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Carboniferous foraminifers of the Yura area, Southern Chichibu Terrane of the western part of Kii Peninsula, Japan

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Abstract. **Carboniferous and Permian limestones, as well as pre-Cretaceous cherts and basaltic volcaniclastic and volcanic rocks, are tectonically intermingled with lower Jurassic to upper Cretaceous siliciclastic rocks in the Yura area, Southern Chichibu Terrane of the western part of Kii Peninsula, Japan. They are seamount originated and highly fossiliferous. Fifty species assignable to 26 genera of Carboniferous foraminifers were distinguished from the limestone blocks in the Yura area (Kaimori, Tatego, and Shirasaki). Among them, 21 species assignable to 11 genera are systematically described, including two new species (*Akiyoshiella kaimoriensis* and *Semistaffella vachardi*). Foraminiferal biostratigraphic constraints on the limestone blocks result that the Kaimori block ranges from the middle Bashkirian to Kashirian and the Tatego blocks from the Visean/Serpukhovian to upper Serpukhovian or partly to Bashkirian, while a part of the Shirasaki block, from which the Carboniferous was first distinguished, is lower and middle Kasimovian. Characteristic species are *Akiyoshiella kaimoriensis*, *Profusulinella prisca*, and *Bradyina nautiliformis* in Kaimori; *Eostaffella mosquensis* and *Bradyina* sp. A in Tatego; and *Protriticites variabilis*, *Obsoletes burkemensis*, and *Montiparus matsumotoi* in Shirasaki.**

Key words: Carboniferous, foraminifers, limestone blocks, Southern Chichibu Terrane, Yura area

Introduction

Occurrences and paleontological implications of late Paleozoic and Mesozoic fossils are efficiently summarized in the "*Historical Records of Yura Town*", Wakayama Prefecture, Japan. They comprise Carboniferous and Permian fusulines and non-fusuline foraminifers (Ishii, 1985), Triassic to Cretaceous radiolarians (Yao, 1985b), Permian to Cretaceous corals and Jurassic hydrozoans (Yamagiwa, 1985), and Jurassic and Cretaceous pelecypods and ammonoids (Ichikawa, 1985). Stratigraphy, geologic age, and tectonic development of the Yura area, established by the end of the 1970s, have been reconsidered and completely reformed since 1980s especially by radiolarians, as well as those factors for other areas of Japan. Radiolarian biostratigraphy in the Yura area revealed that cherts and basaltic pyroclastic and volcanic rocks, and at least late Paleozoic limestones are all exotic to the surrounding siliciclastic rocks successively ranging from the upper Lower Jurassic to the Upper Cretaceous, showing a distinct younging age polarity from north to south (Yao, 1984, 1985a, b).

Among the upper Paleozoic limestone blocks several to hundreds meters in the Yura area, the Carboniferous ones exposed at Kaimori and Tatego facing the Pacific are particularly remarkable. The occurrence of *Akiyoshiella* in the Jurassic terranes of Japan is confined to Kaimori (Ishii, 1985) and the southern Kanto Mountains (Kobayashi, 1994). Outside Japan, *Akiyoshiella*, which is common in the Permian Akiyoshi Terrane, is only known from the Cache Creek Terrane of British Columbia, Canada (Thompson *et al*., 1953) and Primorye, Far East Russia (Sosnina and Nikitina, 1976). *Eostaffella* and other fusuline and non-fusuline foraminifers suggest a Visean/Serpukhovian age for a few small limestone blocks exposed at Tatego (Ishii, 1985). The development of these upper lower Carboniferous limestones is very rare in the Jurassic terranes of Japan in contrast to their widespread distribution in the Akiyoshi Terrane (e.g. Ueno, 1989). Late Carboniferous fusulines were first found in Shirasaki.

The main purpose of this paper is to describe these foraminifers of the Yura area. Twenty-four limestone samples treated herein were collected in 1975, 1996, and 1998. However, since the late 1990s the limestones formerly exposed, from which the present materials were

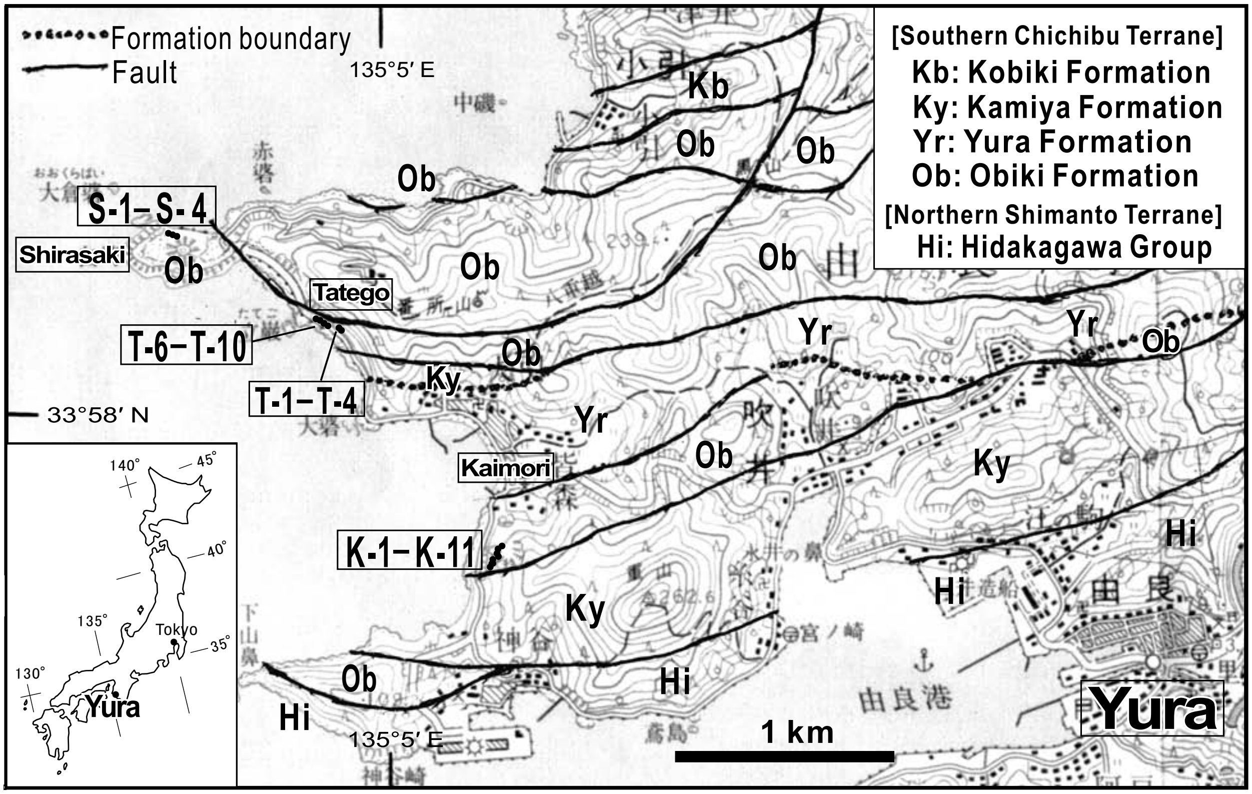

Figure 1. Localities of 24 limestone samples collected at Kaimori, Tatego, and Shirasaki plotted on the topographic map showing the distribution of pre-Cretaceous rocks in the western part of Yura Town. Simplified distribution of the rocks is based on Yao (1984). Topographic map is from 1:50,000 maps "Gobo" published by the Geospatial Authority of Japan.

obtained, have been completely or mostly lost by residential development works at Kaimori, by road construction works at Tatego, and by prefectural park construction works at Shirasaki. Fifty foraminiferal species assignable to 26 genera and three taxa of indeterminable genus were distinguished through the taxonomic consideration of 526 limestone thin sections. Among them, 21 species assignable to 11 genera are systematically described in this paper, including two new species, *Akiyoshiella kaimoriensis* and *Semistaffella vachardi*. Biostratigrahic constraints on these limestone blocks are studied on the basis of foraminiferal assemblages of the present material. Limestone thin sections of foraminifers illustrated are all stored in the collection of the Museum of Nature and Human Activities, Hyogo, Japan (Fumio Kobayashi Collection).

Geologic setting

The Chichibu Terrane in the western part of Kii Peninsula is tectonically divided into the Northern Chichibu, Middle Chichibu (Kurosegawa), and Southern Chichibu terranes, along with other areas in the Outer Zone of Southwest Japan. Pre-Cretaceous rocks in the mapped area lying in the western part of Yura Town (Figure 1) belong to the Southern Chichibu Terrane and northernmost Northern Shimanto Terrane. The huge blocks of pelagic limestone characteristic of the southern part of the Southern Chichibu (Sambosan) Terrane are not developed in the Yura area.

Pre-Cretaceous rocks in the mapped area were divided by Yao (1984) into the upper Lower Jurassic to Barremian Chuki Group and Coniacian to Santonian Kobiki Formation constituting the Southern Chichibu Terrane, and Aptian? to Santonian Hidakagawa Group of the Northern Shimanto Terrane (Figure 1). The Chuki Group is subdivided from older to younger into the Obiki, Yura, and Kamiya formations. The Obiki Formation is further subdivided into the Oshimayama, Banshoyama, and Tatego members. The upper Paleozoic limestone blocks are restricted to the Tatego Member, and the Upper Triassic ones to the Banshoyama Member. The Jurassic–Cretaceous Torinosu-type limestone marked in the Middle and Southern Chichibu terranes is contained in the Yura and Kamiya formations in the Yura area. Younging polarity from north to south is recognized in these strata based on radiolarians (Yao, 1984).

According to Yao's (1984) stratigraphic subdivision, limestone blocks exposed at Kaimori, Tatego, and Shirasaki are assigned to the Callovian to Tithonian Tatego Member (Figure 1). In addition to late Paleozoic limestone and greenstone blocks, many chert blocks yielding Middle Triassic to Early Jurassic radiolarians are contained in the Tatego Member (Yao, 1984). Thirteen species of Permian fusulines from Shirasaki, 12 species of Carboniferous fusulines from Kaimori and Tatego, and 13 species of Carboniferous non-fusuline foraminifers from Tatego are illustrated in Ishii (1985) without descriptions.

Material and age

Twenty-four samples were collected from the Carboniferous limestone blocks exposed at Kaimori, Tatego, and Shirasaki (Figure 1). Diagnostic limestone lithologies of six samples are shown in Figure 2. Foraminifers distinguished in each sample are summarized in Table 1.

The limestone block exposed south of Kaimori is massive and faulted without distinct stratification and without any siliciclastic intercalations. Although it might be separated into several fault-bounded blocks, any stratigraphic and biostratigraphic relationships between them could not be ascertained by the field works. Therefore, eleven samples were collected in the interval of 90 m from north to south (K-1 to K-11) along the foot of the western slope of the limestone block. The most noticeable limestone lithologies in the field are pelloidal ooid grainstone in K-1 (Figure 2.1) and K-4, crinoidal fusuline packstone in K-2 almost exclusively occupied by *Akiyoshiella kaimoriensis*, and fusuline packstone in K-3 (Figure 2.2) with a great many individuals of *Profusulinella prisca* (Deprat, 1912). Bioclastic grainstone/packstone in K-9 (Figure 2.3) contains taxonomically variable species of foraminifers (Table 1), among which *Bradyina nautiliformis* von Möller, 1878 is the most prevalent. *Akiyoshiella ozawai* Toriyama, 1953 is confined to K-9. Non-fusuline foraminifers are more dominant than fusulines in K-5 (algal crinoidal bioclastic packstone), K-6 (wackestone), K-7 (bioclastic grainstone), and K-8 (crinoidal packstone). On the other hand, two samples (K-10, K-11) are brecciated and recrystallized. Foraminifers are confined to a few taxa that escaped the remarkable recrystallization in them.

The occurrence of *Akiyoshiella* was ascertained both in the northward (K-2) and the southward (K-8, K-9) sides of the Kaimori block. *Akiyoshiella* is restricted to the stratigraphic interval between the *Profusulinella beppensis* Zone (Vereyan) and the *Fusulinella biconica* Zone (upper Kashirian) in the Akiyoshi Limestone Group (Kobayashi, 2017). *Profusulinella prisca* only recognized in K-3 ranges from the upper Vereyan to Kashirian with an acme in the lower Kashirian (e.g. Rauzer-Chernousova *et al.*, 1951; Groves *et al.*, 2007). Most specimens identified by many specialists with *Eostaffella postmosquensis* Kireeva *in* Rauzer-Chernousova *et al.*, 1951 and *Eostaffella pseudostruvei* (Rauzer-Chernousova and Belyaev *in* Rauzer-Chernousova *et al*., 1936) are concentrated to the Bashkirian. On the other hand, *Semistaffella variabilis* (Reitlinger, 1961) characteristic in the lower Bashkirian (Reitlinger, 1961; Brenckle, 2005) is absent in Kaimori. Other species of *Semistaffella* in the Yura area are common in the middle to upper Bashkirian and partly upward to the lower Moscovian, as described below. Accordingly, the age range of the Kaimori block is considered to be from the middle Bashkirian to the Kashirian.

More than 15 limestone blocks mostly less than 5 m in diameter were sporadically exposed in the roadside slope facing the limestone pinnacle at Tatego. Nine samples from seven limestone blocks were collected and examined. Well preserved foraminifers are recognized in T-6 (bioclastic packstone/grainstone, Figure 2.6) from block C, T-8 (algal packstone) from block E, T-9 (algal packstone) from block F, and T-10 (ooid grainstone) from block G. Fusulines belonging to Fusulinidae suggesting a younger than late Bashkirian age are completely absent in these and other samples of Tatego. On the other hand, *Eostaffella mosquensis* Vissarionova, 1948, *E. kanmerai* (Igo, 1957), *Semistaffella variabilis* and *Pseudoendothyra umbo* Rozovskaya, 1963 exclusively occur in the limestone blocks of Tatego (T-4, T-6 and T-10) in the Yura area (Table 1). *Eostaffella mosquensis* ranges from the upper Visean Mikhailovsky horizon (Rozovskaya, 1963) to the lowest Bashkirian Siuransky horizon (Groves, 1988) with an acme in the Serpukhovian in the stratotype regions of Russia. In Japan, *E. mosquensis* and/or *E. kanmerai* are restricted to the basal part of the Ichinotani Formation (Igo, 1957), and lower part of the Atetsu Limestone (Sada, 1964) and the Akiyoshi Limestone Group (Ueno, 1989; Ozawa and Kobayashi, 1990). These limestones are considered to be largely correlated to the Visean/Serpukhovian to middle/upper Serpukhovian of Russia. *Pseudoendothyra umbo* was described from the Protvinsky horizon of the upper Serpukhovian in the Moscow Basin (Rozoskaya, 1963). Based on the biostratigraphic ranges of these species, block C (T-6) is correlated to the Visean/Serpukhovian to middle Serpukhovian and block G (T-10) to the upper Serpukhovian. Other blocks in Tatego might be roughly Serpukhovian, and some of them might range into the Bashkirian, though this is uncertain because of the few age-diagnostic species in the present material.

