
Original article

Latest Permian (Changhsingian) foraminifers in the Mikata area, Hyogo—Late Paleozoic and Early Mesozoic foraminifers of Hyogo, Japan, Part 3—

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Abstract

The Changhsingian foraminiferal fauna of the Mikata area is the most variable in its taxonomic composition among the contemporaneous faunas of the Maizuru Terrane. Thirty-one species assignable to 15 and four indeterminate genera were identified from the five samples examined. They are represented by four species of *Palaeofusulina* and *Colaniella parva* and occur in both lenticular limestone and conglomerate of the Mikata Formation correlating to the upper formation of the Maizuru Group. These foraminifers are commonly more or less recrystallized and deformed. The seemingly different taxonomic composition of them among the five samples is due to the post-depositional geothermal and geodynamic events in the Maizuru Terrane. The Mikata foraminifers and their occurrences are important paleogeographically and are concerned with the origin and tectonic evolution of the Maizuru Terrane along with the stratigraphy, lithology, and other fossils of Permian and Triassic formations in the terrane.

Key words: Foraminifers, Latest Permian (Changhsingian), Mikata area, Hyogo, Serial descriptive works.

Introduction

The Permian and Triassic formations in the Miharaiyama area, of which the late Middle Permian (Capitanian) foraminifers are described and discussed by Kobayashi (2006a), continue southwestward to the Mikata area, 40 km north of Himeji, Hyogo (see Kobayashi, 2006a, Figure 1-C). Because of occurrences of the uppermost Permian foraminifers and lowermost Triassic ammonoids and bivalves from this area, they are important for the Permian-Triassic boundary and its related tectonic and paleontologic problems of Japan. The complicated geologic structure in this area, however, has caused a serious disagreement on the stratigraphic relationships between these formations (Shimizu, 1962; Shimizu et al., 1962; Kanmera and Nakazawa, 1973; Working Group on the Permian-

Triassic Systems, 1975). Despite several difficulties connected with poor exposure and tectonic disturbance, the standard stratigraphic succession established in the Maizuru and Yakuno areas (Suzuki et al., 1982; Nakazawa et al., 1958) is applicable to the Permian and Triassic formations in the Mikata area (Kobayashi, 2003).

Occurrences of the *Lepidolina kumaensis* fauna and *Palaeofusulina sinensis* fauna, very characteristic in the Permian formations of the Maizuru Terrane, have been well-known since Shimizu (1962), who originally established the stratigraphy of the Permian and Triassic formations in the Mikata area. Ishii et al. (1975) listed seven species of *Colaniella*, *Palaeofusulina* aff. *sinensis* and the other 13 species of foraminifers assignable to eight genera and showed some of their illustrations. However, fossil localities of these

species in the area were not shown by Ishii et al. (1975). The stratigraphy, lithology, and fossils of Permian and Triassic formations, especially of the Permian ones in the Mikata area, are concerned with the origin and tectonic evolution of the Maizuru Terrane (Kobayashi, 1999; 2003).

The purpose of this paper is: (1) to show in detail the fundamental data of the Mikata area cited in Kobayashi (2003), in which it was concluded that all limestone blocks and clasts of the Maizuru Terrane are exotic and were derived from the

Akiyoshi Terrane (Permian accretionary complexes) and eastern continental margin of South China; and (2) to analyze the Changhsingian foraminiferal faunas of the Mikata area. This paper is the third in a serial descriptive work titled Late Paleozoic and Early Mesozoic foraminifers of Hyogo, Japan. 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).

