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Original article

Late Middle Permian (Capitanian) foraminifers in the Miharaiyama area, Hyogo—Late Paleozoic and Early Mesozoic foraminifers of Hyogo, Japan, Part 2—

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Abstract

Permian foraminiferal faunas of the Miharaiyama area in the Maizuru Terrane consist of 40 species assignable to 27 and two indeterminate genera in four samples of conglomerate from the middle formation of the Maizuru Group. Except for Colaniella sp., 39 species are late Middle Permian (Capitanian) in age. The faunal composition of these species is similar to that of the *Lepidolina kumaensis* fauna of the Kuma Formation in the Kurosegawa Terrane of Kyushu. *Lepidolina kumaensis, L. multiseptata, Chusenella acris, Lantschichites cuniculata, Kahlerina ussurica,* and *Sichotenella ussurica* are characteristic and common in the Miharaiyama area and the Kuma Formation. These and similar species also occur in South China and Primorye. Limestone pebbles including *Colaniella* sp. indicate that the middle formation of the Maizuru Group in the Miharaiyama area is Lopingian in age. In addition to these fusulinoidean species, the genus *Sumatrina* and *Lepidolina maizurenis* from the Maizuru Terrane have particular paleogeographical and tectonical implications.

Key words: Foraminifers, Late Middle Permian (Capitanian), Miharaiyama area, Hyogo,Serial descriptive works.

Introduction

The Maizuru Terrane is a distinct geotectonic unit of the Inner Zone of Southwest Japan and is discontinuously distributed from the west end of Fukui prefecture to the north of Hiroshima, trending ENE-WSW with a width of 15−20 km, forming a nappe overlying the Ultra-Tamba Terrane (Permian accretionary complex) and underlying the Akiyoshi Terrane (another Permian accretionary complex) (Fig. 1). The Maizuru Terrane consists of the Yakuno complexes referable to a dismembered ophiolite (Yakuno Ophiolite) and Permian and Triassic formations (Nakazawa et al., 1958; Shimizu et al., 1962; Suzuki, 1987; Hayasaka, 1990). The lithology and geochemistry of the Yakuno complexes and stratigraphy, lithology, and fossil assemblages of these formations are important in considering the tectonic history of the Maizuru and other Japanese terranes.

Among Permian fossils of the Maizuru Terrane, foraminifers are available for paleogeographic and tectonic reconstruction of the terrane in Middle to Late Permian time (Kobayashi, 1997a; 1997b; 1999; 2003). Characteristic foraminiferal faunas and the lithology of the limestone blocks and clasts in the terrane strongly suggest their derivation from the Akiyoshi Terrane and the eastern continental margin of South China (Kobayashi, 2003). Fusulinoideans from the Maizuru Terrane in Kyoto prefecture were systematically described by Nogami (1958; 1959). Some of the latest Permian (Changhsingian) foraminifers were listed and illustrated by Ishii et al. (1975) from several localities in the terrane.

In Hyogo prefecture, the Capitanian *Lepidolina kumaensis* fauna and the Changhsingian *Colaniella*-

Palaeofusulina fauna have been reported from 16 and 5 localities, respectively (Kobayashi and Takemura, 1995). All of these fossil localities are restricted to the Maizuru Terrane. They have not been described, and the faunal composition of them are not well known.

This paper describes and discusses the late Middle Permian (Capitanian) foraminifers from the Miharaiyama area in the northern part of Hyogo prefecture. They were cited by Kobayashi (2003) in his discussion on the paleogeographic and tectonic evolution of the Maizuru Terrane. This paper is the second of the serial descriptive works under the title of Late Paleozoic and Early Mesozoic foraminifers of Hyogo, Japan, and is a continuation from the paper (Kobayashi, 2005), which discusses the Middle Permian (Wordian) foraminifers of Kametsubo. All limestone thin sections used in this paper are stored in the collection of the Museum of Nature and Human Activities, Sanda, Hyogo, Japan (Fumio Kobayashi Collection).

