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Middle Permian Foraminifers of the Omi Limestone, Central Japan

By

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Abstract Forty-six species belonging to thirty-three genera of Middle Permian foraminifers are distinguished from the Omi Limestone, distributed in the northeastern end of the Circum-Hida Belt of Southwest Japan. Among them, twenty-three species of fusulinacean foraminifers are described. They are almost identical in species level with those from limestones in the Yamaguchi Belt of Southwest Japan. Middle Permian fusulinaceans from the Omi, Akiyoshi, Taishaku and Atetsu Limestones, and from small limestone lenses of the Maizuru Belt are more intimately related to those from Southeast Asia, South China and Northeast China(a part of Jilin) than those from rest of Japan on special empahasis on the occurrence of Sumatrininae.

Introduction

The Permian subduction complexes in the Inner Zone of Southwest Japan include late Early Carboniferous to Middle Permian limestone blocks, for example, the Akiyoshi, Taishaku and Atetsu Limestones. After the interpretation of limestone lithology, development of basic lava and pyroclastics as their base, no intercalation of terrigenous sediments, occurrence of the Permian radiolarians from the surrounding non-calcareous rocks, and the Triassic shelf deposits unconformably overlying the subduction complexes, these limestones have been derived from reef sediments on sea mounts and incorporated with surrounding non-calcareous rocks until last stage of Permian.

The fusulinacean foraminifers in these limestones, especially Middle Perminan ones, are significantly different from the contemporaneous ones found in the Jurassic subduction complexes of Japan. Middle Permian fusulinaceans from the Permian subduction complexes in Japan are more closely related paleobiogeographically to those from Southeast Asia, South China and a part of Jilin, Northeast China (HAN, 1980).

The Omi Limestone, distributed in the northeastern end of the Circum-Hida Belt in central Japan, have been pointed out to be an affinity to the limestone blocks of the Yamaguchi Belt lighologically as well as paleontologically (e.g. TORIYAMA, 1967). The following Middle Permian fusulinaceans were described from the Omi Limestone: *Schwagerina* (*Verbeekina*) *deprati* YABE, *Doliolina lepida* SCHWAGER and *Neoschwagerina craticulifera* SCHWAGER by HAYASAKA (1924), *Yabeina hayasakai* OZAWA by OZAWA (1925c) and IGO (1960), and *Lepidolina shiraiwensis* (OZAWA) by OZAWA (1975).

Sumatrina longissima DEPRAT and *Lepidolina hyasakai* (OZAWA) were illustrated by HASEGAWA *et al.* (1979) without description. However, there are several undescribed species important to correlation besides them. Although the fusulinaceans of Japan have been reviewed in 1960's (e.g. TORIYAMA, 1967), recent knowledges on collision-accretion tectonics need re-examination of them.

During the descriptive work of Late Paleozoic foraminifers, I have collected numerous specimens of Middle Permian foraminifers in the Omi Limestone. The detailed stratigraphy of each limestone including foraminifers could not be determined because of complex fault-bounded relationship. The present paper reports the description of twenty-three species of Middle Permian fusulinaceans from the Omi Limestone and briefly discusses the faunal correlation of the Middle Permian fusulinacean assemblage of Japan.