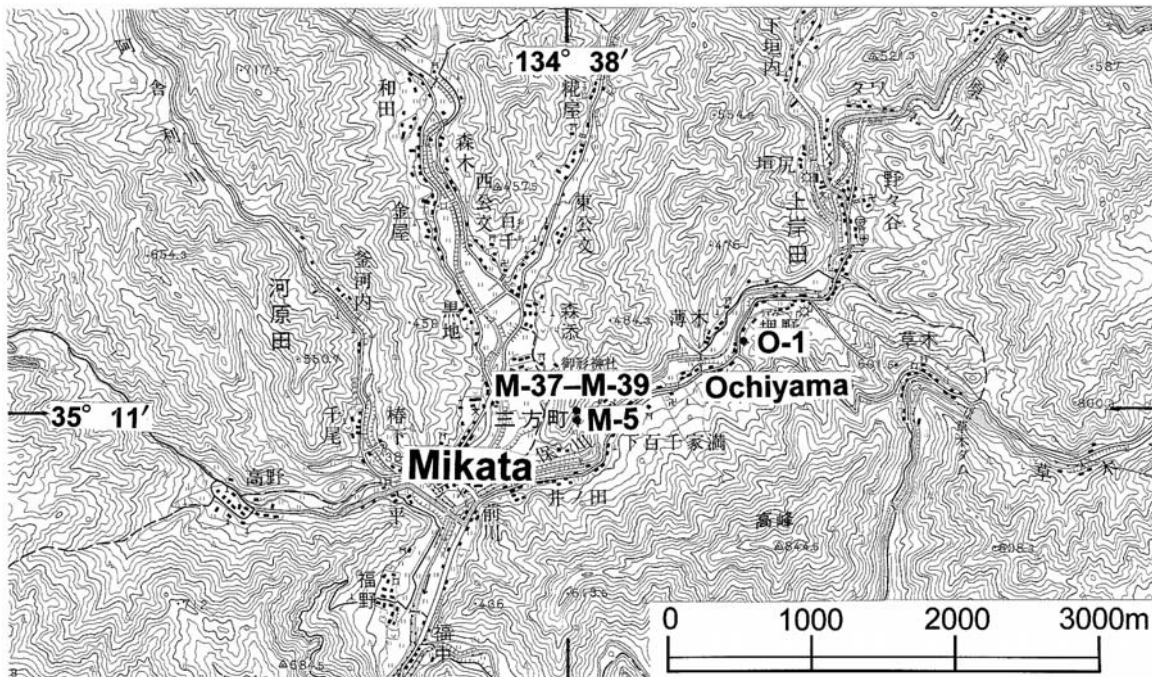


Figure 1. Sample locations in the Mikata area. Topographical map is from 1:50,000 map “Oyaichiba” of Geographical Survey Institute of Japan.

Brief note on the stratigraphy of Permian and Triassic formations

The Permian and Triassic formations in the Mikata area were divided into the Middle–Upper Permian Maizuru Group and further subdivided into the Iuchi, Mikata, Yokoyama, and Kuratoko Formations from lower to upper, and the Lower Triassic Kamikishida Formation by Shimizu (1962). The Kamikishida Formation corresponds to the lower part of the Yakuno Group in the type area of Kyoto prefecture (Nakazawa et al., 1958). In Hyogo prefecture, the Upper Triassic Sencho Formation only crops out in the vicinity of Sencho, a few kilometers east of this area. It is correlated to the N2 formation of the Nabae Group in the type area (Wadatsumi and Shimizu, 1963).

The stratigraphy of the Maizuru Group proposed by Shimizu (1962) was revised by the ammonoid-bearing Lower Triassic slaty mudstone tectonically intercalated between the uppermost Permian and the upper Middle Permian strata in the Mikata area (Working Group on the Permian-Triassic System, 1975) and by the reexamination of the geologic structure and stratigraphy of the group throughout the Maizuru Terrane (Kanmera and Nakazawa, 1973; Working Group on the Permian-Triassic System, 1975; Ishii et al., 1975; Suzuki et al., 1982). The lithology and foraminiferal biostratigraphy of the Maizuru Group between the type and these areas suggest the Iuchi, Yokoyama, and Mikata Formations in ascending stratigraphic order, and penecontemporaneous heteropic facies between the Yokoyama and Kuratoko Formations in

the Mikata area. Although the direct contact relationship among them can not be confirmed and their original stratigraphy is largely disturbed, an approximate correlation is possible between the Iuchi, Yokoyama, and Mikata Formations in this area and the lower, middle, and upper formations in the Maizuru area, respectively.

The Iuchi Formation consists mostly of basic lava and pyroclastic rocks. The Yokoyama Formation is characterized by conglomerate with *Lepidolina kumaensis* Kanmera. The Mikata Formation is marked by limestone and conglomerate with *Palaeofusulina sinensis* Sheng and Chang and *Colaniella parva* (Colani). In addition to the foraminifer faunas contained in pebbles, the conglomerate of the Mikata Formation differs from that of the Yokoyama Formation in its composition of pebbles, mostly of limestone and having a more calcareous matrix. The limestone of the Mikata Formation is less than 5 m thick, lenticular in shape, and intercalated within mudstone and muddy sandstone. It is more or less conglomeratic and contains argillaceous and tuffaceous materials in places.