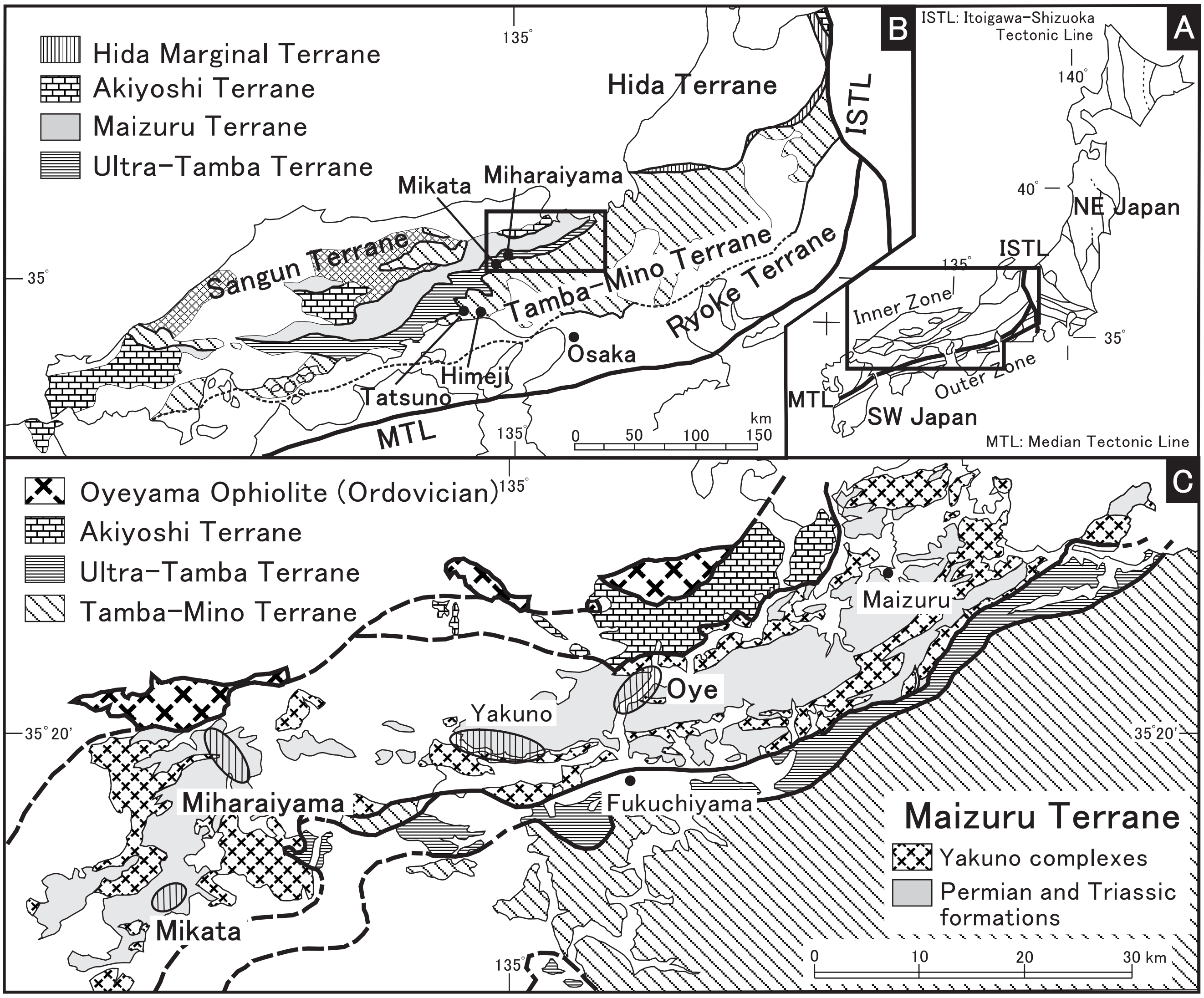

Figure 1. (A) Geotectonic framework of the Japanese Islands. (B) Distribution of pre-Cretaceous terranes in the Inner Zone of Southwest Japan. (C) Distribution of the Yakuno complexes and Permian and Triassic formations in the eastern part of the Maizuru Terrane (after Kobayashi, 2003).

Stratigraphy of the Maizuru Group

The Permian and Triassic formations in the Maizuru Terrane are divisible into the Middle to Upper Permian Maizuru Group, the Lower to Middle Triassic Yakuno Group, and the Upper Triassic Nabae Group, three of which are in unconformable relationships with each other (Nakazawa et al., 1958; Shimizu et al., 1962). They are typically exposed in the Maizuru and Yakuno areas (Fig. 1). These groups consist mostly of mudstone, sandstone, and conglomerate, and completely lack deep-oceanic sediments. In addition to these rocks, a small amount of lenticular limestone is intercalated within siliciclastic rocks of the upper part of the Maizuru Group and the upper part of the Yakuno Group. Limestone clasts are contained in the conglomerate of the middle and upper parts of the Maizuru Group and in the basal conglomerate of the Yakuno Group.

The Maizuru Group is subdivided into lower, middle, and upper formations. It is estimated to be 1500 to 3000 m thick, but it is uncertain exactly how thickness it is because of the complicated geologic structure and other reasons. According to the stratigraphic summary by Kobayashi (2003), the lower formation is more than 750 m thick and consists of weakly-metamorphosed basaltic rocks and mudstone having Middle Permian radiolarians in places. The middle formation, which is 500 to 1500 m thick, consists of dominant mudstone and alternating beds of sandstone and mudstone, and subordinate sandstone, acidic tuff, and conglomerate with the *Lepidolina kumaensis* fauna. Late Middle Permian and early Late Permian radiolarians occur in the mudstone and acidic tuff. However, *Colaniella* sp. contained in a limestone clast of the conglomerate with the *Lepidolina kumaensis* fauna from the Miharaiyama area apparently shows the Late Permian (Lopingian) age of the middle formation. The upper formation, 100 to more than 700 m thick, is composed mainly of sandstone, mudstone, and alternating beds of sandstone and mudstone. Lenticular limestone and conglomerate less than 10 m thick and exclusively yielding Late Permian foraminifers are intercalated within the mudstone. The latest Permian (Changhsingian) radiolarians have not been extracted from the upper formation.

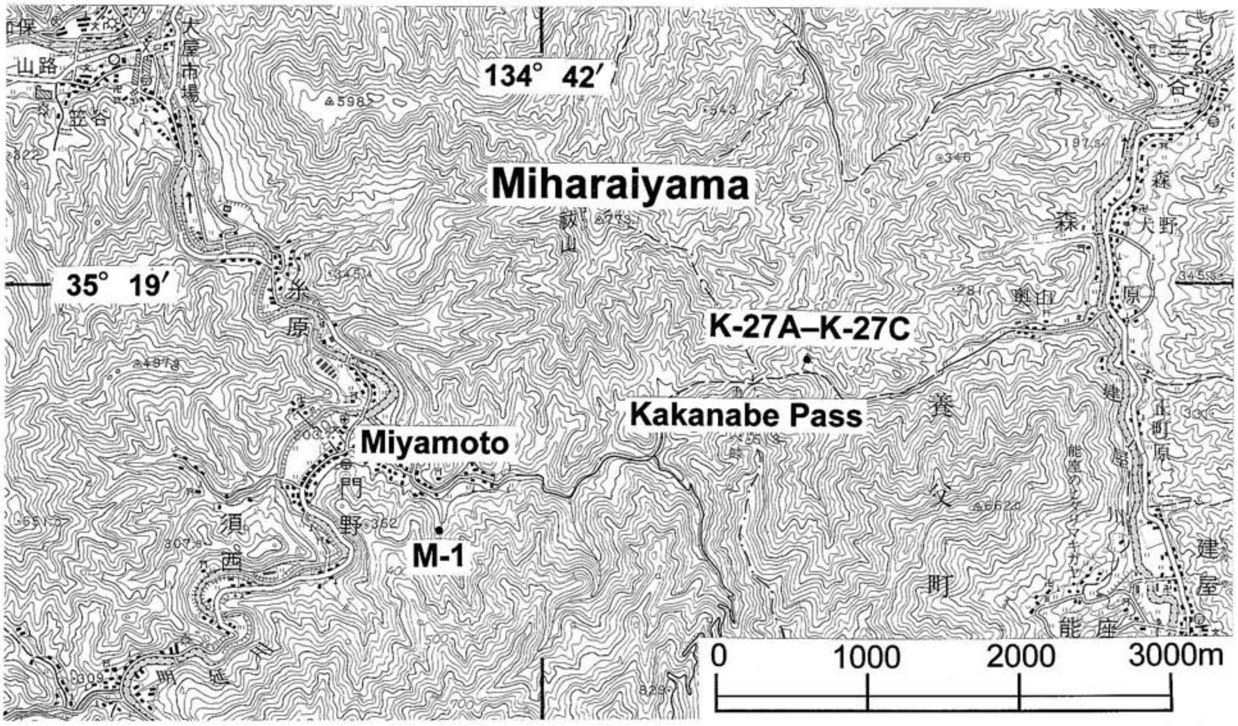

Figure 2. Sample locations in the Miharaiyama area. Topographic map is from 1:50,000 map "Oyaichiba" of Geographical Survey Institute of Japan.

