Original article

Early Permian Fusulinaceans in the Hanagiri–Shimokuzu Area, eastern part of the Kanto Mountains, Japan

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Abstract

Early Permian fusulinaceans occur in exotic blocks of limestone and tuff breccias in the Hanagiri Shimokuzu area, eastern part of the Kanto Mountains (Jurassic Chichibu Terrane), central Japan. Characteristic schwagerinid species in this area are *Paraschwagerina magna* Skinner and Wilde, *Schwagerina hawkinsiformis* Igo, *Chalaroschwagerina kalmykovae* Davydov, and *Pseudofusulina duplithecata* Igo. These and some other species in and around this area are common to and deeply connected faunistically with those of the Mino Tamba Terrane and some Circum-Pacific terranes including Nadanhada, Sikhote-Alin, Koryak, Oregon, and California. They are completely absent in the Permian Akiyoshi Terrane. Foraminiferal faunal similarities between Jurassic terranes of Japan and these Circum-Pacific terranes are important paleogeographically and tectonically, and strongly suggest the dispersal of these terranes from the Panthalassan domain.

Key words: Early Permian fusulinaceans, exotic blocks, Hanagiri Shimokuzu area, faunal affinity, Panthalassan domain

Introduction

In the eastern part of the Kanto Mountains, Jurassic accretionary complexes are widely distributed in both northern and southern sides of the Mikabu ophioilitic rocks of the Sambagawa Terrane (Figure 1). Fusulinaceans in this region were collectively described by Huzimoto (1936) and Morikawa (1955). During the author's field mapping more than twenty years ago, a number of Late Paleozoic foraminifers were discriminated in many limestone blocks and breccias of this region. They have been left undescribed except for an ozawainellid *Pamirina* from the Hanagiri-Shimokuzu area (Kobayashi, 1977). Among the Early Permian fusulinaceans, paleobiogeographically important ones are the following four species of Early Permian schwagerinids: *Paraschwagerina magna* Skinner and Wilde, *Schwagerina hawkinsiformis* Igo, *Chalaroschwagerina kalmykovae* Davydov, and *Pseudofusulina duplithecata* Igo.

On the basis of faunal analysis, this paper pointed out that Early Permian fusulinaceans in and around the Hanagiri-Shimokuzu area are similar to those of the Mino-Tamba Terrane of Japan and some Circum-Pacific terranes (Nadanhada, Sikhote-Alin, Koryak, Oregon, and California), and dissimilar to those of the Permian terrane (Akiyoshi Terrane) of Japan. Their faunal composition in these terranes is important paleogeographically and tectonically along with Middle to Late Permian foraminifers, and suggest that limestones in these terranes were originated in and drifted far and wide from the Panthalassan domain in different times (Kobayashi, 1997, 1999, 2003, 2004).

Among 33 species of Early Permian foraminifers, nine species of fusulinaceans are systematically described in this paper. All limestone thin sections in the Hanagiri-Shimokuzu are stored in the collection of the Museum of Nature and Human Activities, Sanda, Hyogo, Japan (Fumio Kobayashi Collection), including several tens ones containing

Pamirina which were formerly kept in the Institute of Geology and Mineralogy, Tokyo University of Education.

Geologic setting

Jurassic accretionary complexes in Southwest Japan are divided into the Chichibu Terrane in the Outer Zone (Pacific Ocean-side) and its counterpart Mino-Tamba Terrane in the Inner Zone (Japan Sea-side). The Chichibu Terrane in Southwest Japan extends eastward to the Kanto Mountains belonging to Northeast Japan. In the eastern part of the mountains, Jurassic accretionary complexes are divided into six tectonostratigraphic units, Kuroyama, Takahata, Kabasaka, Hanagiri, Nakato, and Nitayama formations, from north to south (Figure 1).

According to Sashida (1992), these formations are common in the occurrence of chaotic rocks referable to tectonic melange, and consist of Carboniferous to Permian limestones and basaltic rocks, Permian to Early Jurassic cherts, and Early to Middle Jurassic siliciclastic rocks. They are distinguishable in each other by differences of their lithology, and chronologic distribution of exotic blocks and the surrounding siliciclastic rocks. The Hanagiri Formation is the oldest among these six formations, and consists of Permian basaltic rocks and limestones, Lower Permian and Triassic cherts, and Lower Jurassic siliciclastic rocks, which were dated by radiolarian biostratigraphy.

Limestones in the Hanagiri Formation are mostly accompanied by basaltic rocks partly showing the pillow structure. They are also contained within basaltic pyroclstics as breccias showing the conglomeratic appearance as named the Shimokuzu Conglomerate and Kamikuzu Conglomerate by Morikawa (1952; 1955). Internally, siliciclastic rocks, however, are lacking in these pyroclastic rocks except for those brought by later tectonics. Limestone blocks and breccias are generally fossiliferous.

Material

Eight samples (H-1 to H-8) containing late Early Permian fusulinaceans are treated in this paper. They are collected from limestones and tuff breccias in the Hanagiri-Shimokuzu area (Figure 1). Although the exact size is unknown, all of these limestones and tuff breccias occur in mudstone and sandstone.

Two limestone samples (H-1 and H-2) were collected from the middle and upper parts of the largest limestone block in this area. This limestone