The largest limestone block exposed at Shirasaki (Shirasaki Limestone) in the Yura area was divided by

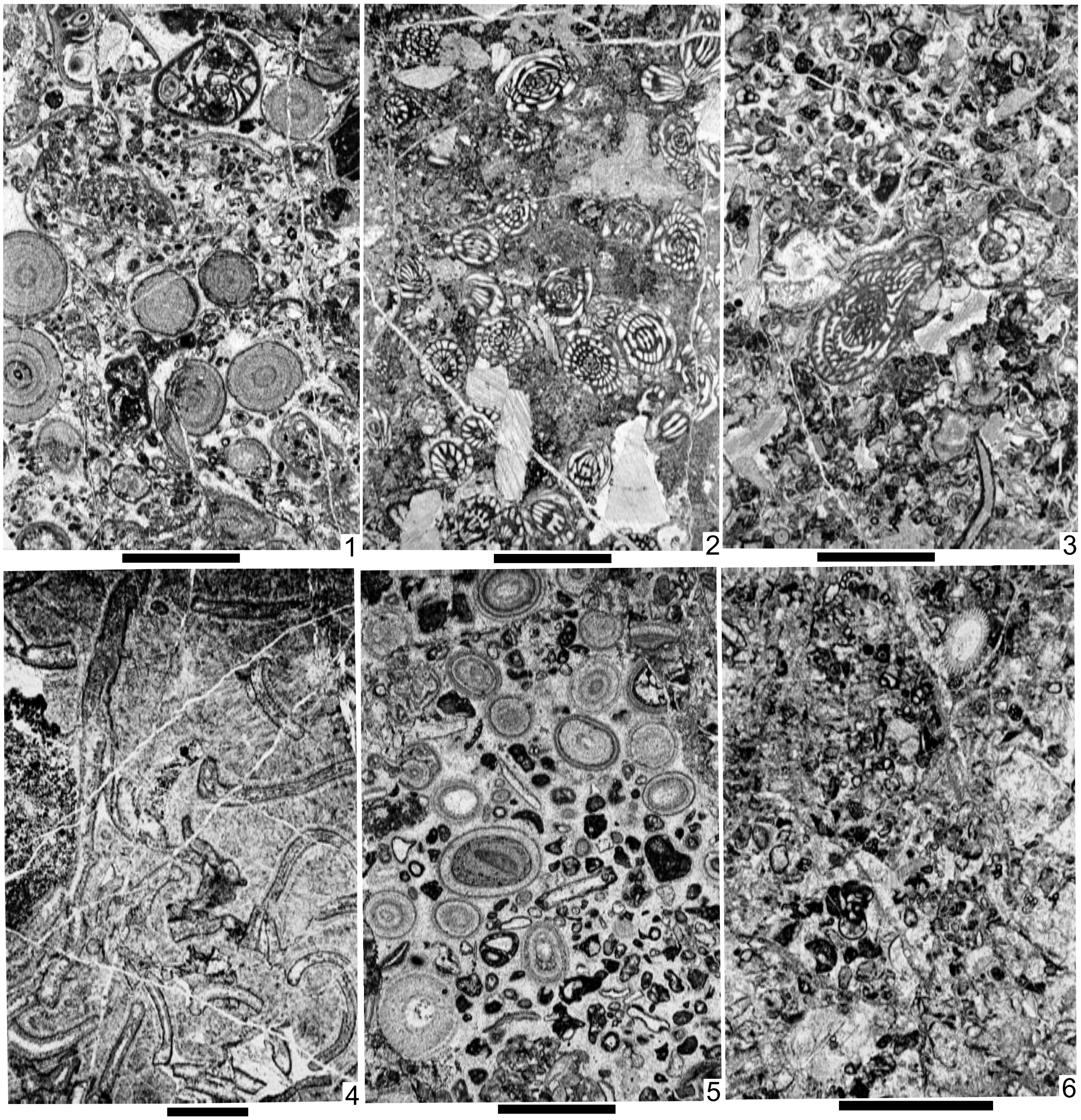

Figure 2. Carboniferous limestone lithology of the Yura area. **1,** pelloidal ooid grainstone, K-1; **2,** fusuline packstone, K-3; **3,** bioclastic grainstone/packstone, K-9; **4,** phyloid algal floatstone, S-3; **5,** ooid grainstone, S-4; **6,** algal bioclastic packstone/grainstone, T-6. Scale bar shows 2 mm.

Ishii (1985) into three biostratigraphic units by fusulines, Sh_1 (lower part of the lower Permian), Sh_2 (lower and middle parts of the middle Permian), and Sh_3 (upper part of the middle Permian). Four sample localities (S-1 to S-4) correspond to the northern part of the distributional area of the unit Sh_2. S-1 (fusuline grainstone) contains *Protriticites variabilis* Bensh, 1972 and *Obsoletes burkemensis* Volozhanina, 1962, while *Montiparus matsumotoi* (Kanmera, 1955) occurs in S-2 (algal grainstone/packstone). Based on the fusuline biostratigraphy in the Akiyoshi Limestone Group (Kobayashi, 2017), the former two species are assigned to the lower Kasimovian

Table 1. Foraminifers contained in eleven limestone samples at Kaimori and four at Shirasaki, and in nine from seven limestone blocks at Tatego.

Species	Kaimori block											Tatego block									Shirasakiblock			
													A		B	C	D	E	F	G				
	K-1	K-2	K-3	K-4	K-5	K-6	K-7	K-8	K-9	K-10	K-11	T-1	T-2	T-3	T-4	T-6	T-7	T-8	T-9	T-10	S-1	S-2	S-3	S-4
Tolypammina sp.						✖			×									×						
Tubertinid gen. and sp. indet.	×	×	×				×	×	×					×	×	×		×	×		×		×	
Turrispiroides multivolutus		×														✖		×						
Glomospiroides sp.					×											×			×		×			
Haplophragmina sp.									×		×													×
Calcivertella sp.						✖										×								
Globivalvulina bulloides					✖	✖														×	×			
Globivalvulina granulosa		×	×																	✖				
Globivalvulina moderata	×								✖					×										
Globivalvulina sp. A						✖												×						
Globivalvulinid gen. and sp. indet.				×	×	×		×		×		×											×	
Palaeotextularid gen. and sp. indet.		×	×	×	×			×	×					×				×		×		×		×
Climacammina aljutovica	✖	×							×															
Climacammina aff. *padunensis*																		✖						
Deckerella spp.							×		×													×		×
Endothyra excellens						✖		×	✖							✖		✖						
Endothyra aff. *excellens*					×				×							✖			×					
Endothyra igoi																✖			✖					
Endothyra prisca	×	×		×			×									✖	×							
Endothyra aff. *bashkirica*		✖			×				✖			×				✖		×						
Endothyra aff. *bowmani*									✖										×					
Endothyra? sp.									✖							✖								
Endostaffella? sp.									✖							×								
Iricrinella? sp.																✖		×						
Planoendothyra sp.					×											✖								
Bradyina nautiliformis			×						✖															
Bradyina cf. *cribrostomata*									✖															
Bradyina sp. A				×																✖				
Bradyina sp. B	✖																							
Bradyina sp. C	×																				✖	×		
Bradyina sp. D																								✖
Bradyina sp. E	✖																							
Tetrataxis parviconica								×	✖															
Pseudoendothyra umbo																				✖				
Reitlingerina musashiensis				✖	×																			
Mediocris breviscula	✖				×	✖										×		×						
Pseudonovella sp.									✖															
Eostaffella kanmerai																✖								
Eostaffella mosquensis															×	✖								
Eostaffella postmosquensis	✖				×	×		×						×										
Eostaffella pseudostruvei	✖	×			×				×										×					
Eoschubertella sp. A		×							×												×	✖		
Eoschubertella sp. B																								×
Semistaffella bluensis	×								✖															
Semistaffella minuta		✖	×						✖															
Semistaffella vachardi	✖																							
Semistaffella variabilis																				✖				
Profusulinella prisca			✖																					
Akiyoshiella kaimoriensis		✖						✖	×															
Akiyoshiella ozawai									✖															
Protriticites variabilis																					✖			
Obsoletes burkemensis																					✖			
Montiparus matsumotoi																						✖		

✖: illustrated ×: not illustrated

(middle upper Carboniferous) and *M. matsumotoi* to the middle Kasimovian. S-3 (phylloid algal floatstone, Figure 2.4) and S-4 (ooid grainstone, Figure 2.5) are provisionally correlated to the Kasimovian in spite of the absence of age-diagnostic species except for *Bradyina* sp. D similar to *B. nautiliformis* and *Eoschubertella* sp. B from S-4. The limestone from which these four Carboniferous samples were collected is in fault contact with the middle Middle Permian (lower Wordian) limestone containing *Parafusulina kinosakii* (Morikawa, 1958) and *Neofusulinella giraudi* Deprat, 1915, from which the additional Permian sample S-5 was collected.

Systematic paleontology

Order Foraminiferida Eichwald, 1830
Suborder Fusulinina Wedekind, 1937
Superfamily Endothyroidea Brady, 1884
Family Endothyridae Brady, 1884
Genus ***Endothyra*** Phillips, 1846

Type species.—*Endothyra bowmani* Phillips, 1846.

Endothyra excellens (Nodine-Zeller, 1953)

Figures 3.24–3.28, 3.36–3.38

Plectogyra excellens Nodine-Zeller, 1953, p. 198, pl. 28, figs. 8, 9; Zhao *et al*., 1984, p. 105, pl. 18, figs. 19, 20.
Endothyra excellens (Nodine-Zeller). Rich, 1980, p. 21, pl. 6, figs. 7, 10, 13; Reitlinger, 1980, pl. 1, figs. 2, 3.

Description.—Test discoidal with broadly rounded periphery and compressed laterally, and with three and a half to four whorls. Diameter 0.59 to 0.67 mm and width 0.23 to 0.28 mm. Proloculus about 0.02 to 0.04 mm in diameter. Inner whorls streptospirally coiled and largely oblique to outer one or two whorls almost planispirally coiled and with distinct septal furrows. Chambers inflated and 6 to 8 in the last whorl. Septa inclined anteriorly and some are gently curved. Secondary deposits more or less variably developed throughout the test and hooklike on the chamber floor of the last whorl. Wall thin, microgranular, and not differentiated.

Remarks.—This species was originally described by Nodine-Zeller (1953) from the upper Chesterian (Clore Limestone) of Illinois. Except for slight differences of longer and more inclined septa, other test characters are closely similar between the present specimens and the types. Nearly centered horizontal axial sections of the present material are also similar to those identified with this species and reassigned to *Endothyra* by Rich (1980) and Reitlinger (1980). Rich (1980) thought that this species should be placed into a group commonly denoted as *Endothyra bowmani* based on its mode of coiling and degree of chamber inflation.

Endothyra igoi Kobayashi, 1994

Figures 3.41–3.43

Endothyra igoi Kobayashi, 1994, p. 620, figs. 3.1–3.7.

Remarks.—*Endothyra* having larger tests from four samples of Tatego (T-6, T-8) and two of Kaimori (K-6, K-9) than others from the Yura area is attributed to *Endothyra igoi* described by Kobayashi (1994) from the Serpukhovian to lower Bashkirian limestone blocks in the southern Kanto Mountains based on many similarities of the test size, mode of coiling, and shallow septal sutures. It is distinguished from *Endothyra excellens* and *E.* aff. *excellens* by its larger test with shallower septal sutures. This species is distinguished from *E. rotayi* Lebedeva, 1954 from the lower Carboniferous of the Kuznets Basin (Lebedeva, 1954) by more irregular coiling and more rapidly enlarging chambers.

Family Bradyinidae Reitlinger, 1950
Genus ***Bradyina*** von Möller, 1878

Type species.—*Bradyina nautiliformis* von Möller, 1878.

Bradyina nautiliformis von Möller, 1878

Figures 5.1–5.14

Bradyina nautiliformis von Möller, 1878, p. 83, pl. 3, fig. 4a–d; pl. 10, fig. 3a, b; Lee and Chen in Lee *et al*., 1930, p. 104, pl. 5, figs. 5–9; Rauzer-Chernousova *et al.*, 1940, p. 47, pl. 8, figs. 1–3; pl. 9, figs. 1–3; Putrya, 1956, p. 371, pl. 1, figs. 9–11; Bogush, 1963, p. 55, pl. 2, fig. 2; Lin, 1978, p. 36, pl. 7, fig. 16; Igo and Adachi, 1981, p. 110, pl. 6, fig. 15; Zhao *et al*., 1984 (*non*), p. 108, pl. 19, figs. 1, 2; Adachi, 1985, p. 115, pl. 18, fig. 1 (= Igo and Adachi, 1981, pl. 6, fig. 15).