Materials

The Middle Permian foraminifers studied in this paper were obtained from four samples of conglomerate. Three (K-27A, K-27B, K-27C) were collected from the lenticular conglomerate that was more than 5 m thick within mudstone exposed near the Kakanabe Pass. The other one (M-1) was from an erratic conglomerate in the south of Miyamoto in the Miharaiyama area (Fig. 2). The localities of K-27A to K-27C correspond to Locality 6 and M-1 to Locality 3, respectively, by Kobayashi and

Takemura (1995) who summarized all microfossils reported from Hyogo prefecture up to 1993.

The conglomerate is characterized by small, angular to subrounded limestone clasts and bioclasts of crinoids, bryozoans, foraminifers, green algae, brachiopods, and calcisponges within a calcareous argillaceous matrix (Fig. 3). In addition to limestone clasts, the conglomerate contains poorly-sorted granules, pebbles, and cobbles of dominant acidic tuff, basalt, basic tuff, sandstone, and mudstone, and of subordinate chert, andesite, granite, gneiss, and gabbro. Almost all limestone clasts are considered to be the Capitanian from the exclusive occurrence of foraminifers referable to the *Lepidolina kumaensis* fauna, except for those containing Lopingian Colaniella sp. (Kobayashi, 2003, Fig. 5-D).

These conglomerates are characteristic in the middle formation of the Maizuru Group in Hyogo prefecture, and are also known from the upper formation of the group in the Oye area of Kyoto prefecture (Kobayashi, 2003). The lithologic characters of the conglomerate of the middle formation are common to those of the upper formation with *Palaeofusulina-Colaniella* fauna in that they have calcareous argillaceous matrices. However, the latter differs from the former in having a more calcareous and more narrowly-spaced matrix, more densely-packed, more dominant, and larger-sized limestone clasts, and fossil contents (Kobayashi, 2003).

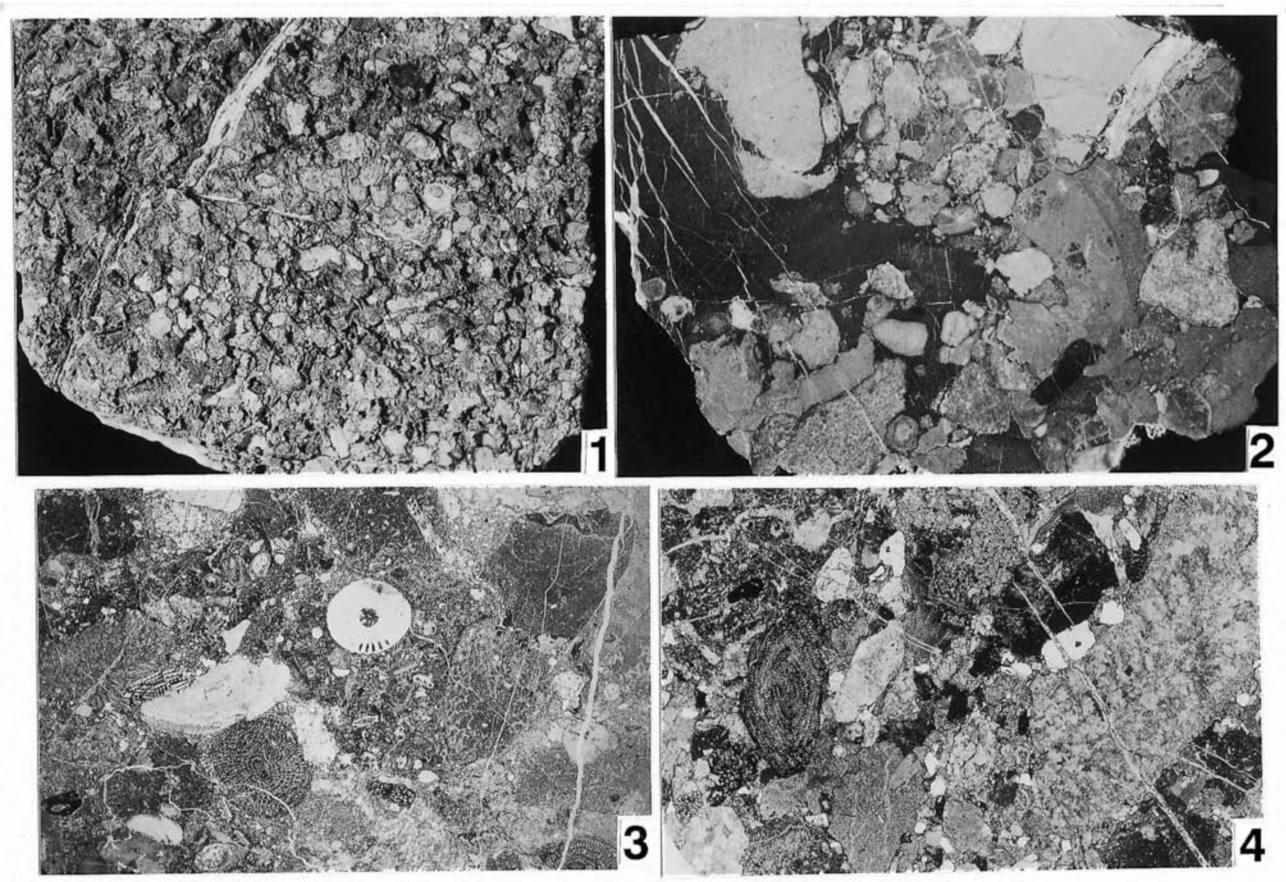

Figure 3. Photographs of the conglomerate of the Maizuru Group in the Miharaiyama area. Many angular to subrounded, ill-sorted granules and pebbles, mostly of limestone in addition to sandstone, mudstone, acidic tuff, and others, and bioclasts of fusulinoideans, crinoids, bryozoans, green algae, and others are packed within the calcareous argillaceous matrix. 1. Weathered surface, K-27B, ×0.58. 2. Polished surface, K-27A, ×3. 3. Thin section, K-27A, ×3. 4. Thin section, M-1, ×3.1.

