i>             |      | X    |      |       |       | X     |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |      |       |       |       |       |       |       |       |   |  |
| <i>Paraleeina cubiformis</i> n. sp.             |      | X    | X    |       |       |       |       |       |       |       |       |       |       |       |       | X     |       | X     |       |       | X     |       |      |       |       |       |       |       |       |       |   |  |
| <i>Paraleeina magna</i>                         | X    | X    | X    |       |       |       | X     | X     | X     |       | X     | X     |       |       | X     | X     |       | X     |       |       |       | X     |      |       |       |       |       |       |       |       |   |  |
| <i>Paraleeina toriyamai</i> n. sp.              |      |      |      |       | X     | X     |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |      |       |       |       |       | X     |       |       |   |  |
| <i>Paraleeina</i> sp.                           |      |      |      |       | X     | X     |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |      |       |       |       |       |       | X     |       |   |  |
| <i>Parafusullina solidissima</i>                |      |      |      |       |       | X     |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       | X     |      |       |       |       |       |       |       |       |   |  |
| <i>Parafusulina</i> sp.                         |      |      | X    |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       | X    |       |       |       |       |       |       |       |   |  |
| Number of thin sections                         | 19   | 17   | 19   | 18    | 22    | 28    | 22    | 19    | 14    | 15    | 13    | 41    | 4     | 16    | 19    | 20    | 12    | 30    | 6     | 24    | 14    | 15    | 17   | 18    | 9     | 9     | 5     | 11    | 15    | 12    |   |  |

X: illustrated  
x: not illustrated

#### 4. CORRELATION AND AGE

The Sakamotozawa Formation with continental affinities in the South Kitakami is designated as the stratotype of the Cisuralian in Japan. It is biostratigraphically divided into five from lower to upper: *Zellia nunosei*, *Monodiexodina langsonensis*-*Nipponitella explicata*, *Pseudofusulina vulgaris*, *Pseudofusulina fusiformis*, and *Pseudofusulina ambigua* zones (Kanmera & Mikami, 1965). Many characteristic fusulines as represented by “*Monodiexodina*”, *Nipponitella*, and *Zellia* occur in the formation. These fusulines in the South Kitakami are barren or almost absent in the coeval limestone blocks of seamount origin in the Permian and Jurassic terranes of Japan.

It is made clear that the base of Asselian is defined by the first appearance of *Sphaeroschwagerina fusiformis* in the Akiyoshi Terrane (T. Ozawa & Kobayashi, 1990; Watanabe, 1991). Although Watanabe (1991) proved the absence of Asselian in the Sakamotozawa Formation, detailed correlation with the stratotypes of the South Urals and Tethyan regions is left unresolved in the Sakmarian and Artinskian throughout Japan. Many age-diagnostic Sakmarian species common to those in the South Urals and some Artinskian ones to those in the Tethyan regions

are discernible in the Akiyoshi Limestone, as described above. Based on them, biostratigraphic correlation and chronostratigraphic calibration of the Akiyoshi Limestone are described and discussed, and related problems in the Sakamotozawa Formation are commented on (Fig. 7).

##### 4.1. *Globifusulina nux* Zone (P-3) and *Globifusulina krotowi* Zone (P-4)

Schwagerinids recognized in the P-3 and P-4 comprise eleven species. Among them, those restricted to the P-4 are *Globifusulina krotowi*, *Verneuilites urdalensis*, *V. abnormis*, and *Leeina callosa*. *Globifusulina nux*, *Sakmarella paramölleri*, *Pseudochusenella alamelloso*, *P. pointeli*, and *Sakmarella* sp. occur in both P-3 and P-4. *Pseudochusenella pointeli* is also rarely present in sample B-105 (P-5). *Biwaella* sp. ranges from the P-2 (*Alpinoschwagerina nagatoensis* Zone) to P-5. According to Rauzer-Chernousova (1940), *Verneuilites urdalensis*, *V. abnormis*, and *Leeina callosa* occur in the Sterlitamakian (upper Sakmarian), and *Pseudochusenella pointeli* in the upper Asselian and Tastubin (lower Sakmarian) in the western slope of the Urals. Rauzer-Chernousova (1949a, b) showed that *Sakmarella*

| Cisuralian |           |               | Kungurian  | Saraninian                                                                           | (Tethys)                                                                                          | South Urals                                                           | West Tethys                                                                                                | Akiyoshi                                                                                                                                                                                                                                                                           | South Kitakami                        |                        |              |                                                            |                                                                                                                                                                                           |
|------------|-----------|---------------|------------|--------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------|------------------------|--------------|------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|            |           |               |            |                                                                                      |                                                                                                   | Rauzer-Chernousova (1940, 1949b,1965),<br>R.-C. & Shcherbovich (1958) | Leven (2009)                                                                                               | this paper                                                                                                                                                                                                                                                                         | modified from Kanmera & Mikami (1965) |                        |              |                                                            |                                                                                                                                                                                           |
| Artinskian | Sakmarian | Sterilimikian | Burtsevian | Yakhtashian                                                                          | Bolorian                                                                                          |                                                                       | <i>Misellina dyhrenfurthi</i> ,<br><i>Cuniculinella globosaeformis</i> ,<br><i>Paraleeina postkrafftii</i> | P-8                                                                                                                                                                                                                                                                                | <i>Misellina dyhrenfurthi</i>         | Sakamotozawa Formation | upper member | « <i>Pseudofusulina ambigua</i> »,<br><i>Misellina</i> sp. |                                                                                                                                                                                           |
|            |           |               |            |                                                                                      |                                                                                                   | Saraninian                                                            | <i>Parafusulina solidissima</i>                                                                            | <i>Pamirina darvasica</i> ,<br><i>Leeina krafftii</i> ,<br><i>Praeskinnerella cushmani</i> ,<br><i>Darvasites ordinatus</i> ,<br><i>Chalaroschwageina vulgaris</i> ,<br><i>Chalaroschwagerina darvasica</i> ,<br><i>Darvasites contractus</i> ,<br><i>Darvasella vulgariformis</i> | P-7                                   |                        |              | <i>Pamirina leveni</i>                                     | <i>Leeina fusiformis</i> ,<br><i>L. krafftii</i> , <i>Darvasites minatoi</i> ,<br><i>Praeparafusulina pseudojaponica</i> ,<br><i>Chalaros. vulgaris</i> ,<br><i>Robustos. schellwieni</i> |
|            |           |               |            |                                                                                      |                                                                                                   |                                                                       |                                                                                                            |                                                                                                                                                                                                                                                                                    | Irginian                              |                        |              | P-6                                                        |                                                                                                                                                                                           |
|            | Sakmarian | Tastubian     | Sakmarian  | <i>Verneuilites urdalensis</i> ,<br><i>Leeina callosa</i>                            | <i>Robustoschwagerina schellwieni</i> ,<br><i>Zellia heritschi</i> ,<br><i>Sakmarella mölleri</i> | P-5                                                                   | <i>Chalarosch. vulgaris</i> ,<br><i>Chalarosch. compacta</i> ,<br><i>Paraschwagerina fax</i>               | <i>Juresanella perplexa</i> ,<br><i>Robustoschwagerina schellwieni</i> ,<br><i>Acervoschwagerina endoi</i> ,<br><i>Nipponitella explicata</i>                                                                                                                                      |                                       |                        |              |                                                            |                                                                                                                                                                                           |
|            |           |               |            |                                                                                      |                                                                                                   | <i>Concavutella concavutus</i> ,<br><i>Juresanella juresanensis</i>   | <i>Chalarosch. vulgaris</i> ,<br><i>Chalarosch. compacta</i> ,<br><i>Paraschwagerina fax</i>               |                                                                                                                                                                                                                                                                                    |                                       |                        |              |                                                            |                                                                                                                                                                                           |
|            | Asselian  | upper         | Asselian   | <i>Sphaeroschwagerina sphaerica</i> , <i>Globif. krotowi</i> ,<br><i>Globif. nux</i> | <i>Sphaeroschwagerina glomerosa</i> ,<br><i>Dutkevitchia splendida</i>                            | P-2                                                                   | <i>Alpinoschwagerina nagatoensis</i>                                                                       | no deposition                                                                                                                                                                                                                                                                      |                                       |                        |              |                                                            |                                                                                                                                                                                           |
|            |           |               |            |                                                                                      |                                                                                                   | <i>Sphaeroschwagerina fusiformis</i>                                  | <i>Sphaeroschwagerina fusiformis</i> ,<br><i>Likharevites kokupectensis</i>                                |                                                                                                                                                                                                                                                                                    |                                       |                        | P-1          | <i>Sphaeroschwagerina fusiformis</i>                       |                                                                                                                                                                                           |

Fig. 7: Correlation of fusuline biozonations and faunas in the Cisuralian.



*paramöller*i ranges from the upper Asselian to Tastubian and *Pseudochusenella pointeli* from the middle Asselian to Tastubian, and *Pseudochusenella alamellosa* occur in the Tastubian of South Urals. On the other hand, *Globifusulina krotowi* and *G. nux* exclusively occur in the Asselian and do not extend higher into the Sakmarian in the Urals according to Rauzer-Chernousova (1940, 1949a, b, 1965). Closely similar stratigraphic distributions of these species, clarified by Rauzer-Chernousova, are also confirmed in the Timan region by Grozdilova & Lebedeva (1961). However, *Pseudofusulina* sp. A and *Pseudofusulina fabra* Leven & Shcherbovich, 1980, both of which are closely similar to *Globifusulina nux* and the former is associated with *Sakmarella* aff. *paramöller*i, are reported by Leven & Shcherbovich (1980) from the Sakmarian of Darvas. They pointed out that generic and specific compositions of fusulines in south to west Darvas testify to a rapid isolation of the Tethys and east European basins at the beginning of the Sakmarian.

*Robustoschwagerina* distinguished at only one locality near Kaerimizu, was not detected in the mapped area. It was assigned to the upper Artinskian and was named *R. schellwieni* Hanzawa, 1939 by T. Ozawa & Kobayashi (1990), whereas to the Sakmarian and named as *R. schellwieni pamirica* Leven & Shcherbovich, 1978 by Watanabe (1991). These disagreements force to reexamine the subdivision and correlation of the Sakmarian and Artinskian in the Kaerimizu area.

Taking (1) the coexistence of the two zonal species of the P-3 and P-4 with other Sakmarian species established in the South Urals, (2) the Sakmarian faunal isolation between Tethys and Russian Platform as supposed by Leven & Shcherbovich (1980), (3) no Asselian fusuline faunal elements in the P-3 and P-4, and (4) stratigraphic level of the P-3 apparently above the Asselian in the Akiyoshi Limestone into account, these two zones of Akiyoshi are safely correlated together to the stratotypes of the Sakmarian of Russia. This assumption involves that *Globifusulina nux* and *G. krotowi* are not restricted in the Asselian but range upward to the Sakmarian at least in the Akiyoshi Limestone.

Faunal composition of the lower member of the Sakamotozawa Formation is considerably different from that of the Sakmarian of Akiyoshi. *Zellia*, absent in Akiyoshi, ranges from the Sakmarian to the lower Artinskian, and is diagnostic in the upper part of the Grenzland Formation and the Upper *Pseudoschwagerina* Limestone (Zweikofel Formation) in the Carnic Alps (Forke, 2002; Davydov *et al.*, 2013). It is also characteristic in the upper part of the Charymdara Formation (lower Artinskian) of Darvas (Leven, 1992). Stratigraphic range of *Juresanella perplexa* (Grozdilova & Lebedeva, 1961) proposed from the Tastubian of Timan, previously identified with “*Monodiexodina langsonensis* (Saurin, 1950)” by Kanmera & Mikami (1965) and herein reassigned, suggests the lower Sakmarian of the *Zellia nunosei* Zone. Moreover, the lower member is

considered to extend to the lower part of the Artinskian judging from the occurrence of *Robustoschwagerina schellwieni*, and *Acervoschwagerina endoi* Hanzawa, 1949 and *A. gongendaniensis* Kobayashi in Kobayashi & Furutani, 2019. Because, the first species more dominant in the *Pseudofusulina vulgaris* Zone of the upper member occurs also in the lower member according to Kanmera & Mikami (1965). The second and third species, probably corresponding to *Acervoschwagerina* sp. A described by Kanmera and Mikami, are characteristic in the Artinskian of the Jurassic Mino Terrane (Kobayashi, 2008; Kobayashi & Furutani, 2009, 2019).

#### 4.2. *Chalaroschwagerina vulgaris* Zone (P-5)

*Chalaroschwagerina vulgaris*, *C. globosa*, and *C.* sp. A are the remarkable faunal elements of this zone. Although the classification of these and their allies is more or less different among authors, almost all of these species are confined to the Artinskian throughout Tethyan regions and Japan (e.g. Nogami, 1961; Kalmykova, 1967; Leven, 2009). *Chalaroschwagerina pulchra* is characteristic in the middle Wolfcampian of the McCloud Limestone, North California (Skinner & Wilde, 1965). *Praeskinnerella cushmani* originally described from the Artinskian Swine Limestone of Jiangsu (Chen, 1934) is confined to this zone except for one sample (B-234) from the P-6. *Leeina chihshiaensis* was described from the uppermost part of the Chihshia Limestone of southern Gansu (Lee, 1931; Chen, 1934) and from the Darvasian of Darvas (Kalmykova, 1967).

Precise correlation between this zone of Akiyoshi and the upper Cisuralian of South Urals is difficult on account of complete absence of *Chalaroschwagerina* in the latter. Although detailed biostratigraphic comparison of the *Chalaroschwagerina vulgaris* Zone between Akiyoshi and Tethyan regions is not easy, this zone in Akiyoshi is supposed to be correlated to the lower and middle parts of the Yakhtashian, since the P-5 underlies the *Paraleeina magna* Zone (P-6). This provisional correlation is not conflict with the occurrence of *Parafusulina solidissima* from the P-6, as mentioned below. The P-5 never ranges down to the Sakmarian on account of no faunal elements of the Sakmarian in P-5.

The correlation of the *Chalaroschwagerina vulgaris* Zone and its correspondances by previous authors in Akiyoshi is problematic, as insisted by Kobayashi (2017). Watanabe (1991) divided the Sakmarian and Artinskian of Akiyoshi from lower to upper, the *Paraschwagerina akiyoshiensis*-*Pseudofusulina firma* Zone in the Wakatakeyama area or *Robustoschwagerina schellwieni pamirica* Zone in the Kaerimizu area (Sakmarian), the *Pseudofusulina vulgaris vulgaris* Zone (lower Artinskian), and the *Misellina claudiae* Zone (upper Artinskian). Whereas, the “*Pseudofusulina* ex. gr. *vulgaris*” Zone directly overlying the Asselian “*Alpinoschwagerina? fusiformis*” Zone

(Ueno, 1989), and the “*Pseudofusulina vulgaris*” Zone conformably overlying the Asselian *Pseudoschwagerina muongthensis* Zone (Y. Ota & M. Ota, 1993) suggest us that the *Chalaroschwagerina vulgaris* Zone ranges down to the Sakmarian. However, specific identification of *vulgaris* and its allies by these authors is doubtful. Similarly, *Pseudofusulina vulgaris globosa* described by Y. Ota (1995, 1998) should be synonymized with *Pseudofusulina firma* Shamov, 1958. Accordingly, a part of the *P. vulgaris globosa* Zone assigned by Y. Ota to the Artinskian should be transferred from the Artinskian to the uppermost part of the Asselian, based on the Asselian and Sakmarian biostratigraphy of the stratotype sections of South Urals by Rauzer-Chernousova (1965). These taxonomic and chronologic revisions lead to the reconsideration of the biostratigraphic subdivision and international correlation of the Akiyoshi Terrane made by Zhang & Wang (2017) who tried them on the basis of Y. Ota (1995, 1998).

*Dutkevitchia splendida* (Bensh, 1962) was designated as the zonal species of the upper Sakmarian of the Akiyoshi Limestone by T. Ozawa & Kobayashi (1990). However, it is different from the original specimens from northern Fergana (Bensh, 1962) and corresponds to a large form of *Chalaroschwagerina* sp. A in this paper. Moreover, “*Paraschwagerina akiyoshiensis* Toriyama, 1958” and “*Paraschwagerina* ex. gr. *möller*i (Schellwien, 1908)” illustrated by them are different from the type materials, forcing their reconsideration of the zonation of the Sakmarian and Artinskian in the Akiyoshi Limestone.

#### 4.3. *Paraleeina magna* Zone (P-6) and *Pamirina leveni* Zone (P-7)

Abundant to common occurrences of such schwagerinids as *Paraleeina magna*, *P. cubiformis* n. sp. and *Leeina krafftii* from many stratigraphic levels, and absence of *Chalaroschwagerina* are characteristic in the P-6. The first and third species are also distributed in the Yakhtashian of the Tethyan regions, in addition to *Pseudofusulina* cf. *nalivkini* (e.g. Leven, 1967, 2009) from one sample (B-234). On the other hand, *Pseudofusulina dzamantalensis* distinguished in the P-6 is reported from the Bolorian to Kubergandian of southeast Pamir (Leven, 1967). According to Leven (2010), *Pamirina* branched off the *Zadodella-Grovesella* lineage in early Yakhtashian and survived into the Bolorian.

Fusulines not found out in the mapped area but distinguished in the Kaerimizu area, are *Leeina fusiformis* and *Cuniculinella vulgarisformis* from the P-6 and P-7 zones in Kaerimizu, respectively. The latter is diagnostic in the Bolorian along with *Cuniculinella globosaeformis* Leven, 1967 (Leven, 2009). Although detailed biostratigraphic correlation of the fusulines of the P-6 and P-7 to that of Yakhtashian and Bolorian ones of west Tethyan regions is not easy, P-6 and P-7 are presumed

to be correlative to the upper part of the Yakhtashian on account of their biostratigraphic intervention between P-5 and P-8 in Akiyoshi.

Biostratigraphic and chronostratigraphic calibration of the P-6 and P-7 is supported by the occurrence of *Parafusulina solidissima* from two samples (B-249, B-544). This species was established by Rauzer-Chernousova (1949b) from the Saraginian of South Urals. Biostratigraphic correlation between South Urals and other regions is, however, difficult on account of weak mutual relationships of the Artinskian fusuline faunas, as represented by complete absence of *Chalaroschwagerina* and *Paraleeina* in the South Urals, besides no biostratigraphic informations of conodonts from the carbonate facies throughout the Permian of Akiyoshi Terrane.

The P-6 conformably overlying the P-5 is also confirmed in the Atetsu Limestone (Nogami, 1961) where characteristic fusuline faunas of the younger *Paraleeina magna* and older *Chalaroschwagerina vulgaris* zones are closely similar to those of Akiyoshi. Fusulines designated as the zonal and subzonal species of the upper member of the Sakamotozawa Formation (Kanmera & Mikami, 1965) were not found from the Artinskian in the mapped area. They are *Leeina fusiformis* (Schellwien & Dyhrenfurth, 1909), *Darvasites minatoi* (Kanmera & Mikami, 1965), and *Praeparafusulina pseudojaponica* (Dutkevich in Likharev, 1939). The second and third species are probably absent in the Akiyoshi. The third species corresponding to *Pseudofusulina* aff. *japonica* (Gümbel, 1874) by Kanmera & Mikami (1965), was established by Dutkevich based on *Schellwienia japonica* from the Fuching Limestone, North China by Lee (1927) as the type species of the genus. The third species is also reported from the Yakhtashian of Darvas (Kalmykova, 1967).

#### 4.4. *Misellina dyhrenfurthi* Zone (P-8)

The P-8 is undoubtedly correlated to the Bolorian (lower Kungurian) based on the occurrence of *Misellina dyhrenfurthi* and *M. parvicostata* widely distributed in the Tethyan regions. According to Leven (2009) who comprehensively reviewed with the fusuline biostratigraphy and correlation of the Upper Paleozoic of the west Tethyan regions, the both species of *Misellina* are restricted to the Bolorian, and former species is older than the latter in Darvas (Leven, 1992) and in eastern Iran (Leven & Vaziri, 2004). Whereas in Akiyoshi, they co-occur at least in three samples of Kaerimizu (Kobayashi, 2019) and in one sample (B-369) in the mapped area, suggesting them together without the zonal subdivision in the Akiyoshi Limestone. The upper member of the Sakamotozawa Formation is conformably overlain by terrigenous clastic rocks without intercalation of carbonates. From its uppermost part, “*Pseudofusulina*

*ambigua*” Zone settled by Kanmera & Mikami (1965), Ueno *et al.* (2009) reported *Misellina* sp. Therefore, the upper member of the Sakamotozawa Formation is considered to extend into the Bolorian.

## 5. SYSTEMATIC PALEONTOLOGY

Order Foraminiferida Eichwald, 1830

Suborder Fusulinina Wedekind, 1937

Superfamily Fusulinoidea von Möller, 1878

Family Ozawainellidae Thompson & Foster, 1937

Genus *Pamirina* Leven, 1970a

**Type species:** *Pamirina darvasica* Leven, 1970a, p. 23.

*Pamirina leveni* Kobayashi, 1977

Pl. III, fig. 1; Pl. V, figs 38-39, 46-49

1960. *Staffella* sp. Kanuma, p. 57, pl. 12, figs 29-31.  
 1966. *Paramillerella*? sp. Takaoka, p. 5, pl. 1, figs 5-6.  
 1977. *Pamirina leveni* Kobayashi, pp. 11-14, pl. 1, figs 13-38.  
 1977. *Pamirina tethydis* Kobayashi, p. 11, pl. 1, figs 1-12.  
 1991a. *Pamirina (Levenia) leveni* Kobayashi.— Ueno, pp. 746-747, fig. 3.8-23.  
 1991b. *Pamirina (Levenia) leveni* Kobayashi.— Ueno, fig. 6.6-10.  
 2019. *Pamirina leveni* Kobayashi.— Kobayashi, pp. 56-57, pl. 3, figs 32, 38, 45-50.

**Remarks:** Morphologic characters of the present material closely resemble those of the types of this species (Kobayashi, 1977). The genus *Pamirina* is easily distinguished from *Praemisellina* described below by its smaller test with smaller proloculus, more whorls, tightly coiled inner whorls, and much thinner wall (see Pl. III, figs 1, 2b). Thin translucent layer referable to protheca is only recognized in the outer few whorls and inner few whorls consist of structureless single layer in this species. Finely alveolar wall is confined to the final one or two whorls of an advanced form of the genus (Kobayashi, 1977).

**Occurrence and stratigraphic distribution:** Rare at B-367, B-456, and B-461 in the *Pamirina leveni* Zone (P-7).

Genus *Zarodella* Sosnina, 1981

**Type species:** *Zarodella zhamoidai* Sosnina, 1981, p. 28.

*Zarodella zhamoidai* Sosnina, 1981

Pl. V, figs 41, 44-45

1981. *Zarodella zhamoidai* Sosnina, pp. 28-30, pl. 2, figs 1-5, 17.  
 par 1991a. *Pamirina (Levenia) evoluta* Sheng & Sun, 1975.— Ueno, pp. 747-748, figs 4.1-4.2, 4.4-4.8 (fig. 4.3a, 4.3b = *Pamirina evoluta*).  
 par 1991b. *Pamirina (Levenia) evoluta* Sheng & Sun.— Ueno, figs 6.11-6.12, 6.14 [= figs 4.8, 4.2, 4.6b of Ueno

- (1991a), respectively], [figs 6.10, 6.13 = fig. 4.3b of Ueno (1991a), both = *Pamirina evoluta*].  
 2010. *Zarodella zhamoidai* Sosnina.— Leven, figs 1.1-1.6 [= Sosnina's (1981) pl. 2, figs 1-4, 17, 5, respectively].

**Remarks:** Several specimens with small nautiloid to thick lenticular test slightly depressed along axis of coiling were obtained. They consist of almost planispirally coiled 2.5 to 3 whorls and large proloculus. Wall is thin and its differentiation is not recognized. Septa are long, straight, and regularly arranged. These features are well analogous with those of the type species of *Zarodella* proposed by Sosnina (1981) from the uppermost Lower Permian of Far East. Diaphanotheca layer in outer whorl(s) in the original description is doubtful. The present specimens are not assigned to *Pamirina* in their much larger proloculus. Seven specimens except for one named as *Pamirina (Levenia) evoluta* illustrated by Ueno (1991a) from the Kaerimizu area are better to be transferred to this species from proloculus size, and thickness and structure of wall. The genus *Zarodella* should be included in the Family Ozawainellidae as considered by Leven (2010) who discussed phylogenetic relationships among *Zarodella*, *Grovesella*, and *Pamirina* in detail.

**Occurrence and stratigraphic distribution:** Rare at B-252 and B-260 in the *Paraleeina magna* Zone (P-6), and rare at B-367 in the *Pamirina leveni* Zone (P-7).

Family Staffellidae Miklukho-Maklay, 1949

Genus *Chenella* Miklukho-Maklay, 1959

**Type species:** *Orobias kueichiensis* Chen, 1934, p. 15.

**Remarks:** *Chenella* established by Miklukho-Maklay (1949) based on a monotypic specimen from the uppermost part of the Chihhsia Limestone of Anhui Province, China (Chen, 1934) has been assigned into Ozawainellidae. In spite of similar shape and expansion of the test, it is distinguished from *Sichotenella* by its fewer whorls, thicker wall, and absence of eostaffelin-type initial whorls. *Chenella* is herein transferred from Ozawainellidae to Staffellidae based on the wall structure of the type species consisting of thin tectum and thicker “diaphanotheca” according to Chen (1934). In addition to much larger test, wall is considerably thicker than that of other lenticular-shaped genera of Ozawainellidae. “Diaphanotheca” in the original description of *Orobias kueichiensis* might be referable to translucent layer similar to protheca-like layer. A different category of *Chenella* from genera of Ozawainellidae is understood by comparing the test size, length and width of corresponding whorls, and thickness and structure of the wall between “*Orobias kueichiensis*” and “*Orobias angulata* Colani, 1924”, both of which were described by Chen (1934). One specimen illustrated as *Chenella* sp. in Kobayashi (2012, fig. 6.28) from a limestone pebble of conglomerate of the Tsunemori Formation is similar



to the type species of *Chenella* in its wall structure and growth pattern of the test.

Furthermore, *Chenella* is characteristic in its small number of whorls in comparison with large lenticular test, as represented by only four whorls in the type material of Chen (1934). Kalmykova (1972) questionably transferred such species having much smaller test with pointed periphery as *mathildae* and *ivanovi* than “*Orobias kueichihensis*” to *Chenella*. These two Russian species were originally assigned to *Staffella* by Dutkevich (1934). In my opinion, lenticular forms previously included in *Staffella* or *Nankinella*, having weakly recrystallized test with more or less pointed periphery and less than five whorls, and relatively thick wall composed of tectum and thicker translucent layer are better to be reassigned to *Chenella*.

***Chenella mathildae* (Dutkevich, 1934)**

Pl. III, figs 9-12

1934. *Staffella mathildae* Dutkevich, pp. 37-38, 78-80, pl. 4, figs 12-16.

1972. *Chenella?* *mathildae* (Dutkevich).— Kalmykova, pl. 2, figs 2a, 2b (= Dutkevich, 1934, pl. 4, fig. 12); 3a, 3b (= Dutkevich, 1934, pl. 4, fig. 14).