Description.—Test nautiloid, broadly rounded, and with shallow umbilicus. Mature test consists of three and a half to four whorls, 1.85 to 2.41 mm in diameter and 0.80 to 1.74 mm in width. The lenticular first whorl followed by two to three rapidly expanding outer whorls. Six or seven highly inflated, hemispherical chambers in the final whorl. Septa thin, rapidly thickened from the second whorl and inclined vertically to arched anteriorly in middle and outer whorls. Pre- and post-septal laminae or plates converging toward the septa form chamberlets or canals near the septa. Proloculus spherical to subspherical, 0.055 to 0.138 mm in longer diameter. Wall of final whorl 0.053 to 0.098 mm in thickness with slightly depressed septal sutures. It consists of a thin microgranular tectum and an inner much thicker, coarsely and rather

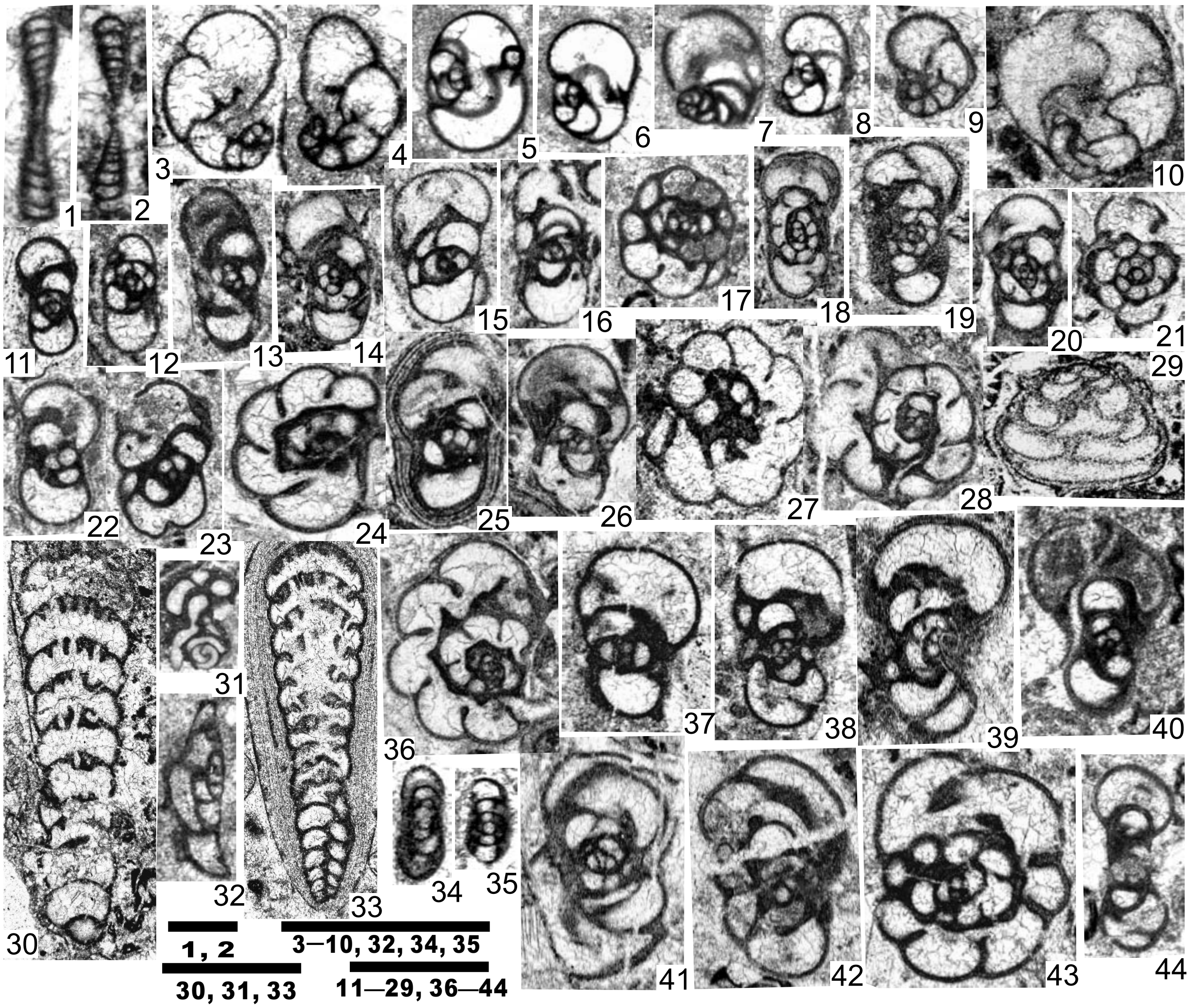

Figure 3. **1, 2,** *Turrispiroides multivolutus* (Reitlinger, 1949); 1, D2-053181; 2, D2-053171; both T-6; **3, 4,** *Globivalvulina bulloides* (Brady, 1876); 3, D2-053127, K-5; 4, D-053150, K-6; **5–8,** *Globivalvulina* sp. A; 5, D2-053144; 6, D2-053142; 7, D2-053137; 8, D2-053140; all K-6; **9,** *Globivalvulina granulosa* Reitlinger, 1950, D2-004951, T-10; **10,** *Globivalvulina moderata* Reitlinger, 1949, D2-036466, K-9; **11, 12,** *Endothyra prisca* Rauzer-Chernousova and Reitlinger in Rauzer-Chernousova *et al*., 1936; 11, D2-036581; 12, D2-053163; both T-6; **13, 14,** *Endothyra*? sp.; 13, D2-036581, T-6; 14, D2-036473, K-9; **15, 16,** *Endostaffella*? sp.; 15, D2-036485; 16, D2-036471; both K-9; **17–19,** *Endothyra* aff. *bashkirica* (Potievskaya, 1964); 17, D2-053178, T-6; 18, D2-036491, K-9; 19, D2-036320, K-2; **20, 21,** *Endothyra* aff. *bowmani* Phillips, 1846; 20, D2-036452; 21, D2-036450; both K-9; **22, 23,** *Endothyra* aff. *excellens* (Nodine-Zeller, 1953); 22, D2-053178; 23, D2-036587; both T-6; **24–28, 36–38,** *Endothyra excellens* (Nodine-Zeller, 1953); 24, D2-036488, K-9; 25, D2-036478, K-9; 26, D2-036475, K-9; 27, D2-053151, K-6; 28, D2-036488, K-9; 36, D2-036475, K-9; 37, D2-036579, T-6; 38, D2-036605, T-8; **29,** *Tetrataxis parviconica* Lee and Chen in Lee *et al*., 1930, D2-036483, K-9; **30,** *Climacammina* aff. *padunensis* Ganelina, 1956, D2-036599, T-8; **31,** *Tolypammina* sp., D2-053154, K-6; **32,** *Calcivertella* sp., D2-053151, K-6; **33,** *Climacammina aljutovica* Reitlinger, 1950, D2-036259, K-1; **34, 35,** *Mediocris breviscula* (Ganelina, 1951); 34, D2-053072, K-1; 35, D2-053156, K-6; **39, 40,** *Iricrinella*? sp.; 39, D2-036587; 40, D2-053166; both T-6; **41–43,** *Endothyra igoi* Kobayashi, 1994; 41, D2-036582, T-6; 42, D2-036609, T-9; 43, D2-036588, T-6; **44,** *Planoendothyra* sp., D2-053172, T-6. Scale bar of 0.1 mm is for 1, 2; of 0.5 mm for 3–10, 32, 34, 35; of 0.5 mm for 11–29, 36–44; of 1 mm for 30, 31, 33.

regularly perforate keriotheca.

Remarks.—Size and shape of the test and proloculus, degree of depth of umbilicus, and thickness of wall of the many specimens that have been identified with this species vary considerably among authors. These variabilities are also evident in the specimens illustrated from the present single sample (K-9). They are supposed to represent the intraspecific variation of *Bradyina nautiliformis*,

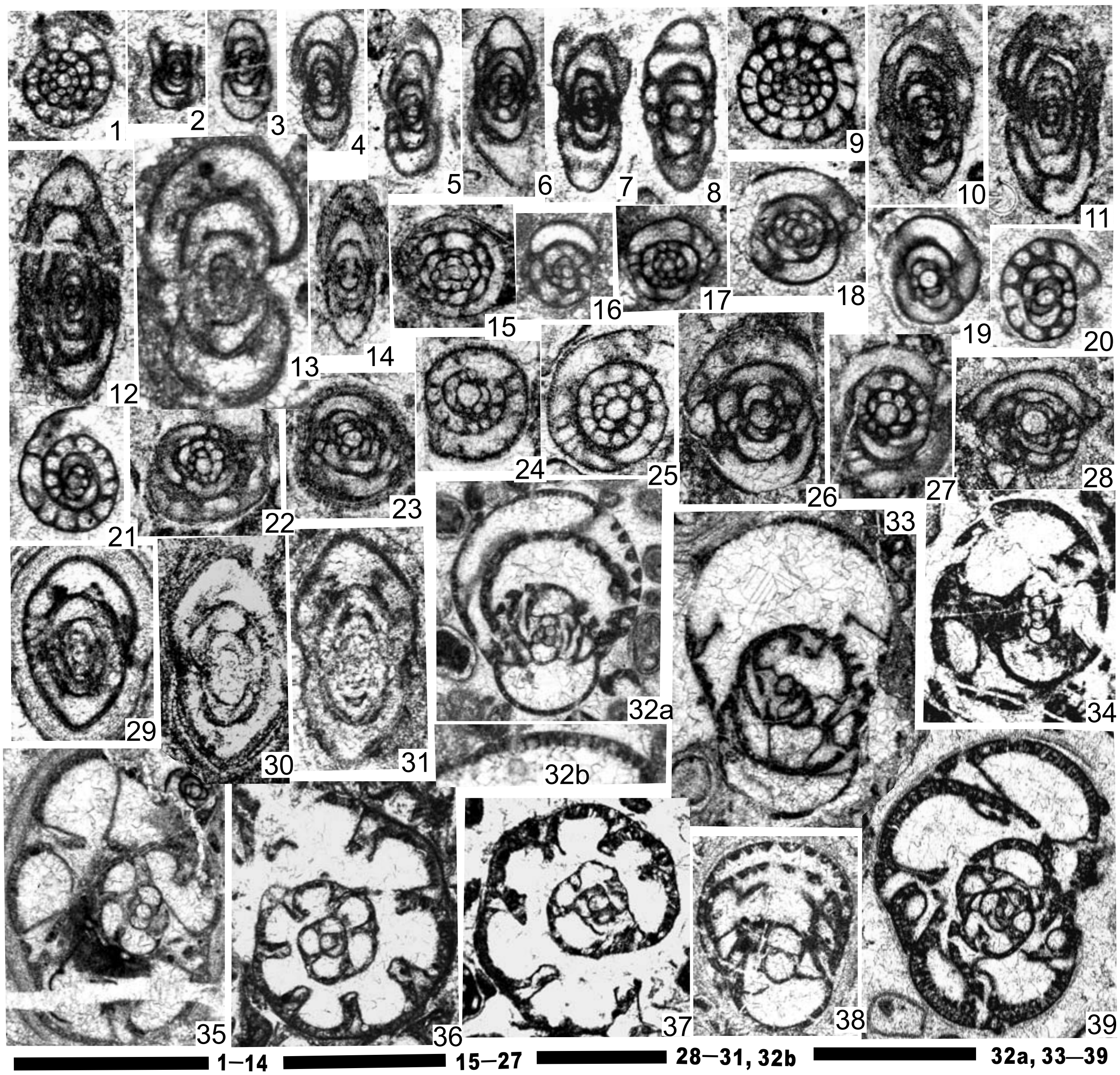

Figure 4. **1–4,** *Eostaffella postmosquensis* Kireeva in Rauzer-Chernousova *et al*., 1951; 1, D2-053069; 2, D2-053063; 3, D2-053072; 4, D2-036257; all K-1; **5–8,** *Eostaffella pseudostruvei* (Rauzer-Chernousova and Beljaev in Rauzer-Chernousova *et al*., 1936); 5, D2-053077; 6, D2-036256; 7, D2-053082; 8, D2-053069; all K-1; **9–11,** *Eostaffella mosquensis* Vissarionova, 1948; 9, D2-036575; 10, D2-036581; 11, D2-036577; all T-6; **12,** *Eostaffella kanmerai* (Igo, 1957), D2-036579, T-6; **13,** *Pseudoendothyra umbo* Rozovskaya, 1963, D2-004949, T-10; **14,** *Pseudonovella* sp., D2-036473, K-9; **15–17,** *Semistaffella variabilis* Reitlinger, 1961; 15, D2-004953; 16, D2-004951; 17, D2-004949; all T-10; **18–21,** *Semistaffella vachardi* sp. nov.; 18, D2-053089; 19, D2-053084; 20, D2-053079; 21, D2-053064; all K-1; **22–24,** *Semistaffella bluensis* (Ross and Sabins, 1965); 22, D2-036470; 23, D2-036473; 24, D2-036467; all K-9; **25–27,** *Semistaffella minuta* (Sada, 1975); 25, D2-036490, K-9; 26, D2-036293, K-2; 27, D2-036462, K-9; **28,** *Eoschubertella* sp. A, D2-036726, S-2; **29–31,** *Reitlingerina musashiensis* (Kobayashi, 1994); 29, D2-053106; 30, D2-053109; 31, D2-053117; all K-4; **32, 33,** *Bradyina* sp. A, 32, D2-004952; 33, D2-004951; both T-10; **34,** *Bradyina* sp. C, D2-0366704, S-1; **35,** *Bradyina* sp. E, D2-053077, K-1; **36, 37,** *Bradyina* cf. *cribrostomata* Rauser-Chernousova and Reitlinger in Rauser-Chernousova and Fursenko, 1937; 36, D2-036481; 37, D2-036474; both K-9; **38,** *Bradyina* sp. B, D2-053071, K-1; **39,** *Bradyina* sp. D, D2-036738, S-4. Scale bar of 0.5 mm is for 1–14, of 0.5 mm for 15–27, of 0.5 mm for 28–31, 32b, and of 1 mm for 32a, 33–39.

though some (e.g. Figure 5.7) having a relatively deeper umbilicus appear to be *Bradyina compressa* Morozova, 1949, and some others (e.g. Figure 5.5) having a thicker and more coarsely alveolar wall appear to be related to *B. magna* Roth and Skinner, 1930. Two specimens described by Zhao *et al*. (1984) from the upper Carboniferous of the southern margin of the Tarim Basin are presumed to be excluded from this species and reassigned to a species of *Bradyinelloides* by their thicker and coarser wall with irregularly aligned porous keriotheca.

Bradyina cf. ***cribrostomata*** Rauzer-Chernousova and Reitlinger in Rauzer-Chenousova and Fursenko, 1937

Figures 4.36, 4.37

cf. *Bradyina cribrostomata* Rauzer-Chernousova and Reitlinger in Rauzer-Chernousova and Fursenko, 1937, p. 295, figs. 231a–c, 234a, b; Rauzer-Chernousova *et al.*, 1940, p. 51, pl. 8, figs. 4, 5; pl. 9, figs. 4–6.

Remarks.—The two sagittal sections illustrated and a few other oblique sections from sample K-9 are probably differentiated from *Bradyina nautiliformis* by their smaller test, wall with more coarsely alveolar pores, and shorter septa more gently inclined anteriorly and regularly flanked by thin pre- and post-septal lamellae as long as the septa. By these features, the present specimens are compared to *B. cribrostomata* first described by Rauzer-Chernousova and Reitlinger in Rauzer-Chernousova and Fursenko (1937) from the core samples of the Samara Bend region of the Volga River. Subsequently, bradyinins identified with the types of this species were described and/or illustrated by many workers (e.g. Grozdilova and Lebedeva, 1960; Brazhnikova *et al*., 1967; Fomina, 1977; Lin, 1978; Potievskaya in Wagner *et al*., 1979). Some of them might be more or less different from the present specimens. However, detailed comparisons with them are refrained from on account of the insufficiency of the present material.