Materials

Three samples of the limestone and two of the conglomerate from the Mikata area were used in this paper. The other ones were excluded because of the unfavorable state of preservation of the foraminifers.

Two limestone (M-5, M-39) and two conglomerate (M-37, M-38) samples were collected along a small valley east of the Mikata Spa (Mahoroba-no-yu) and the other one limestone (O-1) came from the largest limestone block of the Mikata area cropping out in Ochiyama (Fig. 1). The locality of samples M-5, -37, -38, and -39, and of O-1 respectively correspond to Locality 22 and Locality 21 in Kobayashi and Takemura (1995).

All limestone and conglomerate of the Mikata Formation, including the five samples treated herein, were more or less recrystallized and deformed by the post-depositional tectonics of the Maizuru Terrane. Fossils are dominated by calcsponges, bryozoans, and crinoids, and foraminifers are generally subordinate to accessory. In the conglomerate sample M-38, which did not suffer from remarkable recrystallization and deformation, many limestone pebbles and bioclasts were densely

packed within a calcareous silty matrix containing many smaller bioclasts (Fig. 2-1, 2-2; Kobayashi, 2003, Fig. 6). Both pebbles and bioclasts are restricted to the latest Permian, and those of other ages are completely lacking in the conglomerate so far as the age determination by foraminifers. The limestone is highly fossiliferous, and contains poorly-sorted, abundant bioclasts of crinoids, bryozoans, green algae, and foraminifers in the sample O-1 (Fig. 2-3).

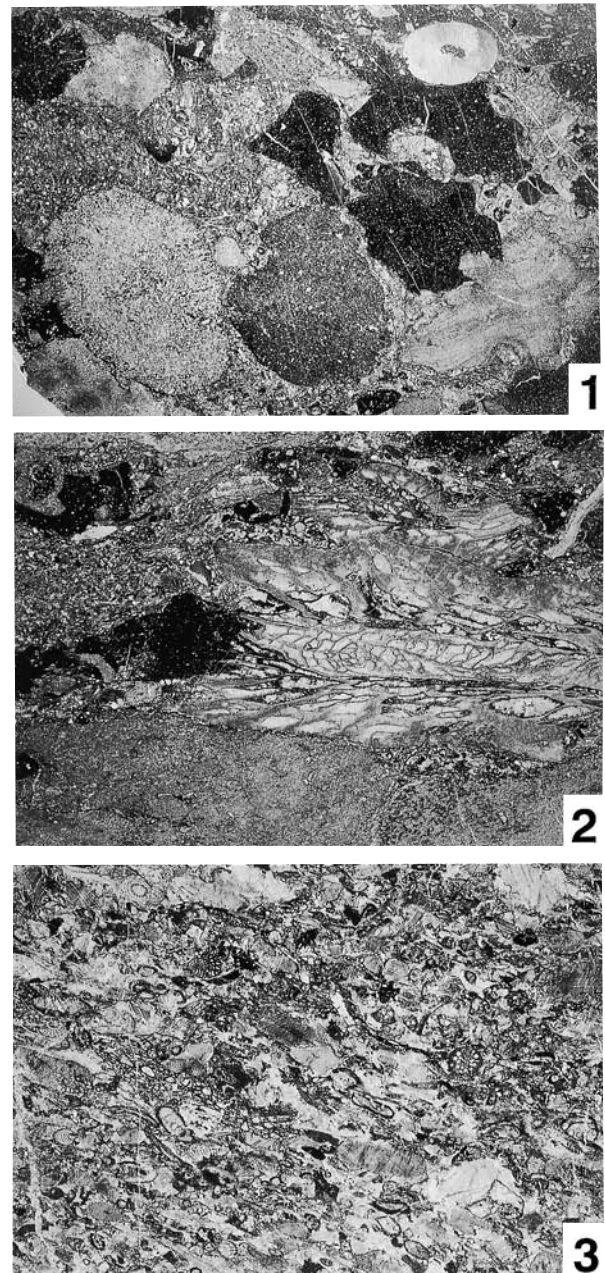


Figure 2. Photomicrographs of the conglomerate and limestone in the Mikata Formation of the Maizuru Group. 1, 2. Conglomerate containing many limestone pebbles and bioclasts. Both M-38, 1:×3; 2:×4.5. 3. Highly fossiliferous bioclastic limestone. O-1. ×4.5.