**Remarks:** This species from the bore-hole samples of the Upper Carboniferous of the Preurals (Dutkevich, 1934) was differentiated from lenticular forms of *Staffella* by its fewer whorls of the test with umbilical depressions in outer whorls. It was questionably transferred to *Chenella* by these differences and revised to the Sakmarian in age by Kalmykova (1972). The Akiyoshi specimens are closely similar to the original five specimens and identified with this species in size, shape, and growth pattern of the test more or less variable by specimens, though umbilical cavities are not distinct as those of the types.

*Chenella* sp. illustrated from the limestone conglomerate of the Tsunemori Formation (Kobayashi, 2012) is easily distinguished from this species by its much more rapidly expanding outer whorls with indistinct umbilical cavities. *Chenella mathildae* closely resembles *Pseudoendothyra? constricta* proposed by Hy. Igo *et al.* (1993) from the upper Yakhtashian near Loei, Thailand in many respects. However, wall is thicker especially in inner whorls and umbilical cavities are less distinct in the former.

**Occurrence and stratigraphic distribution:** Common at B-298, and rare at B-261 and B-404 in the *Paraleeina magna* Zone (P-6).

***Chenella rhomboides* n. sp.**

Pl. IV, figs 18-24

1958. *Nankinella* spp. Toriyama, pp. 68-69, pl. 6, figs 14-15 (*N. spp.*, form A); pl. 6, figs 16-17 (*N. spp.*, form B).

2012. *Pseudoreichelina* sp. B. Kobayashi, figs 6.42, 6.50-6.51.

2012. *Nankinella* sp. B. Kobayashi, fig. 6.49.

par 2017. *Pseudoreichelina darvasica* Leven, 1970b.— Kobayashi, pl. 1, fig. 40 (non pl. 1, figs 39, 42 = *Pseudoreichelina darvasica*; non pl. 1, fig. 43 = *Pseudoreichelina obiniouensis*).

**Etymology:** From the rhomboidal test.

**Type specimens:** Holotype D2-057516 (axial section, Pl. IV, fig. 21). Paratypes: two axial sections (D2-066406, Pl. IV, fig. 19; D2-057543, Pl. IV, fig. 20), one sagittal section (D2-063882, Pl. IV, fig. 24), and three tangential sections (D2-063879, Pl. IV, fig. 18; D2-057846, Pl. IV, fig. 22; D2-063972, Pl. IV, fig. 23).

**Type locality:** Six localities about 315 to 1,375 m apart from Wakatakeyama.

**Diagnosis:** Weakly recrystallized, rhomboidal test with 4 to 4.5 whorls with bluntly pointed periphery and protruding poles sometimes with umbilical cavities. Wall weakly recrystallized, relatively thick, and consisting of a thin layer comparable to tectum and a much thicker translucent layer partly showing finely alveolar structure.

**Description:** Test rhomboidal, weakly recrystallized, and of 4 to 4.5 whorls. Periphery bluntly pointed, lateral sides almost straight, and poles protruding sometimes with shallow umbilical cavities. Original test outline is more or less lost due to the abrasion of outer whorls in specimens. Length 0.48? to 0.74? mm, and width 0.862 to 1.373 mm. Length is 0.69? mm and width is 1.370 mm in the holotype, giving about 0.5 in form ratio, taking the abrasion of the polar regions into account.

Proloculus spherical and 0.080 to 0.137 mm in diameter, and 0.098 mm in the holotype. Length and width of the whorls gradually increasing outward. Poles of the terminal whorl shallowly umbilicated in most specimens. The first to the fourth whorl in the holotype is 0.165, 0.304, 0.46?, and 0.69? mm in length; and 0.270, 0.502, 0.847, and 1.370 mm in width.

Wall weakly recrystallized and 0.03 to 0.04 mm approximately in the last whorl, but its thickness variable in places and exactly uncertain due to partial covers of secondary deposits and/or recrystallization. It consists of thin layer comparable to tectum and underlying much thicker translucent layer partly showing finely alveolar structure. Septa inclined anteriorly and more or less recrystallized. Tunnel low and narrow, and its path straight. Secondary deposits comparable to chomata are indistinct.

**Remarks:** Seven specimens illustrated, though most of them are more or less abraded, are assigned to *Chenella* rather than to *Parastaffella*, *Pseudoendothyra*, or *Reitlingerina* in their larger test, lower degree of recrystallization of the test, and larger proloculus. They are distinguished from “*Staffella*” *preobrajenskyi* Dutkevich, 1934 proposed on the basis of six specimens from the bore-hole samples of the Verkhne-Chussovsky

Gorodki of Preurals (Sakmarian in age according to Kalmykova, 1972) in their larger test with more pointed periphery and more protruding poles, based on which they are considered to be a new species of *Chenella*. Other test characters including wall structure are closely similar each other.

This new species is different from *Chenella mathildae* of the original and the present materials, and *Chenella tosaensis* (Suyari, 1962) by its larger test and more protruding poles. *C. tosaensis* originally assigned to *Millerella* was described from the Jurassic Chichibu Terrane (Kameiwa Formation) in Shikoku.

*Chenella* sp. illustrated in Pl. IV, figs 30-32, 35 is distinguished from this new species by slenderer test with more pointed periphery. More widely depressed polar regions in the former are unctetian due to either evolute coiling and/or abrasion of polar regions of the outer whorls. Two forms of *Nankinella* spp. described from the Artinskian of the Akiyoshi Limestone (Toriyama, 1958) and *Nankinella* sp. B from the limestone conglomerate of the Tsunemori Formation (Kobayashi, 2012) are thought to be conspecific with this new species from their similarities of size and shape of the test, and thickness and structure of the wall. Different appearances might be a result of the various degree of secondary mineralization and wide morphologic variations of this new species. Likewise, one specimen identified with *Pseudoreichelina darvasica* in Kobayashi (2017, p. 34, pl. 1, fig. 40) is changed herein to this new species.

**Occurrence and stratigraphic distribution:** Rare at B-232, B-234, B-249, B-251, B-252, B-404, B-417, and B-542 in the *Paraleeina magna* Zone (P-6).

Genus *Nankinella* Lee, 1934

**Type species:** *Staffella discoides* Lee, 1931, p. 286.

***Nankinella* cf. *nagatoensis* Toriyama, 1958**

Pl. IV, figs 4-9, 13, 15

Compare:

- 1958. *Nankinella nagatoensis* Toriyama, pp. 65-68, pl. 6, figs 5-13.
- 2012. *Nankinella nagatoensis* Toriyama.— Kobayashi, fig. 6.40-6.41, 6.52.
- 2017. *Nankinella nagatoensis* Toriyama.— Kobayashi, p. 33, pl. 1, figs 51-54.
- 2019. *Nankinella nagatoensis* Toriyama.— Kobayashi, p. 58, pl. 3, figs 21-30, 34-36.

**Remarks:** The present specimens are compared to *Nankinella nagatoensis* due to not so pointed periphery of the test in comparison with the types of Toriyama (1958), and Wakatakeyama (Kobayashi, 2017) and the Kaerimizu (Kobayashi, 2019) specimens. Other test characters resemble each other in these Akiyoshi specimens. Those referable or comparable to *Nankinella nagatoensis* are distinguished from the Early and Middle

Permian *Nankinella*, e.g. *N. orbicularia* Lee, 1934 and *N. hunanensis* (Chen, 1956) from South China (e.g. Lee, 1934; Chen, 1934, 1956; Sheng, 1956) in having smaller test and fewer whorls.

**Occurrence and stratigraphic distribution:** Rare at B-243, C-45, C-55, and C-59 in the *Globifusulina krotowi* Zone (P-4); common at C-50 and rare at C-51 in the *Chalaroschwagerina vulgaris* Zone (P-5); and rare at B-251, B-253, B-261, B-368, and B-460 in the *Paraleeina magna* Zone (P-6).

Genus *Palaeostaffella* Liêm, 1966

**Type species:** *Staffella moelleri* Y. Ozawa, 1925, p. 19.

**Emended diagnosis:** Given by Kobayashi (2019). Staffellids having less than seven whorls gradually expanding outward without tightly coiled inner whorls. Wall thick and composed of a tectum, thin upper layer, and thicker, less dense lower layer showing fibrous structure, and a large proloculus for the test size.

**Remarks:** *Staffella moelleri*, proposed by Y. Ozawa (1925) based on one axial section from the Akiyoshi Limestone, is different from the type species of *Staffella*, *Fusulina sphaerica* Abich, 1859 (= *Staffella moellerana* Thompson, 1935), and many other species of the genus in its absence of tightly coiled inner whorls, fewer whorls, and thicker wall and larger proloculus for the test size. This species was designated as the type species of *Palaeostaffella* by Liêm (1966). *Palaeostaffella* has not been reported from the Pennsylvanian and Asselian of the Akiyoshi Limestone (Kobayashi, 2017). Kobayashi (2019) showed that *Palaeostaffella* is not Moscovian in age as once assumed by Y. Ozawa (1925) and Liêm (1966), but Yakhtashian to early Kubergandian based on the recent Akiyoshi materials.

***Palaeostaffella akudensis* (Hh. Igo, 1996)**

Pl. III, figs 22-30

- 1996. *Sphaerulina akudensis* Hh. Igo, pp. 627-628, fig. 11.9-11.14.
- 2017. *Staffella?* sp. Kobayashi, p. 36, pl. 3, figs 24-31.
- 2019. *Palaeostaffella akudensis* Hh. Igo.— Kobayashi, p. 59, pl. 4, figs 26-28, 31.

**Remarks:** The present specimens are identified with *Sphaerulina akudensis* proposed by Hh. Igo (1996) from the Lower Permian of Hachiman, Mino Terrane and with *Staffella?* sp. described by Kobayashi (2017) from Akiyoshi. The Hachiman material is not assigned to *Sphaerulina* because of absence of tightly coiled lenticular inner whorls. These specimens were reassigned to *Palaeostaffella* by Kobayashi (2019).

**Occurrence and stratigraphic distribution:** Common to rare at B-249, B-252, B-460, B-542, and C-552 in the *Paraleeina magna* Zone (P-6).



***Palaeostaffella subquadrata* Kobayashi, 2019**

Pl. III, figs 31-35; Pl. IV, figs 1-2

2019. *Palaeostaffella subquadrata* Kobayashi, pp. 59-60, pl. 4, figs 35-40.

**Remarks:** The present material is closely similar to the types from the *Paraleeina magna* Zone to the *Misellina claudiae* Zone of the Kaerimizu area in many respects. This species is distinguished from *Palaeostaffella moelleri* (Y. Ozawa, 1925) and *P. akudensis* by its larger and subquadrate test with more distinct fibrous wall, and from *Sphaerulina croatica* Kochansky-Devidé, 1965 by its subquadrate and larger test gradually expanding outward without distinct juvenile whorls, larger proloculus, and fewer whorls. Subquadrate outline of this species somewhat resembles that of *Staffella lacunose* Dunbar & Skinner, 1937 described from the type Leonardian in the Glass Mountains, Texas. However, this species has thicker wall, larger proloculus, and fewer whorls than the Texas species.

**Occurrence and stratigraphic distribution:** Common at B-460 and rare at B-254 and B-257 in the *Paraleeina magna* Zone (P-6), and rare at B-311 in the *Misellina dyhrenfurthi* Zone (P-8).

***Palaeostaffella yobarensis* (Y. Ozawa, 1925)**

Pl. III, figs 13-21

1925. *Staffella yobarensis* Y. Ozawa, p. 20, pl. 3, figs 1b, 5.  
 1958. *Staffella yobarensis* Y. Ozawa.—Toriyama, pp. 69-71, pl. 6, figs 20-28.  
 2012. *Sphaerulina?* sp. Kobayashi, figs 6.46-6.47.

**Remarks:** Toriyama (1958) assumed that *Staffella yobarensis* is the smallest form of the genus *Staffella* and designated the lectotype of the species for the specimen originally illustrated by Y. Ozawa (1925) in pl. 3, fig. 5 from the Akiyoshi Limestone. Illustrated nine herein and many other specimens, apparently identified with this species, are common in subelliptical test having arched to broadly arched periphery, thick wall with translucent fibrous structure (corresponding to Toriyama's "diaphanotheca-like layer") and large proloculus for the test size. Form ratio of the test and the degree of depression of the terminal whorl are variable from specimen to specimen, suggesting broad intraspecific variations of this species. Based on these characters, this species should be reassigned to *Palaeostaffella*.

**Occurrence and stratigraphic distribution:** Rare at B-363 and C-59 in the *Globifusulina krotowi* Zone (P-4), common at B-300 and rare at B-439 in the *Chalaroschwagerina vulgaris* Zone (P-5); common to rare at B-234, B-252, B-254, B-259, B-261, B-308, B-368, B-402, B-414, B-462, and B-546 in the *Paraleeina magna* Zone (P-6); and rare at B-456 in the *Pamirina leveni* Zone (P-7).

Genus *Praemisellina* Kalmykova, 1972

**Type species:** *Praemisellina georgii* Kalmykova, 1972, p. 57.

**Remarks:** Besides lenticular to oval and smaller test, *Praemisellina* is treated as an independent genus of the Staffellidae based on smaller length and width of corresponding whorls in the late ontogenetic stage than those of larger genera such as *Palaeostaffella* and *Chenella*. Relatively large proloculus and thick wall for the test size, and weak recrystallization of the test are common in these three genera. This genus largely differs from *Pamirina* in its weakly recrystallized test with thicker wall (see Pl. III, figs 1, 2b).

**Distribution and Stratigraphic range:** Restricted to the Sakmarian to Artinskian in the Tethyan regions and in the Circum-Pacific regions having early Permian Tethyan faunal elements. Related genera, *Palaeostaffella* and *Chenella* range up to the early Guadalupian in the Kaerimizu area (Kobayashi, 2019).

***Praemisellina minensis* n. sp.**

Pl. II, figs 47-51; Pl. III, figs 2-8

**Etymology:** From the city name, Mine, Yamaguchi Prefecture.

**Type specimens:** Holotype D2-063833 (axial section, Pl. III, fig. 2). Paratypes: Nine axial sections (D2-063557, Pl. II, fig. 47; D2-060618, Pl. II, fig. 48; D2-060627, Pl. II, fig. 49; D2-060640, Pl. II, fig. 50; D2-060617, Pl. II, fig. 51; D2-060646, Pl. III, fig. 5; D2-060624, Pl. III, fig. 6; D2-060655, Pl. III, fig. 7; D2-060619, Pl. III, fig. 8), and two sagittal sections (D2-057895, Pl. III, fig. 3; D2-060654, Pl. III, fig. 4).

**Type locality:** Three localities about 550 to 1,050 m west of Wakatakeyama.

**Diagnosis:** Weakly recrystallized, lenticular to oval test with 4 to 5 whorls and relatively thick wall consisting of thin layer and its underlying much thicker translucent layer. Proloculus is large for the test size.

**Description:** Test lenticular to oval, consisting of 4 to 5 whorls, and weakly recrystallized. Periphery broadly to narrowly arched, lateral sides convex to nearly straight, and polar regions with more or less umbilicated cavities. Length 0.328 to 0.452 mm, width 0.635 to 1.060 mm, and form ratio 0.43 to 0.52.

Proloculus spherical and 0.052 to 0.105 mm in diameter. Inner three whorls involute and gradually increasing their length and width. Their form ratio varies from nearly the same throughout growth to decreasing outwards. The size of the first to the fifth whorl in the holotype is 0.116, 0.208, 0.305, 0.407, and 0.452 mm in length; and 0.168, 0.326, 0.467, 0.683, and 0.984 mm in width.

Wall thick for the test size and its thickness variable in places due to additional deposits and/or recrystallization. Its thickness 0.037 mm in the thickest part of the holotype. Wall composed of a thin layer corresponding to a tectum

and its underlying much thicker translucent layer. Septa gently inclined anteriorly and more or less recrystallized. Septal counts from the first to the fourth whorl 5 or 6, 10 or 12, 13? or 15?, and 17? in two paratypes, though uncertain in outer whorls due to recrystallization. Tunnel low and narrow in inner whorl, but uncertain due to secondary deposits in outer whorls. Rudimentary chomata confined to inner whorls.

**Remarks:** The present new species is somewhat similar to *Praemisellina dagmarae* (Dutkevich, 1934) and *P. georgii*. *P. dagmarae* originally assigned to *Staffella* was described from the Cisuralian of central Urals (Dutkevich, 1934, pp. 22-27, pl. 3, figs 11-15). *P. georgii* was proposed by Kalmykova (1972) on the basis of two specimens (Kalmykova, 1972, pl. 3, figs 1, 2 = Dutkevich, 1934, pl. 3, figs 13, 14) that were separated from five specimens illustrated by Dutkevich (1934), and was designated as the type species of the genus. *Praemisellina minensis* is distinguished from these two Russian species by its lenticular to oval test with smaller form ratio throughout growth, more distinct umbilical cavities, and lesser developed chomata. Other test characters are similar each other. *Praemisellina* cf. *minensis* illustrated in Pl. II, figs 44-46 is also similar to this new species, but differs in having thicker lenticular test and thicker wall in the corresponding whorls.

**Occurrence and stratigraphic distribution:** Common to rare at B-240, B-363, and C-55 in the *Globifusulina krotowi* Zone (P-4); rare at B-295 in the *Chalaroschwagerina vulgaris* Zone (P-5); and common to rare at B-254, B-363, B-398, and C-54 in the *Paraleeina magna* Zone (P-6).

Genus *Pseudoreichelina* Leven, 1970b

**Type species:** *Pseudoreichelina darvasica* Leven, 1970b, p. 19.

***Pseudoreichelina darvasica* Leven, 1970b**

Pl. IV, figs 25-28, 33-34

1970b. *Pseudoreichelina darvasica* Leven, pp. 19-20, pl. 1, figs 6-13.

1992. *Pseudoreichelina darvasica* Leven.– Ueno, pp. 8, 10, fig. 5.1-5.16.

par 2017. *Pseudoreichelina darvasica* Leven.– Kobayashi, p. 34, pl. 1, figs 39, 42 [non pl. 1, fig. 40 = *Chenella rhomboidalis* n. sp.; non pl. 1, fig. 43 = *Pseudoreichelina obiniouensis* (Leven, 1970b)].

par 2019. *Pseudoreichelina darvasica* Leven.– Kobayashi, pp. 58-59, pl. 3, figs 12-14, 15?, 17-18 (non pl. 3, fig. 19 = *Chenella*? sp.).

**Remarks:** Illustrated six specimens of *Pseudoreichelina* are similar to and probably identified with *Pseudoreichelina darvasica* by Leven (1970b) from the Artinskian of southwest Darvas in the size and construction of the test. *Pseudoreichelina* sp. A illustrated in Pl. IV, fig. 29 differs from this species by having

umbilicated polar regions. This species is different from *Pseudoreichelina slovenica* (Kochansky-Devidé, 1966) from Slovenia (Kochansky-Devidé, 1966) and from the Akasaka Limestone (Kobayashi, 2011) in having thicker lenticular whorls in the coiled part of the test.

**Occurrence and stratigraphic distribution:** Rare at B-249, B-252, B-253, B-254, B-261, and B-404 in the *Paraleeina magna* Zone (P-6).

***Pseudoreichelina obiniouensis* (Leven, 1970b)**

Pl. IV, figs 16-17

1970b. *Pseudoendothyra obiniouensis* Leven, pp. 18-19, pl. 1, figs 1-5.

2012. *Pseudoreichelina* sp. A, Kobayashi, figs 6.37-6.39.

par 2017. *Pseudoreichelina darvasica* Leven, 1970.– Kobayashi, p. 34, pl. 1, fig. 43 (non pl. 1, fig. 40 = *Chenella rhomboidalis*; non pl. 1, figs 39, 42 = *Pseudoreichelina darvasica*).

**Remarks:** Two illustrated and some other specimens closely resemble *Pseudoendothyra obiniouensis*, though uncoiled terminal whorl is more distinct. They are reassigned to *Pseudoreichelina* based on the original description by Leven (1970b), modified herein. That is, the uncoiled terminal whorl is seemingly to be underdeveloped, “diaphanotheca” might be referable to translucent layer like protheca, and polar regions are more or less umbilicated in the Leven’s types. By these features characteristic in this species, three specimens from the Tsunemori Formation (Kobayashi, 2012) and one specimen among the four named as *Pseudoreichelina darvasica* from the Wakatakeyama area (Kobayashi, 2017) are transferred to this species.

**Occurrence and stratigraphic distribution:** Rare at B-252, B-254, and B-488 in the *Paraleeina magna* Zone (P-6).

Family Schubertellidae Skinner, 1931

Subfamily Schubertellinae Skinner, 1931

Genus *Schubertella* Staff & Wedekind, 1910

**Type species:** *Schubertella transitoria* Staff & Wedekind, 1910, p. 112.

***Schubertella exilis* Suleimanov, 1949**

Pl. V, figs 15-17, 19-20, 22-24, 28-29, 34

1949. *Schubertella kingi* Dunbar & Skinner, 1937 var. *exilis* Suleimanov, pp. 33-35, pl. 1, figs 11-13.

1961. *Schubertella* cf. *kingi* Dunbar & Skinner var. *exilis* Suleimanov.– Grozdilova & Lebedeva, pp. 174-175, pl. 1, fig. 11.

1963. *Schubertella kingi* var. *exilis* Suleimanov.– Chang, pp. 43-44, pl. 1, fig. 4.

non 2013. *Schubertella exilis* Suleimanov.– Davydov *et al.*, figs 13.26-13.33 (= *Schubertella kingi*).

**Remarks:** Suleimanov (1949) distinguished the species

*exilis* as a variety of *Schubertella kingi* in having a larger and thicker fusiform test. Illustrated specimens herein are closely similar to and safely identified with the original three specimens from the Sakmarin of Bashkirsky, Preurals. The Timan (Grozdilova & Lebedeva, 1961) and Shinjiang (Chang, 1963) materials listed above are probably assigned to *Schubertella exilis* in spite of only one illustration in them. Eight specimens illustrated from the Grenzland and Zweikofel formations in the Carnic Alps (Davydov *et al.*, 2013) might be reassigned to *Schubertella kingi* by their smaller and more elongate test than this species.

**Occurrence and stratigraphic distribution:** Rare at B-242 and C-60 in the *Globifusulina krotowi* Zone (P-4); rare at B-511, C-54, C-60, C-69, and C-71 in the *Chalaroschagerina vulgaris* Zone (P-5); and rare at B-251, B-252, B-308, B-488, and C-54 in the *Paraleeina magana* Zone (P-6).

***Schubertella kingi* Dunbar & Skinner, 1937**

Pl. III, figs 36-38; Pl. V, figs 1-8

1937. *Schubertella kingi* Dunbar & Skinner, pp. 610-611, pl. 45, figs 10-15.  
 par 1958. *Schubertella kingi* Dunbar & Skinner.— Toriyama, pp. 73-75, pl. 7, figs 1, 3, 5-7 (non pl. 7, figs 2, 8 = *Biwaella* sp.; non pl. 7, fig. 4 = *Neofusulinella*? sp.).  
 1970. *Schubertella kingi* Dunbar & Skinner.— Kochansky-Devidé, p. 190, pl. 3, figs 16-18.  
 2017. *Schubertella kingi* Dunbar & Skinner.— Kobayashi, p. 37, pl. 1, figs 22-23, 26-30.

**Remarks:** As well as the Wakatakeyama specimens (Kobayashi, 2017), those identified with this species have smaller and more elongate test with smaller width in corresponding whorls than those of other forms of *Schubertella* distinguished in the studied area. Three specimens among five by Toriyama (1958) are excluded from this species and reassigned to other taxa as shown above by their thickness and structure of the wall.

**Occurrence and stratigraphic distribution:** Rare at B-363 in the *Globifusulina krotowi* Zone (P-4), rare to common at B-558, C-70, and C-71 in the *Chalaroschagerina vulgaris* Zone (P-5); and rare at B-232, B-254, B-404, and B-488 in the *Paraleeina magana* Zone (P-6).

***Schubertella melonica* Dunbar & Skinner, 1937**

Pl. V, figs 18, 21, 25-27, 30-33, 35-37

1937. *Schubertella melonica* Dunbar & Skinner, pp. 611-613, pl. 57, figs 10-14.  
 1993. *Schubertella melonica* Dunbar & Skinner.— Hy. Igo, Ueno & Sashida, pp. 24-25, figs 3.20-3.25.  
 1996. *Mesoschubertella sakagamii* Ueno, pp. 26-27, pl. 6, figs 1-17.  
 2017. *Schubertella melonica* Dunbar & Skinner.— Kobayashi, p. 38, pl. 1, figs 24-25, 31-32, 41.

**Remarks:** Many specimens with or without outer whorls of inflated forms of *Schubertella* were obtained, among which 12 specimens are illustrated. They are closely similar to the types described from the Leonardian of Texas (Dunbar & Skinner, 1937) in many respects, and have more inflated test with thicker wall in outer whorls than other species of *Schubertella* recognized in the mapped area. *Mesoschubertella sakagamii* proposed by Ueno (1996) from the Artinskian of the Akiyoshi Limestone is a junior synonym of *Schubertella melonica* and is excluded from *Mesoschubertella* by its thinner wall and not so massive chomata. In this study, *Mesoschubertella* was only discernible in sample B-234 (Pl. III, fig. 39) from the *Paraleeina magna* Zone.

**Occurrence and stratigraphic distribution:** Rare at B-245, C-58, and C-60 in the *Globifusulina krotowi* Zone (P-4); common to rare at B-295, B-492, C-69, and C-70 in the *Chalaroschagerina vulgaris* Zone (P-5); and rare at B-234, B-251, B-298, and B-308 in the *Paraleeina magana* Zone (P-6).

***Schubertella* sp.**

Pl. V, figs 9-14

**Remarks:** *Schubertella* sp. is distinguished from *Schubertella kingi* and *S. exilis*, described above, by its inflated fusiform test, and from *S. melonica* by its smaller length and width in the corresponding whorls especially in outer whorls.

**Occurrence and stratigraphic distribution:** Rare at B-235, B-237, B-238, and B-239 in the *Globifusulina nux* Zone (P-3); rare at B-243, B-244, B-528, and C-59 in the *Globifusulina krotowi* Zone (P-4); rare at C-64 and C-75 in the *Chalaroschwagerina vulgaris* Zone (P-5); rare at B-308 in the *Paraleeina magna* Zone (P-6); and rare at B-367 in the *Pamirina leveni* Zone (P-7).

Genus *Schubertina* Marshall, 1969

**Type species:** *Schubertina circuli* Marshall, 1969, p. 122.

***Schubertina* sp.**

Pl. V, figs 42-43

1970. *Schubertella* sp. C, Kochansky-Devidé, p. 191, pl. 3, figs 22-23.

**Remarks:** Small and subspherical individuals assignable to *Schubertina* consist of three whorls and have large proloculus. Wall consists of single layer in earlier whorls and its differentiation is obscure in later whorls. Two specimens described as *Schubertella* C from the Sakmarian of the Karavanke Mountains, Slovenia (Kochansky-Devidé, 1970) are an example closely similar to *Schubertina* sp. discernible in the mapped area. *Schubertina* sp. is different from *Schubertina australis* (Thompson & Miller, 1949) in its planispiral coiling throughout the test.