Bradyina sp. A

Figures 4.32, 4.33

Description.—Test nautiloid, broadly rounded, with shallow umbilicus and almost planispiral coiling throughout, and three and a half to four whorls. Diameter 1.82 mm and width 1.28 mm, approximately, in the specimen illustrated in Figure 3.45. Proloculus spherical and 0.072 mm in diameter. Inner one and a half whorls lenticular and tightly coiled. Subsequent two whorls increase their diameter and thickness of wall. Diameter from the first to third whorl is 0.19, 0.48, and 1.12 mm in the specimen shown in Figure 3.44. Remnants of septa and septal sutures are preserved in axial regions. Wall thin throughout whorls for the genus and less than 0.04 mm even in the thickest part. Wall microgranular and not differentiated in the first whorl, then gradually thickened outward and consists of very thin tectum and underlying, thicker, finely perforated granular layer. Finely alveolar structure becomes evident toward the final whorl, though simple and not branching off (Figure 4.32b).

Remarks.—The most diagnostic characters of this unnamed species are its thin wall and a much simpler wall structure than that of the known species of *Bradyina*. According to Mikhailov (1939), the wall of *Janischewskina* is agglutinated and cemented by minute equal-grained particles with fibrous structure and without alveolar structure. Therefore, this unnamed species cannot be assigned to *Janischewskina* due to the finely alveolar structure of the wall in the outer whorls. However, it resembles a species of the genus, in particular *J. typica* Mikhailov, 1935, type species of the genus described from upper Visean core samples of the Samara Bend region of the Volga River (Mikhailov, 1935). *Bradyina* sp. A is assumed to be a new species of the genus having transitional test characters from *Janischewskina* to *Bradyina*. However, this possibility is postponed until more specimens are accumulated.

Superfamily Fusulinoidea von Möller, 1878
Family Ozawainellidae Thompson and Foster, 1937
Subfamily Ozawainellinae Thompson and Foster, 1937
Genus ***Eostaffella*** Rauzer-Chernousova, 1948

Type species.—*Staffella* (*Eostaffella*) *parastruvei* Rauzer-Chernousova, 1948.

Eostaffella kanmerai (Igo, 1957)

Figure 4.12

Millerella kanmerai Igo, 1957, p. 175, pl. 1, figs. 20–26; pl. 2, fig. 14.
Eostaffella kanmerai (Igo). Sada, 1964, p. 230, pl. 21, figs. 8, 16, 17; Sada, 1967, p. 144, pl. 12, figs. 1–10; Sada, 1969, p. 120, pl. 12, figs. 1–13; pl. 13, figs. 1, 2; Niikawa, 1978, p. 538, pl. 1, figs. 11, 12; Rich, 1980 (*non*), p. 40, pl. 18, figs. 6, 8–12, 14?; Ueno, 1989, pl. 1, fig. 7.
Millerella aff. *rossica* Rozovskaya, 1963. Ishii, 1985, pl. 3, fig. 1.
Eostaffella cf. *kanmerai* (Igo). Villa and Stavros in Villa *et al*., 2001, p. 70, pl. 12, figs. 8, 10, 14, 16, 18, 19.

Remarks.—This species was originally described by Igo (1957) and later by Niikawa (1978) from the basal part of the Ichinotani Formation. It is common in the lower part of the Atetsu (Sada, 1964), Taishaku (Sada, 1967, 1969), and Akiyoshi (Ueno, 1989) limestones. The illustrated and other thin sections from the sample of Tatego (T-6), though well oriented ones are few, are similar to these Japanese materials in many respects. They are characterized by rapidly expanding outer whorls with rounded to bluntly pointed periphery and shallow umbilicus. Japanese materials referable to *Eostaffella kanmerai* are considered to the Visean–Serpukhovian based on their stratigraphic distribution and associated foraminifers. Six specimens compared to this species and described by Villa and Stavros in Villa *et al*. (2001) from the lower Bashkirian of the Cantabrian Mountains, Spain are closely similar to the types and probably identical with *E. kanmerai*.

This species resembles the original material of the type species of the genus (*Eostaffella parastruvei*) by Rauzer-Chernousova (1948) in its size and shape of the test with shallow umbilicus and rapidly expanding outer whorls. However, the expansion of the outer whorls is more conspicuous in the former. *Eostaffella kanmerai* is similar to *Millerella rossica* Rozovskaya, 1963, originally described from the Mikhailovsky and Venevsky horizons of the upper Visean of European Russia (Rozovskaya, 1963), in many respects except for having a faintly involute test with more shallowly umbilical poles. One specimen illustrated by Ishii (1985) and presumed to be allied to *M. rossica* might be better reassigned to *E. kanmerai* because of its indistinct evolute coiling of the test. Specimens identified with *E. kanmerai* by Rich (1980) should be reassigned to other species (e.g. *E. proikensis* Rauzer-Chernousova, 1948) based on their smaller tests and gradually expanding whorls.

Eostaffella mosquensis Vissarionova, 1948

Figures 4.9–4.11

Eostaffella mosquensis Vissarionova, 1948, p. 222, pl. 14, figs. 4–6; Ganelina, 1951, 188, pl. 2, figs. 1, 2; Bogush and Yuferev, 1962, p. 172, pl. 6, fig. 26; Rozovskaya, 1963, p. 93, pl. 17, figs. 1–5; Manukalova-Grebeniuk *et al*., 1969, p. 25, pl. 9, figs. 9–12; Ozawa, 1976, p. 121, pl. 22, figs. 1–19; Rich, 1980, p. 41, pl. 18, figs. 13, 15, 16, 20, 25; Ishii, 1985, pl. 3, fig. 2; Matsusue, 1986, pl. 6, figs. 1, 2; Ueno, 1989, pl. 1, fig. 6; Ozawa and Kobayashi, 1990, pl. 1, figs. 16–18.

Remarks.—As well as specimens reported from the lower Serpukhovian of the Akiyoshi Limestone Group (Matsusue, 1986; Ueno, 1989; Ozawa and Kobayashi, 1990), the Tatego specimens are identified with the types described by Vissarionova (1948) in their somewhat large test for the genus with a rounded periphery, shallowly umbilical poles, and five gradually expanding whorls. They are distinguished from *Eostaffella kanmerai* by their less rapidly expanding whorls and shallower umbilicus on both sides of the test, and from *E. pseudostruvei*, described below, by their larger tests with more shallowly umbilical poles.

Eostaffella postmosquensis Kireeva in Rauzer-Chernousova *et al*., 1951.

Figures 4.1–4.4

Eostaffella postmosquensis Kireeva in Rauzer-Chernousova *et al*., 1951, p. 48, pl. 1, figs. 1, 2; Bogush and Yuferev, 1962, p. 178, pl. 7, fig. 3; Manukalova-Grebeniuk *et al*., 1969, p. 25, pl. 6, figs. 9–11; Watanabe, 1974, p. 377, pl. 51, fig. 9–14; Sashida, 1981, p. 7, pl. 3, figs. 11, 12; Zhao *et al*., 1984, p. 56, pl. 1, figs. 9–15; Matsusue, 1986, pl. 6, fig. 8; Groves, 1988, p. 388, figs. 13.14–13.25; Ozawa and Kobayashi, 1990, pl. 2, figs. 3, 4.

Eostaffella (*Eostaffella*) *postmosquensis* Kireeva. Brazhnikova *et al*., 1967, pl. 21, fig. 7.

Eostaffella akiyoshiensis Sada, 1975, p. 9, pl. 1, figs. 15–23; Matsusue, 1986, pl. 6, fig. 9; Sada *et al*., 1992, p. 98, figs. 4.1–4.6, 4.9, 4.10; Sada *et al*., 1995, p. 49, figs. 7.3–7.5.

Remarks.—This well known species has been described by many authors. Some differences among specimens previously identified with this species are recognized in size and form ratio of the test, degree of roundness of the periphery and of depression of the umbilicus, and the number of chambers. These differences are also found in the present specimens that are likewise identified with *Eostaffella postmosquensis*. Eostaffellins named *E. akiyoshiensis* from the Akiyoshi Terrane, listed above, are considered to be a junior synonym of this species based on broad morphologic variation of this species.

Eostaffella pseudostruvei (Rauzer-Chernousova and Belyaev *in* Rauzer-Chernousova *et al*., 1936)

Figures 4.5–4.8

Staffella pseudostruvei Rauzer-Chernousova and Belyaev *in* Rauzer-Chernousova *et al*., 1936, p. 179, pl. 1, fig. 7.

Eostaffella pseudostruvei (Rauzer-Chernousova and Belyaev). Rauzer-Chernousova *in* Rauzer-Chernousova *et al*., 1951, p. 58; Bogush and Yuferev, 1962, p. 176, pl. 6, fig. 33.

Eostaffella pseudostruvei var. *chomatifera* Kireeva *in* Rauzer-Chernousova *et al*., 1951, p. 59, pl. 1, figs. 32, 33; Brazhnikova *et al*., 1967, pl. 21, figs. 10, 11; Manukalova-Grebeniuk *et al*., 1969, p. 27, pl. 6, figs. 19–29.

Eostaffella chomatifera Kireeva. Bogush and Yuferev, 1962, p. 177, pl. 7, fig. 1.

Eostaffella (*Eostaffella*) *pseudostruvei* (Rauzer-Chernousova and Belyaev). Brazhnikova *et al*., 1967, pl. 18, fig. 4; pl. 19, fig. 7; pl. 20, figs. 11–13; pl. 21, fig. 9.

Eostaffella pseudostruvei var. *elegantissima* Manukalova-Grebeniuk *et al*., 1969, p. 29, pl. 9, figs. 4–6.

Eostaffella pseudostruvei chomatifera Kireeva. Lin, 1983, pl. 1, figs. 9, 10.

Remarks.—This species was proposed by Rauzer-Chernousova and Belyaev on the basis of monotypic specimen from the Namurian (?) of the Pechora region. The present specimens are ascribed to this species *sensu lato* based on comparison with many specimens identified by later workers with *Eostaffella pseudostruvei* and its allies.

Similar species to *E. pseudostruvei* are also reported from East Asia, such as *E. bigemmicula* (Igo, 1957) and *E. intermedia* Sheng, 1958. The former, originally described from the Ichinotani Formation (Igo, 1957), resembles this species but for a more rounded periphery. The latter, originally from the Taitzeho Valley, Liaoning, has a more pointed periphery. Although these slight differences are observable, they might still be synonymous with *E. pseudostruvei*.

Subfamily Pseudostaffellinae Putrya, 1956
Genus ***Semistaffella*** Reitlinger, 1971

Type species.—*Pseudostaffella variabilis* Reitlinger, 1961.

Semistaffella bluensis (Ross and Sabins, 1965)

Figures 4.22–4.24

Eoschubertella bluensis Ross and Sabins, 1965, p. 184, pl. 21, figs. 28, 29.

Remarks.—Small, subglobose fusulines with large proloculus and the first whorl coiled at a large angle to the succeeding two whorls of the Kaimori material are similar to those described by Ross and Sabins (1965) from the Lower Pennsylvanian (Atokan) in the Blue Mountains of southeast Arizona. Two specimens illustrated from Arizona were distinguished from *Eoschubertella obscura* (Lee and Chen in Lee *et al*., 1930) by their smaller and more globular test than the types from the lower part of the Huanlung Limestone of South China (Lee and Chen in Lee *et al*., 1930). They are reassigned to *Semistaffella* in their having a more rounded test than almost all species of *Eoschubertella*. *Eoschubertella toriyamai* Ishii, 1962 from the Itadorigawa Group, Ehime Prefecture should probably be reassigned to *Semistaffella*. It differs from *S. bluensis* in its larger test and more poorly developed chomata.

Semistaffella minuta (Sada, 1975)

Figures 4.25–4.27

Pseudostaffella minuta Sada, 1975, p. 21, pl. 7, figs. 6–9.

Remarks.—The largest form referable to *Semistaffella* in the Yura area is identical with *Semistaffella minuta*, originally assigned to *Pseudostaffella* by Sada (1975), from the lower Pennsylvanian (probably Bashkirian) of the Akiyoshi Limestone Group in its size, form and coiling pattern of the test, small number of whorls, large proloculus, and massive chomata. The prolocular size in the original specimens is estimated to be much smaller than the actual size due to the thin sections falling considerably away from the center. With respect to the large proloculus and similar mode of ontogenetic change of the coiling, this species resembles *Semistaffella multiforme* (Villa in Villa and Merino-Tomé, 2016), originally assigned to *Schubertella*, from the Bashkirian/Moscovian transitional interval of the Cantabrian Mountains, Spain (Villa in Villa and Merino-Tomé, 2016). However, the former has a larger test and larger length and width of the corresponding whorls than the latter.

Semistaffella vachardi sp. nov.

Figures 4.18–4.21

Pseudostaffella (*Semistaffella*) sp. Harris *et al*., 1997, figs. 7.31, 7.32.

Etymology.—From Daniel Vachard for his works on Paleozoic and Mesozoic foraminifers.

Type specimens.—The holotype D2-053089, axial section (Figure 4.18) from K-1. Paratypes D2-053084, axial section (Figure 4.19); D2-053079, sagittal section (Figure 4.20); and D2-053064, sagittal section (Figure 4.21); all from K-1.

Type locality.—Kaimori, Yura Town, Hidaka County, Wakayama Prefecture, Japan.

Diagnosis.—Subspherical test with shallow umbilical depressions and irregularly changing axis of coiling. Outer one to one and a half whorls almost planispirally coiled. Asymmetrical chomata resulting in a meandering tunnel path in irregularly coiled whorls.

Measurements.—Length = 0.270–0.392 mm, width = 0.319–0.396 mm, length/width = 0.81–1.08, number of whorls = 3.1–3.5, diameter of proloculus = 0.047–0.070 mm, wall thickness in the final whorl = 0.009–0.013 mm, number of septa in the final whorl = 11–13. In the holotype, length = 0.392 mm; width = 0.363 mm; length/width = 1.08; number of whorls = 3.5; diameter of proloculus = 0.051 mm; wall thickness in the final whorl = 0.011 mm; number of septa in the second whorl = 8.

Description.—Test subspherical with shallow umbilical depressions. Lenticular first and thick lenticular to nautiloid second whorls coiled at large angles. With a more remarkable change of the axis of coiling, the second whorl is followed by an outer subspherical one to one and a half whorls coiled almost planispirally. Proloculus large for the test size and inner whorls tightly coiled against somewhat rapidly expanding outer whorls. Septa plane and some are in contact with the chamber floor. Chomata distinct, asymmetrical, and variable in shape and size resulting in a meandering tunnel path in irregularly coiled whorls. Wall differentiation indistinct in inner lenticular to nautiloid whorls. In outer whorls, wall consists of thin dark layer comparable to tectum and a little thicker inner layer.