Foraminiferal fauna

Forty species assignable to 27 and indeterminate two genera of foraminifers were identified from the conglomerate of the middle formation of the Maizuru Group in the Miharaiyama area (Table 1, Plates 1 — 3). Among them, 39 species, except for the Lopingian Colaniella sp., are thought to be

Capitanian age based on the lack of apparently pre-Capitanian genera and species. The faunal composition was almost the same among the four samples examined.

The Miharaiyama fauna is closely related to the Capitanian fauna from the Kuma Formation (Kanmera, 1954; Kobayashi, 2001). Fifty-five species belonging to 39 genera were distinguished in the Kuma fauna by Kobayashi (2001). The pre-Capitanian genera and species are completely lacking in the conglomerate of the Kuma Formation that occurs in the *Lepidolina* fauna. Furthermore, the lithology of the conglomerate is similar between the middle formation of the Maizuru Group and the Kuma Formation, as described and illustrated by Kobayashi (2001).

The characteristic species common in these two faunas are *Lepidolina kumaensis* Kanmera, *L. multiseptata* (Deprat), *Chusenella acris* (Thompson and Wheeler), *Lantschichites cuniculata* (Kanmera), *Kahlerina ussurica* (Sosnina), and *Sichotenella ussurica* Sosnina. These and similar species also occur in South China (e.g., Sheng, 1963; Rui, 1983) and Primorye (e.g., Sosnina, 1968; Chedija, 1981). Occurrences of other genera such as *Metadoliolina* and *Yabeina* are also common between the Miharaiyama area and the Kuma Formation. On the other hand, *Lepidolina maizurenis,* which is very characteristic in the former, is not recognized in the latter.

A neoschwagerinid genus *Yabeina* is highly dominant in Jurassic terranes of Japan and other Circum-Pacific terranes (Kobayashi, 1997b). The occurrence of *Yabeina* from the Maizuru Terrane is significant paleobiogeographically. Yabeina is very rare in the Permian terranes of Japan, South China, South East Asia, and the Qinghai-Xizang Plateau (Kobayashi, 1997a; 2003). These terranes and continental blocks all belong paleobiogeographically to Province B (Eastern Tethyan Province) and are dominated by the neoschwagerinid genera of *Lepidolina, Afghanella,* and *Sumatrina* (Kobayashi, 1997a; 1999).

Although *Sumatrina* has not been found in the Miharaiyama area, it is known from the Oye area, Kyoto prefecture (Nogami, 1959). The occurrence of *Sumatrina* and/or *Afghanella* is very important paleobiogeographically and tectonically in and around the Japanese Islands. These two neoschwagerinid genera are very common in the Middle Permian throughout the Tethyan regions and are characteristic in the Permian Akiyoshi Terrane. They are, however, completely lacking in the Jurassic terranes of Japan and other Circum-Pacific terranes that are paleobiogeographically assignable to Province C (Kobayashi, 1997a; 1997b). These characteristic Capitanian fusulinoideans and some of the Middle Carboniferous and Late Permian ones led Kobayashi to the conclusion that all limestone blocks and clasts of the Maizuru Terrane were derived from the Akiyoshi Terrane and the eastern continental margin of South China, along with limestone lithologies and tectonic evolution of pre-Cretaceous terranes of East Asia (Kobayashi, 2003).

Systematic paleontology

Order FORAMINIFERIDA Eichwald, 1830
Suborder FUSULININA Wedekind, 1937
Superfamily Fusulinoidea von M`ller, 1879
Family Schubertellidae Skinner, 1931
Genus ***Lantschichites*** Tumanskaya, 1953
Lantschichites sp.
Plate 2, Figures 16, 19

Material.—One tangential and one oblique sections.

Discussion.—This unidentified species of *Lantschichites* is discriminated from L. *cuniculata* (Kanmera) by having a larger and more elongate test and more strongly fluted septa throughout the test. It is more similar to *Lantschichites elegans* Sosnina described from the *Metadoliolina lepida* Zone of Sikhote-Alin by Sosnina (1968) and *Lantschichites splendens* (Skinner and Wilde) from the Maokou Limestone of Guangxi by Sheng (1963) than forms assignable to Lantschichites known from Japan. Further comparison is difficult because there are no axial and sagittal sections from the Miharaiyama area.

Occurrence.— Rare in the samples K-27B and M-1, contained in the limestone pebble and occurring as a bioclast.

Family Neoschwagerinidae Dunbar and Condra, 1927
Subfamily Lepidolininae A. D. Miklukho-Maklay, 1958
Genus ***Lepidolina*** Lee, 1933 emend. Ozawa, 1970
Lepidolina maizurensis Nogami
Figure 4-1, 4-2; Plate 1, Figures 2—4, 8, 9

Lepidolina toriyamai maizurensis Nogami, 1958, p. 106, 108, pl. 2, figs. 1－5.
non. *Yabeina maizurensis* (Nogami). Zaw Win, 1999, p. 64, 65, pl. 13, figs. 1－4.

Material.－Two axial, two parallel, and one oblique sections.

Discussion.－This species was originally described as a subspecies of *Lepidolina toriyamai* Kanmera that is conspecific with *L. kumaensis* Kanmera based on the examination of many topotype materials (Kobayashi, 2001). It has a more inflated test than *L. kumaensis*, but the taxonomic independency of this species is not always acceptable based on its thicker wall as insisted by Nogami (1958). For example, the specimens illustrated in Plate 1, fig. 3 (= Fig. 4-2) and fig. 4 have an exceedingly thin and undifferentiated wall, as does that of *L. kumaensis* in Plate 1, fig. 1 (= Fig. 4-3). The illustrated specimens in this paper suggest that *L. maizurensis* is probably distinguished from L. kumaensis by its smaller proloculus, fewer number of transverse septula, and the first appearance of secondary transverse septula in the later ontogenetic stage (Fig. 4). By these

Table 1. Late Middle Permian foraminifers discriminated in the Miharaiyama area.