**Occurrence and stratigraphic distribution:** Rare at B-243 in the *Globifusulina krotowi* Zone (P-4) and at C-54 in the *Paraleeina magna* Zone (P-6).

Family Schwagerinidae Dunbar & Henbest, 1930

Genus *Biwaella* Morikawa & Isomi, 1960

**Type species:** *Biwaella omiensis* Morikawa & Isomi, 1960, p. 301.

***Biwaella* sp.**

Pl. VIII, fig. 29; Pl. IX, figs 2-14

- par 1958. *Schubertella kingi* Dunbar & Skinner.— Toriyama, pp. 73-75, pl. 7, figs 2, 8 (non pl. 7, figs 3, 5-7 = *Schubertella kingi*; non pl. 7, fig. 4 = *Neofusulinella*? sp.).
- par 1958. *Schubertella* sp. A Toriyama, p. 75, pl. 7, fig. 10 (non pl. 7, figs 9, 11 = *Schubertella* sp.).
2017. *Biwaella* aff. *omiensis* Morikawa & Isomi.— Kobayashi, pp. 44-45, pl. 49, figs 2-8, 11-13.

**Remarks:** Specimens of *Biwaella* successively yielded from the Asselian to Artinskian in the studied area are similar to *Biwaella* aff. *omiensis* described by Kobayashi (2017) from the Wakatakeyama area. As well as *B.* aff. *omiensis*, *Biwaella* sp. illustrated herein differs from *B. omiensis* in its more elongate fusiform to subcylindrical test and underdeveloped chomata. Three specimens assigned to *Schubertella* by Toriyama (1958) from Akiyoshi, listed above, might be referable to this unnamed species.

**Occurrence and stratigraphic distribution:** Rare to common at B-244, B-363, C-55, C-56, and C-58 in the *Globifusulina krotowi* Zone (P-4); common at B-104, B-105, B-273, B-434, B-511, B-557, C-64, C-69, C-70, C-71, C-104, and C-114 in the *Chalaroschwagerina vulgaris* Zone (P-5); and common to rare at B-489 and C-54 in the *Paraleeina magna* Zone (P-6).

Genus *Darvasites* Miklukho-Maklay, 1959

**Type species:** *Triticites ordinatus* var. *daroni* Miklukho-Maklay, 1949, p. 79.

***Darvasites* sp.**

Pl. VIII, figs 22

**Remarks:** The illustrated one and few other specimens have short cylindrical test with shallowly depressed poles in outer whorls. They appear to be related to *Triticites truncatus* originally described by Chen (1934) from the Chuanshanian and Mappingian of Kwangsi, and to *Eoparafusulina truncata* (Chen) by Shi *et al.* (2012) from the Zisongian Stage (Sakmarian) of southern Guizhou. The present specimens, however, are treated as an unnamed species of *Darvasites* because of having more distinct tunnel bordered by more distinct chomata than those of the Chinese species assigned to *Triticites* or *Eoparafusulina*.

**Occurrence and stratigraphic distribution:** Rare at B-539 in the *Paraleeina magna* Zone (P-6).

***Darvasites? ingavati* Hy. Igo, Ueno & Sashida, 1993**

Pl. VIII, figs 18

1993. *Darvasites ingavati* Hy. Igo, Ueno & Sashida, p. 25, figs 5.14-5.20.

**Remarks:** One illustrated axial section and other diagonal sections are closely similar to *Darvasites ingavati* initially described by Hy. Igo *et al.* (1993) from the upper Yakhtashian of Loei, northeast Thailand in size and shape of the test, proloculus size, septal folding, and thickness of wall. They are questionably assigned to *Darvasites* herein because of not so massive chomata and not so distinct tunnel as in the typical forms of *Darvasites*.

**Occurrence and stratigraphic distribution:** Rare at C-67 in the *Chalaroschwagerina vulgaris* Zone (P-5).

***Darvasites? cf. beitepensis* Leven, 1995**

Pl. VIII, figs 26

Compare:

1995. *Darvasites beitepensis* Leven, p. 238, pl. 1, figs 12-13.

**Remarks:** Another form of schwagerinids questionably assigned to *Darvasites* in the mapped area has inflated fusiform test with minute proloculus, and smaller chomata and thinner wall in outer whorls. By these features, besides shape and size of the test and mode of septal foldings, this form is compared to *Darvasites beitepensis* proposed by Leven (1995) from the Yakhtashian near Ankara.

**Occurrence and stratigraphic distribution:** Rare at C-76 in the *Chalaroschwagerina vulgaris* Zone (P-5).

Genus *Eoparafusulina* Coogan, 1960

**Type species:** *Fusulina gracilis* Meek, 1864, p. 4.

***Eoparafusulina cf. ellipsoidalis* (Toriyama, 1958)**

Pl. IX, figs 15-18

Compare:

1958. *Triticites ellipsoidalis* Toriyama, pp. 115-118, pl. 12, figs 13-34.
1989. *Eoparafusulina ellipsoidalis* (Toriyama).— Ueno, pl. 3, fig. 8.
1990. “*Triticites*” *langsonensis* Saurin, 1950.— T. Ozawa & Kobayashi, pl. 6, figs 7-8.
1991. *Eoparafusulina ellipsoidalis* (Toriyama).— Watanabe, fig. 5.1-5.14.
2017. *Eoparafusulina ellipsoidalis* (Toriyama).— Kobayashi, pp. 100, 102, pl. 31, figs 15, 17-18, 20-28; pl. 32, figs 1-20.

**Remarks:** Artinskian specimens assignable to *Eoparafusulina* are compared to *E. ellipsoidalis* characteristic in the lower Asselian of the Akiyoshi

Limestone (Kobayashi, 2017). They have somewhat smaller test and less distinct axial fillings than those reported by the authors listed above from the lower Asselian of Akiyoshi, including “*Triticites*” *langsonensis* illustrated by T. Ozawa & Kobayashi (1990). *Eoparafusulina* cf. *ellipsoidalis* somewhat resembles *Darvasites ikenoensis* (Morikawa & Isomi, 1961) characteristic in the upper Cisuralian of the Mino Terrane (e.g. Kobayashi & Furutani, 2009), in size and shape of the test and mode of septal folding. The latter, however, is distinguished from the former by more tightly coiled inner whorls with thinner wall, larger chamber height in outer whorls, and more distinct tunnel bordered by more developed chomata.

**Occurrence and stratigraphic distribution:** Rare at B-105 and C-69 in the *Chalaroschwagerina vulgaris* Zone (P-5).

Genus *Globifusulina* Alekseeva, Isotova & Polozovz, 1983

**Type species:** *Fusulina krotowi* Schellwien 1908, p. 190.

***Globifusulina krotowi* (Schellwien, 1908)**

Pl. VI, figs 28-30; Pl. VII, figs 1-11

1908. *Fusulina krotowi* Schellwien, pp. 190-192, pl. 20, figs 1-10.

**Remarks:** This species was established in the *Schwagerina* Limestone of the Urals and Timan region. Its allied forms have been classified into an independent species, or subdivided into varieties or subspecies of *krotowi* based on morphologic comparison with the types (e.g. Rauzer-Chernousova, 1940; Grozdilova, 1966). Various taxonomic disposal of this species and its similar forms by authors is supposed to be caused by how to interpret the morphologic variations of the original material of Schellwien's (1908), in which two free specimens of *Fusulina krotowi* var. *nux* are contained. Detailed comparison between *Fusulina krotowi* and *F. krotowi* var. *nux* is, however, almost impossible because of no thin sections of the latter in Schellwien (1908). In the Akiyoshi Limestone, specimens named herein as *Globifusulina krotowi* have more inflated tests than those of the types. The present specimens are differentiated from *Globifusulina nux*, described below, by fewer number of tightly coiled inner whorls and larger length and width of corresponding whorls. Based on more inflated test, *G. krotowi* is distinguished from *Schwagerina princeps* (Ehrenberg, 1842). Although this species was regarded as a junior synonym of *S. princeps* by Kobayashi (2017), it is treated as an independent species of *Globifusulina* in this paper on account of larger and more inflated test with larger chamber height in the corresponding whorls than those of *S. princeps*.

**Occurrence and stratigraphic distribution:** Abundant to common at B-240, B-242, B-243, B-363, C-55, C-56, C-57, and C-59 in the *Globifusulina krotowi* Zone (P-4).

***Globifusulina nux* (Schellwien, 1908)**

Pl. VI, figs 8-9, 11-27

- par 1908. *Fusulina krotowi* Schellwien, pp. 190-192, pl. 20, figs 8-9 (*Fusulina krotowi* var. *nux*).
- 1940. *Pseudofusulina krotowi* var. *nux* (Schellwien).— Rauzer-Chernousova, p. 78, pl. 1, figs 5-6.
- 1958. *Pseudofusulina krotowi* subsp. *nux* (Schellwien).— Rauzer-Chernousova & Shcherbovich, pp. 38-39, pl. 3, figs 3-8.
- 1966. *Pseudofusulina nux* (Schellwien).— Grozdilova, pp. 291-292, pl. 10, fig. 6, [? fig. 4 (*Pseudofusulina nux* forma *gemella*, n. forma Grozdilova)].
- 1980. *Pseudofusulina* sp. A Leven & Shcherbovich, pl. 10, fig. 3.
- ?1986a. *Pseudofusulina nux* (Schellwien).— Davydov, pl. 5, figs 9-10.
- 1986b. *Pseudofusulina nux* (Schellwien).— Davydov, p. 98, pl. 15, fig. 6.
- 1986c. *Pseudofusulina nux* (Schellwien).— Davydov, pp. 119-120, pl. 25, figs 1-3.

**Description:** Inflated fusiform test attaining to 7 to 8 whorls with arched periphery, almost straight lateral sides, and rounded poles. Length 3.98 to 5.45 mm, width 2.46 to 3.07 mm, and form ratio 1.37 to 1.84.

Proloculus spherical and 0.088 to 0.225 mm. Inner two to four whorls tightly coiled and succeeded by rapidly enlarging outer whorls decreasing form ratio outwards. Poles are pointed to bluntly pointed in inner whorls, then gradually increasing their roundness outwards. Wall very thin and not differentiated in inner two to four fusiform whorls. Wall thickened outwards and considerably thick for the test size, consisting of tectum and finely alveolar keriotheca, and partly covered by dark secondary calcareous deposits. Wall thickness variable by specimens and attains to more than 0.15 mm by specimens.

Septa regularly folded and closely spaced throughout the test rarely resulting cuniculi, and very thin and numerous in inner tightly coiled whorls. Septal counts from the first to seventh whorls 11, 15, 19, 23, 26, 28, and more than 30 in the specimen shown in Pl. VI, fig. 26; and 9, 14, 18, 22, 27, 28, and 32 (?) in Pl. VI, fig. 27, respectively. Tunnel low, narrow, straight, and bordered by small but distinct chomata in inner whorls. It becomes higher and irregular in its path in middle and outer whorls. Axial fillings weakly developed.

**Remarks:** Akiyoshi specimens having smaller, and more numerous and more tightly coiled inner whorls than those of *Globifusulina krotowi* are identified as *G. nux* in this paper. However, the definition of these two taxa seems to be more or less different among authors. It is supposed that Rauzer-Chernousova (1940) and Rauzer-Chernousova & Shcherbovich (1958) named *Pseudofusulina nux* for a relatively small form of *Pseudofusulina krotowi* illustrated in Schellwien (1908, pl. 20, fig. 10) among Schellwien's three axial and three sagittal sections.



On the contrary, two axial sections [pl. 20, figs 1 (largest axial section), 10] in Schellwien (1908) were named as *P. nux*, and one axial section (pl. 20, fig. 5 having not so inflated test as pl. 20, figs 1, 10) was named as *P. krotowi* in Grozdilova (1966). Furthermore in Grozdilova (1966), one individual with larger test than *P. nux* was illustrated as a new forma *gemella*.

Relatively inflated form of the present material closely resembles "*Pseudofusulina*" sp. A illustrated by Leven & Shcherbovich (1980) from the Sakmarian of Darvas. Davydov illustrated two specimens of *Pseudofusulina nux* from the Urals (Davydov, 1986a), one specimen from the South Urals (Davydov, 1986b), and three specimens from Darvas (Davydov, 1986c). Among them, the South Urals and Darvas ones are more or less similar to the present Akiyoshi materials. However, the Urals ones are considerably different from the previous Russian and the present specimens of *nux* in its larger proloculus and absence of tightly coiled inner whorls.

Thus, it is hard to find a consensus on the terminology of *Globifusulina krotowi* and its allied forms among authors, in spite of *G. krotowi* designated as the type species of the genus.

**Occurrence and stratigraphic distribution:** Common at B-235, B-237, B-238 and B-239 in the *Globifusulina nux* Zone (P-3); and common to rare at B-240, B-242, B-296, and C-59 in the *Globifusulina krotowi* Zone (P-4).

Genus *Sakmarella* Bensch & Kireeva in Bensch, 1987

**Type species:** *Fusulina mölleri* Schellwien, 1908, p. 188.

***Sakmarella paramölleri* (Rauzer-Chernousova, 1938)**

Pl. VI, figs 1-7, 10

1938. *Pseudofusulina paramölleri* Rauzer-Chernousova, pp. 139, 159; pl. 5, figs 9-10; pl. 6, figs 1-2.

1958. *Pseudofusulina paramölleri* forma *longa* Shcherbovich in Rauzer-Chernousova & Shcherbovich, p. 43, pl. 4, figs 5-6.

1980. *Pseudofusulina* aff. *paramölleri* Rauzer-Chernousova.—Leven & Shcherbovich, pl. 10, fig. 1.

**Remarks:** Important test characters of the present material are proloculus of 0.12 to 0.20 mm in diameter, tightly coiled two to three fusiform whorls followed by elongate fusiform to fusiform whorls with bluntly pointed poles gradually increasing length and width, and closely spaced septa rather regularly folded throughout the test. By these test characters, the Akiyoshi material is identified with the original one proposed by Rauzer-Chernousova (1938) from the horizon above the *Schwageina* Limestone of the Samara Bend and Trans-Volga region.

**Occurrence and stratigraphic distribution:** Common at B-235 in the *Globifusulina nux* Zone (P-3), and common to abundant at B-240, B-244, and C-55 in the *Globifusulina krotowi* Zone (P-4).

***Sakmarella* sp.**

Pl. VII, figs 12-14

**Remarks:** Forms having more inflated fusiform test and more intensely folded septa than those of *Sakmarella paramölleri* are treated as *Sakmarella* sp. They resemble a little *Sakmarella karagasensis* (Rauzer-Chernousova, 1940), first described from the Sterlitamak Series of Preurals (Rauzer-Chernousova, 1940), but have more inflated test and weaker septal folding. This unnamed species also resembles *Sakmarella lubenbachensis* Davydov in Davydov *et al.*, 2013 proposed from the Zweikofel Formation of the Carnic Alps in the mode of septal folding, but has smaller proloculus, smaller test with thinner wall, and smaller length and width in corresponding whorls.

**Occurrence and stratigraphic distribution:** Rare at B-235 in the *Globifusulina nux* Zone (P-3), and common at B-240 and B-244 in the *Globifusulina krotowi* Zone (P-4).

Genus *Verneuilites* Bensch & Kireeva in Bensch, 1987

**Type species:** *Pseudofusulina urdalensis* Rauzer-Chernousova, 1940, p. 85.

***Verneuilites abnormis* (Rauzer-Chernousova, 1940)**

Pl. VIII, figs 1-5

1940. *Pseudofusulina urdalensis* var. *abnormis* Rauzer-Chernousova, pp. 86, 94-95; pl. 4, figs 3-4.

1949. *Pseudofusulina urdalensis* var. *ovoides* Kireeva, pp. 189-190; pl. 6, figs 7-8.

1961. *Pseudofusulina urdalensis* var. *abnormis* Rauzer-Chernousova.—Grozdilova & Lebedeva, pp. 240-241; pl. 14, fig. 1.

**Remarks:** This species was originally treated as a variety of *Pseudofusulina urdalensis* by its smaller test, smaller length and width in the corresponding outer whorls, and weakly developed axial fillings. On the other hand, thick and regularly folded septa with tall and narrow septal folds are common in *urdalensis* and *abnormis*. By the same mode of septal folding as the original one, similar size and shape of the test, and thickness of septa and wall, the present specimens are assigned to *Verneuilites* and identified as *V. abnormis*, nevertheless axial fillings are distinct in some of the present specimens. *Pseudofusulina urdalensis* var. *ovoides* described by Kireeva (1949) from the Tastuba and Sterlitamak Horizons of Bashkirsk, Preurals is presumed to be a junior synonym of this species by its close similarities to the types of *abnormis*.

**Occurrence and stratigraphic distribution:** Common to rare at B-244, B-363 and C-59 in the *Globifusulina krotowi* Zone (P-4).

***Vernueuilites urdalensis* (Rauzer-Chernousova, 1940)**

Pl. VII, figs 22, 25-28

1940. *Pseudofusulina urdalensis* Rauzer-Chernousova, pp. 85-86, 94; pl. 3, figs 11-12; pl. 4, figs 1-2, 7.  
 1940. *Pseudofusulina plicatissima* Rauzer-Chernousova, pp. 87, 95; pl. 4, figs 5-6; pl. 5, figs 1-3.  
 1949. *Pseudofusulina ordinata* Kireeva, p. 189; pl. 5, figs 1-2; pl. 6, fig. 2.  
 1965. *Pseudofusulina urdalensis* Rauzer-Chernousova.—Rauzer-Chernousova, p. 72, pl. 6, figs 7-8.

**Remarks:** Although the intensity of septal folding is weaker and axial filligs are more developed, illustrated five specimens herein are identified with *Pseudofusulina urdalensis* originally described from the Sterlitamak Horizon (upper Sakmarian) of Preurals (Rauzer-Chernousova, 1940). This species was later designated as the type species of *Vernueuilites* (Bensh, 1987).

Both *Pseudofusulina plicatissima* and *Pseudofusulina ordinata* from the lower Sakmarian of Preurals are not easily distinguished from this species by their slight morphologic differences and are assumed to be conspecific. These forms are thought to belong to a species group of pseudofusulinids referable to *Verneuilites* by their regular, tall, and stout septal folds. The Akiyoshi specimens are not assigned to *Sakamarella* and *Leeina* by their stout and tall septal folds reaching the base of chambers.

**Occurrence and stratigraphic distribution:** Common at B-243 and B-244 in the *Globifusulina krotowi* Zone (P-4).

Genus *Pseudochusenella* Bensh, 1987

**Type species:** *Pseudofusulina pseudopointeli* Rauzer-Chernousova in Shcherbovich, 1969, p. 50.

***Pseudochusenella alamellosa* (Rauzer-Chernousova, 1949b)**

Pl. VII, figs 15-18, 21, 24

- 1949b. *Pseudofusulina bellatula* Korzhenevski, 1940 forma *alamellosa* Rauzer-Chernousova, pp. 122-123, pl. 2, fig. 3.

**Remarks:** This species was proposed by Rauzer-Chernousova (1949b) from the Sterlitamak Horizon (upper Sakmarian) of Preurals as a forma of *Pseudofusulina bellatula*, which was first described as a variety of *Pseudofusulina blochini* by Korzhenevsky (1940). The present specimens are the closest to this species among the known species of pseudofusulinids in their size and shape of the test and the mode of septal folding. Further comparison needs more topotype specimens.

**Occurrence and stratigraphic distribution:** Common at B-238 in the *Globifusulina nux* Zone (P-3); and common to rare at B-240, B-242, and C-60 in the *Globifusulina krotowi* Zone (P-4).

***Pseudochusenella pointeli* (Rauzer-Chernousova, 1940)**

Pl. VII, figs 19-20, 23

1940. *Pseudofusulina lutuginiformis* var. *pointeli* Rauzer-Chernousova, pp. 84, 94, pl. 3, figs 7-10.  
 1978. *Pseudofusulina lutuginiformis pointeli* Rauzer-Chernousova.—Leven & Shcherbovich, p. 118, pl. 19, figs 3-4.

**Remarks:** Illustrated three and several other specimens are identified with the original specimens from the “*Schwagerina* Series” (Rauzer-Chernousova, 1940) by their small proloculus followed by inner three to four tightly coiled whorls, further succeeded by rapidly expanding outer whorls. The size and shape of the test throughout whorls, and regularly folded septa are also common in the present and original specimens. This species is discriminated from *Pseudochusenella alamellosa*, described above, by its more elongate test with smaller proloculus.

**Occurrence and stratigraphic distribution:** Common to rare at B-235 in the *Globifusulina nux* Zone (P-3), and at B-240 and B-243 in the *Globifusulina krotowi* Zone (P-4).

Genus *Praeskinnerella* Bensh, 1987

**Type species:** *Schwagerina guembeli* Dunbar & Skinner, 1937, p. 639.

***Praeskinnerella cushmani* (Chen, 1934)**

Pl. VIII, figs 13-17

1934. *Pseudofusulina cushmani* Chen, pp. 72-73, pl. 6, figs 4-6.  
 par 1998. *Schwagerina cushmani* (Chen).—Zhang & Hong, pl. 12, figs 16, 20, (figs 19, 21: questionable).  
 2009. *Praeskinnerella cushmani* (Chen).—Leven, p. 138, pl. 22, fig. 5.  
 2012. *Schwagerina cushmani* (Chen).—Kobayashi, figs 8.19-8.20.  
 2017. *Praeskinnerella* cf. *cushmani* (Chen).—Kobayashi, p. 142, pl. 48, figs 1-4, 5?.

**Remarks:** The present specimens are closely similar to the types from the Artinskian Swine Limestone of Jiangsu in many respects. Slight differences are larger test with more distinct axial fillings in the former. They are reassigned to *Praeskinnerella* by the intensity and regularity of septal folding like those of primitive forms of *Skinnerella*, as presumed by Leven (2009).

**Occurrence and stratigraphic distribution:** Common to rare at B-105, B-273, B-557, C-44, C-62, C-64, and C-76 in the *Chalaroschwagerina vulgaris* Zone (P-5); and rare at B-234 in the *Paraleeina magna* Zone (P-6).

Genus *Leeina* Galloway, 1933

**Type species:** *Fusulina vulgaris* var. *fusiformis* Schellwien & Dyhrenfurth, 1909, p. 165.

***Leeina asiatica* (Kalmykova, 1967)**

Pl. VIII, figs 19-21

1967. *Pseudofusulina pulla* (Lange, 1925) subsp. *asiatica* Kalmykova, p. 174, pl. 6, figs 1-2.  
 1968. *Pseudofusulina pulla asiatica* Kalmykova.– Sosnina, pp. 129-130, pl. 33, fig. 1 (= Kalmykova, 1967, pl. 6, fig. 1).

**Remarks:** The illustrated two and other axial sections are identified with *Pseudofusulina pulla asiatica* proposed by Kalmykova (1967) from the Darvasian in many respects such as size and shape of the test, mode of the septal folding and development of axial fillings. This species is reassigned to *Leeina*, since the test characters are more related to those of the type species of *Leeina* than of *Pseudofusulina*. The species was originally treated as a subspecies of *Schellwienia pulla* Lange, 1925. However, morphologic comparison between the two is impossible because of incompleteness of two illustrated specimens of Lange from Sumatra due to the abrasion of the outer part of the test.

**Occurrence and stratigraphic distribution:** Common to rare at B-273, C-67, and C-71 in the *Chalaroschwagerina vulgaris* Zone (P-5).

***Leeina callosa* (Rauzer-Chernousova, 1940)**

Pl. VIII, figs 6-12

1940. *Pseudofusulina callosa* Rauzer-Chernousova, p. 95, pl. 5, figs 5-7.  
 1965. *Pseudofusulina callosa* Rauzer-Chernousova.– Rauzer-Chernousova, pp. 71-72, pl. 6, figs 5-6.  
 1975. *Schwagerina callosa* (Rauzer-Chernousova).– Sheng & Sun, p. 17, pl. 6, fig. 22.  
 1980. *Pseudofusulina* aff. *callosa* Rauzer-Chernousova.– Leven & Shcherbovich, pl. 10, fig. 13.  
 2011. *Anderssonites callosus* (Rauzer-Chernousova).– Leven & Gorgij, pl. 1, fig. 3.  
 2013. *Leeina callosa* (Rauzer-Chernousova).– Davydov *et al.*, figs 8.5-8.7.

**Remarks:** Although size and number of whorls of the test are exactly uncertain due to abrasion of the test, axial sections of the present material are referable to *Pseudofusulina callosa* described by Rauzer-Chernousova (1940) from the Sakmarian (Sterlitamak Series) of the western slope of the Urals. They resemble the original ones in size and shape of the test, thickness of the wall in corresponding whorls, and the mode of septal folding. This species was transferred to *Schwagerina* by Sheng & Sun (1975) and to *Anderssonites* by Leven & Gorgij (2011). The present material is also similar to three specimens identified with this species from the Carnic Alps, reassigned to *Leeina* by Davydov *et al.* (2013), in mode of septal folding and development of axial fillings.

**Occurrence and stratigraphic distribution:** Common at B-244, C-55, and C-59 in the *Globifusulina krotowi* Zone (P-4).

***Leeina chihsiaensis* (Lee, 1931)**

Pl. VIII, figs 23-24

1931. *Schellwienia chihsiaensis* Lee, pp. 287-288, pl. 1, figs 2, 2a.  
 1934. *Pseudofusulina chihsiaensis* (Lee).– Chen, pp. 74-75, pl. 9, figs 1-8, 12; pl. 10, fig. 18; pl. 11, fig. 10; pl. 14, figs 11-12.  
 1967. *Pseudofusulina chihsiaensis* (Lee).– Kalmykova, p. 193, pl. 15, fig. 4.  
 2012. *Pseudofusulina chihsiaensis* var. *fragilis* Chen, 1934.– Shi, Yang & Liu, p. 176, pl. 8, figs 1, 3-4.

**Remarks:** Elongate fusiform schwagerinids consist of six to eight whorls with broadly arched to straight periphery and narrowly round to bluntly pointed poles. They are characterized by tightly coiled inner few whorls followed by gradually expanding outer whorls with sharply pointed poles, regularly folded septa, and development of axial fillings. By these features, the present specimens are identified as *Leeina chihsiaensis* originally described by Lee (1931) and subsequently by Chen (1934) from the uppermost part of the Chihsia Limestone of southern Gansu. They also resemble the species described by Kalmykova (1967) from the Darvasian of Darvas in many respects. One specimen of Darvas illustrated has more tightly coiled inner whorls than the Chinese types. *Pseudofusulina chihsiaensis* var. *fragilis* described by Shi *et al.* (2012) from the Zisongian Stage (Asselian) of southern Guizhou is closely similar to the types in its size, shape, and growth pattern of the test, and mode of septal folding.

**Occurrence and stratigraphic distribution:** Common at B-511 and C-62 in the *Chalaroschwagerina vulgaris* Zone (P-5).

***Leeina krafftii* (Schellwien & Dyhrenfurth, 1909)**

Pl. XVII, figs 6-15

1909. *Fusulina krafftii* Schellwien & Dyhrenfurth, p. 169; pl. 13, figs 1-6; pl. 16, figs 1-9.  
 1967. *Pseudofusulina krafftii* (Schellwien & Dyhrenfurth).– Kalmykova, pp. 183-184, pl. 10, figs 1-4.  
 par 1967. *Pseudofusulina krafftii* (Schellwien & Dyhrenfurth).– Leven, pp. 146-147, pl. 10, fig. 6 (non fig. 5 = *Paraleeina* sp.).  
 1990. *Pseudofusulina krafftii krafftii* Schellwien & Dyhrenfurth.– T. Ozawa & Kobayashi, pl. 8, fig. 13.  
 2009. *Leeina krafftii* (Schellwien & Dyhrenfurth).– Leven, p. 138, pl. 22, fig. 3.