Remarks.—This new species is separated from *Semistaffella bluensis* by its smaller form ratio of the test and from *S. variabilis* by its larger test with larger length and width of the corresponding whorls. However, the mode and degree of changes of the axis of coiling during growth are similar in these three species. Among the described species, this new species is the closest to *S. multiforme* from the Cantabrian Mountains, Spain. Villa in Villa and Merino-Tomé (2016) recognized broad intraspecific variations of size and shape of the outer whorls and degree of depression of the umbilicus in *S. multiforme*. However, the present new species is distinguished from that species by having a smaller proloculus, smaller test with smaller length and width of corresponding whorls, and not so massive chomata. Although a detailed comparison is only tentative due to lack of a description, two unnamed specimens of *Pseudostaffella* (*Semistaffella*) illustrated by Harris *et al*. (1997) from the Morrowan-Atokan boundary in the Brooks Range (Arctic Alaska) are possibly assigned to this new species.

Occurrence.—Rare in K-1.

Semistaffella variabilis (Reitlinger, 1961)

Figures 4.15–4.17

Pseudostaffella variabilis Reitlinger, 1961, p. 240, pl. 3, fig. 8; Brazhnikova *et al*., 1967, pl. 21, fig. 22.
Pseudostaffella primitiva Reitlinger, 1961, p. 241, pl. 3, fig. 9.
Semistaffella variabilis (Reitlinger). Reitlinger, 1971, pl. 1, figs. 11, 12; Brenckle, 2005, p. 86, pl. 15, figs. 5, 6.
Semistaffella primitiva (Reitlinger). Reitlinger, 1971, pl. 1, fig. 13.
Pseudostaffella (*Semistaffella*) *variabilis* (Reitlinger). Groves, 1988, p. 391, figs. 17.22–17.29.

Remarks.—As discussed by Groves (1988), the taxonomic independence of either *variabilis* or *primitiva*, both of which were first described in the same paper (Reitlinger, 1961) and later reassigned to *Semistaffella* by Reitlinger (1971), is equivocal. Both were later synonymized by Brenckle (2005). Therefore, small and subspherical individuals of *Semistaffella* in the present material are named *S. variabilis*, first described from core samples of the lower Akavassky horizon (lower Bashkirian) of the Russian Platform. They resemble the types in their irregularly coiled whorls throughout the test, rounded periphery and poles.

Family Fusulinidae von Möller, 1878
Subfamily Fusulinellinae Staff and Wedekind, 1910
Genus ***Profusulinella*** Rauzer-Chernousova and Belyaev in Rauzer-Chernousova *et al*., 1936

Type species.—*Profusulinella pararhomboides* Rauzer-Chernousova and Belyaev in Rauzer-Chernousova *et al*., 1936.

Profusulinella prisca (Deprat, 1912)

Figures 6.1–6.29

Schwagerina prisca Deprat, 1912, p. 41, pl. 4, figs. 10–14.
Neofusulinella schwagerinoides Deprat, 1913. Lee and Chen in Lee *et al*., 1930 (*pars*), p. 124, pl. 11, figs. 1, 2. (*non* pl. 10, fig. 12 = *Fusulinella bocki* von Möller, 1877)
Profusulinella deprati (Beede and Kniker, 1924). Chang, 1961, p. 153, pl. 1, fig. 10; Sheng and Sun, 1975, p. 8, pl. 3, fig. 2.
Profusulinella priscoidea Rauzer-Chernousova, 1938, p. 102, pl. 2, figs. 1–3.
Aljutovella priscoidea Rauzer-Chernousova. Rauzer-Chernousova in Rauzer-Chernousova *et al*., 1951, p. 208, pl. 27, figs. 5, 6.
Profusulinella prisca (Deprat). Rauzer-Chernousova *et al*., 1951, p. 165, pl. 15, figs. 1–4; Putrya, 1956, p. 417, pl. 7, figs. 2, 3; Rui *et al*., 1996, p. 48, pl. 5, figs. 5–12; Davydov *et al*., 2001, pl. 1, figs. 3, 4; Leven *et al*., 2006, figs. 11.10, 11.11, 12.1, 12.2.
Profusulinella prisca var. *timanica* Kireeva in Rauzer-Chernousova *et al*., 1951, p. 166, pl. 15, figs. 5, 6; Lin, 1983, pl. 2, fig. 21; Rui *et al*., 1996, p. 50, pl. 4, figs. 1–8.
Profusulinella prisca var. *sphaeroidea* Rauzer-Chernousova in Rauzer-Chernousova *et al*., 1951, p. 167, pl. 16, fig. 1.
Profusulinella timanica Kireeva. Davydov *et al*., 2001, pl. 1, figs. 6, 7.
Profusulinella beppensis Toriyama, 1958. Leven *et al*., 2006, figs. 11.1, 11.4, 11.5.
Profusulinella n. sp. Ishii, 1985, pl. 2, fig. 11.
Profusulinella hinodensis Kobayashi, 1994, p. 627, figs. 4.3–4.7, 6.5.
Depratina prisca (Deprat). Kulagina, 2009, fig. 4a, b.

Description.—Test inflated to highly inflated fusiform with broadly arched periphery and rounded poles. Mature test of five to six whorls, 1.16 to 1.73 mm in length and 0.96 to 1.12 mm in width, giving a form ratio of 1.07 to 1.72. Proloculus almost spherical, 0.049 to 0.096 mm in diameter. Inner two whorls are oval to thick lenticular and succeeded by outer whorls gradually increasing in length and width. Axis of coiling crossing at a large angle between inner and outer whorls.

Wall thin and structureless in inner one or two whorls. Beyond the third whorl, wall differentiation becomes evident, and consists of a tectum, a continuous translucent to transparent layer, and a thin lower tectorium in the middle and outer whorls. Wall differentiation obscure in the final whorl in specimens with a thinner wall. Thickness of wall in the median part of the test about 0.002 to 0.005 mm, and considerably variable from specimen to specimen.

Septa almost plane, but weakly folded only in the polar regions of outer whorls, perpendicular to the wall or gently inclined anteriorly, and closely spaced. Septal counts from the first to sixth whorl 6, 10, 13, 16, 20, and 21 in the specimen illustrated in Figure 6.29. Tunnel a half to one-third as high as chambers, narrow in inner whorls, and widens outward. Its path not straight in outer whorls. Chomata well developed in middle and outer whorls, and

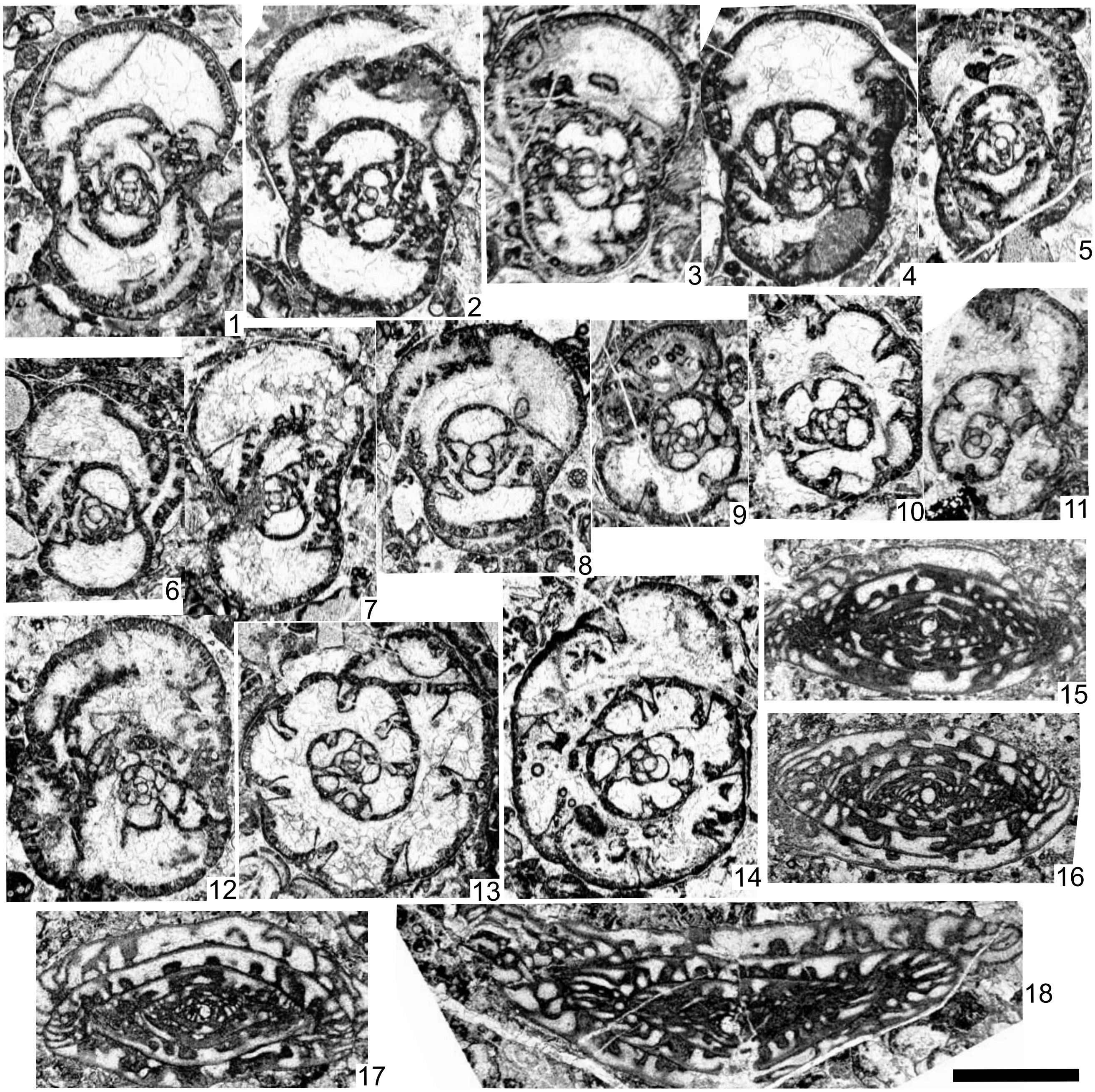

Figure 5. **1–14,** *Bradyina nautiliformis* von Möller, 1878; 1, D2-036450; 2, D2-036480; 3, D2-036464; 4, D2-036459; 5, D2-036452; 6, D2-036471; 7, D2-036492; 8, D2-036453; 9, D2-036456; 10, D2-036485; 11, D2-036480; 12, D2-036476; 13, D2-036455; 14, D2-036488; all K-9; **15–17,** *Akiyoshiella kaimoriensis* sp. nov.; 15, D2-053100; 16, D2-036297; 17, D2-036279; all K-2; **18,** *Akiyoshiella ozawai* Toriyama, 1953, D2-036466, K-9. Scale bar of 1 mm for all.

steeply inclined toward tunnel regions and gently sloping down toward poles in most specimens. Axial fillings not present.

Remarks.—Greater or lesser differences are recognized in many test characters, especially in the form ratio of the test and development mode of chomata in the present material, among which 29 specimens from a single sample (K-3) are illustrated to show variability of test characters. This variability continuously displayed from specimen to specimen are considered to represent the broad intraspecific variation of *Profusulinella prisca*, first described by Deprat (1912) from the Moscovian of east-

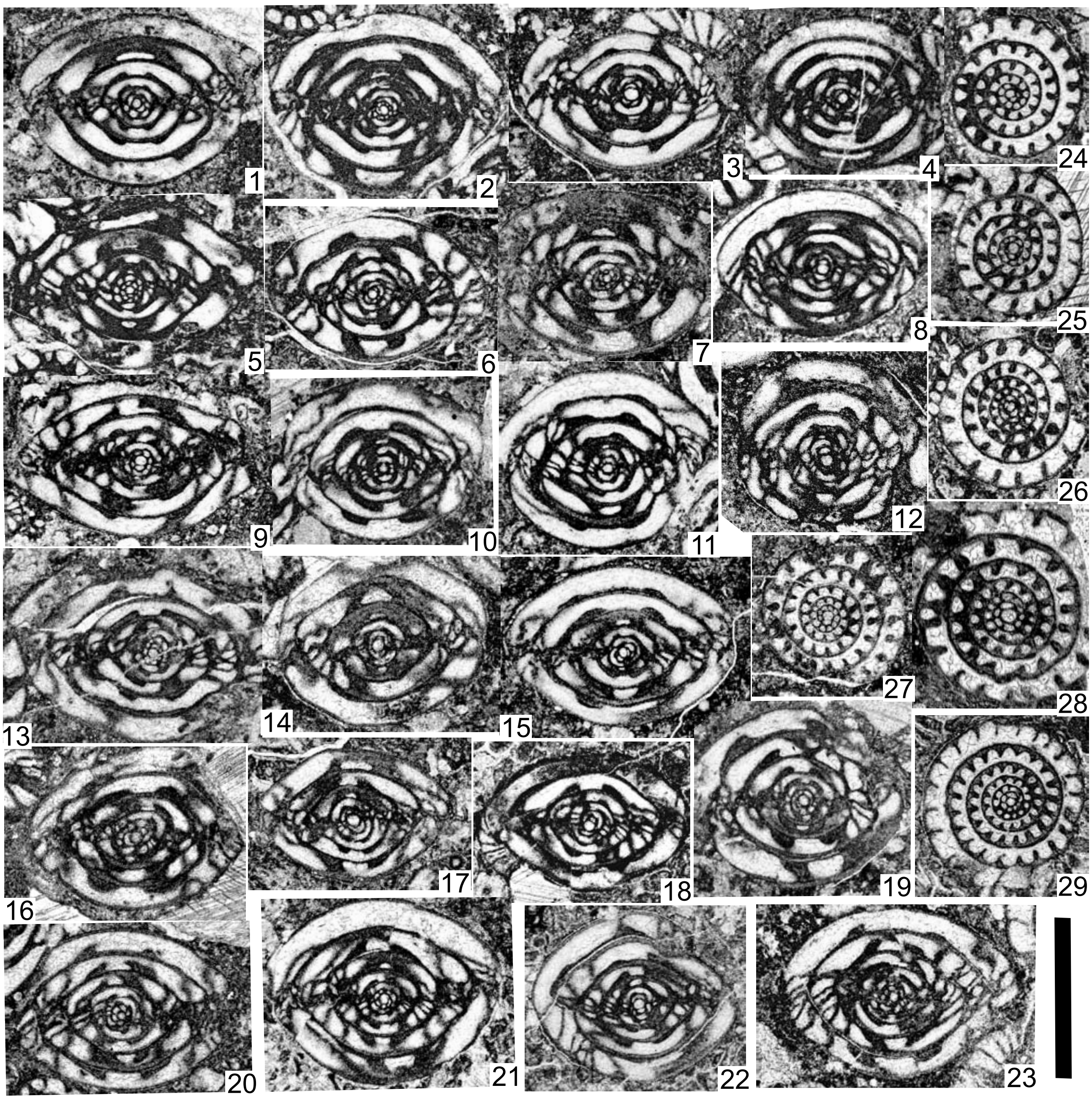

Figure 6. **1–29,** *Profusulinella prisca* (Deprat, 1912); 1, D2-036384; 2, D2-036397; 3, D2-036398; 4, D2-036405; 5, D2-036387; 6, D2-036386; 7, D2-036352; 8, D2-036380; 9, D2-036334; 10, D2-036368; 11, D2-036363; 12, D2-036410; 13, D2-036376; 14, D2-036344; 15, D2-036411; 16, D2-036358; 17, D2-036370; 18, D2-036373; 19, D2-036343; 20, D2-036360; 23, D2-036375; 21, D2-036359; 22, D2-036335; 23, D2-036375; 24, D2-036334; 25, D2-036379; 26, D2-036356; 27, D2-036413; 28, D2-036414; 29, D2-036402; all K-3. Scale bar of 1 mm for all.

ern Yunnan, South China. Specimens listed above are supposed to be conspecific with this species. They might be better summarized as the *P. prisca* group for the sake of taxonomic convenience, as done by Groves *et al*. (2007). On the contrary, *P. prisca* and *P. priscoidea* were treated as different taxonomic groups by Solovieva in Rauzer-Chernousova *et al*. (1996). The former was designated as the type species of *Depratina* included in the family Profusulinellidae and the latter as that of *Piscoidella* in the family Aljutovellidae. In the opinion of the present author, the latter species is a junior synonym of the former, both families are not necessary and *Profusulinella* belongs in the subfamily Fusulinellinae placed under the family Fusulinidae (Kobayashi, 2011).