	K-27A	K-27B	K-27C	M-1	Plate (Figure)
Ladiodiscus planus K. M. Maklay	X		X	X	3 (7, 9-11)
Colaniella sp.		X			
Climacammina sp.	X				3 (13)
Cribrogenerina? sp.				X	
Palaeotextulariidae gen. and sp. indet.		X	X	X	
Tetrataxis sp.				X	3 (15, 16)
Dagmarita chanakchiensis Reytlinger	X				3 (17)
Postendothyra sp.	X				2 (13)
Kahlerina ussurica (Sosnina)	X	X	X	X	3 (1-4)
Rauserella ellipsoidalis Sosnina			X	X	1 (15, 18)
Rauserella? sp.				X	1 (14)
Sichotenella ussurica Sosnina	X		X	X	1 (13)
Dunbarula sp.	X			X	3 (6, 8)
Dunbarula? sp.	X				3 (5)
Lantschichites cuniculata (Kanmera)	X	X	X	X	1 (12, 16, 17)
Lantschichites sp.		X		X	2 (16, 19)
Chusenella acris (Thompson and Wheeler)		X	X	X	2 (11, 14, 18, 20)
Chusenella spp.	X	X	X	X	2 (12, 15, 21)
Schwagerinidae gen. and sp. indet.				X	2 (17)
Metadoliolina multivoluta (Sheng)	X	X	X	X	2 (2, 3)
Lepidolina kumaensis Kanmera	X	X	X	X	1 (1, 5-7)
Lepidolina maizurensis Nogami	X	X	X	X	1 (2-4, 8, 9)
Lepidolina multiseptata (Deprat)	X	X	X	X	2 (1, 5, 6)
Lepidolina? sp.	X	X			2 (8)
Yabeina sp.			X	X	2 (4, 7, 9, 10)
Nankinella sp. A		X	X		1 (10)
Nankinella sp. B		X		X	1 (11)
Streblospira sp.			X		3 (14)
Agathammina sp.		X	X		3 (30, 31)
Agathammina? sp.	X				
Hemigordius sp.			X	X	3 (34)
Multidiscus guangxiensis Lin		X	X		3 (38)
Multidiscus sp.			X		3 (37)
Kamurana? sp.	X			X	3 (35, 36)
Pachyphloia ovata Lange	X	X		X	3 (12, 19-22, 26-29)
Frondina? spp.	X	X	X		
Ichthyofrondina sp.		X		X	3 (18)
Geinitzina? spp.			X	X	3 (23-25)
Robuloides sp.	X				3 (33)
Robuloides? sp.	X		X	X	3 (32)

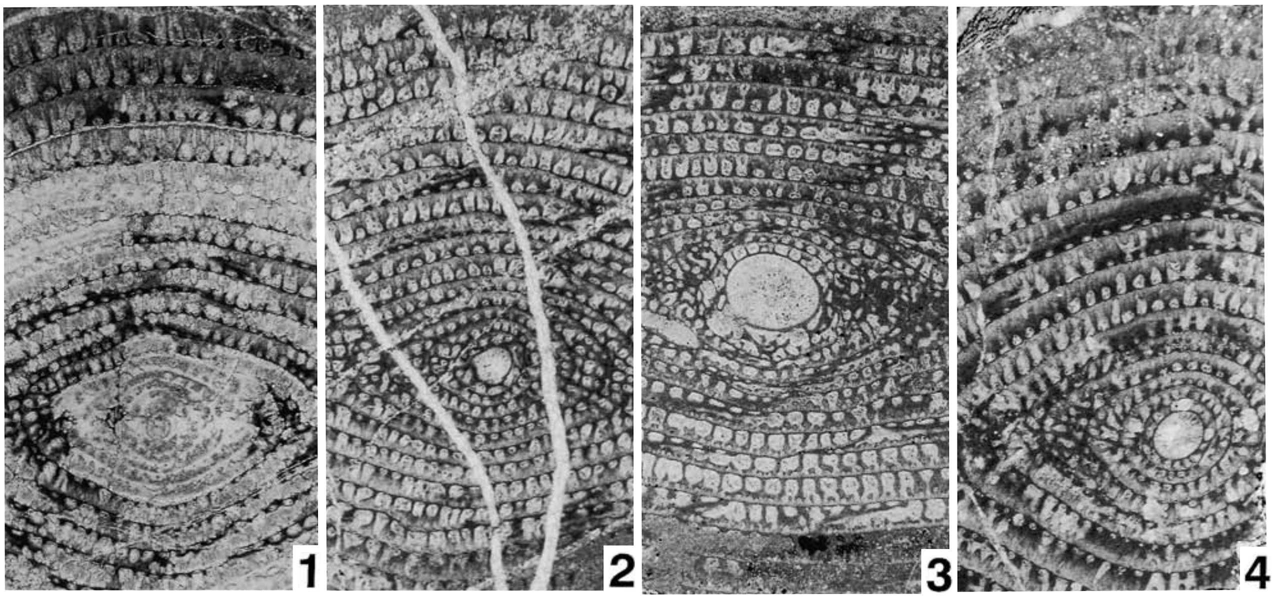

Figure 4. Photomicrographs of the inner whorls of three species of Lepidolina in the Miharaiyama area. All ×20. 1, 2. Lepidolina maizurensis (the same as Pl. 1, figs. 2, 3). 3. Lepidolina kumaensis (the same as Pl. 1, fig. 1). 4. Lepidolina multiseptata (the same as Pl. 2, fig. 1).

differences, this species is thought to be taxonomically independent from *L. kumaensis* in species level rather than in subspecies level.