**Remarks:** The present specimens are characteristic in subcylindrical test with straight to slightly concave periphery and rounded poles, and dense axial fillings. These characters suggest that they are identified with the original ones of *Fusulina krafftii* from Darvas (Schellwien & Dyhrenfurth, 1909). One specimen identified with *Pseudofusulina krafftii* by Leven (1967) from southeast



Pamir has larger test with longer length than the type material. Another one illustrated by Leven is separated from this species by its larger and shorter subcylindrical test with obtuse poles and larger chamber height, by which it is included into *Paraleeina*.

**Occurrence and stratigraphic distribution:** Abundant to common at A-58, A-59, A-60, B-232, B-234, B-254, B-261, and B-368 in the *Paraleeina magna* Zone (P-6).

Genus *Chalaroschwagerina* Skinner & Wilde, 1965

**Type species:** *Chalaroschwagerina inflata* Skinner & Wilde, 1965, p. 73.

***Chalaroschwagerina compacta* n. sp.**

Pl. XIII, figs 1-7

**Etymology:** From tightly coiled inner whorls of the test.

**Type specimens:** Holotype D2-063127 (axial section, Pl. XIII, fig. 4). Paratypes: four axial sections (D2-060755, Pl. XIII, fig. 1; D2-060793, Pl. XIII, fig. 2; D2-060740, Pl. XIII, fig. 5; D2-060586, Pl. XIII, fig. 6), two sagittal sections (D2-066581, Pl. XIII, fig. 3; D2-054993, Pl. XIII, fig. 7).

**Type locality:** Six localities about 20 m north of Wakatakyaman and 540 to 1,440 m SW to W apart from Wakatakeyama.

**Diagnosis:** Small proloculus followed by 2 to 4 tightly coiled inner whorls with thin wall, then by gradually expanding outer whorls with broadly arched periphery and bluntly pointed poles. Septa weakly and regularly folded for the genus.

**Description:** Test inflated fusiform with broadly arched periphery, slightly convex lateral sides, and bluntly pointed poles, and composed of 7 to 8.5 whorls. Length 5.49 to 7.24 mm, width 3.46 to 4.45 mm, and form ratio about 1.6 to 1.8.

Proloculus small, spherical, and 0.16 to 0.26 mm. Two to four tightly coiled inner whorls are succeeded by outer whorls gradually increasing their length and width (Table 4) and with broadly arched periphery and bluntly pointed poles. Wall thin and of single layer in tightly coiled whorls. Wall of the succeeding whorls gradually increasing its thickness and consisting of tectum and finely alveolar keriotheca, and as thick as 0.10 to 0.15 mm in outer whorls.

Septa closely spaced especially in tightly coiled inner whorls, and weakly and regularly folded for the genus. Septal folds low for the genus. Prenotheca present in the middle whorls by specimens. Tunnel low and narrow, bordered by distinct or rudimentary chomata in tightly coiled whorls. Chomata absent in outer whorls. Axial fillings absent or faintly developed.

**Remarks:** Generic diagnosis of *Chalaroschwagerina* and its comparison with related genera (Skinner & Wilde, 1965, p. 72) suggest that the present specimens are supposed to be more reasonably included into *Chalaroschwagerina* rather than to *Schwagerina*, *Globifusulina*, or *Paraschwagerina* from their thicker

wall, intensity and mode of septal folding, and presence of prenotheca. *Chalaroschwagerina* having tightly coiled inner whorls up to four whorls and rather regularly but weakly folded septa has not been reported, based on which the present specimens are proposed herein as a new species of the genus. This new species is distinguished from *Pseudofusulina cabudcuensis* proposed from the *Pseudofusulina vulgaris* and *Misellina-Brevaxina* zones of Darvas (Kalmykova, 1967) by its larger test with smaller proloculus and greater number of tightly coiled whorls.

**Occurrence and stratigraphic distribution:** Common to rare at B-104, B-300, B-558, C-51, C-62, and C-67 in the *Chalaroschwagerina vulgaris* Zone (P-5).

***Chalaroschwagerina globosa* (Schellwien & Dyhrenfurth, 1909)**

Pl. XIII, figs 8-14, 16-17; Pl. XIV, figs 2-8

1909. *Fusulina vulgaris* var. *globosa* Schellwien & Dyhrenfurth, pp. 164-165, pl. 14, figs 3-7.

1961. *Pseudofusulina globosa* (Schellwien & Dyhrenfurth).—Nogami, pp. 212-213, pl. 9, figs 4-7.

1967. *Pseudofusulina globosa* (Schellwien & Dyhrenfurth).—Kalmykova, pp. 178-179, pl. 8, figs 1-4.

non 1998. *Pseudofusulina vulgaris globosa* (Schellwien & Dyhrenfurth).—Y. Ota, pp. 80-83, pl. 7, figs 1 (= Y. Ota, 1995, pl. 5, fig. 3); 2, 3 (= Y. Ota, 1995, pl. 5, fig. 4), (all = *Pseudofusulina firma* Shamov, 1958).

**Remarks:** This taxon has been treated as an independent species or a subspecies among inflated forms of *Chalaroschwagerina vulgaris* group. However, the strict differentiation is not easy among the group based on the mode of septal folding, proloculus size, wall thickness, and development pattern of prenotheca. In this paper, relatively more inflated forms than *C. vulgaris* are provisionally classified as *C. globosa*, as done by Kalmykova (1967) and many other authors. On the other hand, *Pseudofusulina vulgaris globosa* described by Y. Ota (1995, 1998) from the Akiyoshi Limestone should be revised to *Pseudofusulina firma*. Accordingly, a part of his *P. vulgaris globosa* Zone assigned to Artinskian is revised to the upper Asselian, as noted above.

**Occurrence and stratigraphic distribution:** Abundant to common at B-104, B-273, B-558, C-44, C-64, C-65, C-69, C-70, and C-75 in the *Chalaroschwagerina vulgaris* Zone (P-5).

***Chalaroschwagerina pulchra* Skinner & Wilde, 1965**

Pl. XII, figs 12-13, 15

1965. *Chalaroschwagerina pulchra* Skinner & Wilde, p. 73, pl. 57, figs 6-7; pl. 58, figs 1-3.

1995. *Chalaroschwagerina inflata* Skinner & Wilde, 1965.—Ueno, pl. 1, figs 3-4.

**Remarks:** This species was assigned by Skinner & Wilde (1965) to *Chalaroschwagerina*, in having large and relatively elongate fusiform test with bluntly pointed poles and well developed pretheca. Two illustrated specimens named as *C. inflata* by Ueno (1995) are transferred to this species. The occurrence of relatively elongate forms of *Chalaroschwagerina* like this species is restricted to a few localities in the mapped area in contrast to much more dominant inflated forms of the genus from many localities.

**Occurrence and stratigraphic distribution:** Common at B-105, and rare at B-104 and C-44 in the *Chalaroschwagerina vulgaris* Zone (P-5).

***Chalaroschwagerina vulgaris* (Schellwien &  
Dyhrenfurth, 1909)**  
Pl. XI, figs 1-17

1909. *Fusulina vulgaris* Schellwien & Dyhrenfurth, p. 163, pl. 14, fig. 1-2.  
1961. *Pseudofusulina vulgaris* (Schellwien & Dyhrenfurth).– Nogami, pp. 210-211, pl. 9, figs 1-3.  
1967. *Pseudofusulina vulgaris* (Schellwien & Dyhrenfurth).– Kalmykova, pp. 179-181, pl. 8, figs 1-6.  
1990. *Pseudofusulina vulgaris vulgaris* (Schellwien & Dyhrenfurth).– T. Ozawa & Kobayashi, pl. 7, figs 11-12.  
1995. *Chalaroschwagerina vulgaris* (Schellwien & Dyhrenfurth).– Ueno, pl. 1, figs 5-6.  
2012. *Chalaroschwagerina vulgaris* (Schellwien & Dyhrenfurth).– Kobayashi, figs 9.4-9.9.

**Remarks:** Morphologic variations of *Pseudofusulina vulgaris* were made clear by Kalmykova (1967) through the reexamination of the topotype specimens from Darvas. So far as the specimens illustrated by her are concerned, this species is supposed to be distinguished from “*Pseudofusulina*” *globosa* by its larger form ratio and bluntly pointed (not rounded) poles throughout the growth of the test. Consulting her view, the present Akiyoshi specimens, and T. Ozawa & Kobayashi (1990)’s and Ueno (1995)’s ones having these characters are safely identified as *Chalaroschwagerina vulgaris*, as well as those from the small limestone block of the Tsunemori Formation (Kobayashi, 2012). However, the discrimination of this species from *C. globosa* is not easy. To make a clear-cut distinction between these two species and taxonomic treatment of *C. globosa* would be entrusted to future works.

**Occurrence and stratigraphic distribution:** Very abundant at B-273, abundant at C-75; and common at B-511, B-558, C-44, C-51, C-69, C-71, and C-75 in the *Chalaroschwagerina vulgaris* Zone (P-5).

***Chalaroschwagerina* sp. A**  
Pl. XII, figs 1-9, 11, 14

Related to:

1958. *Pseudofusulina vulgaris* (Schellwien & Dyhrenfurth)

var. *megaspherica* Toriyama, pp. 170-172, pl. 22, figs 8-17; pl. 23, figs 1-3.

1958. *Pseudofusulina globosa* (Deprat, 1912) var. *exilis* Toriyama, pp. 175-178, pl. 23, figs 7-16; pl. 24, figs 1-20.  
1987. *Chalaroschwagerina paraampla* Zhou, Sheng & Wang, p. 157, pl. 6, figs 4-5.  
1987. *Chalaroschwagerina ampla* (Skinner & Wilde, 1965).– Zhou, Sheng & Wang, pl. 6, fig. 6.  
1990. *Dutkevitchia splendida* (Bensh, 1962).– T. Ozawa & Kobayashi, pl. 7, figs 9-10.  
1995. *Pseudofusulina exilis* Toriyama.– Ueno, pl. 1, figs 1-2.  
1998. *Pseudofusulina* cf. *vulgaris* (Schellwien & Dyhrenfurth).– Y. Ota, pp. 78-80, pl. 6, fig. 10 (= Y. Ota, 1995, pl. 5, fig. 2)  
1998. *Pseudofusulina* aff. *ambigua* (Deprat, 1913).– Y. Ota, pp. 77-78, pl. 6, fig. 9 (= Y. Ota, 1995, pl. 5, fig. 1).

**Remarks:** Eleven specimens illustrated are not strictly discriminated from *Chalaroschwagerina vulgaris* and *C. globosa* described above. They are treated as *Chalaroschwagerina* sp. A. Many other individuals having intermediate biocharacters common to *C. vulgaris* and *C. globosa* were detected in some Akiyoshi samples. They are also dealt with *Chalaroschwagerina* sp. A in this paper. Described species from Akiyoshi listed above are presumed to be more or less similar to *C. vulgaris*, *C. globosa*, or *C. sp. A* in this paper. However, reasonable taxonomic comparison and distinction of them are difficult.

Two specimens illustrated by T. Ozawa & Kobayashi (1990), designated as the zonal species of the “upper Sakmarian” in the Kaerimizu area, should be excluded from *Dutkevitchia* characteristic in the upper Asselian to Sakmarian of western Tethyan regions (e.g. Bensh, 1962; Leven & Shcherbovich, 1978; Leven, 1971, 1995). They are similar to *Chalaroschwagerina* sp. A in their mode and intensity of septal folding. Moreover, “*Paraschwagerina akiyoshiensis*” by T. Ozawa & Kobayashi (1990) from the *Pseudofusulina vulgaris* Zone of the same area should be renamed and reassigned probably to *Chalaroschwagerina*. Two forms listed above, described by Y. Ota (1998) from Akiyoshi, are presumed to be analogous with *Chalaroschwagerina* sp. A, though morphologic variations of them are not distinctly indicated. *Chalaroschwagerina paraampla* proposed by Zhou *et al.* (1987) and *C. ampla* from the upper Cisuralian of eastern Yunnan appear to be more or less related to *Chalaroschwagerina* sp. A. However, taxonomic independency of the former seems to be questionable, and the latter is quite different from the original specimens assigned to *Cuniculinella* by Skinner & Wilde (1965).

**Occurrence and stratigraphic distribution:** Common and partly abundant at B-104, B-105, B-557, B-558, and C-75 in the *Chalaroschwagerina vulgaris* Zone (P-5).

Genus *Paraleeina* Leven in Leven & Vaziri, 2004

**Type species:** *Parafusulina postkrafftii* Leven, 1967, p. 157.

**Remarks:** *Paraleeina* is distinguished from *Parafusulina* and *Skinnerella* by its less regularly folded septa and massive secondary deposits according to Leven in Leven & Vaziri (2004). It is also different from *Leeina* by its more inflated and larger test with thicker wall and more intensely folded septa.

***Paraleeina cubiformis* n. sp.**

Pl. XIV, figs 9-14; Pl. XV, figs 1-3

**Etymology:** From the cubiform test of this new species.

**Type specimens:** Holotype (axial section, D2-063623, Pl. XIV, fig. 10). Paratypes: six axial sections (D2-041414, Pl. XIV, fig. 9; D2-041382, Pl. XIV, fig. 11; D2-041403, Pl. XIV, fig. 12; D2-041415, Pl. XIV, fig. 14; D2-041414, Pl. XV, fig. 1; D2-041404, Pl. XV, fig. 2); one sagittal section (D2-041398, Pl. XIV, fig. 13); and one tangential section (D2-066401, Pl. XV, fig. 3).

**Type locality:** About 815 m WNW (A-59, A-60), 425 m NNW (B-368), 750 m NW (B-414), and 1,375 m W (B-542) of Wakatakeyama, Akiyoshi, Mine City, Yamaguchi Prefecture.

**Diagnosis:** Cubiform test with almost straight periphery, convex lateral sides, and broadly rounded obtuse poles. The test consists of large and irregularly shaped proloculus, and loosely coiled 6 to 7 whorls. Septa regularly, and moderately to intensely folded. Axial fillings moderately to faintly developed.

**Description:** Test cubiform with almost straight periphery, convex lateral sides, and broadly rounded obtuse poles, and consisting of 6 to 7 whorls. Length 5.56 to 6.2? mm, width 4.6? to 5.6? mm, and form ratio about 1.1 to 1.2 (Table 5), though exactly uncertain due to abrasion of the test pierced by veinlets in most specimens.

Size and shape of proloculus variable, and changeable from subspherical to ellipsoidal. Its longer external diameter 0.34 to 0.74 mm. Shape and size of inner whorls are variable depending upon the orientation of axial section cut across a part of proloculus (Table 5). However, the test is loosely coiled throughout growth without distinct juvenile whorls, and length and width gradually increasing outwards. Form ratio in each whorl decreases outward.

Wall made up of tectum and coarse alveolar keriotheca, gradually thickened outward, and as thick as 0.11 to 0.17 mm in the tunnel region of outer whorls. Septa regularly, and moderately to intensely folded. Cuniculi present in an orientation of tangential sections. Prenotheca poorly developed in specimens. Chomata rudimentary on proloculus. Axial fillings moderately to faintly developed.

**Remarks:** Forms having cubiform test with almost straight periphery and broadly rounded obtuse poles almost throughout growth, and large and irregularly shaped proloculus like in the present material are assumed to be rare in the described schwagerinid species referable to *Paraleeina*. Though similar mode of septal folding,

nine illustrated specimens are different from *Paraleeina magna* by their cubiform test with more broadly rounded obtuse poles. Based on these diagnostic characters, they are considered to be a new species of the genus, though broad intraspecific variations are discernible in *P. magna* (see Pls XIV-XVI). This new species is easily discriminated from *Paraleeina toriyamai* n. sp., described below, by having larger and not spherical proloculus, fewer whorls with thicker wall, and weaker development of axial fillings. On the other hand, almost straight periphery of the test, and the mode and intensity of septal folding are more or less similar each other.

**Occurrence and stratigraphic distribution:** Abundant at A-60; and common at A-59, B-368, B-414, and B-542 in the *Paraleeina magna* Zone (P-6).

***Paraleeina magna* (Toriyama, 1958)**

Pl. XIV, fig. 1; Pl. XV, figs 4-12; Pl. XVI, figs 1-6

- 1958. *Pseudofusulina krafftii* var. *magna* Toriyama, pp. 178-181, pl. 25, figs 1-10; pl. 26, figs 1-15.
- 1961. *Pseudofusulina krafftii magna* Toriyama.– Nogami, pp. 216-217, pl. 10, figs 1-4.
- 1990. *Pseudofusulina krafftii magna* Toriyama.– T. Ozawa & Kobayashi, pl. 8, figs 8-9.
- 1995. *Pseudofusulina* ex. gr. *krafftii* (Schellwien & Dyhrenfurth).– Ueno, pl. 1, fig. 8 (figs 7, 9: questionable).
- 2017. *Paraleeina magna* (Toriyama).– Kobayashi, pp. 144, 146, pl. 49, figs 24-29.
- 2019. *Paraleeina magna* (Toriyama).– Kobayashi, p. 70, pl. 6, figs 5-6, 8-9.

**Remarks:** This species is very common in the upper Lower Permian (Artinskian) limestone in the Akiyoshi Terrane and had been treated as a subspecies of *Pseudofusulina krafftii*. It is reassigned as an independent species of *Paraleeina* based on its larger and more inflated test with larger proloculus and thicker wall, and more intensely folded septa than *Pseudofusulina krafftii*. Illustrated specimens herein are surely identified with the Toriyama (1958)'s original ones showing broad morphologic variations, as revealed in the types of this species. One specimen among three illustrated by Ueno (1995) is surely reassigned to this species in its overall test characters similar to the topotype materials.

**Occurrence and stratigraphic distribution:** Abundant at A-58, A-60, B-252, and B-404; and common at A-59, B-251, B-253, B-259, B-261, B-368, B-460, and B-552 in the *Paraleeina magna* Zone (P-6).

***Paraleeina toriyamai* n. sp.**

Pl. XVI, figs 7-11

**Etymology:** Late R. Toriyama for his contribution to fusuline works.

**Type specimens:** Holotype (axial section, D2-057812, Pl. XVI, fig. 10). Paratypes: three axial sections (D2-057803, Pl. XVI, fig. 7; D2-057806, Pl. XVI, fig. 8; B2-



Table 4: Measurements of *Chalaroschwagerina compacta* n. sp.

| Pl./fig. | No. whorls | Length (mm) | Width (mm) | Form ratio | Prolo. (mm) | Length of whorl (mm) |      |      |      |      |      |      |      | Width of whorl (mm) |      |      |      |      |      |      |      |
|----------|------------|-------------|------------|------------|-------------|----------------------|------|------|------|------|------|------|------|---------------------|------|------|------|------|------|------|------|
|          |            |             |            |            |             | 1                    | 2    | 3    | 4    | 5    | 6    | 7    | 8    | 1                   | 2    | 3    | 4    | 5    | 6    | 7    | 8    |
| 13/1     | 8.5        | 7.15?       | 3.98       | 1.80?      | 0.18        | 0.46                 | 0.74 | 1.15 | 1.89 | 2.95 | 4.18 | 5.38 | 6.73 | 0.28                | 0.43 | 0.61 | 0.90 | 1.37 | 2.07 | 2.76 | 3.62 |
| 13/4     | 8.5        | 7.24        | 4.45?      | 1.63?      | 0.16        | 0.37                 | 0.64 | 1.04 | 1.61 | 2.60 | 3.73 | 4.99 | 6.47 | 0.23                | 0.35 | 0.57 | 0.86 | 1.44 | 2.29 | 3.08 | 4.02 |
| 13/5     | 7          | 5.79        | 3.64       | 1.59       | 0.22        | 0.34                 | 0.76 | 1.48 | 2.35 | 3.72 | 4.85 | 5.79 |      | 0.36                | 0.55 | 0.87 | 1.30 | 1.98 | 2.73 | 3.64 |      |
| 13/6     | 8          | 5.49        | 3.2?       | 1.7?       | 0.26        | 0.38                 | 0.69 | 1.04 | 1.61 | 2.31 | 3.07 | 4.21 | 5.49 | 0.33                | 0.43 | 0.59 | 0.90 | 1.36 | 1.90 | 2.47 | 3.2? |
| Pl./fig. | No. whorls | Length (mm) | Width (mm) | Form ratio | Prolo. (mm) | Number of septa      |      |      |      |      |      |      |      | Width of whorl (mm) |      |      |      |      |      |      |      |
|          |            |             |            |            |             | 1                    | 2    | 3    | 4    | 5    | 6    | 7    | 8    | 1                   | 2    | 3    | 4    | 5    | 6    | 7    | 8    |
| 13/3     | 6.8        | —           | 4.13       | —          | 0.22        | 10                   | 17   | 21   | 25   | 32   | 36   | 31>  |      | 0.35                | 0.60 | 0.93 | 1.58 | 2.44 | 3.35 | —    |      |
| 13/7     | 6.2        | —           | 4.14       | —          | 0.24        | 9                    | 18   | 22   | 28   | 36   | 40   | 9>   |      | 0.43                | 0.77 | 1.28 | 2.04 | 3.21 | 3.94 | —    |      |

Table 5: Measurements of *Paraleeina cubiformis* n. sp.

| Pl./fig. | No. whorls | Length (mm) | Width (mm) | Form ratio | Prolo. (mm) | Length of whorl (mm) |      |      |      |      |      |       | Width of whorl (mm) |      |      |      |      |      |       |
|----------|------------|-------------|------------|------------|-------------|----------------------|------|------|------|------|------|-------|---------------------|------|------|------|------|------|-------|
|          |            |             |            |            |             | 1                    | 2    | 3    | 4    | 5    | 6    | 7     | 1                   | 2    | 3    | 4    | 5    | 6    | 7     |
| 14/9     | 7          | 5.82        | 5.1?       | 1.1?       | 0.50        | 0.66                 | 1.24 | 1.53 | 2.65 | 3.69 | 4.77 | 5.82  | 0.74                | 1.24 | 1.81 | 2.61 | 3.06 | 4.02 | 5.1?  |
| 14/10    | 7          | 6.2?        | 5.6?       | 1.1?       | 0.66        | 1.18                 | 1.69 | 2.37 | 3.17 | 4.14 | 5.31 | 6.2?  | 0.93                | 1.45 | 2.12 | 2.86 | 3.79 | 4.80 | 5.6?  |
| 14/12    | 6          | 5.56        | 4.8?       | 1.2?       | 0.74        | 1.23                 | 1.55 | 2.34 | 3.12 | 3.94 | 5.56 |       | 1.11                | 1.73 | 2.37 | 3.18 | 3.93 | 4.8? |       |
| 14/14    | 6.5        | 5.6?        | 4.6?       | 1.2?       | 0.46        | 0.91                 | 1.48 | 2.20 | 3.14 | 4.22 | 4.99 |       | 0.68                | 1.15 | 1.80 | 2.52 | 3.37 | 4.15 |       |
| 15/1     | 7          | 5.93?       | 5.07?      | 1.17?      | 0.51        | 0.76                 | 1.32 | 1.98 | 2.83 | 3.62 | 4.65 | 5.93? | 0.67                | 1.23 | 1.78 | 2.56 | 3.30 | 4.13 | 5.07? |
| 15/2     | 5.5        | —           | —          | —          | 0.34        | 0.73                 | 1.52 | 2.28 | 3.17 | 3.99 |      |       | 0.57                | 0.99 | 1.61 | 2.24 | 3.01 |      |       |
| Pl./fig. | No. whorls | Length (mm) | Width (mm) | Form ratio | Prolo. (mm) | Number of septa      |      |      |      |      |      |       | Width of whorl (mm) |      |      |      |      |      |       |
|          |            |             |            |            |             | 1                    | 2    | 3    | 4    | 5    | 6    | 7     | 1                   | 2    | 3    | 4    | 5    | 6    | 7     |
| 14/13    | 6.2        | —           | 4.7?       | —          | 0.53        | 6                    | 17   | 20   | 28   | 30   | 33   |       | 0.91                | 1.46 | 2.06 | 2.77 | 3.73 | 4.58 |       |

Table 6: Measurements of *Paraleeina toriyamai* n. sp.

| Pl./fig. | No. whorls | Length (mm) | Width (mm) | Form ratio | Prolo. (mm) | Length of whorl (mm) |      |      |      |      |      |      |       | Width of whorl (mm) |      |      |      |      |      |      |       |
|----------|------------|-------------|------------|------------|-------------|----------------------|------|------|------|------|------|------|-------|---------------------|------|------|------|------|------|------|-------|
|          |            |             |            |            |             | 1                    | 2    | 3    | 4    | 5    | 6    | 7    | 8     | 1                   | 2    | 3    | 4    | 5    | 6    | 7    | 8     |
| 16/8     | 8.5        | 6.6?        | 3.8?       | 1.7?       | 0.26        | 0.53                 | 1.10 | 1.70 | 2.41 | 3.08 | 3.83 | 4.66 | 5.9?  | 0.34                | 0.57 | 0.89 | 1.30 | 1.73 | 2.24 | 2.92 | 3.5?  |
| 16/10    | 8.5        | 7.8?        | 4.7?       | 1.7?       | 0.31        | 0.68                 | 1.40 | 2.24 | 3.27 | 4.18 | 5.22 | 6.09 | 7.15? | 0.43                | 0.65 | 1.07 | 1.53 | 2.12 | 2.72 | 3.57 | 4.38? |
| 16/11    | 9.5        | 7.8?        | 4.3?       | 1.8?       | 0.23        | 0.74                 | 1.34 | 2.06 | 3.05 | 3.97 | ?    | ?    | ?     | 0.40                | 0.61 | 0.93 | 1.26 | 1.72 | 2.18 | 2.69 | 4.01  |
| Pl./fig. | No. whorls | Length (mm) | Width (mm) | Form ratio | Prolo. (mm) | Number of septa      |      |      |      |      |      |      |       | Width of whorl (mm) |      |      |      |      |      |      |       |
|          |            |             |            |            |             | 1                    | 2    | 3    | 4    | 5    | 6    | 7    | 8     | 1                   | 2    | 3    | 4    | 5    | 6    | 7    | 8     |
| 16/9     | 7.8        | —           | 3.5?       | —          | 0.26        | 9                    | 14   | 20   | 25   | 32   | 38?  | ?    |       | 0.41                | 0.63 | 0.89 | 1.35 | 1.88 | 2.46 | 3.15 |       |

057822, Pl. XVI, fig. 11); and one sagittal section (D2-057542, Pl. XVI, fig. 9).

**Type locality:** Two localities about 360 m southwest (B-234) and about 570 m west (B-249) of Wakatakeyama, Akiyoshi, Mine City, Yamaguchi Prefecture.

**Diagnosis:** Hexagonal test with straight periphery, almost straight lateral sides, and rounded poles, and with 8.5 to 9.5 whorls. Septa regularly and intensely folded. Axial fillings well developed with x-letter arrangement.