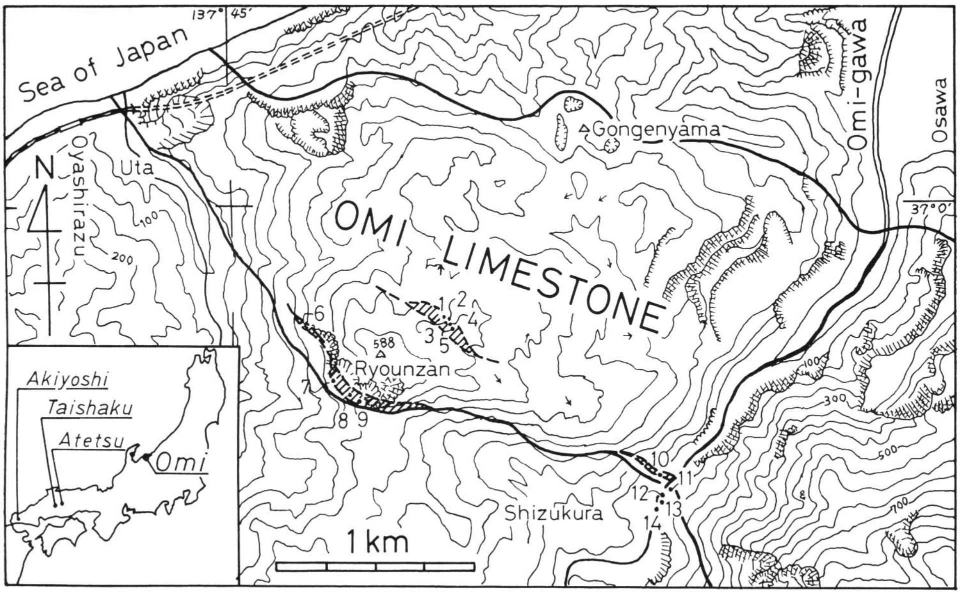
All the thin sections used in the present paper are stored in Department of Geology, National Science Museum, Tokyo. I am indebted to Associate Professor Tomowo OZAWA, Nagoya University, and Dr. YASUJI SAITO, National Science Museum, for their helpful criticisms of the manuscript. I wish to thank Mr. Kozo WATANABE, Higashi-katsushika High School, for his valuable suggestion concerning fusulinacean biostratigraphy of the Omi Limestone.

Occurrence of the Middle Permian limestones

In Omi district, late Early Carboniferous to Middle Permian massive limestone is developed in 12.5× 3 Km across with the WNW to ESE trend. The limestone is partially intercalating with thin basic pyroclastic rocks.

HASEGAWA *et al.* (1969) subdivided the limestone into nine foraminiferal zones, mostly by fusulinaceans. Among them, upper three, the *Parafusulina*, the *Neoschwagerina-Gifuella* and the *Yabeina-Lepidolina* Zones, are assignable to the Middle Permian. They correspond to the P_2 formation of KAWADA (1954) and the P_2 Zone (*Parafusulina-Neoschwagerina-Sumatrina* Zone) of FUJITA (1958).

In comparison with an extensive distribution of the Carboniferous and Lower Permian limestones, the Middle Permian ones are restricted in small areas (Text-fig. 1). The *Parafusulina*-bearing limestones are only located at the northeastern side of Mt. Ryounzan (588 m above sea-level). They consist of algal crinoidal bioclastic limestones (Pl. 13, fig. 2) including abundant fusulinaceans (Pl. 13, fig. 1). The conglomeratic limestones are dominant at the south to southwest side of Mt. Ryounzan across a wide unexposed area except for several outcrops of Moscovian limestones from the *Parafusulina*-bearing limestones. They are partially interbedded with basic pyroclastics less than 50 cm in thickness and include abundant neoschwagerinids with abraded shells. The granule- to cobble-sized fragments of various lithology and different ages are observed in those limestones (Pl. 12, fig, 5; Pl. 13, figs. 4, 5). Among them, the oldest fossil found in the pebble is late Visean to early Serpukhovian *Endothyra* sp. The youngest fusulinaceans, *Neoschwagerina margaritae* and *Sumatrina*



Text-fig. 1. Index map of the Omi Linestone. The fossil localites are indicated as number.

"*longissima*," probably indicate the age of the conglomeratic limestones. Micritic limestones crop out around Loc. 7 in Text-figl. 1 in contact with fault between the conglometatic limestones and the Sakmarian limestones including *Pseudofusulina kraffti*. Although there are no useful fossils for age determination, the micritic limestones include a lenticular block in which *Neoschwagerina simplex* is found in association with *Misellina ovalis* (Pl. 13, figs. 6, 7). The Middle Permian conglomeratic limestone is also distributed in northwest side of Mt. Ryounzan (Loc. 6 of Text-fig. 1). It is in fault contact with the Moscovian limestones including *Fusulinella biconica* and *F. simplicata*, and the Gzhelian ones including *Triticites simplex*.