The three forms assigned to *Yabeina maizurensis* (Nogami) from the Akasaka Limestone described by Zaw Win (1999) are quite different from *Lepidolina maizurensis* in many respects. They are thought to be an evolved form of *Gifuella*, and are not assignable to *Yabeina* and also not similar to *Yabeina columbiana* (Dawson), as Zaw Win thought, on the basis of the close comparison of many topotype specimens from the Akasaka Limestone and the Marble Canyon Limestone of British Columbia (unpublished data by the author).

Occurrence.— Common in the all conglomerate samples examined in the Miharaiyama area, contained in limestone pebbles, and occurring as bioclasts.

Subfamily Neoschwagerininae Dunbar and Condra, 1927

Genus ***Yabeina*** Deprat, 1914

Yabeina sp.

Plate 2, Figures 4, 7, 9, 10

Material.—Three axial and one sagittal sections.

Discussion.— Well-oriented, fully-grown specimens were not obtained. The illustrated specimens are all incomplete, and the test of one axial section is micritized and that of the other two axial and one sagittal sections is partly replaced by siliceous materials. However, they are undoubtedly referable to *Yabeina* from their thicker wall and septula and smaller proloculus than those of *Lepidolina*. They are not assignable to *Neoschwagerina* from the well-developed secondary transverse septula.

These four specimens are similar to *Yabeina higoensis* Kobayashi originally described from the Kuma Formation (Kobayashi, 2001) in many respects such as the test form, relatively small test size for the genus, morphology, development of primary and secondary transverse septula, and in other ways. Similarly, they resemble two specimens identified as *Yabeina columbiana* by Nogami (1958) from the Maizuru Terrane. A conspecific or intimate relation is largely possible among these three forms of *Yabeina.* The conclusive taxonomic treatment of them is, however, reserved herein on account of no fully-grown specimens being available from the Miharaiyama area.

Occurrence.— Rare in the samples K-27C and M-1, contained in limestone pebbles and occurring as bioclasts.

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Plate 1.

Figs. 1, 5−7. *Lepidolina kumaensis* Kanmera.
1: D2-023054, M-1; 5: D2-014009, K-27A; 6: D2-027227, K-27C; 7: D2-023083, M-1; all ×10.

Figs. 2−4, 8, 9. *Lepidolina maizurensis* Nogami.
2: D2-023053, M-1, 3: D2-014029, K-27A; 4: D2-014044, K-27B; 8: D2-014040a, M-1; 9:D2-027240b, K-27C; all ×10.

Fig. 10. *Nankinella* sp. A.
D2-027234, K-27C, ×40.

Fig. 11. *Nankinella* sp. B.
D2-023096, M-1, ×25.

Figs. 12, 16, 17. *Lantschichites cuniculata* (Kanmera).
12: D2-014040b, K-27B; 16: D2-023087, M-1; 17: D2-014030, K-27A; all ×30.

Fig. 13. *Sichotenella ussurica* Sosnina.
D2-014010, K-27A, ×50.

Fig. 14. *Rauserella*? sp.
D2-023080, M-1, ×30.

Figs. 15, 18. *Rauserella ellipsoidalis* Sosnina.
15: D2-023085, M-1; 18: D2-027217, K-27C; both ×40.

Plate 2.

Figs. 1, 5, 6. *Lepidolina multiseptata* (Deprat).
1: D2-014013, K-27A; 5: D2-027237, K-27C; 6: D2-023057, M-1; all ×10.

Figs. 2, 3. *Metadoliolina multivoluta* (Sheng).
2: D2-014036a, K-27B, ×10; 3: D2-023075, M-1, ×15.

Figs. 4, 7, 9, 10. *Yabeina* sp.
4: D2-023077, M-1; 7: D2-027222, K-27C; 9: D2-023097, M-1; 10: D2-023095, M-1; all ×10.

Figs. 8. *Lepidolina*? sp.
D2-014022, K-27A, ×10.

Figs. 11, 14, 18, 20. *Chusenella acris* (Thompson and Wheeler).
11: D2-014012, K-27B; 14: D2-027228, K-27C; 18: D2-023078, M-1; 20: D2-023079, M-1; all ×10.

Figs. 12, 15, 21. *Chusenella* spp.
12: D2-027231, K-27C; 15: D2-023094, M-1; 21: D2-023074, M-1; all ×10.

Fig. 13. *Postendothyra* sp.
D2-014026, K-27A, ×60.

Figs. 16, 19. *Lantschichites* sp.
16: D2-023088, M-1; 19: D2-014036b, K-27B; both ×10.

Fig. 17. Schwagerinidae gen. and sp. indet.
D2-023084, M-1, ×10.

Plate 3.

Figs. 1−4. *Kahlerina ussurica* (Sosnina).
1: D2-023091, M-1, ×20; 2: D2-014026, K-27A, ×20; 3: D2-027235a, K-27C; ×25; 4: D2-027226a, K-27C; ×30.
Fig. 5. *Dunbarula*? sp.
D2-014026, K-27A, ×30.
Figs. 6, 8. *Dunbarula* sp.
6: D2-023061; 8: D2-023098, both M-1, ×30.
Figs. 7?, 9−11. *Lasiodiscus planus* K. M. Maklay.
7: D2-014031; 9: D2-023095; 10: D2-014012; 11: D2-023093; 7, 10: K-27A; 9, 11: M-1, all ×50.
Figs. 12, 19−22, 26−29. *Pachyphloia ovata* Lange.
12: D2-023092a; 19: D2-014017; 20: D2-014027; 21: D2-014030; 22: D2-14029; 26: D2-027215; 27: D2-023093; 28: D2-027226b; 29: D2-023092c; 12, 27, 29: M-1; 19−22: K-27A; 26: K-27C; 20, 21:×30; 27:×50; others:×40.
Fig. 13. *Climacammina* sp.
D2-014022, K-27A, ×15.
Fig. 14. *Streblospira* sp.
D2-027230, K-27C, ×60.
Figs. 15, 16. *Tetrataxis* sp.
15: D2-023061; 16: D2-023092b, both M-1, ×30.
Fig. 17. *Dagmarita chanakchiensis* Reytlinger.
D2-014026, K-27A, ×40.
Fig. 18. *Ichthyofrondina* sp.
D2-014037, K-27B, ×40.
Figs. 23−25. *Geinitzina*? spp.
23: D2-027239, K-27C, ×40; 24: D2-027235b, K-27C, ×30; 25: D2-023088, M-1, ×40.
Figs. 30, 31. *Agathammina* sp.
30: D2-027227a; 31: D2-027227b, both K-27C, ×30.
Fig. 32. *Robuloides*? sp.
D2-014015, K-27A, ×50.
Fig. 33. *Robuloides* sp.
D2-014029, K-27A, ×40.
Fig. 34. *Hemigordius* sp.
D2-023091, M-1, ×40.
Figs. 35, 36. *Kamurana*? sp.
35: D2-023083a, ×100; 36: D2-023083b, ×30, both M-1.
Fig. 37. *Multidiscus* sp.
D2-027240a, K-27C, ×30.
Fig. 38. *Multidiscus guangxiensis* Lin.
D2-027225, K-27C, ×60.