**Description:** Test hexagonal with straight periphery, almost straight lateral sides, and rounded poles, and consisting of 8.5 to 9.5 whorls. Length about 7.8 mm, width about 4.7 mm, and form ratio about 1.7 in the holotype.

Proloculus spherical and its external diameter 0.23 to 0.31 mm. Inner two to three whorls thick fusiform to short ellipsoidal and relatively tightly coiled against later subhexagonal whorls gradually increasing their length and width (Table 6). Roundness of pole increasing outwards.

Wall differentiation not clear in the first to second whorls, beyond which wall consists of tectum and finely alveolar keriotheca. Wall rather thin in comparison with chamber height throughout whorls and as thick as 0.07 to 0.11 mm in the tunnel region of outer whorls.

Septa closely spaced in inner few whorls, and regularly and moderately to intensely folded. Septal folds tall and some are in contact with the base of chambers. Tunnel low and narrow in inner few whorls. Chomata rudimentary on proloculus and in inner one or two whorls. Axial fillings well developed with x-letter arrangement.

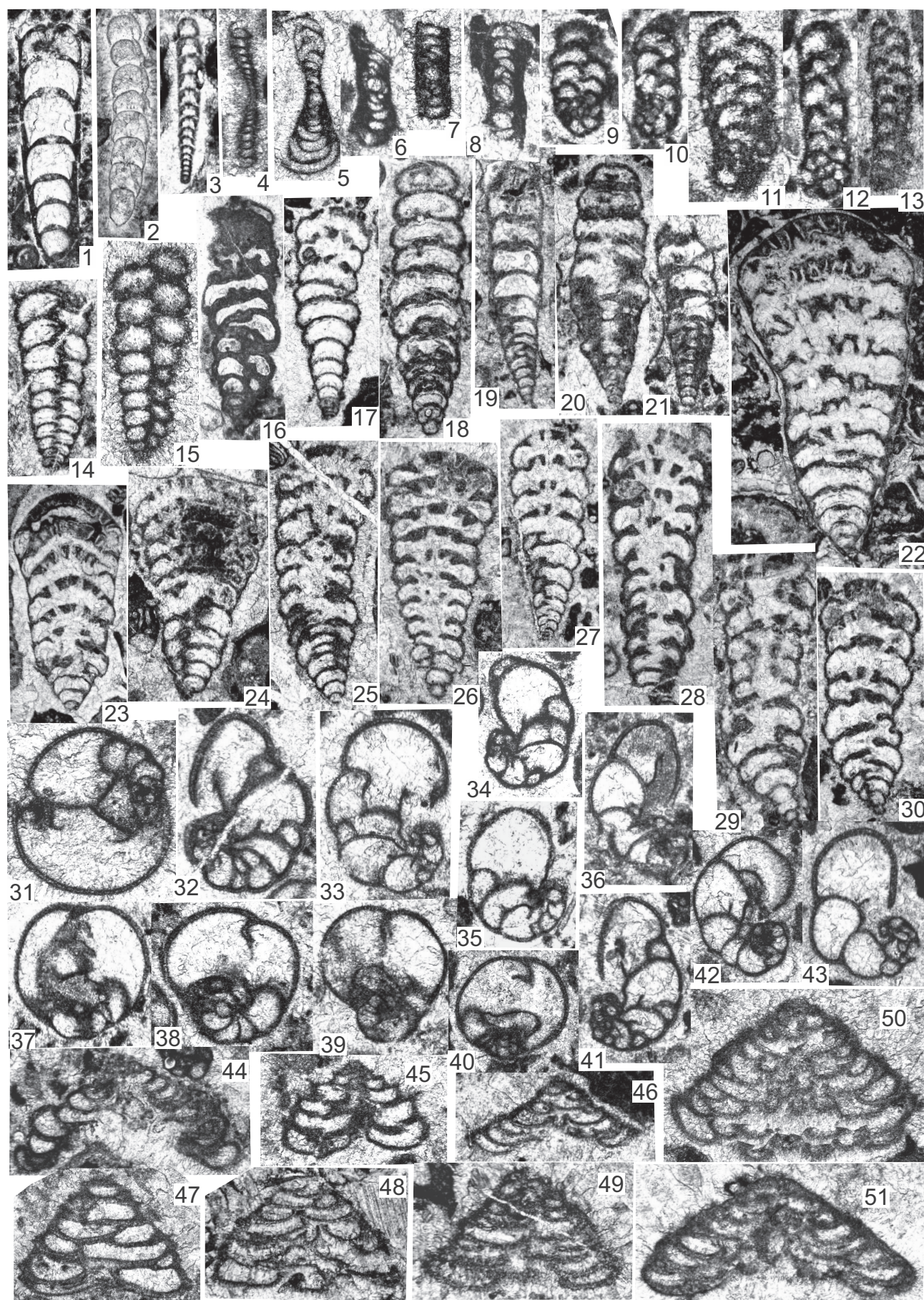
**Remarks:** This new species is discriminated from *Paraleeina magna* by its almost straight periphery not only in outer whorls but also in inner whorls, smaller proloculus, thinner wall both in inner and outer whorls. Among the described species, it is similar to one specimen named as *Pseudofusulina krafftii* by Leven (1967, pl. 10, fig. 5), though slightly deformed, from the Artinskian of southeast Pamir. However, the former is distinguished from the latter by its hexagonal test, relatively tightly coiled inner few whorls, and more strongly folded septa. This new species is unrelated to *Paraleeina akiyoshiensis* proposed by Kobayashi (2019) from the Roadian (*Cancellina pamirica* Zone and the basal part of the *Parafusulina kerimizensis* Zone) of the Akiyoshi Limestone by its hexagonal test, spherical and smaller proloculus, and more weakly folded septa.

**Occurrence and stratigraphic distribution:** Common at B-249 and rare at B-234 in the *Paraleeina magna* Zone (P-6).

#### Plate I

- Fig. 1: *Pseudolangella?* sp. D2-057941, B-259 (P-6).  
 Fig. 2: *Protonodosaria* sp. D2-058013, B-262 (P-6).  
 Fig. 3: *Nodosinelloides* sp. D2-060652, C-55 (P-4).  
 Fig. 4: *Turrispiroides multivolatus* (Reitlinger, 1950). D2-060742, C-62 (P-5).  
 Fig. 5: *Cornuspira?* sp. D2-063544, B-362 (P-6).  
 Figs 6-8: *Hemigordius discoides* Lin, Li & Sun, 1990. 6: D2-057828, B-250 (P-6); 7: D2-060714, C-59 (P-4); 8: D2-057830, B-250 (P-6).  
 Figs 9-10: *Spireitlina* sp. 9: D2-060938, C-79 (P-5); 10: D2-060940, C-77 (P-5).  
 Figs 11-13: *Spireitlina conspecta* (Reitlinger, 1950). 11: D2-063202, B-311 (P-8); 12: D2-061248, C-116 (*Alpinoschwagerina nagatoensis* Zone); 13: D2-060585, C-51 (P-5).  
 Figs 14-15: *Textularia longissima* Reitlinger, 1950. 14: D2-063181, B-308 (P-6); 15: D2-057506, B-232 (P-6).  
 Figs 16-17: *Palaeotextulariidae* gen. and sp. indet. 16: D2-05725, B-233 (P-6); 17: D2-060648, C-55 (P-4).  
 Figs 18-21: *Deckerella* aff. *elegans artiensis* Morozova, 1949. 18: D2-065975, B-489 (P-6); 19: D2-063542, B-362 (P-5); 20: D2-063176, B-308 (P-6); 21: D2-057538, B-234 (P-6).  
 Fig. 22: *Climacammina* sp. A. D2-060776, C-64 (P-5).  
 Figs 23-24: *Climacammina gigas* Suleimanov, 1949. 23: D2-060501, C-44 (P-5); 24: D2-057726, B-243 (P-4).  
 Figs 25-27: *Climacammina* spp. 25: D2-057548, B-234 (P-6); 26: D2-063529, B-360 (P-5); 27: D2-060609, C-54 (P-6).  
 Figs 28-30: *Climacammina fragilis* Reitlinger, 1950. 28: D2-063179, B-308 (P-6); 29: D2-0633848, B-402 (P-6); 30: D2-060617, C-54 (P-6).  
 Figs 31, 37-40: *Globivalvulina laxa* Lin, Li & Sun, 1990. 31: D2-057972, B-261 (P-6); 37: D2-057516, B-232 (P-6); 38: D2-063179, B-308 (P-6); 39: D2-05702, B-254 (P-6); 40: D2-066486, B-552 (P-6).  
 Figs 32-35: *Globivalvulina* sp. A. 32: D2-060601, C-54 (P-6); 33: D2-057999, B-261 (P-6); 34: D2-066411, B-543 (P-6); 35: D2-064187, B-457 (P-6).  
 Figs 36, 41-43: *Globivalvulina* sp. B. 36: D2-066414, B-543 (P-6); 41: D2-063893, B-405 (P-6); 42: D2-066213, B-515 (P-5); 43: D2-063885, B-404 (P-6).  
 Fig. 44: *Polytaxis* sp. D2-057975, B-261 (P-6).  
 Figs 45, 47-49: *Tetrataxis* cf. *paraconica* Reitlinger, 1950. 45: D2-055750, B-234 (P-6); 47: D2-065997, B-492 (P-6); 48: D2-066519, B-554 (P-5); 49: D2-066290, B-527 (P-4).  
 Fig. 46: *Tetrataxis postminima* Potievskaya, 1962. D2-057511, B-232 (P-6).  
 Figs 50-51: *Tetrataxis conica* Ehrenberg, 1854. 50: D2-057996, 51: D2-057993, both B-261 (P-6).





scale bar = 0.5 mm

2 1, 16-18, 20, 22-30 19 14-15, 21, 40, 47-48  
5, 13, 32-39, 41-46, 49-51 3-4, 6-12, 31



***Paraleeina* sp.**

Pl. IX, figs 22-25

**Description:** Test short subcylindrical with straight periphery, almost straight to slightly convex lateral sides, and bluntly pointed poles, and consisting of 7 to 8 whorls. Length more than 7.6 mm, width about 3.85 mm in the specimen shown in Pl. IX, fig. 22, but exactly uncertain due to abrasion of the test in others.

Proloculus spherical in general and its external diameter 0.25 to 0.32 mm. Inner one to two whorls inflated fusiform and succeeded by outer elongate fusiform whorls. Further outer whorls become short subcylindrical with straight periphery and bluntly pointed poles.

Wall is as thick as 0.06 to 0.12 mm in the tunnel region, but uncertain in most specimens due to dense, additional secondary deposits. Septa moderately to intensely folded. Chomata rudimentary on proloculus and in inner one or two whorls. Axial fillings well developed.

**Remarks:** The present specimens are distinguished from *Leeina fusiformis* (Schellwien & Dyhrenfurth, 1909) by their larger and subcylindrical test with more developed axial fillings. Concerning axial fillings completely filling the polar regions throughout the test, this unnamed species is similar to *Leeina krafftii*, but has shorter subcylindrical test. It is distinguished from *Paraleeina toriyamai* by its larger form ratio throughout whorls.

**Occurrence and stratigraphic distribution:** Common at B-234, B-249, and B-461 in the *Paraleeina magna* Zone (P-6).

Genus *Parafusulina* Dunbar & Skinner, 1931

**Type species:** *Parafusulina wordensis* Dunbar & Skinner, 1931, p. 258.

***Parafusulina solidissima*  
(Rauzer-Chernousova, 1949b)**

Pl. VIII, figs 28, 30

1949b. *Parafusulina solidissima* Rauzer-Chernousova, pp. 158-159, pl. 11, figs 5-8.

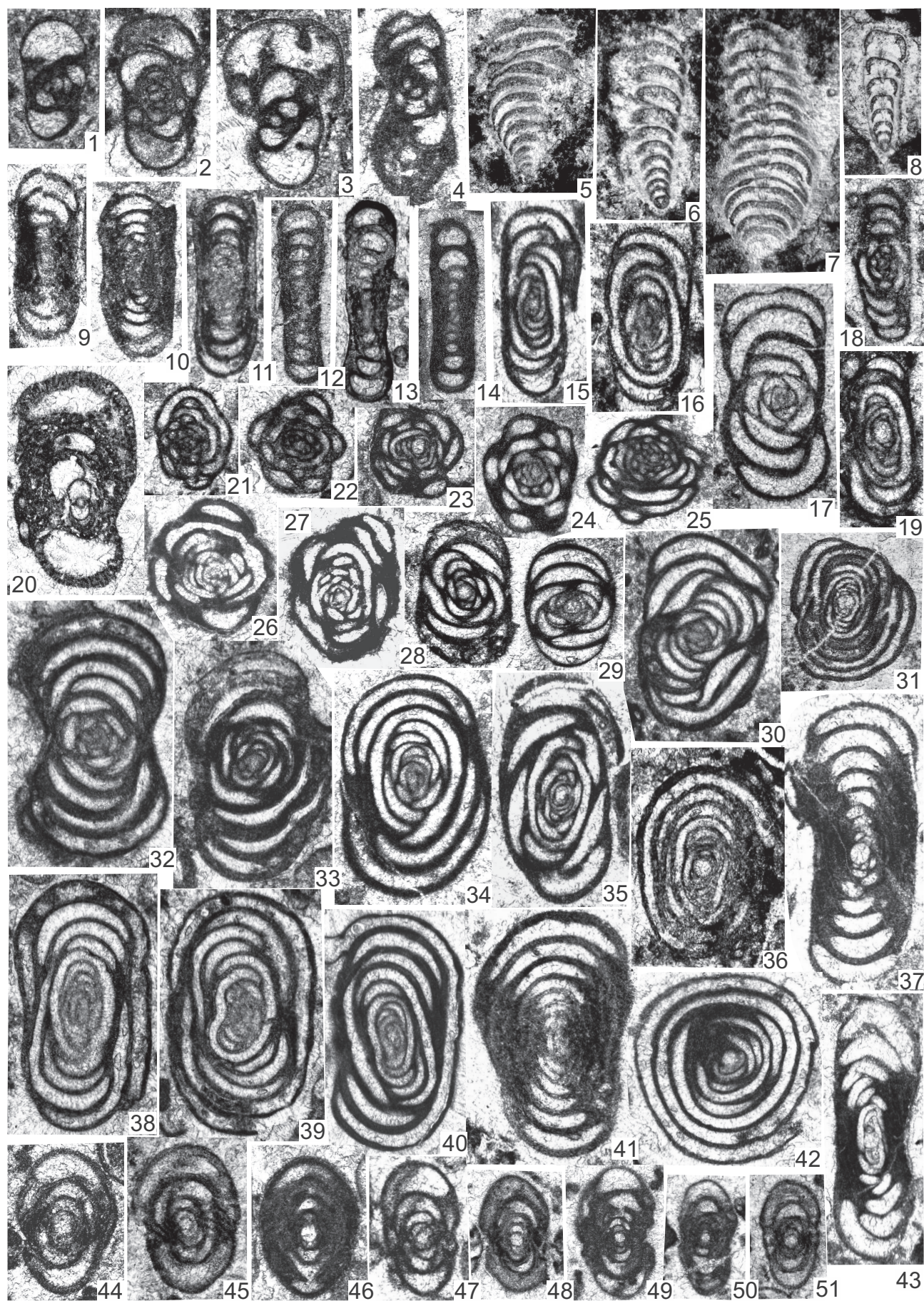
1967. *Parafusulina kaerimizensis* (Y. Ozawa, 1925) subsp. *brevis*, Kalmykova, pp. 208-209, pl. 25, fig. 5; pl. 26, figs 1-2.

**Remarks:** Illustrated two axial, and other incomplete axial and oblique sections are similar to *Parafusulina solidissima* described from the upper Artinskian (Irgina Horizon) of Bashkirsk, Preurals (Rauzer-Chernousova, 1949b) except for somewhat weaker septal folding. Three specimens of *Parafusulina kaerimizensis brevis*, illustrated by Kalmykova (1967) from Darvas are different from *P. kaerimizensis* by their smaller test with smaller number of whorls, absence of inner whorls with relatively thin wall, and weaker septal folding. The

## Plate II

- Figs 1-2: *Endothyra* sp. 1: D2-058008, B-262 (P-6); 2: D2-066637, B-565 (P-4).  
 Figs 3-4: *Endothyra irregularis* Reitlinger, 1950. 3: D2-060842, C-71 (P-5); 4: D2-057852, B-251 (P-6).  
 Figs 5-7: *Geinitzina* spp. 5: D2-064184, B-457 (P-6); 6: D2-063191, B-310 (P-8); 7: D2-057974, B-261 (P-6).  
 Fig. 8: *Pachyphloia*? sp. D2-041393, A-59 (P-6).  
 Figs 9-10: *Hemigordius* sp. 9: D2-057992, B-254 (P-6); 10: D2-065996, B-492 (P-6).  
 Figs 11-14: *Hemigordius rotundatus* Wang, 1982. 11: D2-066410, B-543 (P-6); 12: D2-063952, B-414 (P-5); 13: D2-057812, B-249 (P-6); 14: D2-041397, A-59 (P-6).  
 Figs 15-16, 19: *Agathammina ampla* Lin, 1984. 15: D2-057964, 16: D2-057960; both B-261 (P-6); 19: D2-063637, B-369 (P-6).  
 Figs 17, 30, 32-34: *Agathammina* spp. 17: D2-065613, 30: D2-057966, 32: D2-057978, 33: D2-0579686, 34: D2-066481; 17: B-461 (P-6); 30, 32-33: B-261 (P-6); 34: B-552 (P-6).  
 Fig. 18: *Agathammina* sp. A. D2-063629, B-369 (P-8).  
 Fig. 20: *Bradyina* sp. D2-063487, B-353 (*Alpinoschwagerina nagatoensis* Zone).  
 Figs 21-24, 26-27: *Glomomidiella vulgaris* (Lipina, 1949). 21: D2-057951, B-260 (P-6); 22: D2-060621, C-55 (P-4); 23: D2-066491, B-552 (P-6); 24: D2-041408, A-60 (P-6); 26: D2-064196, B-460 (P-6); 27: D2-063585, B-366 (P-6).  
 Fig. 25: *Hemigordiellina*? sp. D2-060687, C-55 (P-4).  
 Figs 28-29: *Agathammina* sp. B. 28: D2-057961, 29: D2-057999, both B-261 (P-6).  
 Fig. 31: Hemigordiopsidae gen. et sp. indet. D2-041375, A-58 (P-6).  
 Figs 35, 38-40: *Agathammina asymmetrica* Han, 1982. 35: D2-066481, 38: D2-057965, 39: D2-057970, 40: D2-057997; 35: B-552 (P-6), others: B-261 (P-6).  
 Fig. 36: *Hemigordiopsis*? sp. D2-057959, B-261 (P-6).  
 Figs 37, 42: *Neohemigordius* aff. *japonicus* (Y. Ozawa, 1925). 37: D2-066388, 42: D2-066405, both B-542 (P-6).  
 Fig. 41: *Neohemigordius*? sp. A. D2-057522, B-232 (P-6).  
 Fig. 43: *Neohemigordius*? sp. B. D2-057947, B-259 (P-6).  
 Figs 44-46: *Praemisellina* cf. *minensis* n. sp. 44: D2-057533, B-234 (P-6); 45: D2-063828, B-398 (P-6); 46: D2-065401, B-439 (P-5).  
 Figs 47-51: *Praemisellina minensis* n. sp. 47: D2-063557, B-363 (P-6); 48: D2-060618, C-55 (P-4); 49: D2-060627, C-55; 50: D2-060640, C-55 (P-4); 51: D2-060617, C-54 (P-6).







Darvas specimens are transferred to this species based on the similarities of size and shape of the test and mode of the septal folding.

**Occurrence and stratigraphic distribution:** Common at B-249 and B-544 in the *Paraleeina magna* Zone (P-6).

***Parafusulina* sp.**

Pl. IX, figs 26-28

**Remarks:** Based on regularly folded septa with low septal folds, this unnamed species is possibly assigned to *Parafusulina*. The wall is somewhat thick for the genus. *Parafusulina* sp. is similar to *Pseudofusulina khabakovi* Leven, 1967 in having the same mode of septal folding, but differs from it by tightly coiled inner few whorls with thinner wall, more regularly and more intensely folded septa, and denser axial fillings.

**Occurrence and stratigraphic distribution:** Common at B-232 and B-552 in the *Paraleeina magna* Zone (P-6).

Genus *Pseudofusulina* Dunbar & Skinner, 1931

**Type species:** *Pseudofusulina huecoensis* Dunbar & Skinner, 1931, p. 257.

***Pseudofusulina norikurensis* Hy. Igo, 1959**

Pl. XVII, figs 1-5

1959. *Pseudofusulina krafftii* (Schellwien) *norikurensis* Hy. Igo, pp. 244-245, pl. 2, figs 1-3.  
 1961. *Pseudofusulina norikurensis* Hy. Igo.– Morikawa & Isomi, p. 21, pl. 15, figs 1-4; pl. 16, figs 1-7.  
 1996. *Pseudofusulina norikurensis* Hy. Igo.– Hh. Igo, p. 636, figs 5.1-5.3.  
 2019. *Pseudofusulina norikurensis* Hy. Igo.– Kobayashi in Kobayashi & Furutani, pp. 147-148, figs 6.2, 6.5-6.6, 7.2-7.6.

**Remarks:** This species was defined by Hy. Igo (1959) as a subspecies of *Pseudofusulina krafftii* by its broadly

arched periphery, greater number of whorls and more intensely folded septa than *Pseudofusulina krafftii*. More or less variable test characters such as size and shape of the test are distinguished in specimens described by Morikawa & Isomi (1961), Hh. Igo (1996), and Kobayashi in Kobayashi & Furutani (2019). The Akiyoshi specimens are similar to these ones from the Jurassic Mino Terrane in many respects. *Schwagerina semilucera granda* proposed by Nogami (1961) from the *Pseudofusulina krafftii magna* subzone of the Atetsu Limestone resembles this species in its size and shape of the test, and development of axial fillings. However, the septa are more intensely and more regularly folded, and the wall is thinner in the Atetsu specimens.

**Occurrence and stratigraphic distribution:** Common at A-58, B-261, B-404, and B-460 in the *Paraleeina magna* Zone (P-6).

***Pseudofusulina dzamantalensis* (Leven, 1967)**

Pl. IX, figs 29-30

1967. *Parafusulina dzamantalensis* Leven, p. 158, pl. 16, figs 1 (= *Paraleeina dzamantalensis* Leven, 2009, p. 138, pl. 26, fig. 10), 2.  
 1992. *Pseudofusulina dzamantalensis* (Leven).– Leven, p. 101, pl. 20, fig. 1.  
 2009. *Pseudofusulina dzamantalensis* (Leven).– Ueno *et al.*, pp. 50-51, figs 8.1-8.4, 9.5.

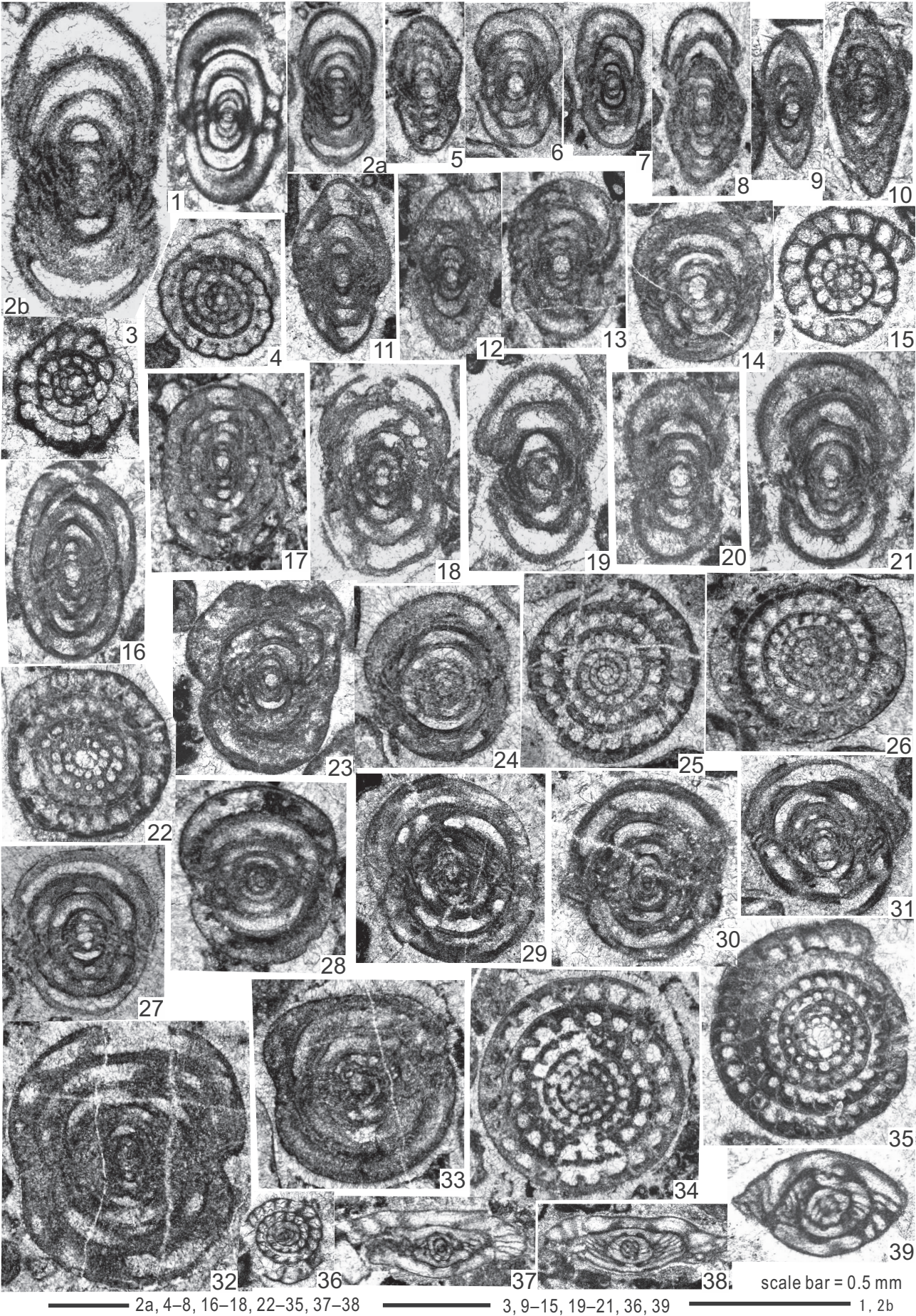
**Remarks:** The illustrated two specimens are similar to *Parafusulina dzamantalensis* proposed from the Artinskian (lower Kubergandian according to Leven, 2009) of southeast Pamir in their size and shape of the test, mode of septal folding relatively weakly folded in tunnel regions, and distinct axial fillings. They are distinguished from *Leeina krafftii* by their more elongate test and larger length and width in corresponding whorls.