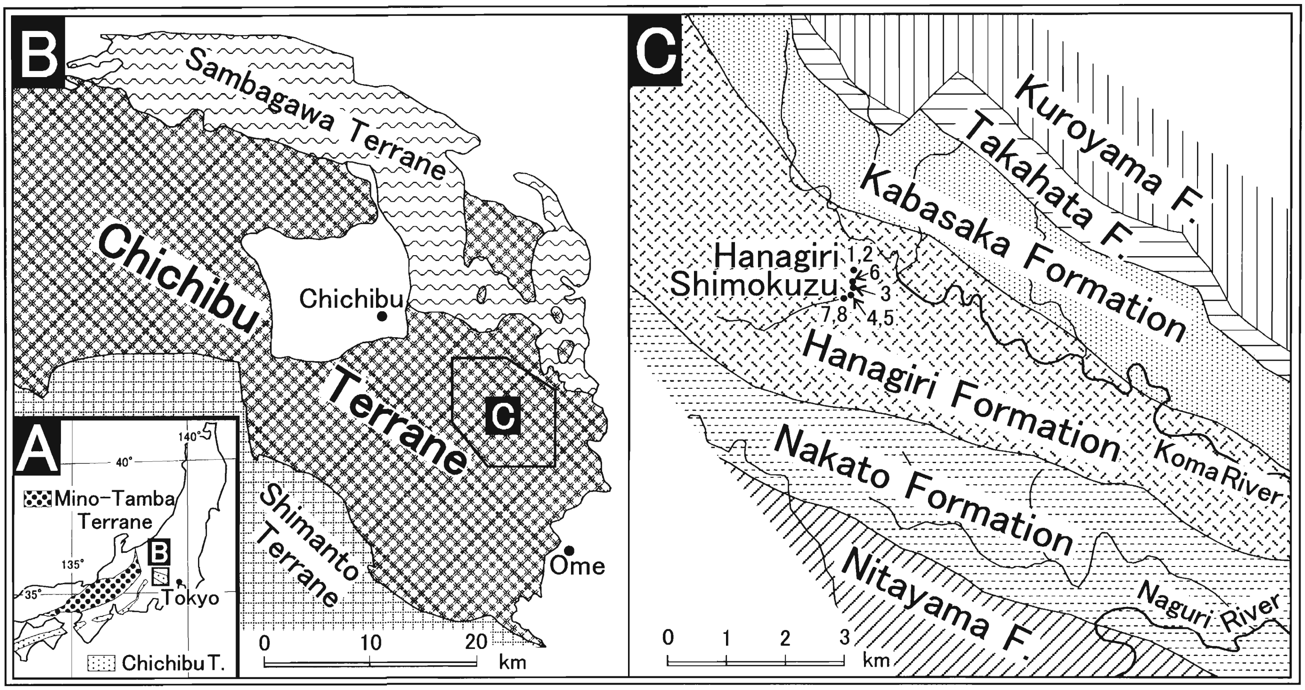

Figure 1. Distribution of Mino-Tamba and Chichibu Terrane (A), geotectonic division of the Kanto Mountains (B), and six formations in the eastern part of the Kanto Mountains (after Sashida, 1992) and sample locations in the Hanagiri-Shimokuzu area (C).

block is about 40 m thick, massive to thickly-bedded, gray to light gray, crystalline and dolomitic in the lower part, and contains many tuffaceous materials. *Pamirina* described by Kobayashi (1977) is obtained from the sample H-1. H-1 and H-2 resemble lithologically in each other, and consist of algal wackestone (Plate 1, Figs. 1, 2). Dasycladacean and other green algae are common in them.

Other six samples (H-3 to H-8) were obtained from angular to subrounded, various-sized clasts of limestone within tuff breccias exposed at the river floor near Shimokuzu (Figure 1). Rock fragments of basaltic lava and tuff, and chert are also contained in these tuff breccias.

H-3 is dolomitic bioclastic wackestone with many bioclasts of green algae, crinoids, and fusulinaceans (Plate 1, Fig. 3). Minute rhombohedral crystals of dolomite, tuffaceous rock fragments, and small bioclasts are abundantly contained in this limestone. H-4 and H-5 are dolomitized, but they are highly fossiliferous and consist of bioclastic grainstone including many fossils of reefal organisms such as dominant green and red algae, crinoids, and calcisponges, subordinate bryozoans and thick-shelled brachiopods, and accessory gastropods, rugose corals, ostracodes, and bivalves (Plate 1, Fig. 4). H-6 and H-8 are grainstone containing many well-washed bioclasts and aggregate grains (Plate 1, Figs. 5, 6).

All of these limestones yield late Early Permian fossils. In addition to them, a limestone clast including Upper Carboniferous (Gzhelian) unidentified species of *Triticites* is also rarely found. This clast is in stylolite contact with other limestone clasts of ooid grainstone, pelloid wackestone, and lime-mudstone (Plate 1, Fig. 7).

Fusulinacean fauna

Thirty-three species assignable to 21 genera and 12 families of foraminifers are identified in eight limestone samples (Table 1). Among them, fusulinaceans attain 21 species, 12 genera, and four families.

Faunal composition is characteristic in H-1 and H-2. *Pamirina leveni* is dominant in H-1, and *Mesoschubertella* and *Biwaella* are prevailing in H-2. Large-sized fusulinaceans are rare and their outer whorls are abraded in these two limestones. Species diversity of foraminifers is low, and only three species are discriminated in H-1 (Table 1).

Schwagerina hawkinsiformis and *Paraschwagerina magna* occur exclusively in H-3. These two species have strongly fluted thin septa and thin wall in comparison with large test. This limestone with these two species is similar to some limestones having *Acervoschwagerina* in the Mino Tamba Terrane and Chichibu Terrane in characteristic lithology of dolomitic bioclastic wackestone with tuffaceous materials. In addition to similar lithologies, these limestones are common in their low species diversity of foraminifers.

Faunal composition of foraminifers is more variable in H-4 and H-5 than in H-1 and H-3 (Table 1). *Chalaroschwagerina kalmykovae* and *Pseudofusulina duplithecata* have large test and thick wall, and are exclusively found in H-4 and H-5. *Darvasites ikenoensis* occurs only in H-5 in this area. No large-sized schwagerinids are found in H-6, H-7, and H-8.

Faunal affinity

Fusulinacean faunas in the Hanagiri Shimokuzu area are different from coeval ones from exotoic limestone blocks of the Permian accretionary complexes of Japan (Akiyoshi Terrne). Common schwagerinid species in this area and the Akiyoshi Terrane is restricted to *Pseudofusulina fusiformis*, which is only found in H-1 in association with *Pamairina leveni*. Outside Japan, schwagerinid species characteristic in the Hanagiri-Shimokuzu fauna are known from the Tethyan affinity terranes in the Circum-Pacific regions such as Koryak, Oregon, and California.

Paraschwagerina magna in this area resembles the original ones from the Shasta Lake area of northern California (Skinner and Wilde, 1965b). Five specimens named *Parachwagerina gigantea* and *Paraschwagerina* aff. *kansasensis* from the eastern part of the Biwa Lake by Morikawa and Isomi (1961) are different from original Texas ones by Beede and Kniker (1924), White (1932), and Dunbar and Skinner (1937). They are more reasonably assigned to *Paraschwagerina magna*. In Japan, these large-sized *Paraschwagerina* are known only in the Jurassic terranes. Outside Japan, *Acervoschwagerina*, which is thought to be morphologically and phylogenetically similar to

Table 1. Early Permian foraminifers distinguished in the Hanagiri-Shimokuzu area.

	H-1	H-2	H-3	H-4	H-5	H-6	H-7	H-8
Pamirina leveni Kobayashi	X							
Toriyamaia laxiseptata Kanmera				X		?		
Mesoschubertella thomponi Sakagami		X		X	X		X	
Schubertella sp. A				X		X		
Schubertella sp. B				X		X	X	X
Schubertella ? sp.		X						
Biwaella omiensis Morikawa and Isomi		X			X	X		
Chalaroschwagerina kalmykovae Davydov				X				
Darvasites ikenoensis (Morikawa and Isomi)					X			
Paraschwagerina magna Skinner and Wilde			X					
Pseudofusulina aganoensis Huzimoto				X				
Pseudofusulina duplithecata Igo					X			
Pseudofusulina fusiformis (Schellwien and Dyhrenfurth)	X							
Pseudofusulina sp. A						X	X	X
Pseudofusulina sp. B								X
Schwagerina hawkinsiformis Igo			X					
Schwagerinidae gen. and sp. indet. A							X	
Schwagerinidae gen. and sp. indet. B		X						
Pseudoendothyra spp.		X		X	X	X	X	X
Pseudoreichelina sp. A				X				
Pseudoreichelina sp. B		X				X		X
Ammovertellina sp.								X
Geinitzina sp.				X				
Pachyphloia ? sp.		X						
Palaeotextularia sp.					X			X
Palaeotextulariidae gen. and sp. indet.		X			X	X		X
Tetrataxis conica Ehrenberg					X			
Tetrataxis spp.			X	X	X			
Globivalvulina spp.		?		X	X	X	X	X
Endothyra sp.			?		X	X		X
Agathammina sp.					X			
Agathammina ? sp.	X							
Hemigordius sp.				X				

Paraschwagerina magna, is characteristic in the Lower Permian exotic limestones of Sikhote-Alin (Sosnina, 1965), Baker Terrane of northeastern Oregon (Blome and Nestell, 1992), and Koryak (Davydov et al., 1996). In the Tethyan regions, the occurrence of *Acervoschwagerina* without question is restricted to *A. inustita* from the Mappingian of Guanxi (Lin et al., 1977).