In the valley of the Omi-gawa near Shizukura, there are many erratics of various limestones of Middle Permian age. *Yabeina hayasakai* (IGO, 1960), *Lepidolina shiraiwensis* (OZAWA, 1975) and *Lepidolina hayasakai* (HASEGAWA *et al.*, 1979) are probably derived from the conglomeratic limestone boulders. However, some of these conglomeratic limestones are thought to be formerly exposed at the banks of the Omi-gawa, after OZAWA (1925b). Although various Middle Permian fusulinaceans are obtained from pebble-to boulder-sized erratics in the river floor of the Omi-gawa, their original outcrops can not be confirmed except for the *Colania*-bearing micritic limestone (Pl. 12, fig. 8) from Loc. 10 shown in Text-fig. 1. The limestone is in contact with fault between the northward distributed Gzhelian limestones and the southward distributed Moscovian(?) ones.

Strong deformation of the southern part of the Omi Limestone by thrust impedes to create a biostratigraphic division of the Middle Permian and to reconstruct their original successions. Nevertheless, continuous sedimentation throughout Middle Perminan time is indicated by the occurrence of common fusulinacean species from Omi, Akiyoshi (TORIYAMA, 1958) and Atetsu (NOGAMI, 1961a, b). Conglomeratic limestones yielding various fossils of different ages suggest the original clinounconformable relationships between the conglomeratic limestones and the underlying strata.

Systematic Paleontology

Superfamily Fusulinacea VON MÖLLER, 1878
Family Staffellidae A. D. MIKLUKHO-MAKLAY, 1949

Genus *Nankinella* LEE, 1933

Nankinella sp. cf. *N. kotakiensis* (FUJIMOTO and KAWADA)

Pl. 2, figs. 27–30

Compare: 1953 *Hayasakaina kotakiensis* FUJIMOTO and KAWADA; Sci. Rep., Tokyo Kyoiku Daigaku, Sec. C, vol. 2, no. 13, p. 208, 209, Pl. 1, figs. 1–10.

Remarks: The present materials are assignable to genus *Nankinella* in spirothecal structure of tectum(?) and lower thicker layer, angular to bluntly pointed periphery and dense secondary calcareous materials filling up the most of chambers. Their general appearence is comparable to the original illustrations of this species (FUJIMOTO and KAWADA, 1953), based on which the genus *Hayasakaina* was proposed.

Occurrence: Locs. 5 (Pl. 2, fig. 28), 11 (Pl. 2, figs. 27, 29, 30), 13(?).

Genus *Pseudoendothyra* MIKAYLOVA, 1939

Pseudoendothyra spp.

Pl. 3, figs. 1, 2

Remarks: Forms having small lenticular shell with obscure internal structures and thick spirotheca are rarely yielded throughout the Middle Permian limestones. They are referable to *Pseudoendothyra*, but more individuals in each locality are necessary for specific identification.

Occurrence: Locs. 5, 8, 9, 10, 11 (Pl. 3, figs. 1, 2).

Family Schubertellidae SKINNER, 1931
Subfamily Schubertellinae SKINNER, 1931

Genus *Mesoschubertella* KANUMA and SAKAGAMI, 1957

Mesoschubertella sp.

Pl. 3, figs. 14, 15

Remarks: The genus *Mesoschubertella* was erected as a new genus of Schubertellinae in its thick spirotheca and its diagnostic spirothecal structure from the Lower Permian (Sakmarian) limestones of Japan (KANUMA and SAKAGAMI, 1957). The present materials are the closest to the genus among the known genera, but the Omi materials have smaller shell and are yielded in association with *Neoschwagerina simplex* (OZAWA). They are somewhat similar to *Dunbarula*, but have different spirothecal structure.

Occurrence: Loc. 7 (Pl. 3, figs. 14, 15)

Genus ***Neofusulinella*** DEPRAT, 1912

Neofusulinella simplex (LANGE)

Pl. 3, figs. 10–13.

1925 *Schubertella simplex* LANGE; Geol.-Mijnb. Genoot. Netherland, Kolon., Verhandl. Geol. Ser., vol. 7, p. 254, pl. 3, figs. 60a–c [non 60d].