**Occurrence and stratigraphic distribution:** Common at B-368 in the *Paraleeina magna* Zone (P-6).

Plate III

- Fig. 1: *Pamirina leveni* Kobayashi, 1977 (same as Pl. V, fig. 49).  
 Figs 2-8: *Praemisellina minensis* n. sp. 2: D2-063833, B-398 (P-6); 3: D2-057895, B-254 (P-6); 4: D2-060654, C-55 (P-4); 5: D2-060646, C-55; 6: D2-060624, C-55; 7: D2-060655, C-55; 8: D2-060619, C-55.  
 Figs 9-12: *Chenella mathildae* (Dutkevich, 1934). 9 D2-063105, B-298 (P-6); 10: D2-063095, B-298; 11: D2-063885, B-404 (P-6); 12: D2-062640, B-261 (P-6).  
 Figs 13-21: *Palaeostaffella yobarensis* (Y. Ozawa, 1925). 13: D2-063550, B-363 (P-4); 14: D2-064064, B-439 (P-5); 15: D2-066444, B-546 (P-6); 16: D2-065783, B-462 (P-6); 17: D2-063618, B-368 (P-6); 18: D2-064064, B-439 (P-5); 19: D2-057903, B-254 (P-6); 20: D2-057534, B-234 (P-6); 21: D2-063854, B-402 (P-6).  
 Figs 22-30: *Palaeostaffella akudensis* (Hh. Igo, 1996). 22: D2-064224, 23: D2-066401, 24: D2-064205, 25: D2-064211, 26: D2-064222, 27: D2-064213, 28: D2-064093, 29: D2-064203, 30: D2-066390, 23, 30: B-542 (P-6); 22, 24-27, 29: B-460 (P-6), 28: B-441 (P-6).  
 Fig. 31-35: *Palaeostaffella subquadrata* Kobayashi, 2019. 31: D2-064203, 32: D2-063202, 33: D2-064208, 34: D2-064201, 35: D2-064217; 31, 33-35: B-460 (P-6); 32: B-311 (P-8).  
 Figs 36-38: *Schubertella kingi* Dunbar & Skinner, 1937. 36: D2-063874, B-404 (P-6); 37: D2-060847, C-71 (P-5); 38: D2-060851, C-71.  
 Fig. 39: *Mesoschubertella* sp. D2-057542, B-234 (P-6).







***Pseudofusulina* cf. *nalivkini* Leven, 1967**

Pl. XVI, figs 12-13

Compare:

1967. *Pseudofusulina nalivkini* Leven, p. 151, pl. 12, figs 5-6.2019. *Pseudofusulina nalivkini* Leven.— Kobayashi in Kobayashi & Furutani, p. 147, figs 3.15-3.16.

**Remarks:** Two specimens illustrated from the Artinskian of the Ryozen Limestone (Kobayashi & Furutani, 2019) were identified with *Pseudofusulina nalivkini* that was originally described from the Artinskian of southeast Pamir (Leven, 1967). They are similar in their size and shape of the test, the mode of septal folding, and development of axial fillings. The Akiyoshi specimens resemble the Ryozen and southeast Pamir ones, but have more rounded periphery of the test.

**Occurrence and stratigraphic distribution:** Common at B-234 and B-261 in the *Paraleeina magna* Zone (P-6).

***Pseudofusulina*? cf. *pavlovi* Leven, 1967**

Pl. IX, figs 19-21

Compare:

1967. *Pseudofusulina pavlovi* Leven, p. 150, pl. 12, figs 3-4.

**Remarks:** The illustrated three axial sections are compared to *Pseudofusulina pavlovi*, originally described by Leven (1967) from the Artinskian and Kubergandian of southeast Pamir, in their elongate fusiform test with straight to slightly concave periphery, somewhat thin wall in comparison with the test size, and rather regularly folded septa. However, inner whorls are more tightly coiled in the present material. This species, questionably assigned to *Pseudofusulina* herein, is distinguished from *Leeina krafftii* by their more tightly coiled and greater

number of initial whorls, smaller proloculus, and thinner wall.

**Occurrence and stratigraphic distribution:** Common at A-59 and B-249 in the *Paraleeina magana* Zone (P-6).

Genus *Paraschwagerina* Dunbar & Skinner, 1936**Type species:** *Schwagerina gigantea* White, 1932, p. 82.***Paraschwagerina fax* (Thompson & Wheeler in Thompson *et al.*, 1946)**

Pl. X, figs 1-7

1946. *Schwagerina fax* Thompson & Wheeler in Thompson *et al.*, p. 27, pl. 1, figs 1-4.1965. *Paraschwagerina fax* (Thompson & Wheeler).— Skinner & Wilde, pp. 68-69, pl. 32, figs 4-8.1990. *Paraschwagerina* sp. ex. gr. *P. mölleri* (Schellwien, 1908).— T. Ozawa & Kobayashi, pl. 8, fig. 6.

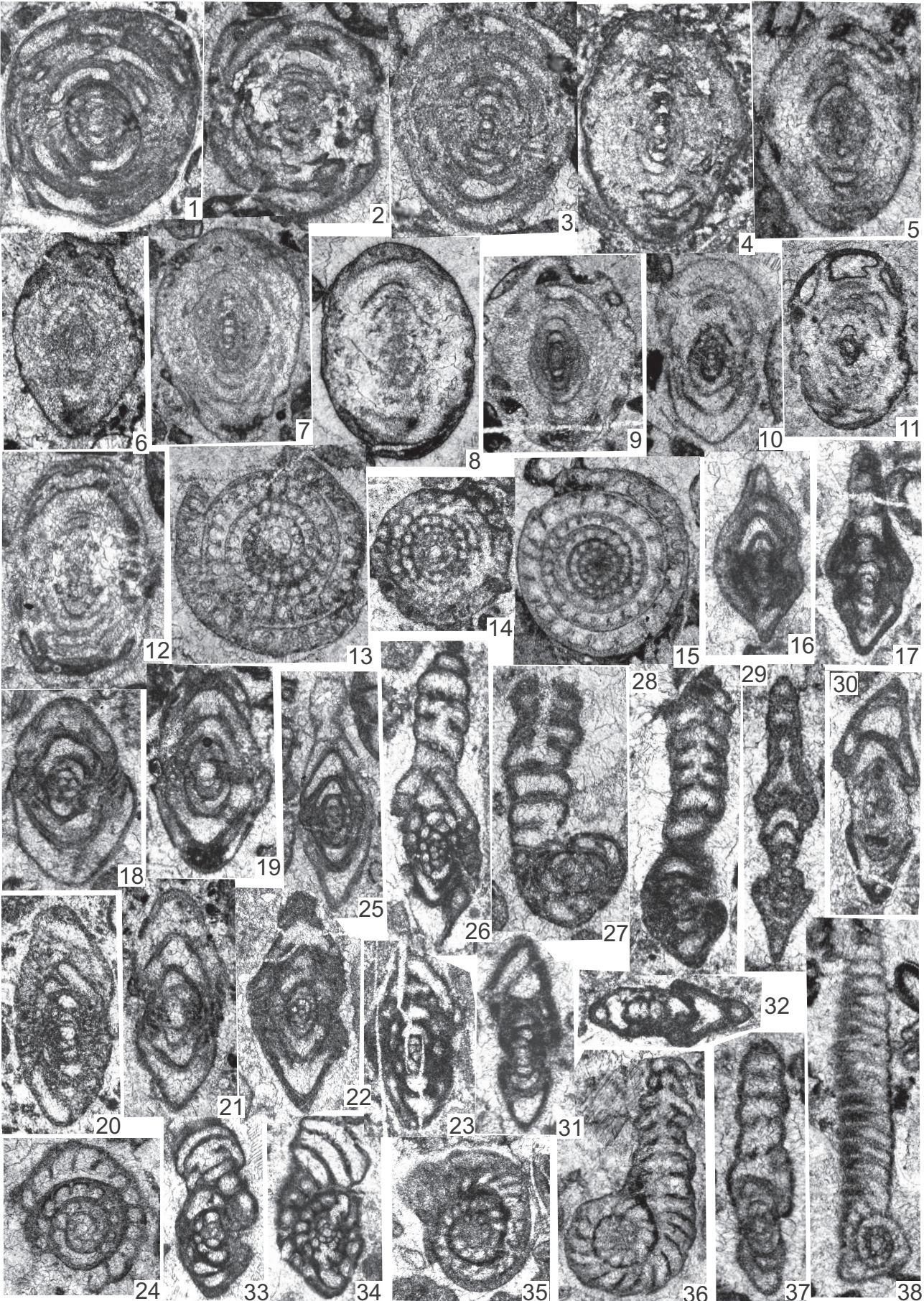
**Remarks:** This species was redefined by Skinner & Wilde (1965) after the reexamination of the original material of Thompson & Wheeler in Thompson *et al.* (1946). The present Akiyoshi specimens are closely similar to the California ones from the McCloud Limestone in many respects such as size and shape, and coiling pattern of the test, strongly folded septa throughout the test, and presence of prenotheca in the median part of the test. One specimen illustrated by T. Ozawa & Kobayashi (1990) from the *Pseudofusulina vulgaris* Zone of Akiyoshi is different from types of *Sakmarella mölleri* (Schellwien, 1908). It is transferred to the present species by the similarity of its growth pattern of the test and mode of septal folding.

**Occurrence and stratigraphic distribution:** Common to rare at B-104, B-373, B-557, B-558, C-44, C-70, and C-71 in the *Chalaroschwagerina vulgaris* Zone (P-5).

## Plate IV

- Fig. 1-2: *Palaeostaffella subquadrata* Kobayashi, 2019. 1: D2-057918, 2: D2-057928, both B-257 (P-6).  
 Fig. 3: *Nankinella?* sp. D2-057949, B-259 (P-6).  
 Figs 4-9, 13, 15: *Nankinella* cf. *nagatoensis* Toriyama, 1958. 4: D2-060517, C-45 (P-4); 5: D2-060566, C-50 (P-5); 6: D2-057723, B-243 (P-4); 7: D2-057883, B-253 (P-6); 8: D2-060573, C-50 (P-5); 9: D2-060692, C-59 (P-4); 13: D2-064196, B-460 (P-6); 15: D2-064092, B-441 (P-6).  
 Figs 10-12, 14: *Staffella* sp. 10: D2-060583, C-51 (P-5); 11: D2-060711, C-59 (P-4); 12: D2-057922, B-257 (P-6); 14: D2-066490, B-552 (P-6).  
 Figs 16-17.: *Pseudoreichelina obiniouensis* (Leven, 1970b). 16: D2-057903, B-254 (P-6); 17: D2-065969, B-488 (P-6).  
 Figs 18-24: *Chenella rhomboides* n. sp. 18: D2-063879, B-404; 19: D2-066406, B-542; 20: D2-057543, B-234; 21: D2-057516, B-232; 22: D2-057846, B-251; 23: D2-063972, B-417; 24: D2-063882, B-404; all P-6.  
 Figs 25-28, 33-34: *Pseudoreichelina darvasica* Leven, 1970b. 25: D2-057872, B-252; 26: D2-057799, B-249; 27: D2-057798, B-249; 28: D2-057877, B-253; 33: D2-057894, B-254; 34: D2-063881, B-404; all P-6.  
 Fig. 29: *Pseudoreichelina* sp. A. D2-063875, B-404 (P-6).  
 Figs 30-32, 35: *Chenella* sp. 30: D2-057843, B-251; 31: D2-063857, B-402; 32: D2-065965, B-488; 35: D2-057842, B-251; all P-6.  
 Fig. 36: *Pseudoreichelina* sp. B. D2-063887, B-405 (P-6).  
 Fig. 37: *Pseudoreichelina discoidea* Ueno, 1992. D2-060617, C-54 (P-6).  
 Fig. 38: *Pseudoreichelina endothyroidea* Ueno, 1992. D2-060579, C-51 (P-5).





scale bar = 0.5 mm

7 15 1-2, 4, 6, 8-11, 13-14, 19-21, 25, 28, 35-36, 38  
3, 5, 12, 16-18, 22-24, 26-27, 30, 32-34 29, 31, 37



Genus *Likharevites* Davydov in Popov *et al.*, 1987  
emend Leven & Gorgij, 2006

**Type species:** *Paraschwagerina? sartauensis* Davydov, 1986b, p. 92.

**Remarks:** Taxonomic definition of *Paraschwagerina* and *Likharevites* is different among Davydov in Popov *et al.* (1987), Davydov *et al.* (2013), Leven & Gorgij (2006), and Leven (2009), as pointed out by Kobayashi (2017). As well as in Kobayashi (2017), forms like *Paraschwagerina akiyoshiensis* Toriyama, 1958 having more irregularly folded septa than those of typical *Paraschwagerina*, are reserved to the genus, and inflated forms having more irregularly and more weakly folded septa are defined as *Likharevites*. Both genera are not strictly differentiated based on the presence or absence and degree of development of prenotheca.

***Likharevites tinvenkiangi* (Lee, 1927)**

Pl. X, figs 13-18

1927. *Schwagerina tinvenkiangi* Lee, p. 121, pl. 23, figs 5-6.

1961. *Paraschwagerina* sp., Nogami, p. 187, pl. 4, fig. 13.

par 1998. *Paraschwagerina* spp., Y. Ota, pp. 98-99, pl. 8, fig. 10 (non 11-13: uncertain).

**Remarks:** Illustrated six specimens are characteristic in minute proloculus followed by tightly coiled four to five whorls with pointed poles. The succeeding inflated

whorls rapidly increase their length and width, and have thin septa weakly and irregularly folded. Although exact size and number of whorls are uncertain due to few well-oriented sections, the present material is identified with *Schwagerina tinvenkiangi* proposed by Lee (1927) from Yatzetsi, Henan. It is different from *Paraschwagerina tinvenkiangi elongata* Leven, 1971 from the Sakmarian of northern Afghanistan (Leven, 1971) in its more weakly and more irregularly folded septa.

Morphologic features of the present material are also found out in *Paraschwagerina* sp. described by Nogami (1961) from the *Pseudofusulina krafftii magna* subzone of the Atetsu Limestone. One specimen of *Paraschwagerina* spp. illustrated by Y. Ota (1998) from the Jigokudai area of Akiyoshi might be also belonging to this species. *Likharevites tinvenkiangi* is easily distinguished from *Alpinoschwagerina nagatoensis* Kobayashi, 2017 from the upper Asselian of the Wakatakeyama area (Kobayashi, 2017) and of the mapped area (Fig. 6.3, 6.4) by thinner wall, more intensely folded septa, and more rapidly expanding outer whorls.

**Occurrence and stratigraphic distribution:** Rare to very rare at B-557, B-558, and C-64 in the *Chalaroschwagerina vulgaris* Zone (P-5); and at B-307 in the *Paraleeina magna* Zone (P-6).

***Likharevites* sp. A**

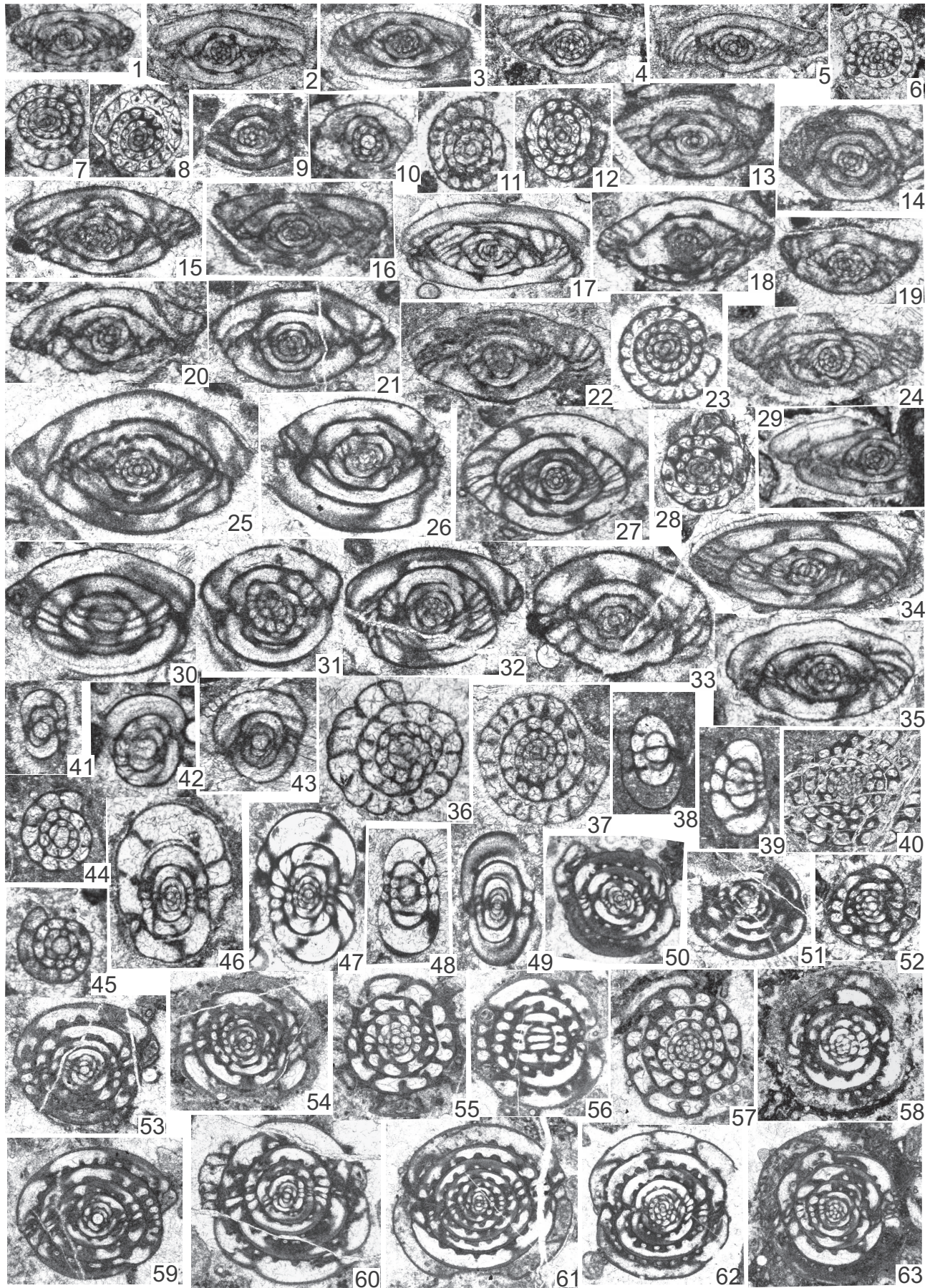
Pl. X, figs 10-12

**Remarks:** In addition to variably and irregularly developed phrenothea, *Likharevites* sp. A is marked

Plate V

- Figs 1-8: *Schubertella kingi* Dunbar & Skinner, 1937. 1: D2-063555, B-363 (P-4); 2: D2-060841; 3: D2-057901, B-254 (P-6); 4: D2-060843; 5: D2-060838; 6: D2-060845; 7: D2-063874, B-404 (P-6); 8: D2-065969, B-488 (P-6); 2, 4-6: C-71 (P-5).
- Figs 9-14: *Schubertella* sp. 9: D2-057614, B-237 (P-3); 10: D2-057718, B-243 (P-4); 11: D2-063172, B-308 (P-6); 12: D2-066301, B-528 (P-4); 13: D2-057616, B-238 (P-3); 14: D2-057757, B-244 (P-4).
- Figs 15-17, 19-20, 22-24, 28-29, 34: *Schubertella exilis* Suleimanov, 1949. 15: D2-060800, C-67 (P-5); 16: D2-057698, B-242 (P-4); 17: D2-060601, C-54 (P-6); 19: D2-057710, B-242 (P-4); 20: D2-057838, B-251 (P-6); 22: D2-057868, B-252 (P-6); 23: D2-063183, B-308 (P-6); 24: D2-060726, C-60 (P-4); 28: D2-065968, B-488 (P-6); 29: D2-060811, C-69 (P-5); 34: D2-060727, C-60 (P-4).
- Figs 18, 21, 25-27, 30-33, 35-37: *Schubertella melonica* Dunbar & Skinner, 1937. 18: D2-057771, B-245 (P-4); 21, 33: D2-065996, B-492 (P-5); 25: D2-063169, B-308 (P-6); 26: D2-063077, B-295 (P-5); 27: D2-057769, B-245 (P-4); 30: D2-063074, B-295 (P-5); 31: D2-063073, B-295 (P-5); 32: D2-060686, C-58 (P-4); 35: D2-063104, B-298 (P-6); 36: D2-063075, B-295 (P-5); 37: D2-057847, B-251 (P-6).
- Figs 38-39, 46-49: *Pamirina leveni* Kobayashi, 1977. 38: D2-063598, 39: D2-063607, 46: D2-065773, 47: D2-065779, 48: D2-065775, 49: D2-065774; 38-39: B-367, others: B-461; all P-7.
- Figs 40, 50-55, 59: *Misellina dyhrenfurthi* (Dutkevich, 1939). 40: D2-064165, 50: D2-063636, 51: D2-063213, 52: D2-063211, 53: D2-063628, 54: D2-063632, 55: D2-063630, 59: D2-063638; 40: B-455; 51-52: B-312; others: B-369; all P-8.
- Fig. 41, 44-45: *Zarodella zhamoidai* Sosnina, 1981. 41: D2-057859, B-252 (P-6), 44: D2-063607, B-367 (P-7); 45: D2-057952, B-260 (P-6).
- Figs 42-43: *Schubertina* sp. 42: D2-060612, C-54 (P-6); 43: D2-057715, B-243 (P-4).
- Figs 56-58, 60-63: *Misellina parvicostata* (Deprat, 1915). 56, 61: D2-063633, 57: D2-063640, 58: D2-063637, 60: D2-063634, 62: D2-063639, 63: D2-063635; all B-369 (P-8).





scale bar = 0.5 mm

56, 61-63      40, 50, 54, 57-58, 60  
1-5, 7-9, 11-16, 19-26, 28-37, 47-49

6, 17-18, 27, 51-53, 55, 59  
10, 38-39, 41-46



by irregularly folded septa producing various-sized and -shaped vesicular chamberlets in middle and outer whorls. It is not assigned to *Acervoschwagerina* in its size and shape of the test and corresponding whorls. *Likharevites* sp. A is somewhat similar to one tangential and one parallel sections compared to *Paraschwagerina stachei* Kahler & Kahler, 1938 by Kochansky-Devidé (1970) from the Sakmarian of Karavanke Mountains, Slovenia. However, the former is distinguished from the latter by having more intensely and more irregularly folded septa, and the presence of distinct prenotheca. *Paraschwagerina* (*Acervoschwagerina*) sp. described by Ishizaki (1962) from the Lower Permian limestone breccia of the Nakakubo Formation (Jurassic Chichibu Terrane, western part of Shikoku) is probably conspecific with the present unnamed species.

**Occurrence and stratigraphic distribution:** Common to rare at B-558, C-71, and C-75 in the *Chalaroschwagerina vulgaris* Zone (P-5).

***Likharevites* sp. B**

Pl. X, fig. 19

**Remarks:** Although exact size and shape of the test are unknown due to few specimens and the absence of well-oriented sections, this unnamed species provisionally assigned to *Likharevites*. *Likharevites* sp. B is discriminated from *Likharevites tinvenkiangi* by its larger test. Other specimens similar to *Likharevites* sp. B are rarely recognized in some other Artinskian samples outside the mapped area in Akiyoshi. These large *Likharevites* in Akiyoshi might be related to two specimens of *Rugososchwagerina globularis* proposed by Qu in Sun *et al.* (1983, pp. 30-31, pl. 8, figs 1-2) from the Maokouan of Gansu in their about five tightly coiled initial whorls, mode of increase of chamber heights in later ontogenetic stage, and thin wall and septa.

Among inflated schwagerinids reported from Japan, these forms appear to be alike to *Likharevites kanmerai* (Nogami, 1961) originally assigned to *Paraschwagerina*, from the Sakmarian of the Atetsu Limestone (Nogami, 1961), in their morphologies such as tightly coiled initial whorls, thin wall, and thin septa. The former, however, has larger test and larger chamber height in outer whorls.

Intensity and mode of septal folding of *L. kanmerai* are similar to those of *Kubergandella* reported from the lower Kubergandian of southeast Pamir (Leven, 1967), Darvas (Davydov in Popov *et al.*, 1987), and Iran (Leven & Gorgij, 2011). However, these two genera are easily distinguishable by their different morphologies of inner whorls.

**Occurrence and stratigraphic distribution:** Rare at B-251 in the *Paraleeina magna* Zone (P-6).

Family Verbeekiniidae Staff & Wedekind, 1910

Subfamily Misellinae Miklukho-Maklay, 1958

Genus *Misellina* Schenck & Thompson, 1940

**Type species:** *Doliolina ovalis* Deprat, 1915, p. 15.

***Misellina dyhrenfurthi* (Dutkevich in Likharev, 1939)**

Pl. V, figs 40, 50-55

- 1939. *Doliolina dyhrenfurthi* Dutkevich in Likharev, p. 42, pl. 4, figs 3-5.
- 1966. *Misellina otai* Sakaguchi & Sugano, pp. 145-147, pl. 1, figs 1-12.
- 1967. *Brevaxina dyhrenfurthi* (Dutkevich).— Kalmykova, pp. 216-217, pl. 30, figs 1-8.
- 1990. *Misellina dyhrenfurthi* (Dutkevich).— T. Ozawa & Kobayashi, pl. 9, figs 1-2.
- 1991b. *Misellina* (*Brevaxina*) *dyhrenfurthi otai* Sakaguchi & Sugano.— Ueno, pp. 981, 983-984, fig. 7.13-25.
- 2019. *Misellina dyhrenfurthi* (Dutkevich).— Kobayashi, p. 73, pl. 16, figs 1-22.