Profusulinella wangyüi Sheng, 1958 originally described from the lower part of the Penchi Series (Vereyan to Kashirian) of Liaoning, North China closely resembles this species, but has more massive chomata and almost straight lateral slopes. Thirty-five specimens identified with *P. ovata* Rauzer-Chernousova, 1938 by Kobayashi (2011) from Turkey are discriminated from *P. prisca* by their smaller tests and more developed chomata throughout growth.

Subfamily Fusulininae von Möller, 1878
Genus ***Akiyoshiella*** Toriyama, 1953

Type species.—*Akiyoshiella ozawai* Toriyama, 1953.

Remarks.—*Akiyoshiella* was placed under the family Eofusulinidae in Rauzer-Chernousova *et al*. (1996). The main reason might be the almost straight periphery of the test characteristic only in the holotype of *Akiyoshiella ozawai*, making it appear *Eofusulina*-like. However, *Eofusulina* has fewer whorls, more regularly and more strongly folded septa, and taller and more rounded septal loops (see e.g. Putrya, 1956) than *Akiyoshiella*. The described specimens of *Akiyoshiella* in Japan, if one is forced to compare them, are morphologically closer to the taxa summarized as the species group of *Fusulina ozawai* Rauzer-Chernousova and Belyaev in Rauzer-Chernousova *et al.*, 1940 (Kashirian to Podolskian) according to Rauzer-Chernousova *et al*. (1951) than to the eofusulines included in the subfamily Eofusulininae of the family Eofusulinidae by Rauzer-Chernousova *et al*. (1996). By these reasons, *Akiyoshiella* is assigned to Fusulininae under Fusulinidae in this paper.

Akiyoshiella kaimoriensis sp. nov.

Figures 5.15–5.17, 7.1–7.19, 8.1–8.18

Akiyoshiella ozawai Toriyama, 1953. Ishii, 1985, pl. 2, fig. 4; Kobayashi, 1994, figs. 4.12–4.14.
Akiyoshiella toriyamai Thompson, Pitrat, and Sanderson, 1953. Ishii, 1985, pl. 2, fig. 5.

Etymology.—From Kaimori in the Yura area.

Type specimens.—The holotype D2-036286, axial section from K-2 (Figure 7.1). Paratypes: 27 axial sections (Figures 5.15–5.17, 7.2–7.19, 8.1–8.6) and 12 sagittal sections (Figures 8.7–8.18). Register numbers of the 39 paratypes are given in the explanation of Figures 5, 7, and 8. The paratypes shown in Figure 7.3 and 7.13 are from K-8, and the others from K-2.

Type locality.—Kaimori, Yura Town, Hidaka County, Wakayama Prefecture, Japan.

Diagnosis.—Inflated to elongate fusiform *Akiyoshiella* characterized by broadly arched periphery and rounded to bluntly pointed poles in the external shape, and considerably variable height and regularity of septal loops in the outer whorls.

Measurements.—Shown in Table 2 (number of whorls, length, width, and form ratio of the test, proloculus size, length and width from the first to sixth whorl, and number of septa from the first to sixth whorl).

Description.—Test inflated to elongate fusiform in shape with broadly arched periphery, almost straight to broadly convex lateral sides, and rounded to bluntly pointed poles. Mature test of four and a half to five and a half whorls, rarely six, 2.48 to 3.50 mm in axial length and 0.97 to 1.60 mm in median width, giving a form ratio of 1.98 to 3.29.

Proloculus almost spherical, 0.093 to 0.160 mm in diameter. The first whorl inflated fusiform to fusiform and succeeded by outer whorls gradually increasing in length and width. Poles in inner and middle whorls are more pointed than those in outer ones. Axis of coiling almost straight.

Wall thin and its differentiation obscure in the first whorl. Wall also thin in outer whorls and consists of tectum, thicker, well continuous light layer comparable to a diaphanotheca, and a lower tectorium. Thickness of wall in the fourth whorl 0.015 to 0.033 mm. Septa closely spaced throughout the test, and more strongly folded in polar regions than in tunnel regions. Height and regularity of septal loops variable by specimens and in the same specimen, and dome-shaped or mushroom-shaped with variable height and width. Some are filled with secondary deposits. Septal counts from the first to fifth whorl 7 to 9, 13 to 15, 17 to 21, 20 to 25, 26 in eight paratypes.

Tunnel less than a half as high as chambers in inner two whorls, and becomes higher in outer whorls. Its path narrow and almost straight in general, but irregularly zigzag in certain specimens. Chomata distinct in inner three to four whorls, but indistinct or absent in outer whorls. Axial fillings not present or weakly developed only in axial regions of inner whorls.

Remarks.—Many test characters, especially of shape and size of the test and chamber height of corresponding whorls, are more or less variable among specimens. These differences should be interpreted as intraspecific variations, since they change continuously and gradually by specimens from the same sample. The present specimens are distinguished from the known species of *Akiyoshiellla* by being shorter and wider in the corresponding whorls and having rounded to more bluntly pointed poles of the external test and of middle to outer whorls, by which they are considered to be a new species of the

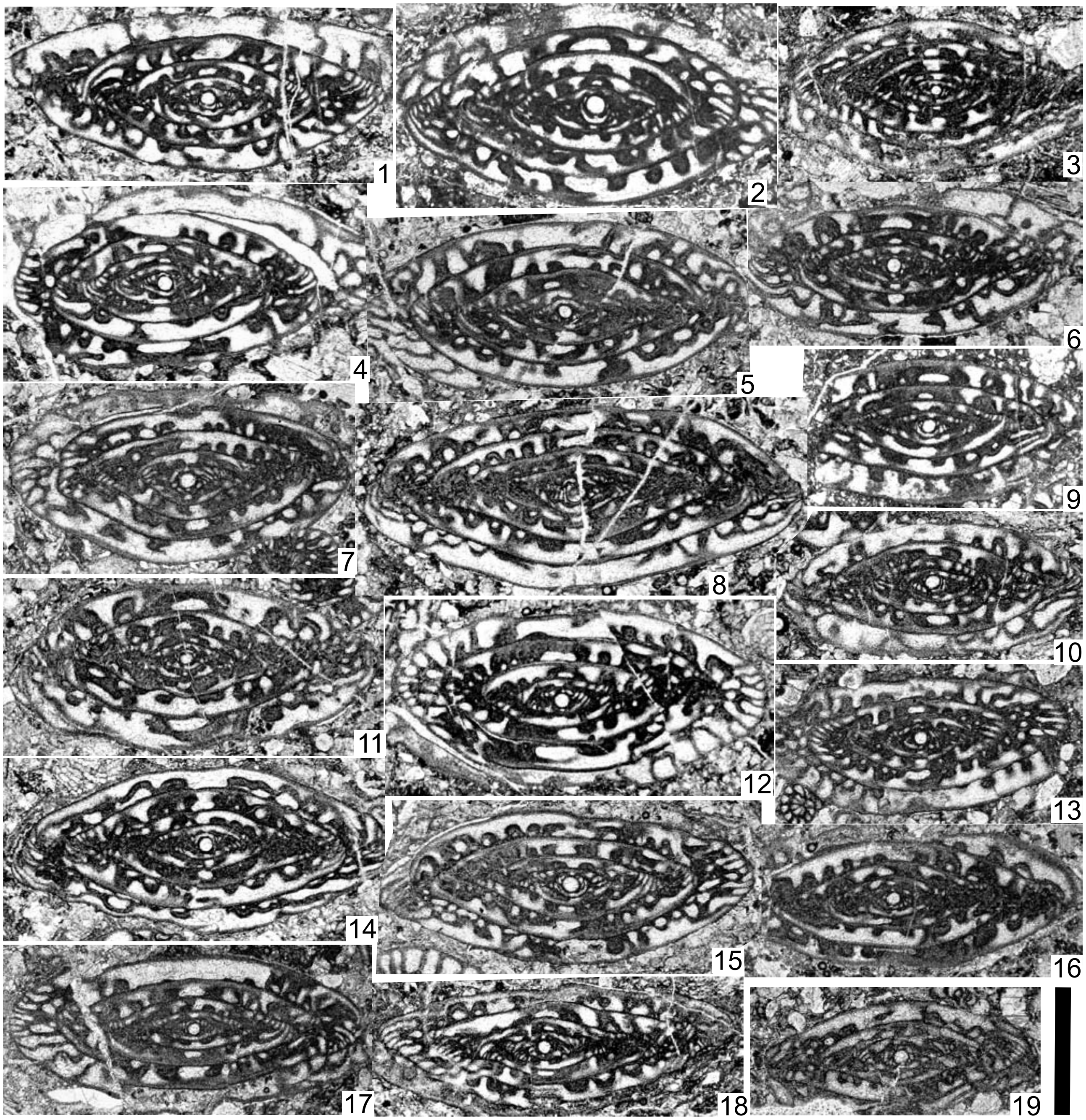

Figure 7. 1–19, *Akiyoshiella kaimoriensis* sp. nov.; 1, D2-036286; 2, D2-036298; 3, D2-036436; 4, D2-036296; 5, D2-036304; 6, D2-036287; 7, D2-036324; 8, D2-036329; 9, D2-053102; 10, D2-036314; 11, D2-036300; 12, D2-036431; 13, D2-036440; 14, D2-036332; 15, D2-036328; 16, D2-036271; 17, D2-036307; 18, D2-036305; 19, D2-036295; 3, 13, K-8; others, K-2. Scale bar shows 2 mm.

genus. Two specimens named *Akiyoshiella ozawai* and *A. toriyamai* by Ishii (1985) from Kaimori are different from the types, and are included in this new species. The former corresponds to the rounded forms and the latter to the elongate forms of this new species. Similarly, three specimens illustrated by Kobayashi (1994) from the Itsukaichi district (southern Kanto Mountains) should be separated from *Akiyoshiella ozawai* and reassigned to *A. kaimoriensis* by their smaller test than that of *A. ozawai* and by their mode of septal folding similar to that of this new species.

Occurrence.—Abundant in K-2 and common to rare in K-8.

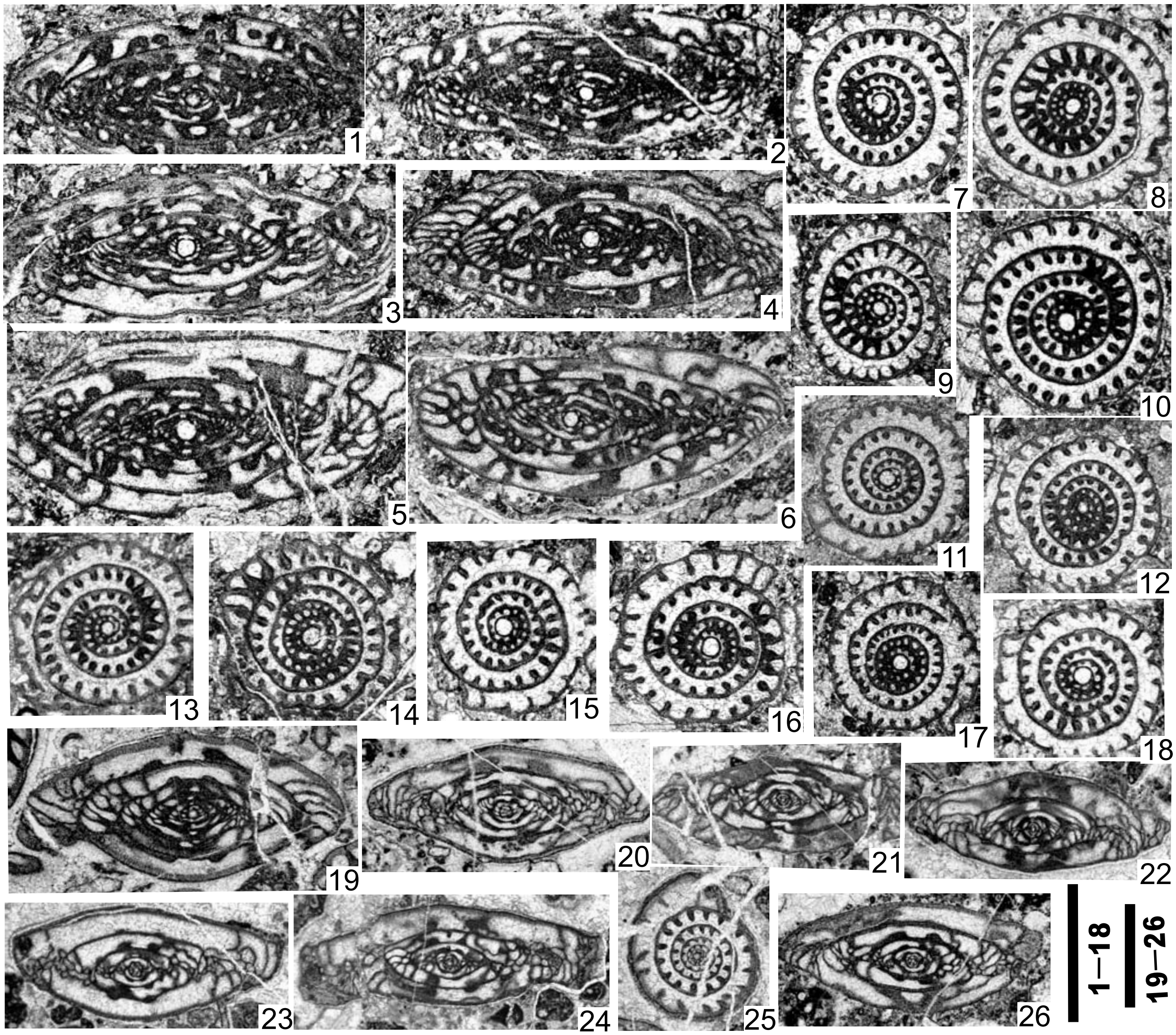

Figure 8. **1–18,** *Akiyoshiella kaimoriensis* sp. nov.; 1, D2-036270; 2, D2-036274; 3, D2-036295; 4, D2-036285; 5, D2-036299; 6, D2-036319; 7, D2-036266; 8, D2-036275; 9, D2-036321; 10, D2-036263; 11, D2-036292; 12, D2-036323; 13, D2-036301; 14, D2-036303; 15, D2-036308; 16, D2-036330; 17, D2-036332; 18, D2-036308; all K-2; **19,** *Montiparus matsumotoi* (Kanmera, 1955), D2-036725, S-2; **20–26,** *Obsoletes burkemensis* Volozhanina, 1962; 20, D2-036702; 21, D2-036722; 22, D2-036714; 23, D-036686; 24, D2-036683; 25, D2-036679; 26, D2-036721; all S-1. Scale bar of 1 mm for 1–18, and of 1 mm for 19–26.