Faunal analysis

Thirty-one species assignable to 15 and four indeterminate genera of the latest Permian foraminifers were identified from the limestone and conglomerate in the Mikata area (Table 1, Plates 1 and 2). The faunal composition appears to be different among the five samples. However, the original taxonomic composition is thought to be not represented by these faunas in the samples M-5, M-37, M-39, and O-1, along with the other Mikata materials. The small number of taxa, especially in sample M-39, was apparently due to its more

remarkable recrystallization and deformation. Therefore, the detailed discussion on the original taxonomic diversity and related problems is less reliable on the basis of materials between the Maizuru and other terranes. The Mikata fauna is, nevertheless, important biostratigraphically and paleobiogeographically because of the dominant and common occurrences of *Palaeofusulina* and *Colaniella* from these five samples. It is well known that *Palaeofusulina* is restricted to the upper part of Upper Permian (Changhsingian) and *Colaniella* to the Upper Permian (Lopingian) in the Tethyan regions.

Table 1. Latest Permian foraminifers discriminated in the Mikata area.

	M-5	M-37	M-38	M-39	O-1	Plate (Figure)
<i>Lasiodiscus</i> sp.			X			1 (42)
<i>Colaniella parva</i> (Colani)	X	X	X	X	X	2 (1-13, 15-22, 25-28)
<i>Colaniella</i> sp.			X			2 (14)
Palaeotextulariidae gen. and sp. indet. A	?		X		X	1 (33)
Palaeotextulariidae gen. and sp. indet. B			X			1 (45)
<i>Tetrataxis</i> sp. A			X		X	1 (38)
<i>Tetrataxis</i> sp. B		X		?	X	1 (43)
<i>Abadehella coniformis</i> Okimura and Ishii.	X				X	1 (44)
Endothriidae gen. and sp. indet.					X	
<i>Reichelina changhsingensis</i> Sheng and Chang			X		X	1 (1-9)
<i>Palaeofusulina prisca</i> Deprat	X		X			1 (12, 13, 15-18)
<i>Palaeofusulina sinensis</i> Sheng	X	X	X	X	X	1 (19, 21-29)
<i>Palaeofusulina</i> sp. A					X	1 (10, 11, 14, 20)
<i>Palaeofusulina</i> sp. B	?	?	X			1 (30, 37)
<i>Nanlingella</i> sp.					X	1 (31, 32)
Staffellidae gen. and sp. indet.	X					
<i>Agathammina</i> sp. A	X			?		2 (29)
<i>Agathammina</i> sp. B		X	X			1 (40)
<i>Agathammina?</i> sp.			X		X	2 (41-43)
<i>Hemigordius</i> sp. A			X			1 (35, 36, 41)
<i>Hemigordius</i> sp. B			X			2 (38)
<i>Hemigordius?</i> sp.					X	
<i>Kamurana</i> spp.		X	X			2 (39, 40, 44-50)
<i>Froncina</i> sp.			X			2 (33)
<i>Froncina?</i> sp.			X			2 (32)
<i>Pachyphloia ovata</i> Lange	X		X		X	2 (23, 24, 30, 31)
<i>Pachyphloia?</i> sp.					X	2 (35)
<i>Geinitzina postcarbonica</i> Spandel			X			2 (34)
<i>Nodosinelloides</i> sp.			X			2 (36, 37)
<i>Robuloides lens</i> Reichel			X			1 (39)
<i>Robuloides?</i> sp.			X			1 (34)

Palaeofusulina is classified into four species. *P. prisca* Deprat (Pl. 1, figs. 12, 13, 15-18) and *P. sp. A* (Pl. 1, figs. 10, 11, 14, 20) are dissimilar to any other forms of *Palaeofusulina* that have been illustrated from the Upper Permian of Japan in

having a larger test and larger height of the terminal whorl. The former is distinguished from the latter by having larger proloculus and more loosely-coiled inner whorls, and from *P. sinensis* Sheng and Chang (Pl. 1, figs. 19, 21-29) by having larger proloculus

and larger height of whorls in the corresponding whorls. The larger and more elongate form, named *Palaeofusulina* sp. B (Pl. 1, figs. 30, 37), may represent the morphologic variation of *Palaeofusulina sinensis*.