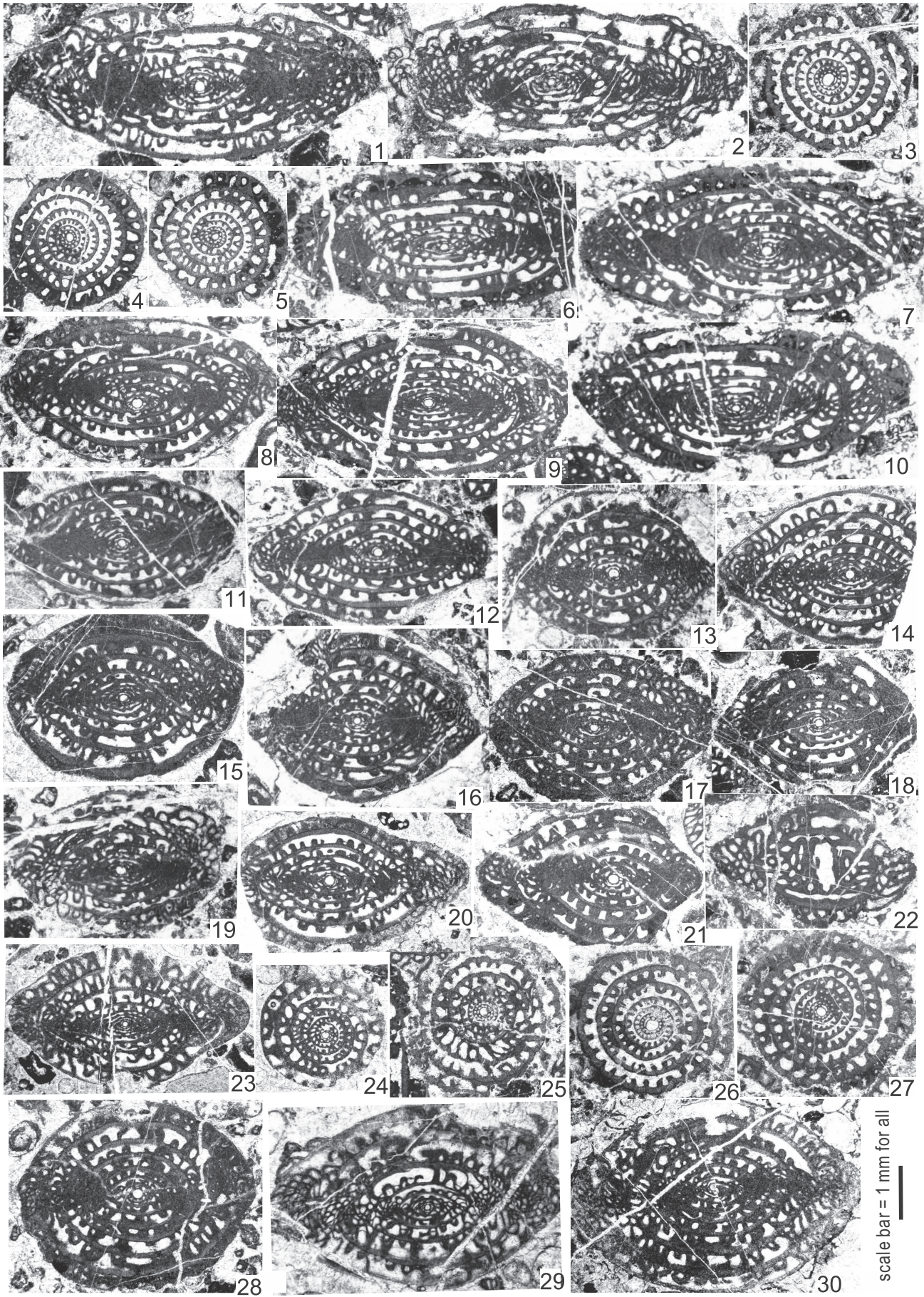
**Remarks:** The specimens illustrated herein are similar to the original three specimens of this species from the upper Lower Permian of Darvas by Dutkevich in Likharev (1939) and later six additional specimens described by Kalmykova (1967). They have larger test than *Misellina otai* Sakaguchi & Sugano, 1966 and *Misellina* (*Brevaxina*) *nipponica* Ueno, 1991b, both of which were proposed from the Kaerimizu area. The latter is somewhat different from this species in its weaker development of parachomata. The former is thought to be a junior synonym of *Misellina dyhrenfurthi*, as suggested by Kobayashi (2019).

**Occurrence and stratigraphic distribution:** Common at B-312, B-369, and B-455 in the *Misellina dyhrenfurthi* Zone (P-8).

Plate VI

- Figs 1-7, 10: *Sakmarella paramöller* (Rauzer-Chernousova, 1938). 1: D2-057569, 2: D2-057752, 3: D2-057762, 4: D2-057757, 5: D2-057748, 6: D2-057747, 7: D2-057735; 10: D2-060653, 1: B-235 (P-3), 10: C-55 (P-4), others: B-244 (P-4).
- Figs 8-9, 11-27: *Globifusulina nux* (Schellwien, 1908). 8: D2-057583, 9: D2-057570, 11: D2-057651, 12: D2-057553, 13: D2-057617, 14: D2-057627, 15: D2-057637, 16: D2-057704, 17: D2-057674, 18: D2-063816, 19: D2-057563, 20: D2-060704, 21: D2-057557, 22: D2-057561, 23: D2-060700, 24: D2-060702, 25: D2-057562, 26: D2-057554, 27: D2-057575; 8-9, 12, 19, 21-22, 25-27: B-235 (P-3); 11, 17: B-240 (P-4); 13-14: B-238 (P-3); 15: B-239 (P-3); 16: B-242 (P-4); 18: B-396 (P-4); 20, 23-24: C-59 (P-4).
- Figs 28-30: *Globifusulina krotowi* (Schellwien, 1908). 28: D2-057648, B-240 (P-4); 29: D2-057712, B-243 (P-4); 30: D2-060663, C-56 (P-4).







***Misellina parvicostata* (Deprat, 1915)**

Pl. V, figs 56-63

1915. *Doliolina parvicostata* Deprat, p. 16, pl. 3, figs 7-9.  
 1975. *Misellina parvicostata* (Deprat).— Sheng & Sun, p. 48, pl. 12, fig. 6.  
 1990. *Misellina parvicostata* (Deprat).— T. Ozawa & Kobayashi, pl. 9, figs 3-4.  
 2019. *Misellina parvicostata* (Deprat).— Kobayashi, pp. 73-74, pl. 16, figs 23-32.

**Remarks:** *Misellina* specimens having larger width in outer whorls and more developed parachomata than those of *Misellina dyhrenfurthi* are named as *M. parvicostata*. The strict distinction between these two species needs more type materials of *M. parvicostata* from the upper Lower Permian of Laos (Deprat, 1915).

**Occurrence and stratigraphic distribution:** Common at B-369 in the *Misellina dyhrenfurthi* Zone (P-8).

## ACKNOWLEDGMENTS

This paper is in focus on the Cisuralian foraminiferal faunas of the Akiyoshi Limestone studied intermittently from late 1990s. The author obtained excellent facilities from Takehiko Haikawa and Masayuki Fujikawa for carrying out the field works of the Akiyoshi Limestone. He is much indebted to Demir Altiner and an anonymous reviewer for their many suggestions that improved the manuscript. Financial support from Grant-in Aid for Scientific Research (C) of Japan Society for promotion of Science in 2013-2015 is thankfully acknowledged for comprehensive arrangement and supplement of fundamental data of the field and laboratory.

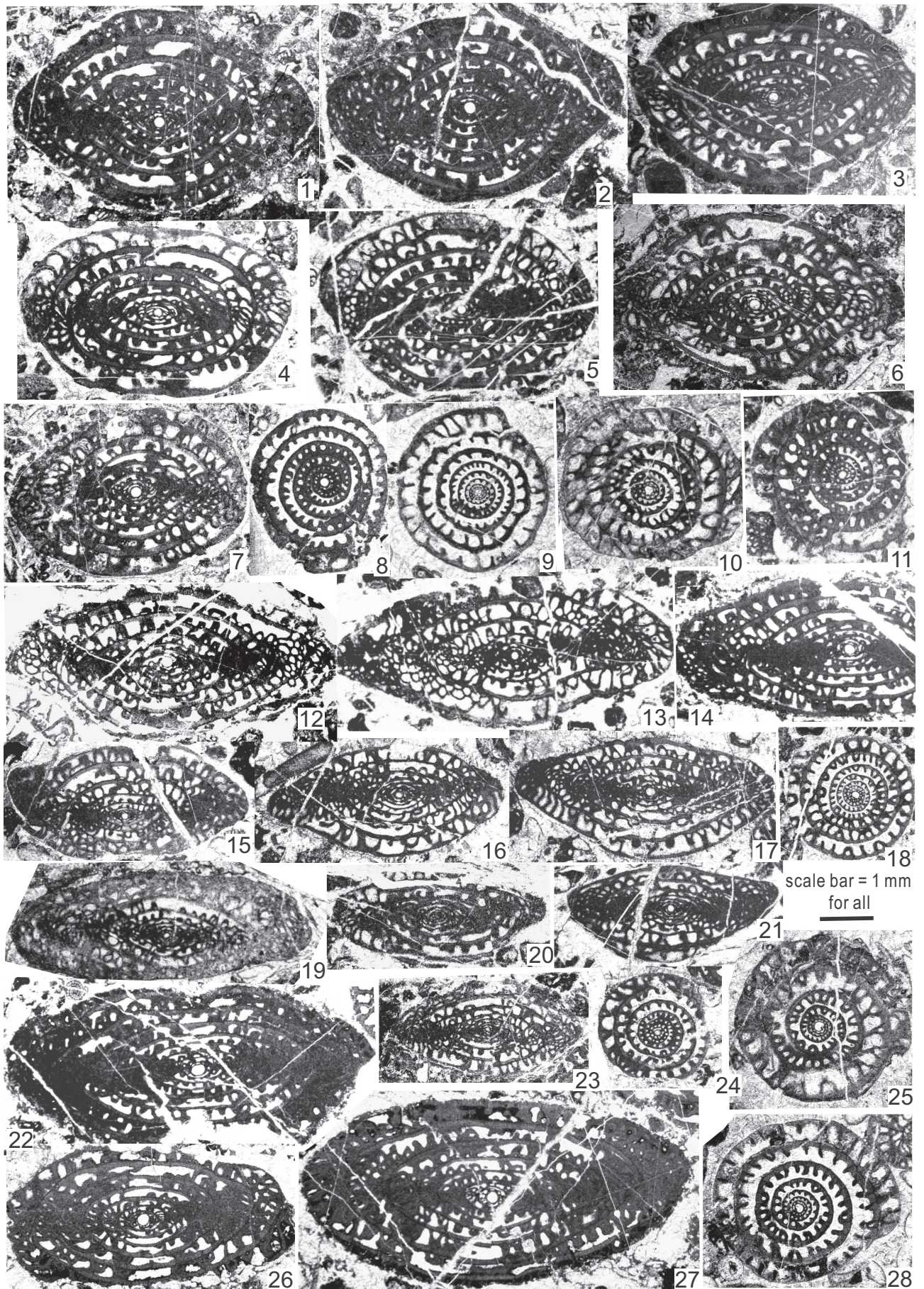
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 Davydov V. I., Krainer K. & Chernykh V. 2013. Fusulinid

## Plate VII

- Figs 1-11: *Globifusulina krotowi* (Schellwien, 1908). 1: D2-057667, B-240; 2: D2-057662, B-240; 3: D2-057655, B-240; 4: D2-063556, B-363; 5: D2-057689, B-240; 6: D2-055707, B-242; 7: D2-060676, C-57; 8: D2-060627, C-55; 9: D2-057724, B-243; 10: D2-057711, B-243; 11: D2-057673, B-240; all P-4.  
 Figs 12-14: *Sakmarella* sp. 12: D-057582, B-235; 13: D2-057657, B-240; 14: D2-057728, B-244; all P-4.  
 Figs 15-18, 21, 24: *Pseudochusenella alamellosa* (Rauzer-Chernousova, 1940). 15: D2-060723, C-60 (P-4); 16-17: D-057625 B-238 (P-3); 18: D-057678, B-240 (P-4); 21: D2-057677 B-242 (P-4); 24: D2-057615, B-238 (P-3).  
 Figs 19-20, 23: *Pseudochusenella pointeli* (Rauzer-Chernousova, 1949b). 19: D2-057727, B-243 (P-4); 20: D2-057677, B-240 (P-4); 23: D2-057552, B-235 (P-3).  
 Figs 22, 25-28: *Verneuilites urdalensis* (Rauzer-Chernousova, 1940). 22: D2-057749, B-244; 25: D2-057713, B-243; 26: D2-057759, B-243; 27: D2-057760, B-244; 28: D2-057719, B-243; all P-4.





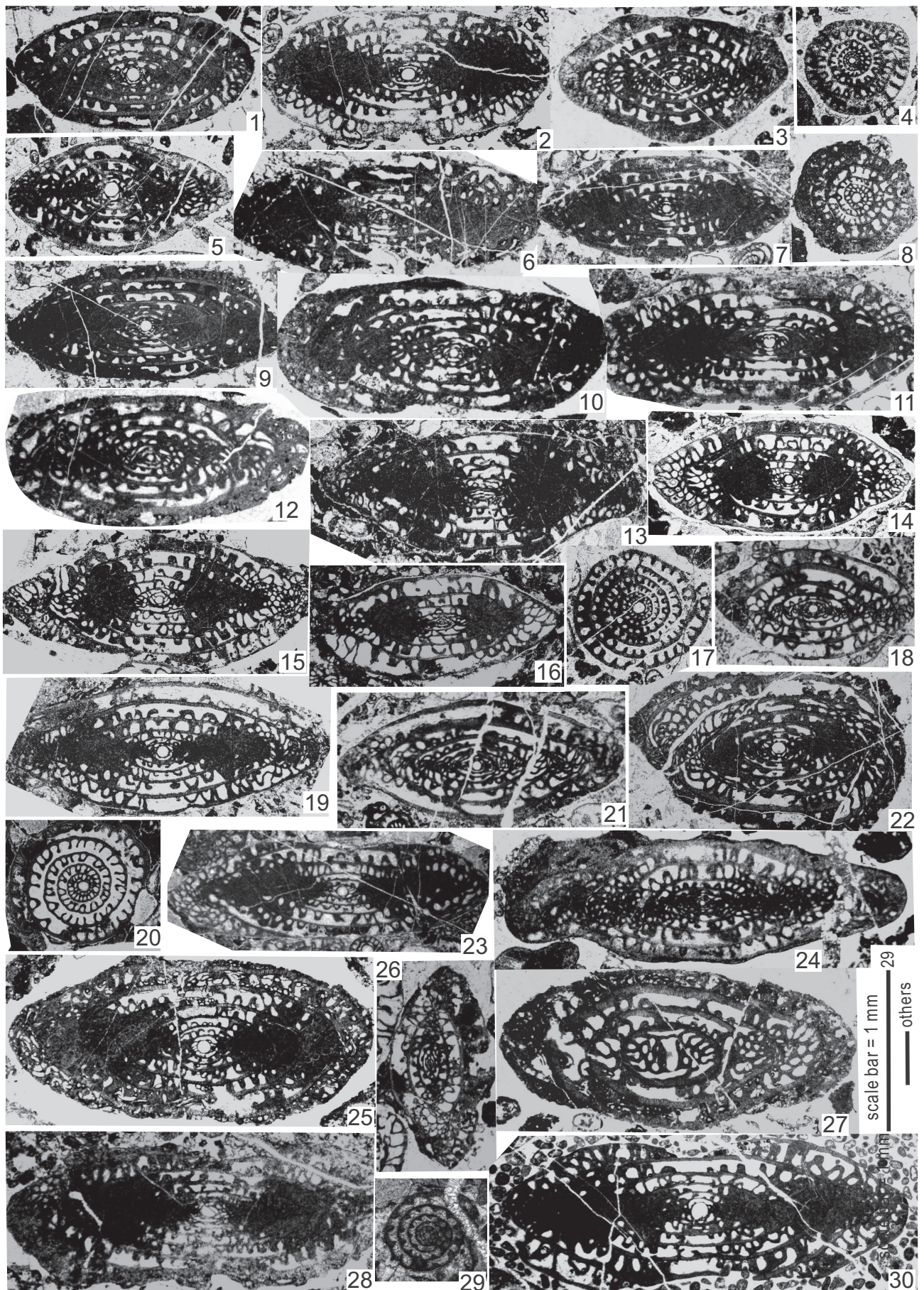


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## Plate VIII

- Figs 1-5: *Verneuilites abnormis* (Rauzer-Chernousova, 1940). 1: D2-057754, 2: D2-063550, 3: D2-060705, 4: D2-060714, 5: D2-060693; 1: B-244; 2: B-363; 3-5: C-59; all P-4.
- Figs 6-12: *Leeina callosa* (Rauzer-Chernousova, 1940). 6: D2-057740, 7: D2-063557, 8: D2-060642, 9: D2-057751, 10: D2-060636, 11: D2-063567, 12: D2-060644; 6, 9: B-244; 7-8, 10, 12: C-55; 11: C-59; all P-4.
- Figs 13-17: *Praeskinnerella cushmani* (Chen, 1934). 13: D2-055029, B-105 (P-5); 14: D2-060490, C-44 (P-5); 15: D2-060913, C-76 (P-5); 16: D2-058197, B-273 (P-5), 17: D2-057543, B-234 (P-6).
- Fig. 18: *Darvasites? ingavati* Hy. Igo, Ueno & Sashida, 1993, D2-060797, C-67 (P-5).
- Fig. 19-21: *Leeina asiatica* (Kalmykova, 1967). 19: D2-060841, C-71 (P-5); 20: D2-058189, B-273 (P-5); 21: D2-060799, C-67 (P-5).
- Fig. 22: *Darvasites* sp. D2-066372, B-539 (P-6).
- Figs 23-24: *Leeina chihsiensis* (Lee, 1931). 23: D2-066184, B-511 (P-5); 24: D2-060749, C-62 (P-5).
- Figs 25, 27: *Verneuilites?* sp. 25: D2-060630, 27: D2-060640; both C-55 (P-4).
- Fig. 26: *Darvasites?* cf. *beitepensis* Leven, 1995, D2-060909, C-76 (P-5).
- Figs 28, 30: *Parafusulina solidissima* Rauzer-Chernousova, 1949b. 28: D2-057819, B-249 (P-6); 30: D2-066424, B-544 (P-6).
- Fig. 29: *Biwaella* sp. D2-066575, B-557 (P-5).





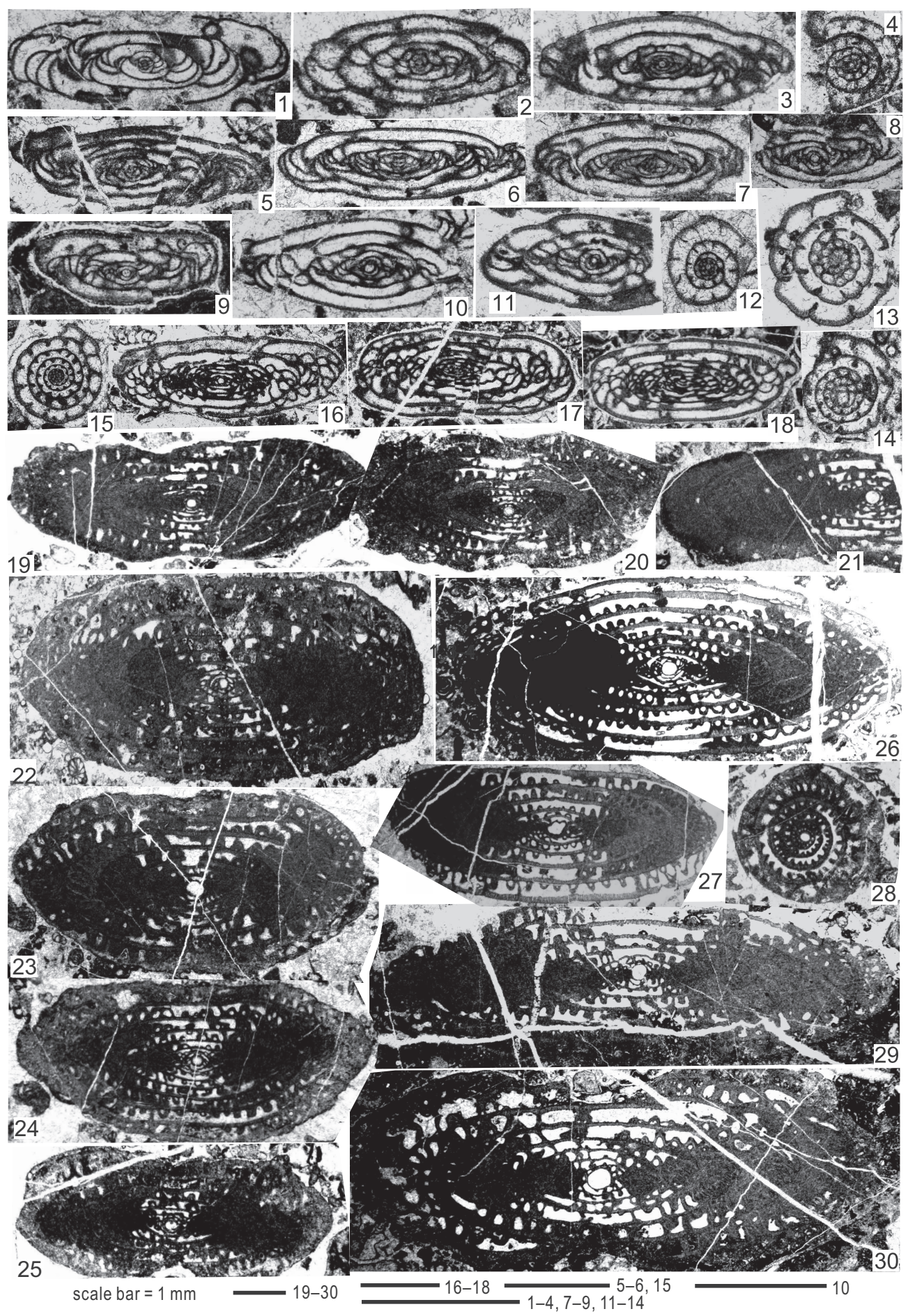


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## Plate IX

- Fig. 1: *Toriyamaia laxiseptata* Kanmera, 1956. D2-063955, B-414 (P-6).
- Figs 2-14: *Biwaella* sp. 2, 4: D2-065975, B-489 (P-6); 3: D2-061267, C-114 (P-5); 5: D2-065976, B-489 (P-6); 6: D2-060681, C-58 (P-4); 7: D2-063560, B363 (P-4); 8: D2-060821, C-70 (P-5); 9: D2-060815, C-69 (P-5); 10: D2-064037, B-434 (P-5); 11: D2-060631, C-55 (P-4); 12: D2-061237, C-114 (P-5); 13: D2-060623, C-55 (P-4); 14: D2-060605, C-54 (P-6).
- Figs 15-18: *Eoparafusulina* cf. *ellipsoidalis* (Toriyama, 1958). 15: D2-055013, 16: D2-055012, 17: D2-055033, 18: D2-060814, C-69 (P-5); 15-17: B-105 (P-5).
- Figs 19-21: *Pseudofusulina*? cf. *pavlovi* Leven, 1967. 19: D2-057825, B-249; 20: D2-057807, B-249; 21: D2-041397, A-59; all P-6.
- Figs 22-25: *Paraleeina* sp. 22: D2-057551, B-234; 23: D2-057532, B-234; 24: D2-057820, B-249; 25: D2-057815, B-249; all P-6.
- Figs 26-28: *Parafusulina* sp. 26: D2-066489, B-552; 27: D2-066487, B-552; 28: D2-057512, B-232; all P-6.
- Figs 29-30: *Pseudofusulina dzamantalensis* (Leven, 1967). 29: D2-063619, 30: D2-063615; both B-368 (P-6).





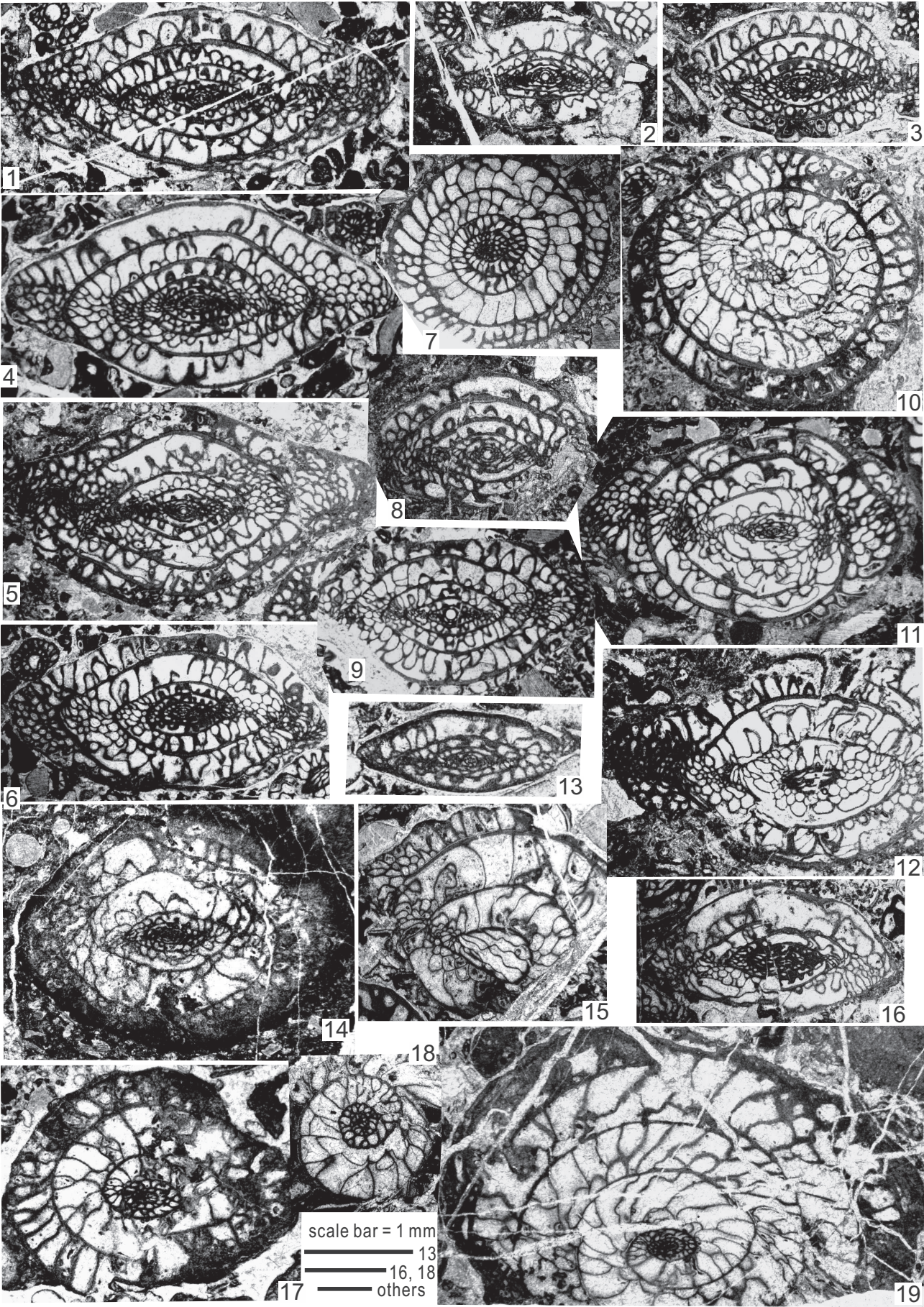


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## Plate X

- Figs 1-7: *Paraschwagerina fax* (Thompson & Wheeler, 1946). 1: D2-054977, B-104; 2: D2-060832, C-70; 3: D2-060510, C-44; 4: D2-060831, C-70; 5: D2-060836, C-71; 6: D2-066548, B-557; 7: D2-066520, B-554; all P-5.
- Figs 8-9: *Chalaroschwagerina* spp. 8: D2-060806, C-68; 9: D2-066576, B-557; both P-5.
- Figs 10-12: *Likharevites* sp. A. 10: D2-060843, C-71; 11: D2-060902, C-75; 12: D2-060850, C-71; all P-5.
- Figs 13-18: *Likharevites tinvenkiangi* (Lee, 1927). 13: D2-060770, C-64; 14: D2-063167, B-307; 15: D2-066589, B-558; 16: D2-066575, B-557; 17: D2-060739, C-62; 18: D2-066588, B-558; 14: P-6, others: P-5.
- Fig. 19: *Likharevites* sp. B. D2-057847, B-251 (P-6).