Remarks: The present materials are related to the original ones referred to *Schubertella simplex* by LANGE (1925) in shell size and incipient chomata. However, the species is considered to be assignable to *Neofusulinella* by spirothecal structure of thin tectum and thick transparent layer with mural pores. It is distinguished from such species of *Neofusulinella* as *N. lantenoisi* DEPRAT, *N. giraudi* DEPRAT and *N. phairayuensis* COLANI by smaller shell and less prominent chomata. The Omi materials have thinner spirotheca than that of the LANGE's ones in loosely coiled outer volutions. The original illustration shown in Pl. 3, fig. 60d would be excluded from this species and assignable to the genus *Dunbarula*.

Occurrence: Locs. 3 (Pl. 3, figs. 11–13), 7 (Pl. 3, fig. 10), 12.

Subfamily Boultoniinae SKINNER and WILDE, 1954

Genus ***Dunbarula*** CIRY, 1948

Dunbarula schubertellaeformis SHENG

Pl. 3, figs. 3–9.

1958 *Dunbarula schubertellaeformis* SHENG; Acta Palaeont. Sinica, vol. 6, no. 3, p. 283, Pl. 1, figs. 8–12; Pl. 4, fig. 5.

Remarks: The present materials are represented by intensely folded and anteriorly curved septa, thin spirotheca composed of tectum and translucent lower layer, discoidally coiled inner volutions and rather loosely coiled outer ones without evident uncoiled prolongation of outer shell. From these biocharacters, they are assignable to the genus *Dunbarula*. Among the described species of the genus, the present materials bear intimate resemblances to *D. schubertellaeformis* from the Maokouan limestone of Chinghai, Northwest China by SHENG (1958). The present forms have more loosely coiled outer volutions than those of the original ones.

Occurrence: Locs. 1(?), 3(?), 5(?), 6, 7, 8 (Pl. 3, figs. 3, 8), 11 (Pl. 3, figs. 4–7, 9), 12, 14.

Dunbarula sp. A

Pl. 3, figs. 23–28.

Remarks: The present materials may be assigned into the genus *Boultonia* rather than to *Dunbarula* based on fusiform to elongate fusiform shell, weakly fluted septa and well discernible chomata. Nevertheless, taking their more well-developed discoidal juvenile volutions and co-existence with *Colania douvillei* (OZAWA) or *Neoschwagerina margaritae* DEPRAT into consideration, generic assignment to *Boultonia* is less possible.

They are comparable with *Dunbarula* sp., originally described as *Schubertella* ? sp. from the Atetsu Limestone by NOGAMI (1961b), in many respects except for more intensely fluted septa of the latter. In comparison with *Dunbarula cascadensis* (THOMPSON, WHEELER and DANNER) from the Gozenyama Formation of the Kwanto Mountains (KOBAYASHI, 1986), the present unidentified species has more number of septa.

Occurrence: Locs. 8, 9 (Pl. 3, fig, 28), 10 (Pl. 3, figs. 23–27).

Dunbarula sp. B

Pl. 3, fig. 16.

Remarks: The present form has a somewhat resemblance to *Dunbarula pseudosimplex* (SHENG), originally referred to the genus Schubertella by SHENG (1958) in its simple framework of shell and wall structure. However, there is a possibility that the species merely represents the incomplete individuals of inflated form of *D. scubertellaeformis* SHENG. Specific identification is left pending because of its insufficient number of individuals.

Occurrence: Loc. 13 (Pl. 3, fig. 16).

Genus ***Minojapanella*** FUJIMOTO and KANUMA, 1953

Minojapanella elongata FUJIMOTO and KANUMA

Pl. 3, figs. 17–22.

1953 *Minojapanella elongata* FUJIMOTO and KANUMA; Jour. Paleont., vol. 27, no. 1, p. 150–152, Pl. 19, figs. 1–11.

Remarks: Although no well-oriented axial and sagittal sections can be obtained, the present materials are identical with the original ones by FUJIMOTO and KANUMA (1953) in most of essential characters. The original description was from the late Early Permian (Sakmarian) limestones of the Mino Mountains, but the present materials are accompanied by *Parafusulina* sp. cf. *P. kaerimizensis* (OZAWA) and *Pseudodoliolina ozawai* YABE and HANZAWA of early Middle Permian age.