Palaeofusulina in Japan is restricted to the Maizuru Terrane and the Kurosegawa (Kurosegawa-South Kitakami) Terrane and is completely lacking in the Upper Permian limestone blocks intermingled within the Jurassic accretionary complexes. Although the Lopingian age of the Mitai Formation, consisting exclusively of limestone and dolostone, is not in doubt (Ota et al., 2000), it is difficult to assign the incomplete specimen named “*Palaeofusulina* sp.” to the genus *Palaeofusulina*. As well as the Mitai Formation, either the Wuchiapingian or Changhsingian age is indeterminate precisely in the limestone block outcropping out near Tao of the Shirokawa-Nomura area in west Shikoku (Kobayashi, 2004). In comparison with the dominant occurrence of other foraminifers, *Palaeofusulina* is rather or very rare in the shelf limestone of the Iwai-Kanyo area (Kobayashi, 1997) and the Kesenuma area (Kobayashi, 2002).

Colaniella is more widely distributed in the Upper Permian than *Palaeofusulina* throughout the Tethyan regions (Kobayashi, 1999). *Colaniella parva* (Colani) of the Mikata area shows wide morphologic variation in the size and outline of the test, apical angle, degree of tapering and overlapping of chambers (Pl. 2, figs. 1–13, 15–28). As is well understood from many transverse sections (Pl. 2, figs. 15–28), the number of primary, secondary, and tertiary platy partitions and mode of incision of these three kinds of platy partitions are variable ontogenetically. The wide morphologic variations of these important characters of the present materials strongly suggest that the colaniellid specimens illustrated by Ishii et al. (1975) from the Mikata area are all conspecific. They were originally classified into three species of *Colaniella* and one unnamed species of *Pseudocolaniella*. These wide morphologic variations in many characters are also very clear in *Colaniella parva* from the Iwai-Kanyo area (Kobayashi, 1997), the Kesenuma area (Kobayashi, 2002), and the Tatsuno area (Kobayashi, 2006b). On the other hand, the complete absence of *Colaniella* in the Wuchiapingian limestone block of the southern

Kanto Mountains (Kobayashi, 2001) and in the Lopingian one of the Shirokawa-Nomura area (Kobayashi, 2004) is important. It is uncertain, however, that the absence resulted from paleoenvironmental control or paleobiogeographic provenance in relation to the Tethys-Panthalassa boundary in the Late Permian time.

Along with *Palaeofusulina* and *Colaniella*, *Nanlingella* is an age-diagnostic schubertellid genus of the Upper Permian (Rui and Sheng, 1981; Kobayashi, 1999). Typical forms of *Nanlingella* known from the Kesenuma area (Kobayashi, 2002), the Gozenyama area (Kobayashi, 2001), and the Mitai Formation (Ota et al., 2000) have not been found in the Mikata area.

Other foraminifers are far inferior to *Palaeofusulina*, *Colaniella*, and *Nanlingella* in their biostratigraphic and paleobiogeographic significance.

The Mikata fauna is similar to the Iwai-Kanyo and Kesenuma faunas in its specific and generic composition. On the other hand, diagnostic non-fusulinoidean genera found in the Iwai-Kanyo fauna such as *Paraglobivalvulina*, *Dagmarita*, and *Paradagmarita* (Kobayashi, 1997) have not been distinguished in the Mikata fauna, although details on their occurrence or absence are uncertain due to post-depositional geothermal and geodynamic event of the Mikata rocks.

The taxonomic composition of other Late Permian foraminifers from important localities of the Maizuru Terrane in Kyoto prefecture (unpublished data by the author) and the Tatsuno area in Hyogo prefecture (Kobayashi, 2006b) are also variable in places, despite taking slight differences of their ages and state of preservation of their mother rocks into consideration. The Mikata fauna is concluded to be the most variable in its taxonomic composition among those of the Maizuru Terrane.

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Plate 1.

Figs. 1–9. *Reichelina changhsingensis* Sheng and Chang.

1: D2-023201a; 2: D2-013990a; 3: D2-013990b; 4: D2-13984a; 5: D2-027194; 6: D2-023199a;
7: D2-013992; 8: D2-027194b; 9: D2-023199b, all M-38, $\times 60$.

Figs. 10, 11, 14, 20. *Palaeofusulina* sp. A.

10: D2-023233; 11: D2-023225, 14: D2-023231; 20: D2-023224a, all O-1, 10, 11: $\times 20$; 14, 20: $\times 25$.