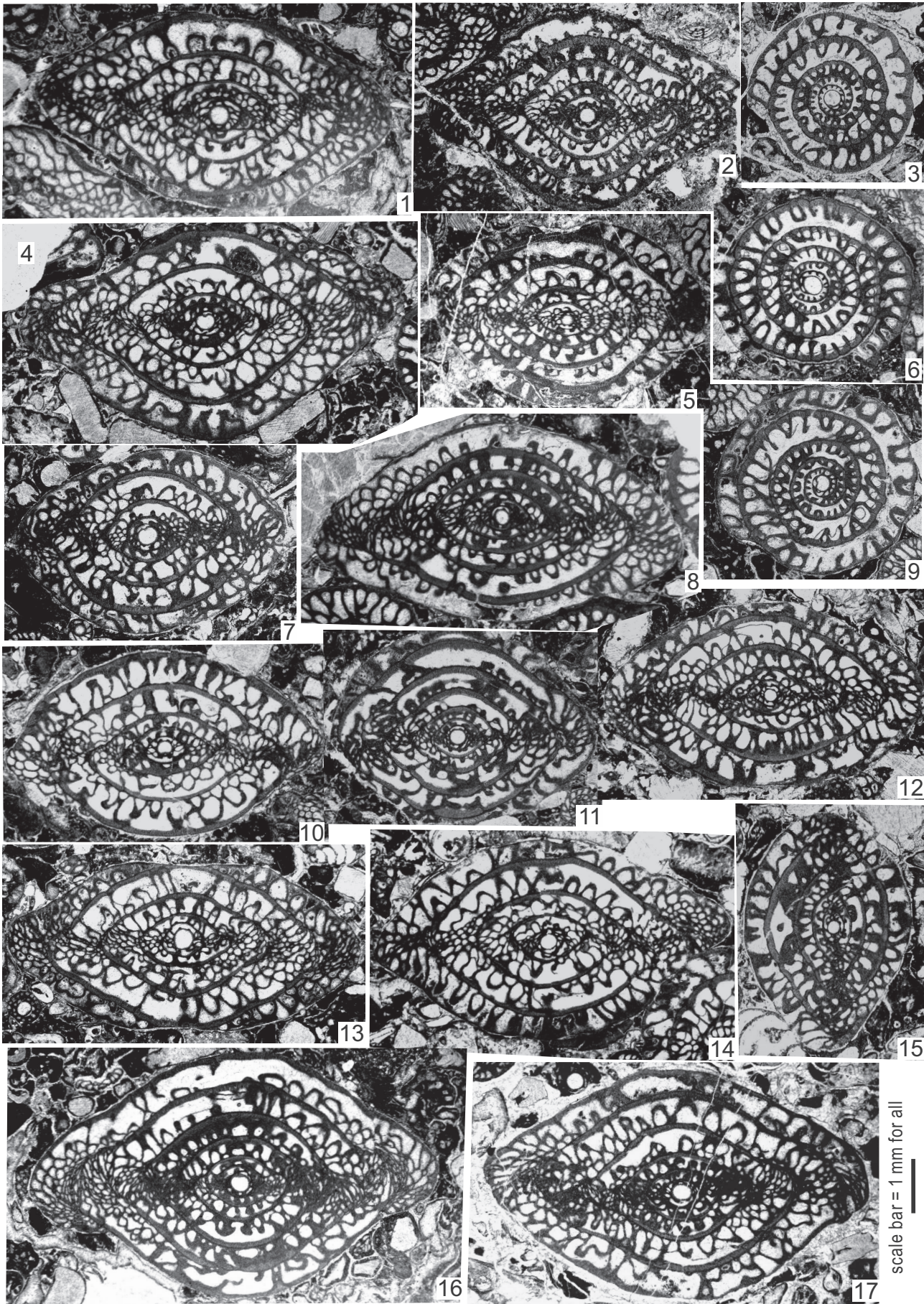


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## Plate XI

Figs 1-17: *Chalaroschwagerina vulgaris* (Schellwien & Dyrenfurth, 1909). 1: D2-058226, B-273; 2: D2-060845, C-71; 3: D2-066577, B-558; 4: D2-058186, B-273; 5: D2-066178, B-511; 6: D2-060879, C-75; 7: D2-058196, B-273; 8: D2-058189, B-273; 9: D2-058192, B-273; 10: D2-060810, C-69; 11: D2-060899, C-75; 12: D2-058205, B-273; 13: D2-058217, B-273; 14: D2-058230, B-273; 15: D2-058232, B-273; 16: D2-069811, C-69; 17: D2-060511, C-44; all P-5.





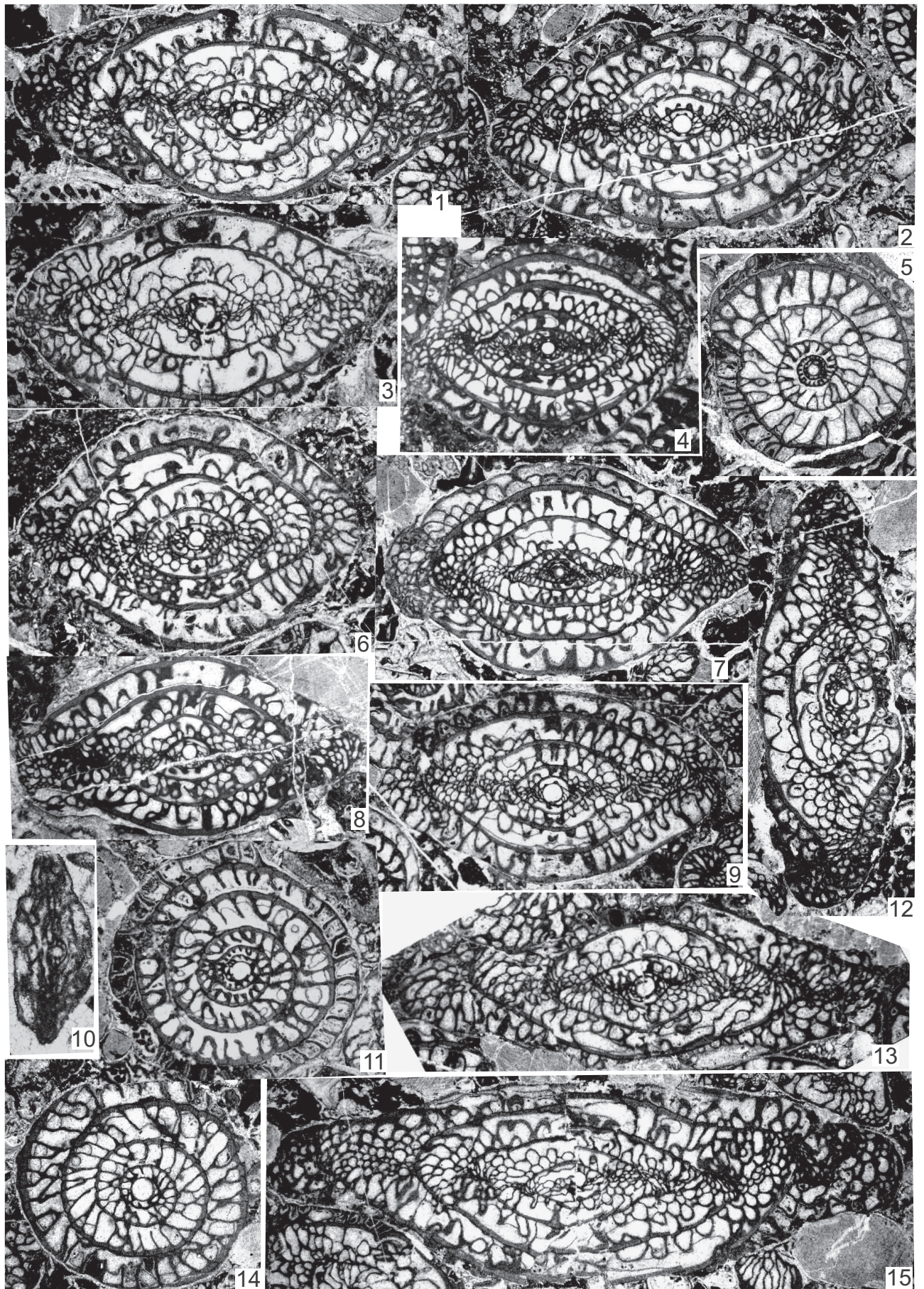


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## Plate XII

- Figs 1-9, 11, 14: *Chalaroschwagerina* sp. A. 1: D2-055013, B-105; 2: D2-054961, B-104; 3: D2-055027, B-105; 4: D2-060900, C-75; 5: D2-054964, B-104; 6: D2-054984, B-104; 7: D2-054967, B-104; 8: D2-066543, B-557; 9: D2-054973, B-104; 11: D2-054960, B-104; 14: D2-055006, B-105; all P-5.
- Fig. 10: *Rugosochusenella* sp. D2-063900, B-406 (P-6).
- Figs 12-13, 15: *Chalaroschwagerina pulchra* Skinner & Wilde, 1965. 12: D2-055024, 13: D2-055018, 15: D2-055026; all B-105 (P-5).





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others



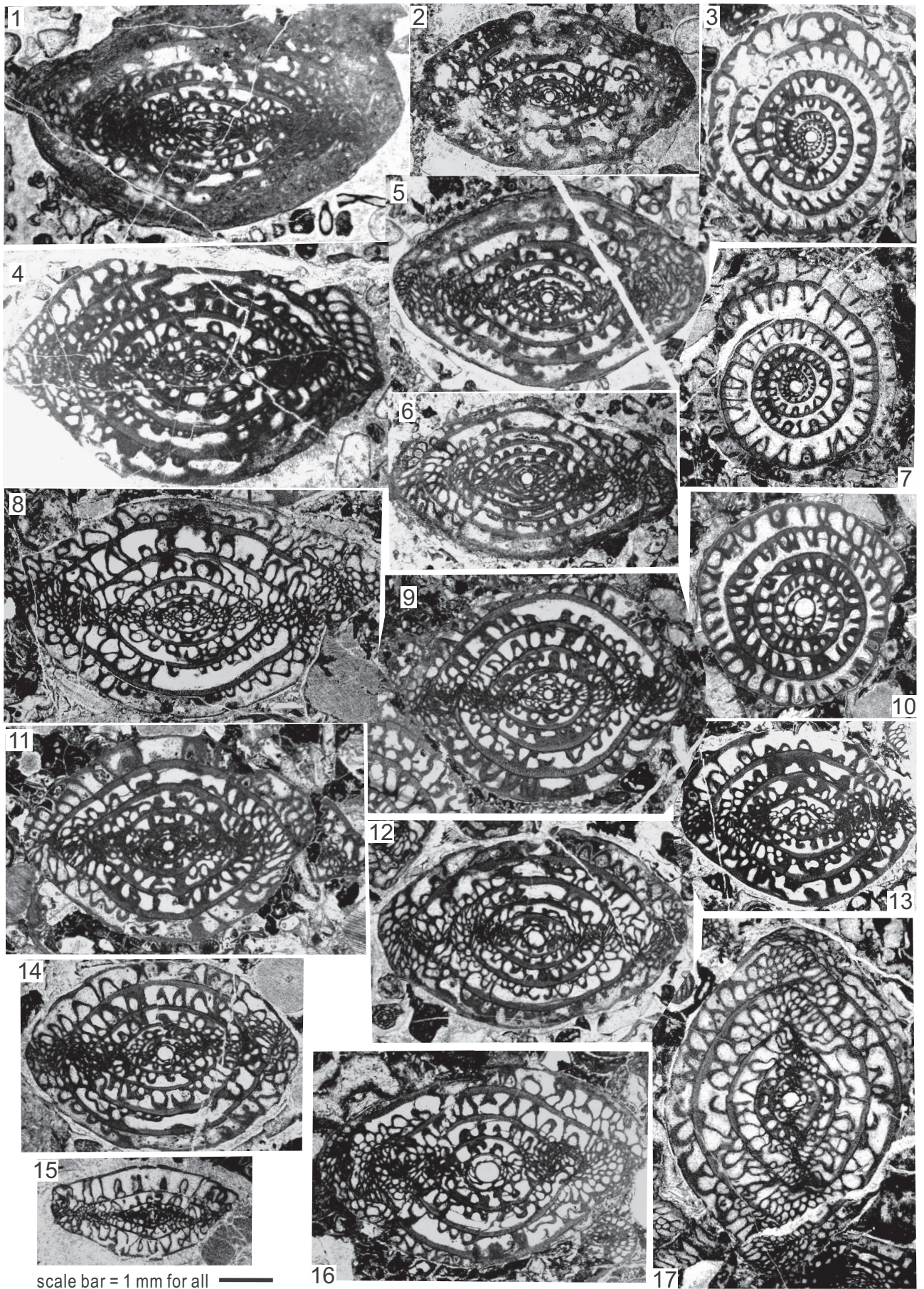
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Plate XIII

- Figs 1-7: *Chalaroschwagerina compacta* n. sp. 1: D2-060755, C-62; 2: D2-060793, C-67; 3: D2-066581, B-558; 4: D2-063127, B-300; 5: D2-060740, C-62; 6: D2-060586, C-51; 7: D2-054993, B-104; all P-5.
- Figs 8-14, 16-17: *Chalaroschwagerina globosa* (Schellwien & Dyhrenfurth, 1909). 8: D2-054969, B-104; 9: D2-060883, C-75; 10: D2-058219, B-273; 11: D2-060783, C-65; 12: D2-060487, C-44; 13: D2-066581, B-558; 14: D2-060504, C-44; 16: D2-058215, B-273; 17: D2-054966, B-104; all P-5.
- Fig. 15: *Likharevites* sp. C. D2-060897, C-75 (P-5).







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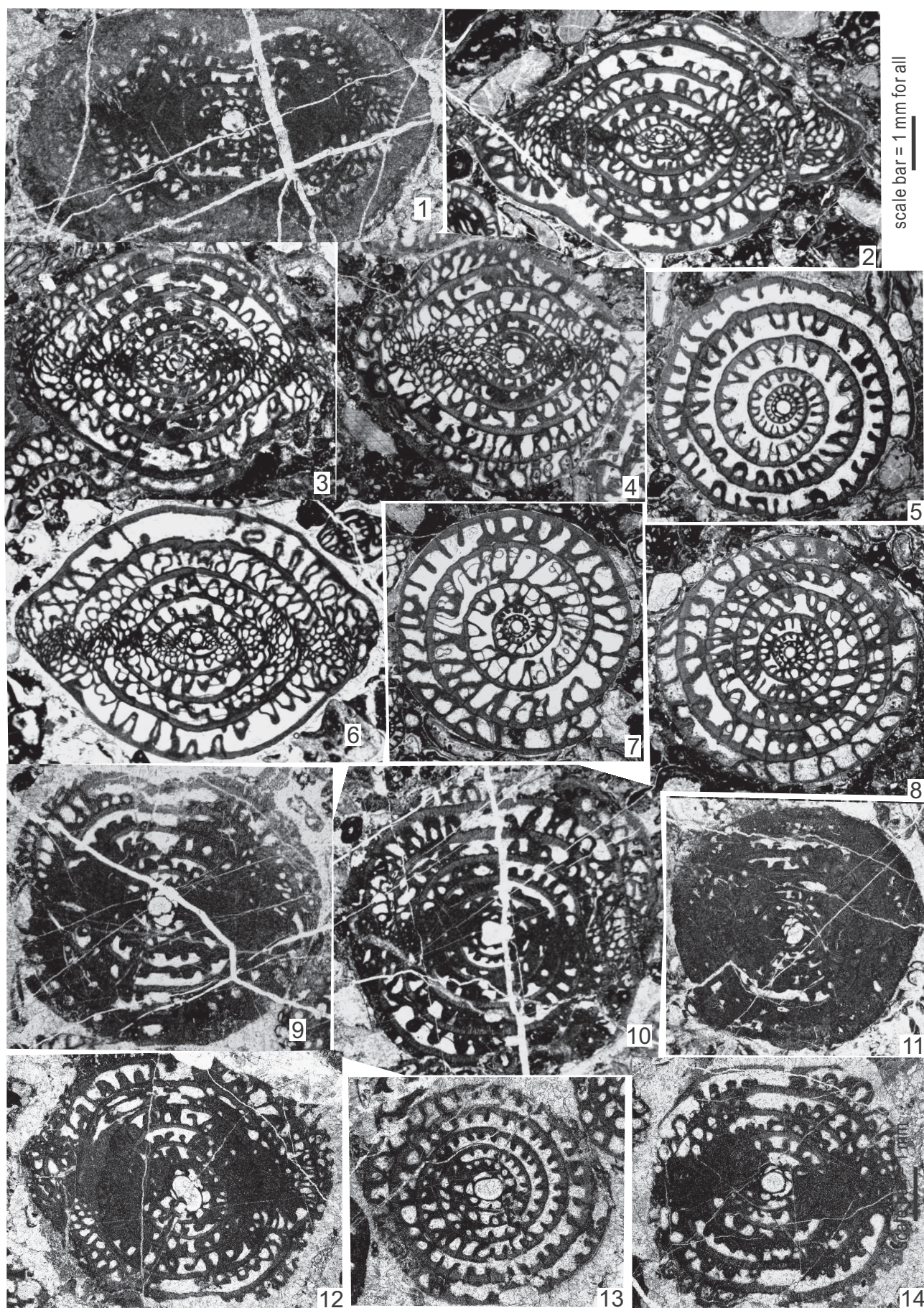
Plate XIV

Fig. 1: *Paraleeina magna* (Toriyama, 1958), D2-057837, B-251 (P-6).

Figs 2-8: *Chalaroschwagerina globosa* (Schellwien & Dyhrenfurth, 1909). 2: D2-060822, C-70; 3: D2-060884, C-75; 4: D2-060883, C-75; 5: D2-060764, C-64; 6: D2-060505, C-44; 7: D2-060770, C-64; 8: D2-060818, C-69; all P-5.

Figs 9-14: *Paraleeina cubiformis* n. sp. 9: D2-041414, A-60; 10: D2-063623, B-368, 11: D2-041382, A-59; 12: D2-041403, A-60; 13: D2-041398, A-60; 14: D2-041415, A-60; all P-6.







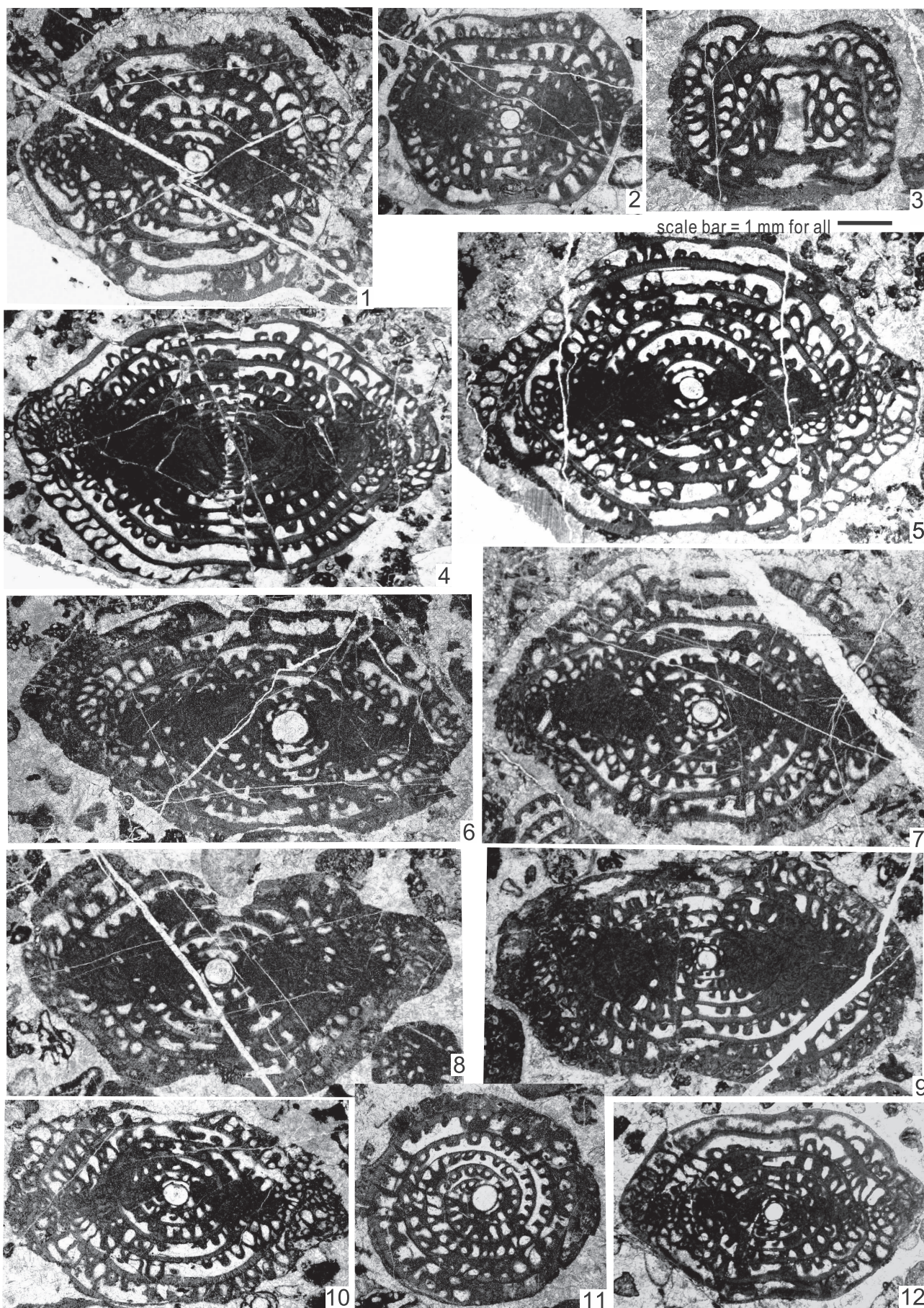
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Plate XV

Figs 1-3: *Paraleeina cubiformis* n. sp. 1: D2-041414, A-60; 2: D2-041404, A-60; 3: D2-066401, B-542; all P-6.

Figs 4-12: *Paraleeina magna* (Toriyama, 1958). 4: D2-063878, B-404; 5: D2-066480, B-552; 6: D2-041365, A-58; 7: D-041401, A-60; 8: D2-041368, A-58; 9: D2-063883, B-404; 10: D2-041406, A-60; 11: D2-041395, A-59; 12: D2-057869, B-252; all P-6.





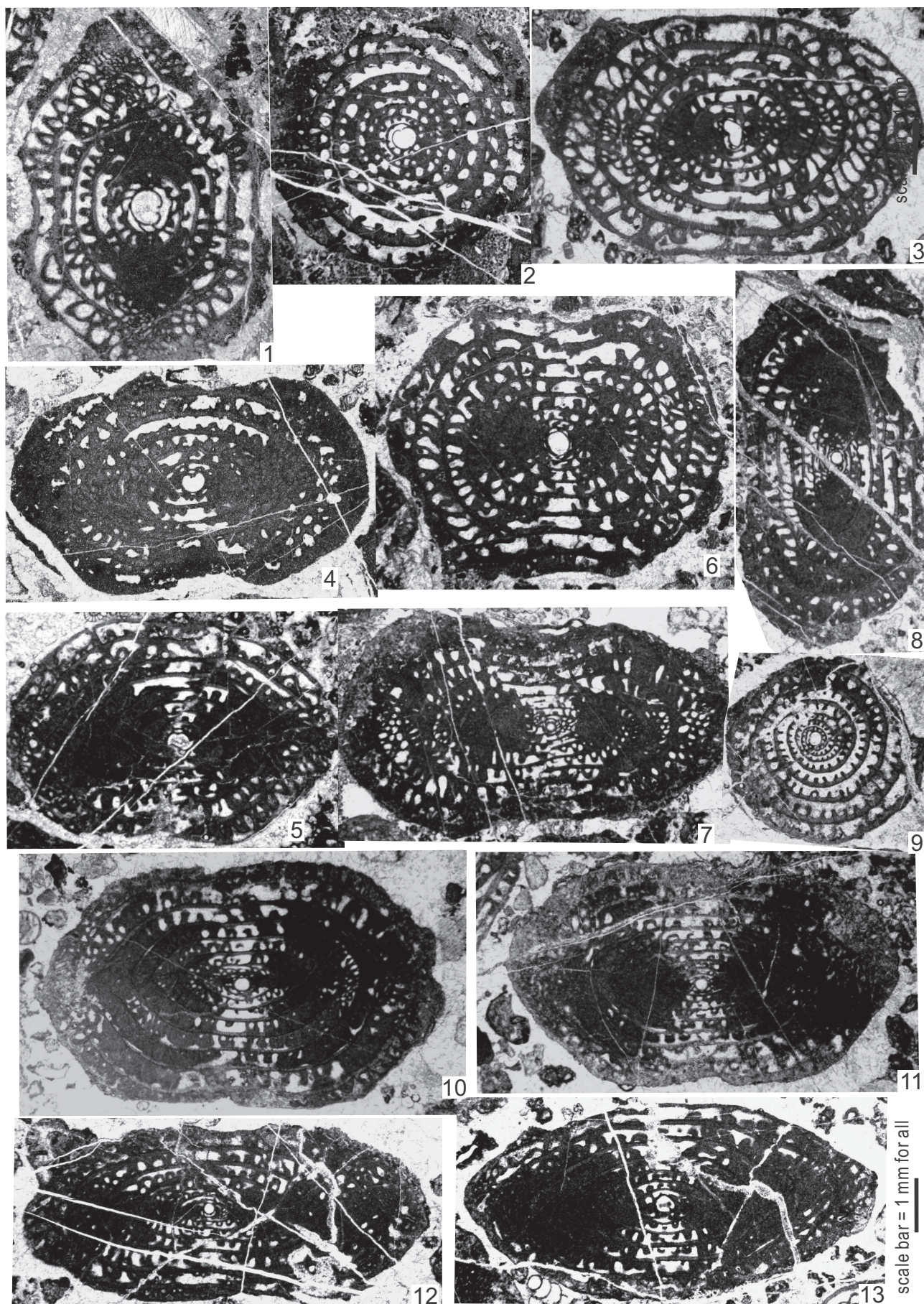


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Plate XVI

- Figs 1-6: *Paraleeina magna* (Toriyama, 1958). 1: D2-041408, A-60; 2: D2-063624, B-368; 3: D2-057961, B-261; 4: D2-041372, A-58; 5: D2-063877, B-404; 6: D2-057877, B-253; all P-6.
- Figs 7-11: *Paraleeina toriyamai* n. sp. 7: D2-057803, B-249; 8: D2-057806, B-249; 9: D2-057542, B-234; 10: D2-057812, B-249; 11: B2-057822, B-249; all P-6.
- Figs 12, 13: *Pseudofusulina* cf. *nalivkini* Leven, 1967. 12: D2-057543, 13: D2-057547; both B-234 (P-6).







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Plate XVII

- Figs 1-5: *Pseudofusulina norikurens* Hy. Igo, 1959. 1: D2-041367, A-58; 2: D2-041371, A-58; 3: D2-063869, B-404; 4: D2-041362, A-58; 5: D2-057959, B-261; all P-6.
- Figs 6-15: *Leeina krafftii* (Schellwien & Dyhrenfurth, 1909). 6: D2-057537, 7: D2-057516, 8: D2-057534, 9: D2-0257535, 10: D2-057512, 11: D2-057541, 12: D2-057973, 13: D2-057531, 14: D2-057505, 15: D2-057538; 6, 8-9, 11, 13, 15: B-234; 7, 10, 14: B-232; 12: B-261; all P-6.