Schwagerina hawkinsiformis was originally described from the Lower Permian exotic limestones of the northern Mino Terrane by Igo (1965). This species shows wide intraspecific variation in the Hanagiri-Shimokuzu materials. *Schwagerina hawkinsi* described by Kobayashi (1957) from the Mino Terrane is considered to be identical with *Schwagerina hawkinsiformis* and different from original ones from the Glass Mountains of Texa by Dunbar and Skinner (1937). Similar forms are also reported from the northern Mino Terrane (Kanuma, 1959).

Pseudofusulina duplithecata was originally described from the limestone pebble of the Osobudani Conglomerate exposed in the Hida-Marginal Terrane, north of Mino Terrane by Igo (1956). It is considered to be Bolorian (Kungurian) age based on its assiciation with *Misellina minor* (Deprat). Subsequently, it was described from the northern Mino Terrane (Igo, 1965). Some schwagerinids described under different names from the Lower Permian limestones of the Tamba-Mino and Chichibu Terranes (Morikawa, 1955; Morikawa and Isomi, 1961; Suyari, 1962; Sashida, 1980) are thought to be synonymous with *P. duplithecata*. *Parafusulina impensa* from the upper Wolfcampian to lower Leonardian of central California by Douglass (1967) seems to be related to this species.

Chalaroschwagerina kalmykovae was described from the exotic limestone block of Koryak (Davydov et al., 1996). Although it is somewhat similar to *Pseudofusulina duplithecata*, these two species are not co-existed in the limestones of the Hanagiri Shimokuzu area. Identical forms with this species are reported from the Lower Permian limestones of the Mino Tamba and Chichibu terranes (Morikawa, 1955; Kobayashi, 1957; Kanuma, 1959; Sakaguchi, 1963). Similar forms to *Chalaroschwagerina kalmykovae* are known from the Lower Permian of Qinghai (Sheng and Sun, 1975) and the Yahtashian (Artinskian) of Afghanistan by Leven (1997).

Darvasites ikenoensis from H-5 is different from species of *Nagatoella* in smaller test, fewer number of whorls, and others. It is identical with original ones by Morikawa and Isomi (1961) from the Mino Terrane. Some specimens, including this species, which were assigned to *Nagatoella* in Japan, should be referable to *Darvasites*, as exemplified by *Nagatoella* sp. by Kanmera (1963), *Nagatoella minatoi* by Kanmera and Mikami (1965), and *Nagatoella ikenoensis* by Choi (1973). *Nagatoella fujimotoi*, described from Shimokuzu by Morikawa (1951), is synonymous with *Nagatoella orientis* (Ozawa). The distribution of true *Nagatoella* is restricted to the Permian Akiyoshi Terrane (e.g., Ozawa, 1925), Jurassic Chichibu Terrane (Morikawa, 1951), the Nadanhada Range (Li et al., 1979; Han, 1985), the upper Wolfcampian to lower Leonardian of central California (Douglass, 1967), and Baker Terrane of northeastern Oregon (Blome and Nestell, 1992).

Biwaella omiensis, Pamirina leveni, Toriyamaia laxiseptata, and *Mesoschubertella thompsoni* are also characteristic in the the Hanagiri Shimokuzu fauna, and their occurrences are related to limestone lithology as well as important schwagerinids in this area.

In conclusion, schwagerinid species characteristic in the Hanagiri Shimokuzu area resemble those of northern and central parts of the Mino Tamba Terrane and some Circum Pacific terranes including Nadanhada, Sikhote Alin, Koryak, Oregon, north and central California, and Chiapas of southernmost Mexico. They are absent in the Permian accretionary terrane (Akiyoshi Terrane) of Japan. Foraminiferal faunal similarities among the Hanagiri Shimokuzu area, other Jurassic terranes of Japan, and some Circum Pacific terranes are important paleogeographically and tectonically. They show that limestone blocks in these terranes were originated in and drifting from the Panthalassan domain.

Systematic paleontology

Systematically described herein are limited to biostratigraphically and paleobiogeographically important species and other species whose taxonomic status is less well understood are also described. Subsequent descriptions by later authors under the same taxonomic status as original one are excluded from the synonym list.

Order FORAMINIFERIDA Eichwald, 1830
Suborder FUSULININA Wedekind, 1937
Superfamily Fusulinacea von Möller, 1879
Family Ozawainellidae Thompson and Foster, 1937
Genus ***Pamirina*** Leven, 1970

Type species.–Pamirina darvasica Leven, 1970, p. 23, 24, pl. 1, figs. 1-12, 23, 24.

Pamirina Leven, 1970, p. 23 (original designation).

Chinlingella Wang and Sun, 1973, p. 152, 171, type species: *Chinlingella chinlingensis* Wang and Sun, p. 152, 153, 172, pl. 1, figs. 12, 17-32, pl. 3, figs. 1, 5, 10 (original designation).

Pamirina (*Pamirina*) Ueno, 1991, p. 744 (name transferred).

Pamirina (*Levenia*) Ueno, 1991, p. 745, 756 (name invalidly proposed); type species:

Pamirina leveni Kobayashi,1977, p. 11-14, pl. 1, figs. 13-38.

Pamirina (*Levenella*) Ueno, 1994, p. 405 (name proposed to replace).

Diagnosis.–Small discoidal test with rounded periphery, minute proloculus followed by five or more whorls enlarging rapidly. Wall structureless in inner few whorls, tectum and protheca in the succeeding ones; tectum and finely alveolar keriotheca present in outer few whorls of the advanced forms. Septa plane and long. Single low tunnel bordered by small chomata which is indistinct in the final whorl.

Discussion.–Pamirina is considered to be the ancestor of verbeekinid fusulinaceans (Kobayashi, 1977). It should not be placed under Staffellidae as

Loeblich and Tappan (1988) but Ozawainellidae on account of the wall structure and phylogenetic development from Ozawainellidae to Verbeekinidae. *Chinlingella* is not valid, as it was preoccupied by *Pamirina*. It is difficult to distinguish *Levenella* from *Pamirina* in subgeneric status by slight differences of wall structure, shape and form ratio of test along with those of whorls, and the stratigraphic position as Ueno (1991) insisted.

Distribution.–Turkey, Iran, Afghanistan, Darvas, South East Asia, South China, and Japan.

Pamirina leveni Kobayashi

Paminina leveni Kobayashi, 1977, p. 11-14, pl. 1, figs. 13-38 (original description).

Pamirina tethydis Kobayashi 1977, p. 11, pl. 1, figs. 1-12.