Akiyoshiella ozawai Toriyama, 1953

Figure 5.18

Akiyoshiella ozawai Toriyama, 1953, p. 253, pl. 35, figs. 1–9; pl. 36, figs. 1–3; Watanabe, 1974, p. 387, p. 53, figs. 1–4; Ueno, 1989, pl. 2, fig. 10; Ozawa and Kobayashi, pl. 2, figs. 15–17; Kobayashi, 2017, figs. 7.17, 7.18.

Akiyoshiella sp. A Toriyama 1953, p. 255, pl. 36, figs. 4–8.

Akiyoshiella toriyamai Thompson, Pitrat, and Sanderson, 1953, p. 550, pl. 58, figs. 1–16; Watanabe, 1974, p. 387, pl. 53, figs. 5–10, Ueno, 1989, pl. 2, fig. 9.

Akiyoshiella fusulinoides Sosnina in Sosnina and Nikitina, 1976, p. 30, pl. 13, fig. 5.

Akiyoshiella sp. Sosnina and Nikitina, 1976, pl. 13, fig. 6.

Remarks.—Much larger specimens than *Akiyoshiella kaimoriensis*, though rare, were recognized only in sample K-9. They have five whorls, almost straight periphery and sharply pointed poles in the middle and outer whorls, by which they are identified with *A. ozawai*. These and other test characters closely resemble those of the holo-

Table 2. Measurements of *Akiyoshiella kaimoriensis* sp. nov.

Figure	No. whorls	Length (mm)	Width (mm)	Form ratio	Prolo-culus (mm)	Length of whorl (mm)						Width of whorl (mm)					
						1	2	3	4	5	6	1	2	3	4	5	6
5.15	4.5	2.68	1.17	2.30	0.135	0.41	1.17	1.95	2.52			0.21	0.41	0.64	1.03		
5.16	4.5	2.58	1.12	2.31	0.143	0.47	1.09	1.75	2.38			0.26	0.44	0.69	1.05		
5.17	5.5	2.94	1.32	2.23	0.120	0.29	0.59	1.15	1.86	2.51		0.19	0.31	0.51	0.81	1.14	
7.1	5	3.18	1.22	2.61	0.145	0.39	0.80	1.55	2.39	3.18		0.17	0.31	0.54	0.88	1.22	
7.2	5.5	3.16	1.60	1.98	0.160	0.30	0.78	1.50	2.36	2.98		0.27	0.39	0.82	1.00	1.42	
7.3	5.5	2.68?	1.22	2.20?	0.093	0.28	0.64	1.13	1.77	2.34		0.16	0.28	0.48	0.76	1.04	
7.4	5.5	?	1.42	—	0.133	0.34	0.78	1.28	1.81	2.51?		0.21	0.35	0.56	0.85	1.20	
7.5	5	2.89	1.33	2.17	0.124	0.38	0.92	1.49	2.20	2.89		0.22	0.36	0.61	0.96	1.33	
7.6	5	2.95?	1.17?	2.52?	0.130	0.28	0.79	1.34	2.25	2.95?		0.19	0.31	0.52	0.85	1.17?	
7.7	5	2.88	1.38	2.09	0.147	0.36	0.75	1.60	2.04	2.88		0.22	0.43	0.57	1.03	1.38	
7.8	6	3.50	1.39	2.52	0.098	0.31	0.69	1.23	2.19	2.80	3.50	0.17	0.31	0.40	0.77	1.05	1.39
7.9	4.5	—	1.11	—	0.110	0.44	1.08	2.38	—			0.19	0.49	0.59	0.94		
7.10	4.5	2.48	1.06	2.34	0.125	0.43	0.83	1.55	2.14			0.20	0.37	0.57	0.87		
7.11	5	2.93	1.30	2.25	0.108	0.31	0.69	1.32	2.20	2.93		0.18	0.27	0.52	0.85	1.30	
7.12	5	3.11?	1.43	2.17?	0.123	0.53	1.07	1.77	2.43	3.11?		0.22	0.39	0.65	1.06	1.43	
7.14	5	2.99	1.32	2.27	0.110	0.43	0.99	1.61	2.31	2.99		0.16	0.35	0.62	0.96	1.32	
7.15	5	2.96	1.19	2.49	0.145	0.37	0.78	1.51	2.15	2.96		0.19	0.30	0.51	0.78	1.19	
7.17	5	2.90?	1.24	2.34?	0.110	0.40	0.83	1.60	2.26?	2.90?		0.17	0.31	0.54	0.87	1.24	
7.18	5	3.11	1.03	3.02	0.115	0.40	0.84	1.52	2.44	3.11		0.18	0.31	0.52	0.81	1.03	
8.3	4.5	2.83	1.02	2.77	0.143	0.33	0.85	1.47	2.34			0.21	0.35	0.59	0.84		
8.4	5	2.86	1.13?	2.53?	0.133	0.35	0.69	1.32	2.02	2.86		0.19	0.33	0.52	0.82	1.13?	
8.1	4.5	2.58	1.06	2.43	0.123	0.32	0.81	1.60	2.24			0.18	0.33	0.58	0.83		
8.2	4.5	3.19	0.97	3.29	0.125	0.39	0.96	1.91	2.70			0.19	0.37	0.57	0.82		

Figure	No. whorls	Length (mm)	Width (mm)	Form ratio	Prolo-culus (mm)	Number of septa						Width of whorl (mm)					
						1	2	3	4	5	6	1	2	3	4	5	6
8.15	4.6	—	1.18	—	0.143	7	14	18	22	14>		0.28	0.45	0.72	1.04		
8.9	4.7	—	1.19	—	0.128	8	13	16	24	21>		0.23	0.41	0.66	1.00		
8.11	4.7	—	1.22	—	0.135	8	14	18	23	20>		0.24	0.38	0.64	0.98		
8.7	4.8	—	1.41	—	0.173	8	15	19	25	23>		0.30	0.50	0.79	1.22		
8.16	4.7	—	1.34	—	0.145	8	15	17	20	18>		0.28	0.42	0.70	1.06		
8.13	4.7	—	1.35	—	0.123	9	14	18	24	20>		0.24	0.43	0.70	1.13		
8.10	4.6	—	1.56	—	0.143	9	14	21	27	18>		0.35	0.55	0.89	1.31		
8.8	5.6	—	1.57	—	0.130	9	14	17	21	26	20>	0.22	0.38	0.59	0.96	1.44	

type of *A. ozawai* (Toriyama, 1953, pl. 35, fig. 1) from the Akiyoshi Limestone Group. Periphery of the test in all other specimens of Toriyama (1953) is broadly rounded.

For the purpose of morphologic comparison among *Akiyoshiella ozawai* and *A. kaimoriensis* from Kaimori and *A. ozawai* from the Akiyoshi Terrane, nine specimens from three localities representing different stratigraphic levels in the Akiyoshi Limestone Group and two specimens from the Omi Limestone are illustrated in Figure 9. Specimens with an almost straight periphery such as the holotype are rather exceptional and fewer than others in the Akiyoshi Limestone Group (Figure 9). More inflated forms than the holotype and paratypes of the species are interpreted to represent broad morphologic variations of this species, since morphologic changes are continuous from specimen to specimen (Figure 9). Abnormally grown specimens of *Akiyoshiella*, wordily emphasized in Toriyama (1953), are rare at least in the Japanese materials.

Akiyoshiella fusulinoides proposed by Sosnina in Sosnina and Nikitina (1976) from Primorye is considered to be a junior synonym of *A. ozawai* because of having almost the same test characters as those of the types, and is attributed to an elongate form of the species. Thompson *et al*. (1953) proposed *A. toriyamai* from the Cache Creek Group of British Columbia by its slenderer test, smaller proloculus, and seemingly heavier axial fillings. In this paper, it is supposed to correspond to elongate forms of *A. ozawai* taking the broad morphologic variation of the species from the Akiyoshi Limestone Group into consideration (Toriyama, 1953; Figure 9). Similarly, specimens identified with *A. toriyamai* described by Watanabe (1974, pl. 53, figs. 5–10) from the Omi Limestone and that illustrated by Ueno (1989) from the Akiyoshi Limestone Group are attributed to *A. ozawai*.

Family Schwagerinidae Dunbar and Henbest, 1930

Genus ***Montiparus*** Rozovskaya, 1948

Type species.—*Fusulina montipara* von Möller, 1878.

Montiparus matsumotoi (Kanmera, 1955)

Figure 8.19

Triticites matsumotoi Kanmera, 1955, p. 184, pl. 11, figs. 6–25.
Triticites matsumotoi kattoi Suyari, 1962, p. 15, pl. 5, figs. 1–3.
Triticites matsumotoi suitaensis Suyari, 1962, p. 17, pl. 5, figs. 4–6.
Montiparus matsumotoi (Kanmera). Ozawa and Kobayashi, 1990, pl. 4, figs. 4, 5; Kobayashi, 1994, p. 632, figs. 4.17, 4.18; Y. Ota and M. Ota, 1993, pl. 1, figs. 4, 5; Kobayashi, 2017, p. 47, pl. 11, figs. 1–24.
Montiparus matsumotoi matsumotoi (Kanmera). Watanabe, 1991, figs. 18.7–18.12.
Montiparus matsumotoi inflatus Watanabe, 1991, figs. 18.1–18.6 (without description).

Remarks.—Considerable differences supposed to represent the intraspecific variation of *Montiparus matsumotoi* are recognized in the types from the Yayamadake Limestone (Kanmera, 1955). More inflated forms than *M. matsumotoi* were informally named as *M. matsumotoi inflatus* by Watanabe (1991) from the Omi Limestone without description. They resemble this species and might represent its inflated form. Two new subspecies, listed above, proposed by Suyari (1962) from the Miyanokuchi Formation, central part of Shikoku are also thought to be inflated forms of *M. matsumotoi*, as suggested by Kobayashi (1994).

One illustrated herein and some other, not well oriented specimens from sample S-2 are apparently identified with *Montiparus matsumotoi* in the close similarity of their test characters to those of the types from the Yayamadake Limestone (Kanmera, 1955) and of many specimens from the Wakatakeyama area of Akiyoshi (Kobayashi, 2017). One specimen illustrated as *Triticites* aff. *montiparus* (von Möller, 1878) by Ishii (1985) from the Shirasaki Limestone is distinguished both from *M. montiparus* and *M. matsumotoi* by its less developed chomata, though detailed comparison is impossible. Five specimens named *T. stuartensis* by Thompson (1965) from the Cache Creek Terrane in British Columbia are reassigned to *Montiparus*. They might be synonymous with *M. matsumotoi*, though having massive chomata not extending poleward.

Genus ***Obsoletes*** Kireeva, 1950

Type species.—*Fusulina obsoleta* Schellwien, 1908.

Remarks.—As pointed out by Kobayashi (2017), significant differences are not easily found out even by the slight difference of wall composition between *Obsoletes* and *Protriticites*. *Obsoletes obsoletus*, designated as the type species of the genus (Kireeva, 1950), was assigned to *Protriticites* by Rozovskaya (1950), as well as by Putrya (1948) who established the genus *Protriticites*. Both genera are thought to be independent of each other by most workers without showing clear morphologic differences between the two. In this paper, *Obsoletes* is provisionally separated from *Protriticites* by its more elongate test with thinner wall.