Occurrence: Locs. 1 (Pl. 3, figs. 17–22), 5.

Family Schwagerinidae DUNBER and HENBEST, 1930

Genus ***Chusenella*** HSU, 1942

Chusenella sp.

Pl. 3, fig. 33.

Remarks: The *Colania douvillei* limestone rarely yields schwagerinids besides of *Pseudofusulina padangensis* (LANGE). They are belonged to the *Chusenella* based on rapid expansion of outer shell with rather thick spirotheca, regularly fluted speta and tightly coiled inner volutions. Specific identification is impossible due to insufficient number of individuals.

Occurrence: Locs. 10 (Pl. 3, fig. 33), 11 (?).

Genus ***Parafusulina*** DUNBAR and SKINNER, 1931

Parafusulina sp. cf. ***P. kaerimizensis*** (OZAWA)

Pl. 3, figs. 34, 35; Pl. 4, figs. 1–13.

1925 *Schellwienia kaerimizensis* OZAWA; Jour. Coll. Sci., Imp. Univ. Tokyo, vol. 45, art. 6, p. 31, 32; Pl. 4, figs. 6, 7; Pl. 6, figs. 5 non Pl. 4, fig. 5.

Remarks: One of the axial section, originally illustrated in Pl. 6, fig. 5 (OZAWA, 1925c) from Kaerimizu, was designated as the lectotype of this species by TORIYAMA (1958). The other of the axial section shown in Pl. 4, fig. 5 (OZAWA. 1925c) from Tomuro, Tochigi prefecture is excluded from the present species. TORIYAMA (1958) re-examined some biocharacters of this species from various localities of the Akiyoshi Limestone. He recognized a broad variation in rate of expansion of shell, spirothecal thickness and intensity of axial filling.

As well as the topotype specimens, the Omi ones are mostly abraded in their outer shells, consequently giving dissimilar appearence on the strength of a state of preservation. The Omi and topotype specimens are common in axial filling, thin spirotheca of inner volutions, prolocular size and septal folding. But, the former has thicker spirotheca in outer volutions. The present species differs from *Parafusulina edoensis* (OZAWA) in smaller proloculus, thinner spirotheca and more tightly coiled inner volutions, and from *Parafusulina japonica* (GÜMBEL) in intense axial filling.

Occurrence: Locs. 1 (Pl. 3, fig. 35; Pl. 4, figs. 7, 8), 2 (Pl. 3, fig. 34), 3 (Pl. 4, figs. 1, 2, 4–6), 4 (Pl. 4, fig. 11), 5 (Pl. 4, figs. 3, 9, 10, 12, 13).

Genus ***Pseudofusulina*** DUNBAR and SKINNER, 1931

Pseudofusulina padangensis (LANGE)

Pl. 3, figs. 31, 32.

1925 *Schellwienia padangensis* LANGE; Geol.-Mijnb. Genoot. Netherland, Kolon., Verhandl. Geol. Ser., vol. 7, p. 255–258, pl. 3, figs. 62a–62f.

Remarks: Only two centered- and several excentered-oblique sections are obtained in association with *Colania douvillei* (OZAWA) or *Lepidolina shiraiwensis* (OZAWA). They are nearly identical with those from the Gozenyama Formation of the Kwanto Mountains (KOBAYASHI, 1986). Although further comparison with the original materials from Sumatra (LANGE, 1925) is needed, the present materials are probably referable to original ones.

Occurrence: Locs. 10 (Pl. 3, figs. 31, 32), 11, 13.

Pseudofusulina ? sp. cf. ***P. crassa*** (DEPRAT)

Pl. 3, figs. 29(?). 30.

Compare 1913 *Fusulina crassa* DEPRAT; Mém. Serv. Géol. l'Indochine, vol. 2, fasc. 1, p. 27, 28, Pl. 6, figs. 1–5.