Pamirina (*Levenia*) *leveni* Kobayashi: Ueno, 1991, p. 746, 747, Figs. 3.8-3.23.

Material.–38 specimens of *Pamirina* illustrated in Kobayashi (1977).

Discussion.–Kobayashi (1977) showed many specimens of *Pamirina leveni* and *P. tethydis*. They co-occur in the Hanagiri Limestone, and are uneasily distinguishable in each other based on wide morphologic variations of these two forms. *Pamirina leveni* differs from *Pamirina darvasica* Leven and *Pamirina chinlingensis* (Wang and Sun) in having smaller test with shorter axis of coiling and complete lack of alveolar keriotheca throughout whorls.

Genus ***Toriyamaia*** Kanmera, 1956

Toriyamaia laxiseptata Kanmera

Plate 2, Figures 12, 13

Toriyamaia laxiseptata Kanmera, 1956, p. 252-255, pl. 36, figs. 1-14 (original description).

Rauserella? sp. Kobayashi, 1957, pl. 1, figs. 29, 30.

Rauserella? sp. Choi, 1973, pl. 2, fig. 1.

Biwaella omiensis Morikawa and Isomi: Morikawa and Isomi, 1961, p. 8, 9, pl. 1, figs.14-16.

Rauserella sp. Kawano, 1961, p. 58, pl. 1, fig. 1.

non. *Toriyamaia laxiseptata* Kanmera: Choi, 1973, pl. 2, fig. 9 (= *Biwaella* sp. indet.)

Material.–One axial and one sagittal sections.

Discussion.–The present materials are safely identical with original ones from the Kozaki Formation at Uminoura and Kozaki in Kyushu (Kanmera, 1956), though more number of septa are countable in the corresponding whorls. Original ones are associated with *Misellina claudiae*, showing slightly younger age than the present ones. There are some examples synonymous with or erronously identified with this species as listed above.

Toriyamaia laxiseptata is commonly found in the Lower Permian of the Kuma Mountains (Kanmera, 1956, 1963), Abukuma Mountains (Ueno, 1992), and South Kitakami Mountains (Kanmera and Mikami, 1965; Choi, 1973), all of which are referable to South Kitakami-Kurosegawa Terrane. This species is also sporadically distributed in the Chichibu Terrane (Ozawa, 1975) and Mino-Tamba Terrane (Kobayashi, 1957; Morikawa and Isomi, 1961), and Akiyoshi Terrane (Kawano, 1961). Outside Japan, this species and unidentified species of *Toriyamaia* have been known from the eastern part of the Paleotethyan regions of South China (e.g., Sheng, 1963; Lin et al., 1977; Zhou et al., 1987) and Thailand (Toriyama, 1975). However, three specimens named *Toriyamaia elliptica* by Li (1985) from Chongzuo of Guangxi should be excluded from *Toriyamaia*, because any diagnostic biocharacters of *Toriyamaia* can not be found out from the illustrated specimens. *Toriyamaia minima* described from the Lower Permian of Hebei Province by Han (1976) has smaller test and more well-developed juvenile whorls than *Toriyamaia laxiseptata*, and is assumed to be a distinct species.

Family Schubertellidae Skinner, 1931

Genus ***Mesoschubertella*** Kanuma and Sakagami, 1957

Mesochubertella thompsoni Sakagami

Plate 2, Figures 13-37

Mesoschubertella thompsoni Sakagami, in Kanuma and Sakagami, 1957, p. 43, 44, pl. 9, figs. 1-10 (original description).

Schubertella magna Lee and Chen: Ishizaki, 1962b, p. 139, pl. 7, fig. 5.

non. *Mesoschubertella* aff. *thompsoni* Sakagami: Ueno, 1992, p. 1271, 1272, Figs. 4.14, 4.15, 4.17, 4.18 = *Schubertella* sp. indet.).

Material.–Nine axial, eleven tangential, five sagittal sections.

Description.–Test small and inflated fusiform. Mature test with 6 to 6.5 whorls, about 1 to 1.5 mm in length and about 0.8 to 1 mm in width giving form ratio 1.1 to 1.7. Spherical proloculus less than 0.06 mm. First one or two whorls endothyroidly and tightly coiled, beyond juvenile whorls later whorls expand rapidly with a sharp change of axis of coiling.

Wall consists of tectum and very thin protheca or undifferentiated in endothyroid whorls, tectum and protheca in outer whorls, and indistinct fine alveolar keriotheca partly in the final whorl. Septa closely spaced, thick in comparison with small test, plane or weakly fluted in polar regions. Tunnel low and its angle considerably variable both by whorls and by specimens. Chomata well developed and asymmetrical.

Discussion.–The present materials are highly variable in test size, wall thickness, height of whorls, proloculus size, tunnel angle, development of chomata, and their ontogenetic changes. These different appearances are thought to be merely represent the intraspecific variation of *Mesochubertella thompsoni.*

Mesoschubertella consists of three species. When this genus was proposed, *M. thompsoni* Sakagami and M. *shimadaniensis* Kanuma were described in the same paper (Kanuma and Sakagami, 1957). The former is the type species of this genus from the Chichibu Terrane in the southeast end of the Kanto Mountains, and the latter is based on specimens having rugose wall from the northern Mino Mountains. The third example is forms assigned to *Multiavoella* (Li, 1985), that is junior synomymous with *Mesoschubertella.*

Mesoschubertella thompsoni is also reported from northern Thailand (Sakagami and Iwai, 1974) and northern Kanto Mountains (Kanuma and Matsukawa, 1974). A specimen named *Schubertella magna* by Ishizaki (1962b) from the Chichibu Terrane of western Shikoku is undoubtedly identical with this species. Species and generic assignment of the southern Abukuma materials by Ueno (1992) are doubtful and some of them are not referable to *Mesochubertella* but to *Schubertella* because of their thin wall and indistinct chomata.

Multiavoella was proposed as a new schubertellid genus from Guangxi by Li (1985). Although four species were distinguished, they are thought to be invalid taxonomically in each other. Because, different appearence of biocharacters in them seems to only represent the intraspecific variation. Guangxi materials are recognized as a new species of *Mesochubertella* and easily distinguished from the known species by their distinct characters of larger test and more number of whorls. They seem to be important evolutionally, but further discussion is impossible on account of insufficient stratigraphic and paleontologic descriptions.

Family Schwagerinidae Dunbar and Henbest, 1930

Genus ***Biwaella*** Morikawa and Isomi, 1960

Biwaella omiensis Morikawa and Isomi

Plate 2, Figures 38-46

Biwaella omiensis Morikawa and Isomi, 1960, p.302 304, pl. 54, figs. 1-5 (original description).

Oketaella takahashii Morikawa and Kobayashi, 1960, p.308-310, pl. 55, figs. 1-11.

Oketaella shiroisiensis Morikawa and Kobayashi, 1960, p.310-312, pl. 55, figs. 12-19.

Schubertella haginoensis Suyari, 1962, p. 6, 7, pl. 2, figs. 1, 2, non. fig. 3.

Schubertella haginoensis fusiformis Suyari, 1962, p. 7, 8, pl. 2, figs. 4-6.