Obsoletes burkemensis Volozhanina, 1962

Figures 8.20–8.26

Obsoletes burkemensis Volozhanina, 1962, p. 124, pl. 1, fig. 2; Kobayashi, 2017, p. 46, pl. 9, figs. 3, 5–9, 11, 12.
Fusulinella hirokoae Suyari, 1962 (*pars*), p. 13, pl. 3, figs. 9, 11, 13 (*non* pl. 3, figs. 10, 12 = indeterminate *Protriticites*); Sada, 1964, p. 239, pl. 23, figs. 12–15.
Schubertella popensis Thompson, 1965, p. 228, pl. 33, figs. 1–5.
Obsoletes obsoletus (Schellwien). Ozawa and Kobayashi, 1990 (*pars*),

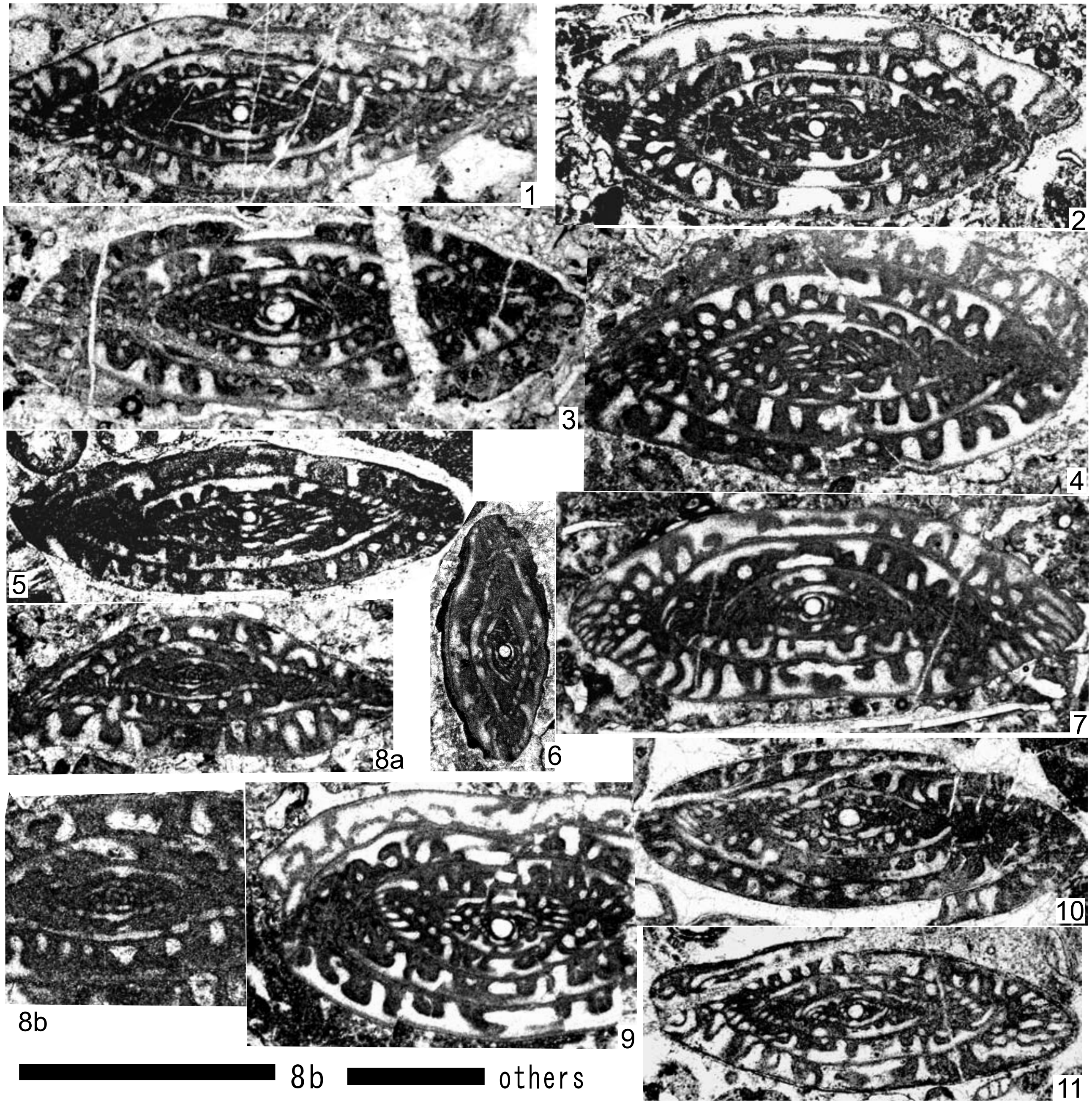

Figure 9. *Akiyoshiella ozawai* from the Akiyoshi Limestone Group (**1–9**) and Omi Limestone (**10, 11**). 1, 3, 5, 6, 10, 11, elongate forms; 2, 4, 9, inflated forms; 7, intermediate forms; 8, microspheric form. 1, D2-051192 (= Kobayashi, 2017, fig. 7.18); 2, D2-051280 (=Kobayashi, 2017, fig. 7.17); 3, D2-051101; 4, D2-065913; 5, D-067935; 6, D2-068200; 7, D2-051279; 8, D2-065912; 9, D2-051287; 10, D2-004179; 11, D2-004176. 1, A-260; 3, A-256; 2, 7, 9, A-266 from south of the Wakatakeyama area, Akiyoshi; 4, 8, B-481 from 265 m N of Tanaiwa, Akiyoshi; 5, B-585 from 1.1 km west of Chojyagamori, Akiyoshi; 6, B-613 from 560 m N of Tanaiwa, Akiyoshi; 10, 11; 775 m east of J.R. Oyashirazu Station, Omi. Scale bar shows 1 mm.

pl. 3, figs. 17, 18 (*non* pl. 3, fig. 16 = *Obsoletes obsoletus*).

Praeobsoletes burkemensis (Volozhanina). Remizova, 1993, p. 166, fig. 1f; Davydov *et al*., 2000, pl. 8, figs. 8–10.

Remarks.—The Shirasaki specimens are closely similar to and identified with *Obsoletes burkemensis* originally described from the *Protriticites* Zone (lower Kasimovian) of the Timan-Pechora region by Volozhanina (1962) in their not so elongate test as in typical *Obsoletes*, tightly coiled inner whorls, and thinner wall in inner whorls. They are also identified with the eight specimens from the Wakatakeyama area of Akiyoshi (Kobayashi, 2017), in spite of more tightly coiled inner whorls and smaller proloculus in some of them. Three specimens among five proposed by Suyari (1962) as a new species of *Fusulinella* are considered to be reassigned to *Obsoletes* in their thinner wall with a protheca-like translucent layer not referable to a diaphanotheca. They are probably identical with *O. burkemensis*. The other two specimens among the five should be reassigned to *Protriticites* in their thicker translucent layer of the wall in the middle and outer whorls. Five specimens named *Schubertella popensis* by Thompson (1965) from British Columbia are closely similar to the three specimens among Suyari's (1962) five which are attributed herein to *O. burkemensis*. They are more or less different from almost all species of *Schubertella* on account of their much stronger chomata and much more rapidly expanding outer whorls.

This species was designated as the type species of *Praeobsoletes* proposed by Remizova (1993), who thought that *Praeobsoletes* is a transitional form from *Fusulinella* to *Obsoletes*. The species treated as *Praeobsoletes* was also reported from northern Greenland by Davydov *et al*. (2001). However, a detailed comparison is impossible on account of the few specimens and no description of morphologic features of the test. It seems to be not easy to separate *Praeobsoletes* from *Obsoletes*.

Genus ***Protriticites*** Putrya, 1948

Type species.—*Protriticites globulus* Putrya, 1948.

Protriticites variabilis Bensh, 1972

Figures 10.1–10.27

Protriticites variabilis Bensh, 1972, p. 22, pl. 1, figs. 1–4; Kobayashi, 2017, p. 46, pl. 9, figs. 18–33.
Protriticites subschwagerinoides Rozovskaya, 1950. Ozawa and Kobayashi, 1990 (*pars*), pl. 3, fig. 20 (*non* pl. 3, figs. 19, 21 = *Protriticites subschwagerinoides*).

Description.—Test elongate fusiform with broadly arched periphery and bluntly pointed poles. Axis of coiling straight. Mature test consists of five and a half to six and a half whorls, about 2.9 to 3.9 mm in length and about 1.1 to 1.6 mm in width. Form ratio about 2.2 to 3.4. Proloculus spherical and 0.04 to 0.08 mm in diameter. The first to second whorls subspherical to inflated fusiform, tightly coiled, followed by succeeding whorls rather rapidly expanding outwards.

Wall thin, structureless in inner two whorls, and composed of tectum and thin lower layer in the next few whorls. In middle and outer whorls, wall consists of a tectum, finely perforate light-colored layer, and discontinuous lower tectorium. Faint alveolar keriotheca-like layer preserved in outer whorls in certain specimens. Thickness of wall about 0.04 to 0.06 mm in outer whorls.

Septa closely spaced, not folded in the median part of the test, but weakly folded in polar regions. Septal counts in the last whorls 17 to 19. Tunnel path almost straight. Chomata massive and well developed, but not present or rudimentary in the last whorl in most specimens.

Remarks.—The Shirasaki specimens of *Protriticites* are certainly identical with the types of *Protriticites variabilis* in their shape and size of the test, mode of septal folding, and development of chomata. A perforate layer partly appearing as a diaphanotheca is due to the weak recrystallization of the present material. *Protriticites variabilis* was originally described by Bensh (1972) from the lower Kasimovian of southern Fergana. *Protriticites variabilis* is also known from the lower Kasimovian of the Wakatakeyama area of Akiyoshi (Kobayashi, 2017). Although the present and the Akiyoshi specimens have considerably variable test characters, chomata are more massive and the test is a bit slenderer in the latter. One specimen among three identified with *P. subschwagerinoides* by Ozawa and Kobayashi (1990) is separated and reassigned to this species in its more elongate fusiform test. *Protriticites robustus* Ueno, 1991 and *Protriticites* sp. both described from the Akiyoshi Limestone Group by Ueno (1991) should be separated from the genus and transferred to a species of *Montiparus* on account of their larger test, larger proloculus, and thicker alveolar wall, as suggested by Kobayashi (2017).

Family Staffellidae Miklukho-Maklay, 1949
Genus ***Pseudoendothyra*** Mikhailov, 1939

Type species.—*Fusulinella struvii* von Möller, 1879.

Pseudoendothyra umbo Rozovskaya, 1963

Figure 4.13

Pseudoendothyra umbo Rozovskaya, 1963, p. 89, pl. 16, figs. 6, 7.

Remarks.—This species was proposed by Rozovskaya (1963) from the Protvinsky horizon (upper Serpukhovian) of the Moscow Basin for pseudoendothyrins having a moderately sized test with a more broadly rounded periphery and more deeply depressed umbilicus than other species. One axial and other oblique sections of the present material closely resemble the original ones in these characteristic features of the test.

Genus ***Reitlingerina*** Rauzer-Chernousova, 1985

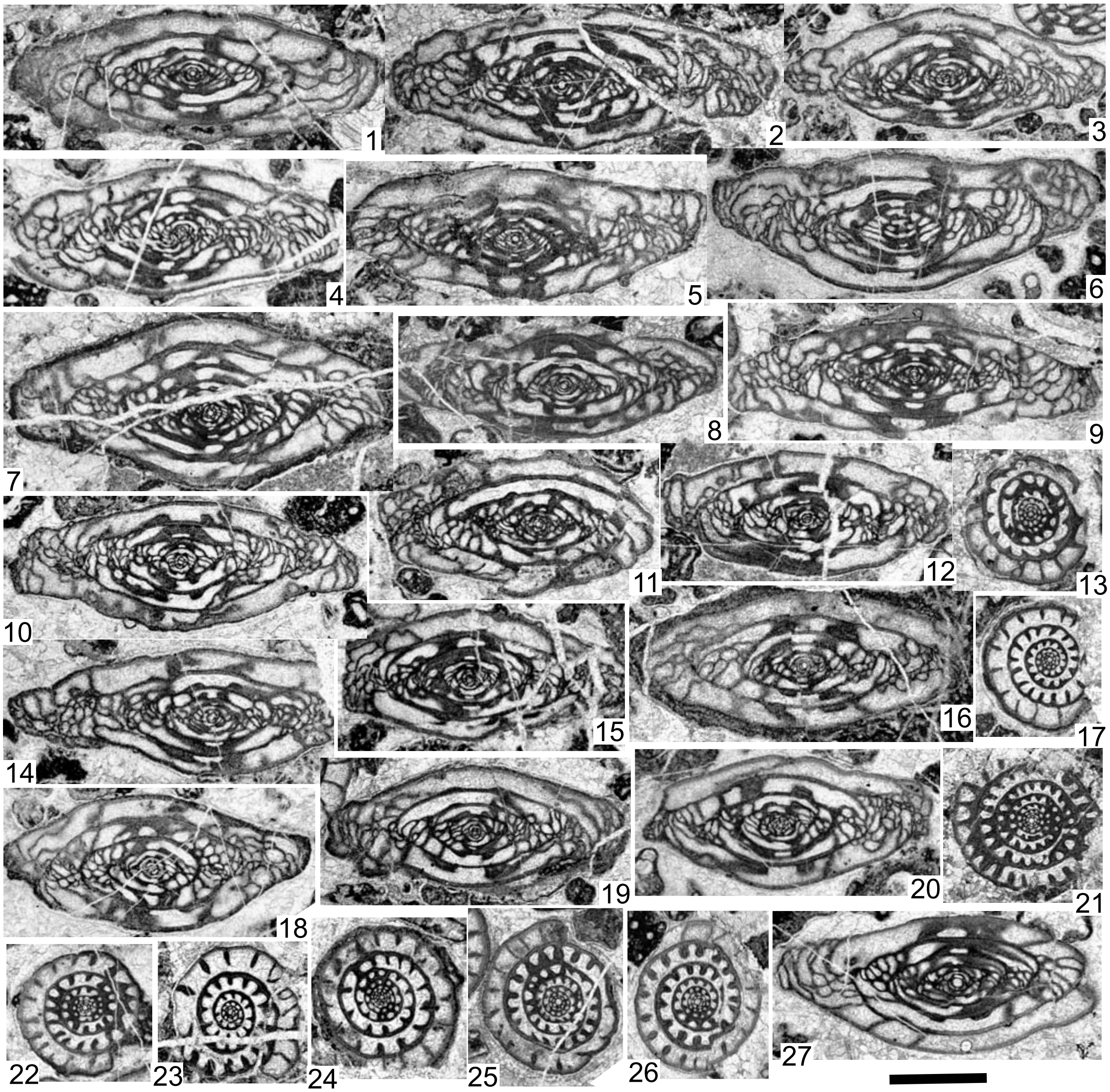

Figure 10. **1–27,** *Protriticites variabilis* Bensh, 1972; 1, D2-036677; 2, D2-036687; 3, D2-036699; 4, D2-036693; 5, D2-036702; 6: D2-036705; 7, D2-036711; 8, D2-036719; 9, D2-036696; 10, D2-036697; 11, D2-036703; 12, D2-036713; 13, D2-036720; 14, D2-036707; 15, D2-036690; 16, D2-036718; 17, D2-036715; 18, D2-036706; 19, D2-036712; 20, D2-036691; 21, D2-036675; 22, D2-036708; 23, D2-036680; 24, D2-036688; 25, D2-036704; 26, D2-036709; 27, D2-036706; all S-1. Scale bar shows 1 mm.

Type species.—*Fusulinella bradyi* von Möller, 1878.

Reitlingerina musashiensis (Kobayashi, 1994)

Figures 4.29–4.31

Pseudoendothyra musashiensis Kobayashi, 1994, p. 634, figs. 5.2–5.9.

Remarks.—The genus *Reitlingerina* is distinguished from *Nankinella* by its smaller test and fewer whorls, and from *Pseudoendothyra* by its pointed to bluntly pointed periphery. The two specimens (Figures 4.30, 4.31) are surely identical with *Reitlingerina musashiensis*, originally assigned to *Pseudoendothyra*, from the upper Serpukhovian (?) to lower Bashkirian limestone blocks of the Itsukaichi district (Kobayashi, 1994). The other (Figure 4.29) appears to be more alike to the type species of *Pseudoendothyra*, *P. struvii* illustrated by von Möller (1879) and Mikhailov (1939), by its larger form ratio of the test. However, it is included in this species taking the broad morphologic variation of the Itsukaichi material into account.

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