Remarks: The exact size of shell is unknown because of abrasion of outer shell. Only one axial section has regularly folded septa, pointed poles of each volution and dense axial filling. The present forms are comparable to *Fusulina crassa* originally described from Laos by DEPRAT (1913). However, more number of well-oriented sections is necessary for specific identification. The sagittal section shown in Pl. 3, fig. 29 may be exclusive due to less number of septa. Generic assignment of this species is undeterminable.

Occurrence: Locs. 6, 8 (Pl. 2, figs. 29, 30), 9.

Family Verbeekinidae STAFF and WEDEKIND, 1910
Subfamily Verbeekininae STAFF and WEDEKIND, 1910

Genus ***Verbeekina*** STAFF, 1909

Verbeekina verbeeki (GEINITZ)

Pl. 11, figs. 10–14.

1876 *Fusulina verbeeki* GEINITZ; Palaeontographica, Bd. 22, p. 399, 400.

Remarks: The present species is accompanied by *Neoschwagerina margaritae* DEPRAT or *Lepidolina shiraiwensis* (OZAWA) in Omi. Differences in sizes of proloculus and shell, number of volution and tightly coiled juvenile volutions are discernible between the two of different age.

Occurrence: Locs. 8 (Pl. 11, figs. 11, 13), 11 (Pl. 11, fig. 12,) 14 (Pl. 11, figs. 10, 14).

Subfamily Misellininae A. D. MIKLUKHO-MAKLAY, 1958

Genus ***Misellina*** SCHENCK and THOMPSON, 1940

Misellina ovalis (DEPRAT)

Pl. 5, figs. 1–12.

1915 *Doliolina ovalis* DEPRAT; Mém. Serv. Géol. l'Indochine, vol. 4, fasc. 1, p. 15, 16, Pl. 3, figs. 1–4.

Remarks: The present materials are very characteristic in their broad and low pendant protrusions from lower surface of spirotheca. Each of the protrusions is roughly corresponding to one parachomata, and is occasionally in contact with the top of parachomata. All of these protrusions are not always considered to be produced due to the orientation of axial section cut through anteriorly curved portions of septa, since they occur in all of the axially-cut individuals. They appear to be primary transverse septula of primitive forms referable Neoschwagerinidae. However, they must be distinguished from septula because they are also recognizable in such advanced forms of *Misellina* as *M. claudiae* (DEPRAT). From these respects, the present forms are considered to be a transitional form between a species of *Misellina* and an unspecified direct descendant referable to Neoschwagerinidae.

The Omi materials are probably identical with *Misellina ovalis* (DEPRAT) originally described from Laos (DEPRAT, 1915), but the original ones are uncertain in exact size of shell and possibly lack in outermost volution. The present materials are allied to the Hopei ones by SHENG (1962) and most of Kwangsi and Kueichow ones by SHENG (1963) in which SHENG recognized broad variation of this species in prolocular size, spirothecal thickness and development of parachomata. Various forms of *Misellina* and primitive forms of Neoschwagerinidae are known from Pamir (LEVEN, 1967). Among them, *Misellina ovalis* (DEPRAT) and *Cancellina nipponica* OZAWA identified by LEVEN are closely similar to the present materials. This species is distinguished from *M. claudiae* (DEPRAT) in thinner spirotheca and slender parachomata.

Occurrence: Locs. 7 (Pl. 5, figs, 1, 3–11), 12 (Pl. 5, figs. 2, 12).

Genus *Pseudodoliolina* YABE and HANZAWA, 1932

Pseudodoliolina ozawai YABE and HANZAWA

Pl. 5, figs. 13–17.

1932 *Pseudodoliolina ozawai* YABE and HANZAWA; Proc. Imp. Acad. Japan, vol. 8, no. 2, p. 40–42.

Remarks: In the Rat Buri limestone of Thailand, TORIYAMA and KANMERA (in TORIYAMA, 1975) proposed three new species and one un-named species of *Pseudodoliolina*. All of them are with smaller size of shell than that of the previously-known species of the genus. They are appeared to be considerably difierent from the present species in prolocular and shell sizes, and length and width of the corresponding volutions. However, it is not acceptable that the three "new species" are independant in each other, taking the following two respects into consideration. One is that the fusulinaceans of the Rat Buri Limestone have more or less undergone deformation, and differences of form ratio and outlines of shell as well as each volution are closely related to degree and orientation of deformation. The other is a biostratigraphic distribution of the three "new species" in the limestone.