Schubertella kingi Dunbar and Skinner: Ishizaki, 1962a, p. 109, 110, pl. 29, fig. 3.

Biwaella sp. Leven, 1971, p. 13, pl. 1, figs. 3, 4.

Toriyamaia provecta Wang and Sun, 1973, p. 154, pl. 3, fig. 9 (= Sun et al., 1983, p. 8, 9, pl. 2, fig. 23)

Schubertella sp.: Sakagami and Iwai, 1974, p. pl. 4, fig. 27.

Biwaella provecta (Wang and Sun): Sheng and Sun, 1975, p. 22, pl. 1, fig. 24; Wang et al., 1981, p. 35, pl. 8, figs. 8, 13, 14; Da and Sun, 1983, p. 80, pl. 16, fig. 8.

Biwaella guizhouensis Liu, Xiao and Dong, 1978, p. 57, pl. 11, figs. 6-8.

Biwaella ex. gr. *omiensis* Morikawa and Isomi: Leven and Sherbovich, 1978, p. 87, pl. 1, fig. 15.

Biwaella sp. No. 1, Leven and Sherbovich, 1978, p. 87, pl. 1, fig. 14.

Biwaella sp. No. 2, Leven and Sherbovich, 1978, p. 88, pl. 1, fig. 16.

Toriyamaia laxiseptata Kanmera: Sun et al., 1983, p. 9, pl. 2, fig. 20.

Triticites planoseptus Chang: Da and Sun, 1983, p. 55, pl. 9, fig. 16.

Biwaella tieliekensis Da: Da and Sun, 1983, p. 80, pl. 16, fig. 9.

Biwaella pulchra Da: Da and Sun, 1983, p. 80, 81, pl. 16, fig. 10.

non. *Triticites omiensis* (Morikawa and Isomi): Han, 1975, p. 148, pl. 14, figs. 16-18.

Material.–Eight axial and one sagittal sections.

Discussion.–Diagnostic characters in this species of the Hanagiri-Shimokuzu materials are essentially the same as those given by Kobayashi (1993) based on illustrated four and other specimens from limestone pebbles of the Kanyo Formation in the southern Kanto Mountains. Largely to moderately different appearences in axial and nearly axial sections are thought to be due to nearly straight but slightly occilating axis of coiling in addition to wide intraspecific variation of this species, which resulted unreasonable identification and many taxonomically invalid species by previous authors. Some have been erroneously assigned to *Oketaella* (Morikawa and Kobayashi, 1960), *Schubertella* (Suyari, 1962; Ishizaki, 1962a; Sakagami and Iwai, 1974), *Toriyamaia* (Wang and Sun, 1973; Sun et al., 1983), and *Triticites* (Da and Sun, 1983).

As already indicated by Kobayashi (1993), some European and American species of *Biwaella* are uneasily distinguished from the type species of *Biwaella*. They are *Biwaella europanica* from the Lower Permian of Montenegro (Kochansky-Devidé and Milanović, 1962) and *B. americana* from the Wofcampian of New Mexico (Skinner and Wilde, 1965a). *Biwaella explicata* described by Han and Zhao from Tarim (Zhao et al., 1984) differs from B. *omiensis* by weakly fluted septa and rapidly enlarging test.

Biwaella sp. from the Gzhelian pebble in the southern Kanto Mountains (Kobayashi, 1993), *Biwaella*? *tshelamtshiensis* described from the Gzhelian of southwest Darvas (Davydov, 1984) and *Biwaella*? sp. from the Gzhelian of northeast Thailand (Ueno and Igo, 1993) are largely different from type species of *Biwaella*. These latest Carboniferous materials need further examination in their generic assignment. Because, they are connected not only with their generic status but also deeply with problems of both a justification of the phylogeny of Biwaellinae proposed by Davydov (1984) and the evolution of *Sphaeroschwagerina* and other early Permian inflated Schwagerinidae.

Genus ***Chalaroschwagerina*** Skinner and Wilde, 1965b

Chalaroschwagerina kalmykovae Davydov

Pate 5, Figures 1-9

Chalaroschwagerina kalmykovae Davydov in Davydov et al., 1996, p. 233, pl. 7, fig. 1.

Pseudofusulina vulgaris (Schellwien): Morikawa, 1955 (part), p. 89, 90, pl. 9, fig. 6.

Pseudofusulina cf. *vulgaris* (Schellwien): Kobayashi, 1957, p. 282, pl. 2, fig. 6.

Pseudofusulina vulgaris (Schellwien): Kanuma, 1959, p. 74, 75, pl. 8, figs. 13, 14.

Pseudofusulina sp., Sakaguchi, 1963, p. 106, 107, pl. 8, fig. 1.

Material.–Four axial, three tangential, one sagittal, and one parallel sections.

Discussion.–Present specimens are characterized by ovoid test with rounded poles, relatively small proloculus in comparison with large test, very thick wall, thin septa strongly fluted in polar and axial regions and weakly in tunnel regions, presence of prenotheca, absence of axial filling, and absence of chomata except for rudimentary ones on proloculus and first one or two whorls. From these characters they are safely identical with *Chalaroschwagerina kalmykovae* from Koryak by Davydov in Davydov et al. (1996), although the morphologic variation is not fully understood from in the original description based on one specimen. This species seems to be similar to *Pseudofusulina immensa* from the Yahtashian (Artinskian) of Afghanistan by Leven (1997) except for more elongate test with rather pointed poles of the latter. *Chalaroschwagerina kalmykovae* also resembles the specimen named *Pseudofusulina confusa* (Rauser) from Qinghai Province of China (Sheng and Sun, 1975) except for more strongly fluted septa in tunnel regions.

Light layer between tectum and keriotheca, that was regarded to be characteristic in *Pseudofusulina duplithecata* and taxonomically important (Igo, 1956), is observed in some Shimokuzu specimens referable to this species. It is also present in *Pseudofusulina* sp. from the Tamba Mountains by Sakaguchi (1963) which is most like to the present Shimokuzu specimens in many respects. A part of specimens by Morikawa (1955) and two specimens by Kanuma (1959), both of which were named *Pseudofusulina vulgaris*, are identical with *Chalaroschwagerina kalmykovae*. One specimen compared with *Pseudofusulina vulgaris* by Kobayashi (1957) are also largely different from *Chalaroschwagerina vulgaris* in respects to very thick, coarse wall and much larger test. Many characters characteristic in this species are found in these four examples from Jurassic terranes of Japan. All of them are thought to be identical with this species.

Genus ***Darvasites*** A.D. Miklukho-Maklay, 1959
Darvasites ikenoensis (Morikawa and Isomi)
Plate 3, Figures 1-3

Nagatoella ikenoensis Morikawa and Isomi, 1961, p. 22, 23, pl. 20, figs. 6-13.

Material.–One axial, one tangential, and one parallel sections.

Discussion.–The present materials are assignable to *Darvasites* from well-developed chomata throughout whorls, by which and smaller test they are distinguishable from *Nagatoella*. Among the described species, they are thought to be closest to *Darvasites ikenoensis* originally described by Morikawa and Isomi (1961) and probably identical with the species. They are easily distinguished from *Darvasites ordinatus* and D. *contractus*, well established species in the Tethyan regions, from smaller test and slower expansion of test. No axial sections of the mature stage, however, were shown in the original description. Further discussion needs well-oriented topotype specimens from the Mino Terrane.