Figs. 12, 13, 15–18. *Palaeofusulina prisca* Deprat

12: D2-013957b; 13: D2-013941; 15: D2-013970, M-5; 16: D2-027195; 17: D2-013947; 18: D2-013949; 16: M-38, others: M-5; 13: $\times 20$, others: $\times 25$.

Figs. 19, 21–29. *Palaeofusulina sinensis* Sheng.

19: D2-027178, M-38; 21: D2-027156, M-38; 22: D2-027163, M-38; 23: D2-013946, M-5; 24: D2-013971, M-5; 25: D2-027207, M-38; 26: D2-013941, M-5; 27: D2-013984, M-37; 28: D2-013985, M-37; 29: D2-013944, M-5, all $\times 25$.

Figs. 30, 37. *Palaeofusulina* sp. B.

30: D2-027162; 37: D2-013989b; both M-38, $\times 20$.

Figs. 31, 32. *Nanglingella* sp.

31: D2-023230a; 32: D2-023238; both O-1, $\times 30$.

Fig. 33. Palaeotextulariidae gen. and sp. indet. A

D2-023201b, M-38, $\times 60$.

Fig. 34. *Robuloides?* sp.

D2-023201c, M-38, $\times 30$.

Figs. 35, 36, 41. *Hemigordius* sp. A.

35: D2-027187, 36: D2-013994a; 41: D2-013994b; all M-38, $\times 60$.

Fig. 38. *Tetrataxis* sp. A.

D2-027192, M-38, $\times 30$.

Fig. 39. *Robuloides lens* Reichel.

D2-023214, M-38, $\times 60$.

Fig. 40. *Agathammina* sp. B.

D2-023201d, M-38, $\times 40$.

Fig. 42. *Ladiodiscus* sp.

D2-027193, M-38, $\times 60$.

Fig. 43. *Tetrataxis* sp. B.

D2-023224b, O-1, $\times 30$.

Fig. 44. *Abadehella coniformis* Okimura and Ishii.

D2-023232a, O-1, $\times 40$.

Fig. 45. Palaeotextulariidae gen. and sp. indet. B

D2-027174, M-38, $\times 10$.

Plate 2.

Figs. 1–13, 15–22, 25–28. *Colaniella parva* (Colani).

1: D2-023217a; 2: D2-023217b; 3: D2-013972; 4: D2-013967; 5: D2-013950; 6: D2-013953; 7: D2-023230b; 8: D2-023230c; 9: D2-013981; 10: D2-027171a; 11: D2-013966; 12: D2-027174a; 13: D2-023232b; 15: D2-027174b; 16: D2-027169; 17: D2-013997; 18: D2-023217c; 19: D2-013982; 20: D2-02324c; 21: D2-023219a; 22: D2-023232c; 25: D2-027171b; 26: D2-013974; 27: D2-013942; 28: D2-013971; 1, 2, 7, 8, 13, 18, 20–22: O-1; 3–6, 11, 26–28: M-5; 9, 19: M-37; 10, 12, 15, 16, 25: M-38; 17: M-39; 1–13: $\times 30$; 15–22, 25–28: $\times 40$.

Fig. 14. *Colaniella* sp.

D2-027200, M-38, $\times 60$.

Figs. 23, 24, 30, 31. *Pachyphloia ovata* Lange.

23: D2-013989f; 24: D2-027163; 30: D2-023230d; 31: D2-023221; 23, 24: M-38; 30, 31: O-1;
23, 30, 31: $\times 40$; 24: $\times 60$.

Fig. 29. *Agathammina* sp. A

D2-013957a, M-5, $\times 30$.

Fig. 32. *Fronдина?* sp.

D2-027179, M-38, $\times 40$.

Fig. 33. *Fronдина* sp.

D2-013989c, M-38, $\times 60$.

Fig. 34. *Geinitzina postcarbonica* Spandel.

D2-027179, M-38, $\times 30$.

Fig. 35. *Pachyphloia?* sp.

D2-023219b, O-1, $\times 30$.

Figs. 36, 37. *Nodosinelloides* sp.

36: D2-023201e; 37: D2-023201f; both M-38, $\times 30$.

Fig. 38. *Hemigordius* sp. B.

D2-013989d, M-38, $\times 40$.

Figs. 39, 40, 44–50. *Kamurana* spp.