Plate 1

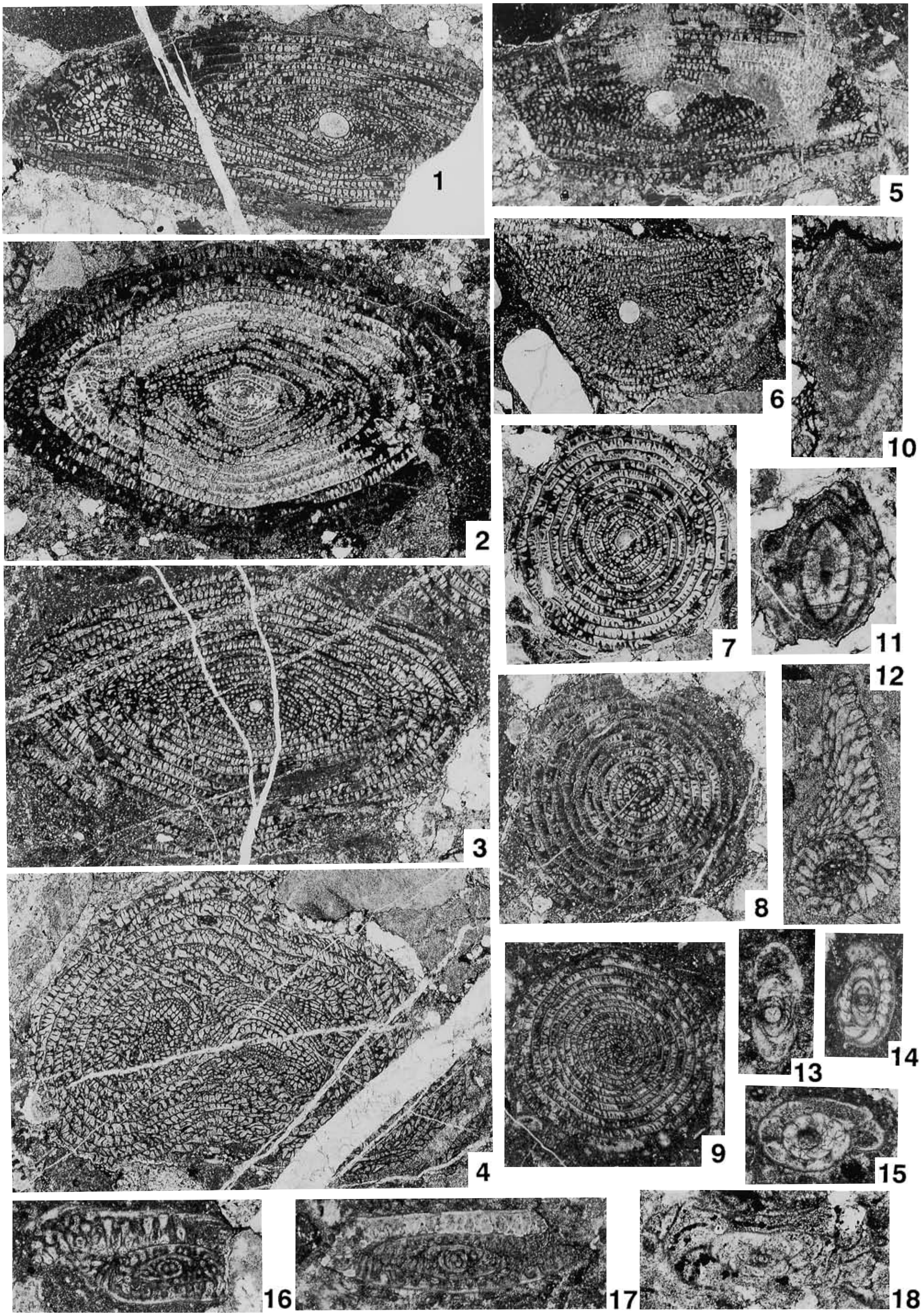


Plate 2

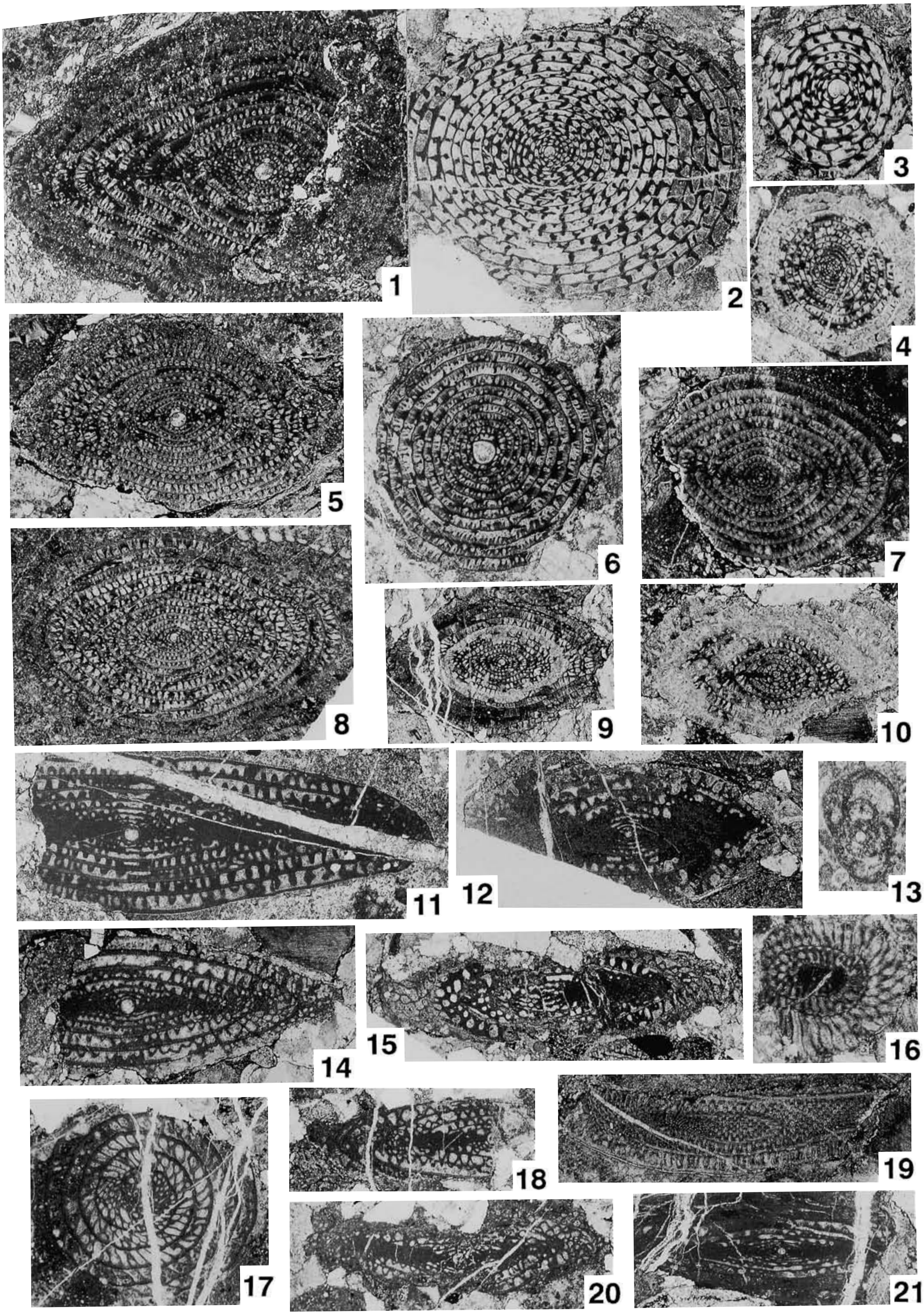