Genus ***Paraschwagerina*** Dunbar and Skinner, 1936
Paraschwagerina magna Skinner and Wilde
Plate 3, Figures 5-7

Paraschwagerina magna Skinner and Wilde, 1965b, p. 68, pl. 26, figs. 6-10; pl. 27, figs. 1-3.

Paraschwagerina gigantea (White): Morikawa and Isomi, 1961, p. 11, 12, pl. 5, figs. 1-3.

Material.–One axial, one tangential, and one parallel sections.

Discussion.–*Paraschwagerina magna* is very rarely found in the Hanagiri-Shimokuzu area in association with *Schwagerina hawkinsiformis*. Original ones were described from the basal part of the Zone D of the Wolfcampian McCloud Limestone in the Shasta Lale area of northern California in association with a species referable to *Pseudofusulinella* and *Pseudofusulina* (Skinner and Wilde, 1965b). Although faunal assemblages are different between Shasta Lake and Shimokuzu, *Paraschwagerina* in both areas are closely similar morphologically except for weaker development of prenotheca in middle part of outer test of the former.

Four specimens named *Parachwagerina gigantea* from the eastern part of the Lake Biwa (Morikawa and Isomi, 1961) are reasonably assigned to this species by many characters common to them. This species is distinguished from *Paraschwagerina gigantea* described from the Wofcampian of the Glass Mountains (White, 1932; Dunbar and Skinner, 1937) by more irregularly fluted septa. *Paraschwagerina* aff. *kansasensis* described by Morikawa and Isomi (1961) is possibly assignable to this species on the basis of wide morphologic variation in test size and septal fluting of middle and outer whorls of the original specimens by Skinner and Wilde (1965b). It is quite different from the original specimens of *Paraschwagerina kansasensis* from the Wolfcampian of the Glass Mountains of Texas (Beede and Kniker, 1924; Dunbar and Skinner, 1937) in rapidly expanding larger test, height of whorls, more irregularly fluted septa. These morphologic characters suggest closer relation between *Paraschwagerina magna* and *Acervoschwagerina*.

Genus ***Pseudofusulina*** Dunbar and Skinner, 1931
Pseudofusulina duplithecata Igo
Plate 6, Figures 1-14

Pseudofusulina duplithecata Igo, 1956, p.297-299, pl. 18, figs. 1-10; pl. 19, figs. 1-3, 6.

Pseudofusulina sp. A. Igo, 1956, p. 299, pl. 19, figs. 4, 5, 7, 8.

Pseudofusulina sp. B. Igo, 1956, p. 299, pl. 19, fig. 9.

Parafusulina kaerimizensis (Ozawa): Morikawa, 1955, p. 107, 108, pl. 15, figs. 11-13.

Parafusulina takeyamai Morikawa and Isomi, 1961, p. 24, pl. 7, fig. 13.

Schwagerina toyamaensis Suyari, 1962, p. 24, Pl. 8, figs. 4-6.

Pseudofusulina midoriensis Sashida, 1980, p. 300, pl. 35, figs. 1-3.

Material.–Nine axial and five sagittal sections.

Discussion.–The present materials somewhat resemble *Chalaroschwagerina kalmykovae* in thick wall with light layer, but the former is different from the latter by more strongly fluted septa and development of axial filling. The Shimokuzu materials are nearly the same as the original ones (Igo, 1956) and subsequent ones (Igo, 1965). The light layer between tectum and keriotheca is thought to be a supplementary character sometimes present in schwagerinids having thick wall, and to be insufficient for new generic or subgeneric criterion as Igo (1956) inclined to propose.

Slight differences of wall thickness and form ratio in *Pseudofusulina* sp. A and *P*. sp. B by Igo

(1956) are thought to represent the intraspecific variation of the co-existed *Pseudofusulina duplithecata*. *Schwagerina toyamaensis* described from the Chichibu Terrane of Shikoku (Suyari, 1962) resembles this species in important test characters, and is thought to be synonymous with this species. *Pseudofusulina midoriensis* from the Uoganeyama Limestone of the Mino Terrane by Sashida (1980) is also synonymous with this species, though it is slightly deformed. Thick wall characteristic in this species is not clear in insufficient illustrations named *Parafusulina kaerimizensis* by Morikawa (1955) from limestone pebble of Shimokuzu, the same locality as of the present materials. Specimens by Morikawa (1955) are thought to be misidentified. A part of specimens named *Parafusulina takeyamai* (pl. 7, fig. 13, in Morikawa and Isomi, 1961) is different from other illustrated specimens (pl. 19, figs. 1-8, in Morikawa and Isomi, 1961) in wall thickness and mode of septal fluting. It is probably identical with *Pseudofusulina duplithecata*.

Parafusulina impensa from the upper Wolfcampian to lower Leonardian of central California by Douglass (1967) is thought to be closely related to or synonymous with this species. It is associated with *Nagatoella orientis* (Ozawa) and *Misellina californica* Douglass. More irregularly, more weakly fluted septa, smaller proloculus, and thicker wall of *Parafusulina impensa* suggest its closer resemblance to this species than to *Parafusulina diabloensis* Skinner and Wilde from Texas and *Parafusulina edoensis* (Ozawa) from Akiyoshi of Japan, as insisted by Douglass (1967).

Genus **Schwagerina** von Möller 1877

Schwagerina hawkinsiformis Igo

Plate 3, Figures 8-11; Plate 4, Figures 1-12

Schwagerina hawkinsiformis Igo, 1965, p. 216, 217, pl. 30, figs. 7, 8.

Schwagerina hawkinsi Dunbar and Skinner: Kobayashi, 1957, p. 288, 289, pl. 2, fig. 5.

Material.–Eleven axial and five sagittal sections.

Description.–Test large for the genus, inflated fusiform, with broardly arched periphery, nearly straight lateral slopes, and bluntly pointed poles. Mature test with eight to nine whorls, and about 7.6 to 12 mm in length and about 4.7 to 6.5 mm in width, giving approximate form ratio 1.6 to 2.1. Proloculus spherical to nearly spherical, 0.26 to 0.51 mm in outer diameter. The first one to one and a half whorls tightly coiled, then gradually enlarging. Wall thin in comparison with test size, less than 0.1 mm even in the thickest part, and composed of tectum and alveolar keriotheca.

Septa numerous, closely speced, and count 11 to 13, 23 to 27, 28 to 34, 38 to 42, 42 to 48, 44 to 52, 47 to 58, and 51 to 56 from the 1 st to 8 th whorl in the illustrated four sagittal sections except for that shown in Plate 4, Figure 11. They strongly and rather regularly fluted throughout test. Cunniculi not present. Combined folds of ajdacent septa observable even in the median part of test. Prenotheca developed in outer whorls of specimens. Tunnel low and narrow, and its path rather regular. Chomata lacking except for rudimentary chomata on the proloculus. Axial filling variable by specimens, well developed in both sides of tunnel in specimens, but indistinct or completely lacking in others.