39: D2-027172; 40: D2-027186; 44: D2-023214; 45: D2-027192; 46: D2-013989e; 47: D2-027201; 48: D2-027172a; 49: D2-027172b; 50: D2-027174, all M-38, 39, 40, 50: $\times 40$; 44, 48, 49: $\times 30$; 45–47: $\times 60$.

Figs. 41–43. *Agathammina?* sp.

41: D2-027183, $\times 30$; 42: D2-027168, $\times 16$; 43: D2-027203, $\times 20$, all M-38.

Plate 1

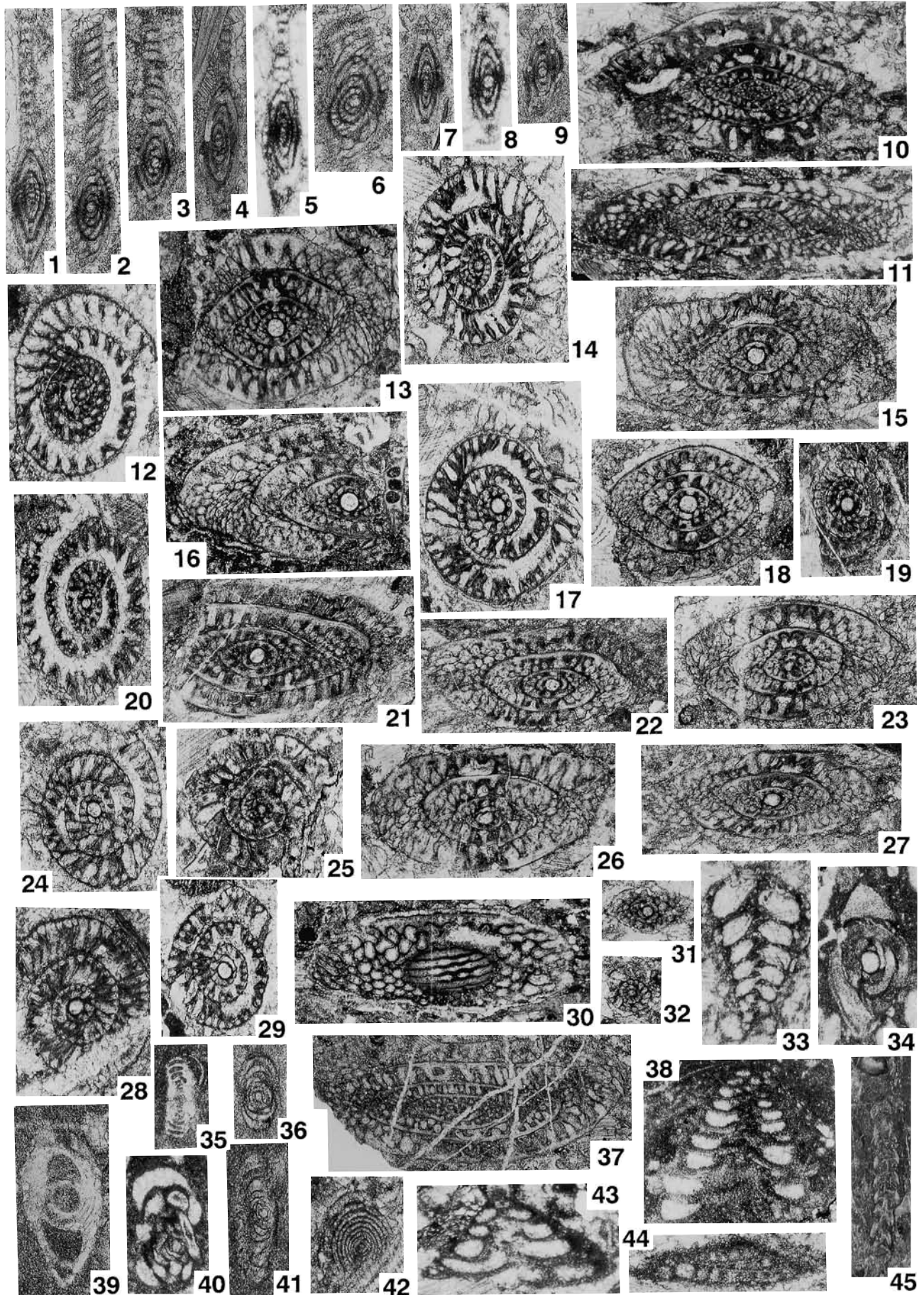


Plate 2