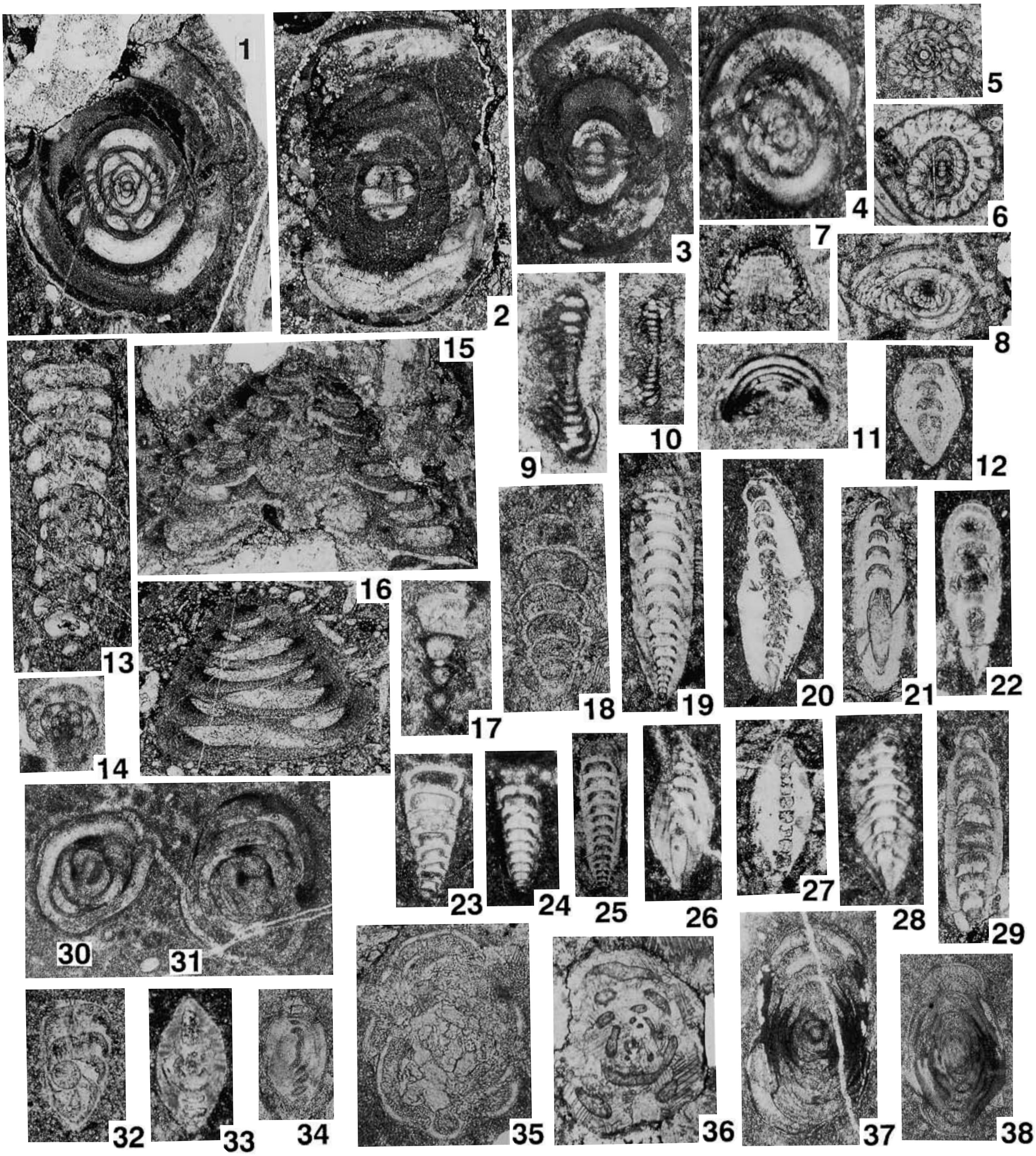


Plate 3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