Discussion.–Igo (1965) proposed *Schwagerina hawkinsiformis* from the Lower Permian limestone block of northern Mino Terrane based on differences of more inflated test and stronger septal fluting of this species than those of *Schwagerina hawkinsi* Dunbar and Skinner from the Leonardian of the Glass Mountains of Texas (Dunbar and Skinner, 1937). In addtion to these differences, this species is distinguishable from *S. hawkinsi* by thinner wall and smaller proloculus. *Pseudofusulina gujyoensis* from the Lower Permian limestone block of the Mino Terrane (Kanuma, 1959) is closely similar to this species except for globular inner whorls of *P. gujyoensis*. Although conclusion is reserved because of lack of outer or outermost whorls in four illustrated specimens, *Schwagerina gruperaensis* from the Wolfcampian of Chiapas of southernmost Mexico (Thompson and Miller, 1944) appear to be dissimilar to the holotype of *S. hawkinsiformis*. However, they are thought to be related to this species from wide intraspecific variation of this species in the present materials.

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Plate 1. Photomicrographs of the Lower Permian limestone in the Hanagiri-Shimokuzu area.

Figs. 1, 2. Limestone block.

1. Wackestone containing many specimens of *Pamirina leveni*, D2-003425, H-1, x 5.1.
2. Wackestone containing *Mesoschubertella thompsoni*, D2-003401, H-2, x 5.1.

Figs. 3-7. Granules to boulders of limestone contained in tuff breccias.

3. Cobble of wackestone containing *Schwagerina hawkinsiformis*, D2-003540, H-3, x 3.7.
4. Cobble of grainstone containing calcispomges, fusulinaceans (*Pseudofusulina duplithecata*), brachipods, green algae, crinoids, and rugose corals, D2-003586, H-5, x 3.1.
5. Boulder of well-washed grainstone completely excluding lime-mud, D2-003619, H-8, x 5.1.
6. Pebble of grainstone composed of well-sorted, fine-grained bioclasts and aggregate grains, D2-003598, H-6, x 5.1.
7. Breccias of granules and pebbles of lime-mudstone, wackestone, pelloid grainstone containg Gzhelian *Triticites* sp., ooid grainstone (upper left end), which are penetrated by styolite seams of dark tuffacous materials and many calcite veinlets, D2-003570, 3 m apart from H-5, x 4.9.

Plate 2.

Figs. 1, 2. *Pseudoendothyra* sp. 1: D2-003542a; 2: D2-003556a, both H-4, x 40.

Fig. 3. *Pseudoreichelina* sp. A. D2-003545a, H-4, x 30.

Fig. 4. *Schubertella* sp. A. D2-003595a, H-6, x 40.

Figs. 5-10. *Schubertella* sp. B. 5: D2-003553a; 6: D2-003597a; 7: D2-003597b; 8: D2-003597c; 9: D2-003595b; 10: D2-003553b, 5, 10: H-4; others: H-6, all x 40.

Figs. 11, 12. *Toriyamaia laxiseptata* Kanmera. 11: D2-003556b; x 30, 12: D2-003542b; x 20, both H-4.

Figs. 13-37. *Mesoschubertella thomposoni* Sakagami. 13: D2-003394; 14: D2-0079; 15: D2-003382; 16: D2-003377; 17: D2-003383; 18: D2-003397; 19: D2-003392a; 20: D2-003385; 21: D2-003393; 22: D2-003384; 23: D2-003376a; 24: D2-003376b; 25: D2-003388a; 26: D2-003381; 27: D2-003389; 28: D2-003392b; 29: D2-003380a; 30: D2-003380b; 31: D2-003380c; 32: D2-003395; 33: D2-003390c; 34: D2-003376c; 35: D2-003392c; 36: D2-003396; 37: D2-003391, all H-2, x 30.

Figs. 38-46. *Biwaella omiensis* Morikawa and Isomi. 38: D2-003597d; 39: D2-003388b; 40: D2-003376d; 41: D2-003386; 42: D2-003376e; 43: D2-003378; 44: D2-003390b; 45: D2-003387; 46: D2-0080d, all H-2 except for 38: H-6, all x 20.

Plate 3.

Figs. 1-3. *Darvasites ikenoensis* (Morikawa and Isomi). 1: D2-003582; 2: D2-003580; 3: D2-003581a, all H-5, x 10.

Fig. 4. *Pseudofusulina fusiformis* (Schellwien and Dyhrenfurth). D2-003420, H-1, x 8.

Fig. 5-7. *Paraschwagerina magna* Skinner and Wilde.
5: D2-003503; x 10, 6: D2-003502; x 10, 7: D2-003523; x 8, all H-3.

Figs. 8-11. *Schwagerina hawkinsiformis* Igo. 8: D2-003517; x 8, 9: D2-003504; x 10, 10: D2-003515; x 8, 11: D2-003508; x 8, all H-3.

Fig. 12. Schwagerinidae gen. and sp. indet. A. D2-003600, H-7, x 8.

Fig. 13. *Pseudofusulina* sp. B. D2-003612, H-8, x 8.

Plate 4.

Figs. 1-12. *Schwagerina hawkinsiformis* Igo. 1: D2-003512; 2: D2-003516; 3 D2-003521; 4: D2-003505; 5 D2-003522; 6: D2-003513; 7: D2-003514; 8: D2-003507; 9: D2-003506; 10:D2-003509; 11: D2-003519; 12: D2-003518, all H-3, x 8.

Figs. 13-16. *Pseudofusulina aganoensis* Huzimoto. 13: D2-003552b; 14: D2-003542c; 15: D2-003550; 16: D2-003554, all H-4, x 8.

Plate 5.

Figs. 1-9. *Chalaroschwagerina kalmykovae* Davydov.
1: D2-003555; 2: D2-003544; 3: D2-003543; 4: D2-003546; 5: D2-003553c; 6: D2-003547; 7: D2-003545b; 8: D2-003551; 9: D2-003549, all H-4, x 8.

Figs. 10-12. *Pseudofusulina* sp. A.
10: D2-003599; H-7, 11: D2-003618; H-8, 12: D2-003619; H-8, all x 8.

Plate 6.

Figs. 1-14. *Pseudofusulina duplithecata Igo.* 1: D2-003593; 2: D2-003571; 3: D2-003583a; 4: D2-003594; 5: D2-003578; 6: D2-003579; 7: D2-003584; 8: D2-003590; 9: D2-003581b; 10: D2-003583b; 11: D2-003572; 12: D2-003575; 13: D2-003589; 14: D2-003591, all H-5, x 8.

Plate 1

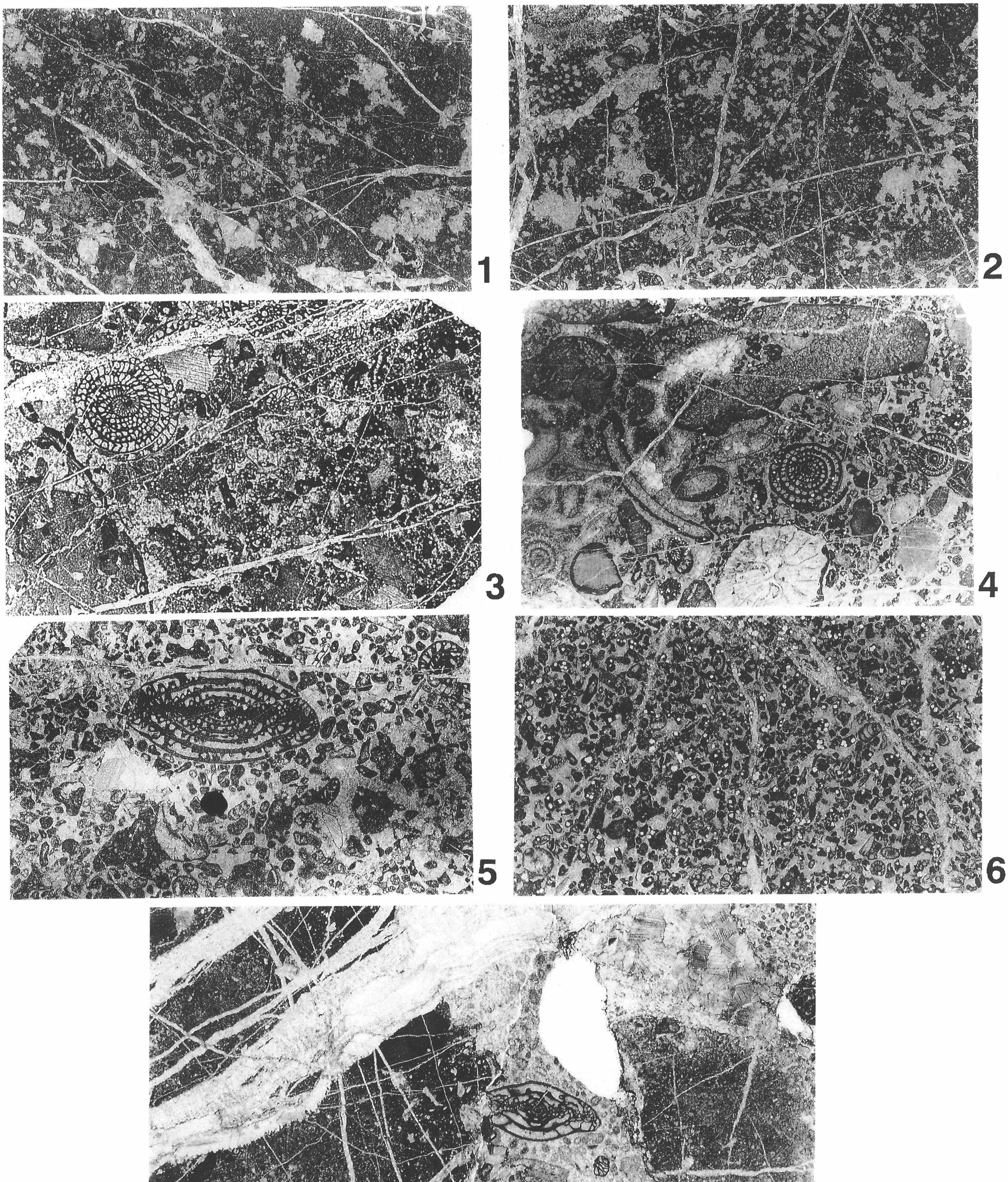
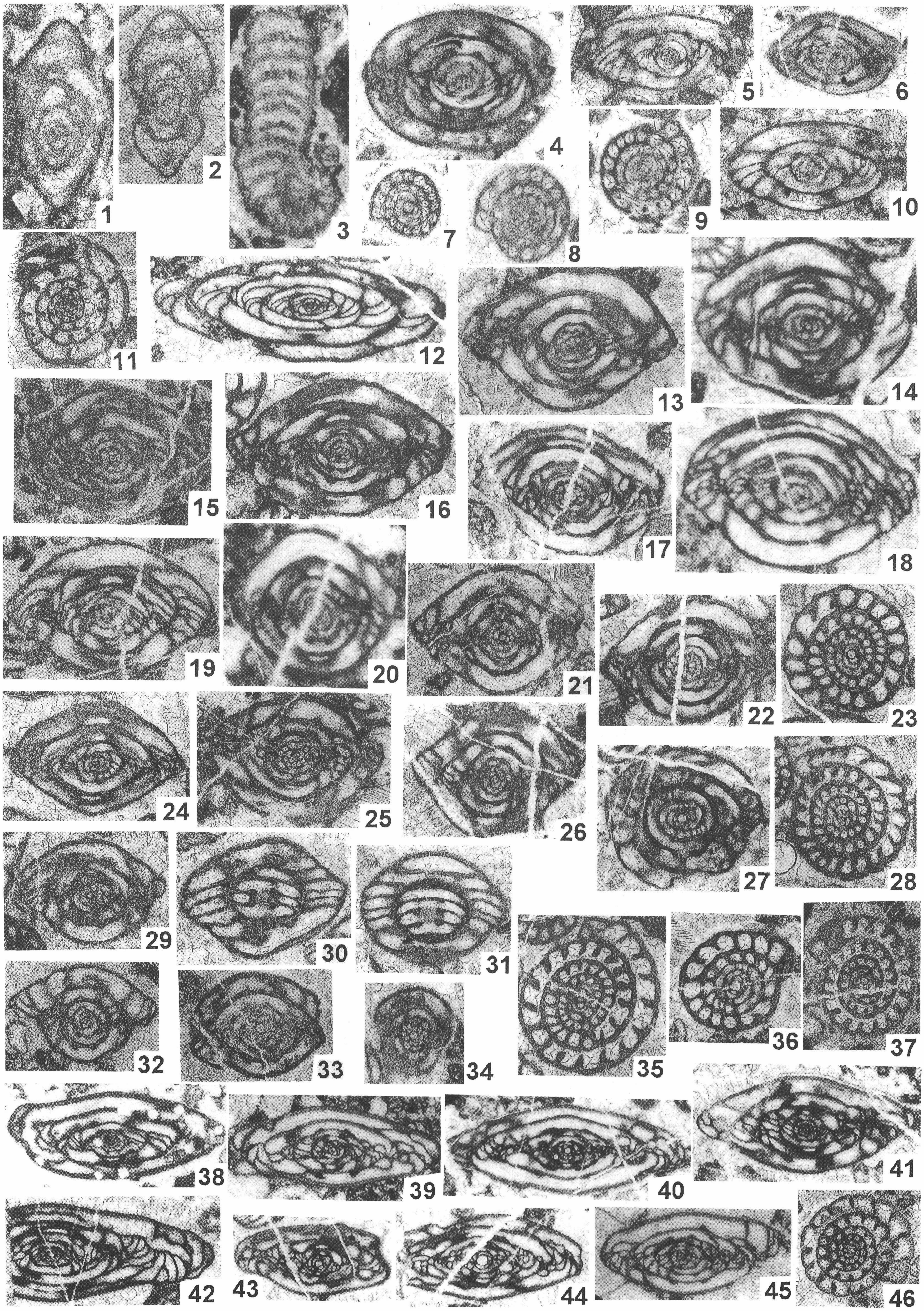


Plate 2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