Pseudodoliolina in the Omi Limestone are yielded from the well-sorted bioclastic limestones as shown in Pl. 13, figs. 1, 2 as well as in the HAYASAKA's illustrations (Pl. 3, figs. 6, 7) in 1924. They appear to be more similar to the three "new species" from the Rat Buri Limestone than *Pseudodoliolina ozawai* of the original description (YABE and HANZAWA, 1932). However, more primitive appearence of the most of the present materials is apparently attributed to abrasion of outer volutions, since the larger-sized individuals occur in the same limestones. Specific identification of the present materials with P. ozawai is also supported by the stratigraphic correlation between the Omi and the Akasaka Limestones.

Occurrence: Locs. 1, 3, 4, 5 (Pl. 5, figs. 13–17).

Pseudodolina pseudolepida (DEPART)

Pl. 5, figs. 18–21; Pl. 6, fig. 18.

1912 *Doliolina pseudolepida* DEPRAT; Mém. Serv. Géol. l'Indochine, vol. 1, fasc. 3, p. 46, Pl. 5, figs. 6–9; Pl. 6, fig. 4.

Remarks: In comparison with the original materials of DEPRAT (1912) and subsequent many ones identified with this species from various localities, the present ones have slender parachomata. Another diagnostic characters are alike in each other.

Occurrence: Locs. 6 (Pl. 5, fig. 20), 8 (Pl. 5, figs. 18, 19), 9 (Pl. 6, fig. 18), 10, 13 (Pl. 5, fig. 21), 14.

Family Neoschwagerinidae DUNBAR and CONDRA, 1928
Subfamily Neoschwagerininae DUNBAR and CONDRA, 1928

Genus *Neoschwagerina* YABE, 1903

Neoschwagerina margaritae DEPRAT

Pl. 7. figs. 1–3.

1913 *Neoschwagerina margaritae* DEPRAT: Mém. Serv. Géol. l'Indochine, vol. 2, fasc. 1, p. 58–60, Pl. 9, figs. 1–3.

Remarks: Exact length, width, form ratio and number of volution of the present materials are uncertain, becuse almost all of the present materials are lack in outer shell due to abrasion. The well-preseved specimens of this species closely resemble the primitive forms of *Yabeina globosa* (YABE), but both are distinguishable in development of secondary transverse septula and axial septula. The Omi materials are identical with the orginal ones from northern Vietnam (DEPRAT, 1913) in most of biocharacters. More rounded periphery and more bluntly pointed poles in middle and late stages of the former are considered to be intraspecific variation of this species. *N. margaritae* is almost undistinguishable from *N. cheni* SHENG except for larger size of shell and more number of volutions. Among the described materials from the various limestones in Japan, the present ones are the closest to the Atetsu ones by NOGAMI (1961b).

Occurrence: Locs. 6 (Pl. 7, fig. 3), 8 (Pl. 7, figs. 1, 2), 9.

Neoschwagerina simplex OZAWA

Pl. 6, figs. 1–17.

1927 *Neoschwagerina simplex* OZAWA; Jour. Fac. Sci., Imp. Univ. Tokyo, vol. 21, part 5, p. 153, 154, Pl. 34, figs. 7–11, 22, 23; Pl. 37, figs. 3a, 6a.

Remarks: *N. simplex* was established from the Nn Zone of the Akasaka Limestone (OZAWA, 1927). Later, HONJO (1959) designated the lectotype for the specimen originally illustrated in Pl. 34, fig. 8 of OZAWA (1927). This species is one of the most primitive species of the genus and is considered to be the direct descendant from *Maklaya pamirica* (LEVEN), a type species of *Maklaya.* The two are common in minute proloculus followed by endothyroidly coiled juvenile volutions, thick spirotheca, thick and short septa, massive parachomata, incipiently-developed short and broad primary transverse septula and lack of both secondary transverse and axial septula.

Transitional morphologic characters among *Maklaya pamirica*, the present species and *Neoschwagerina* craticulifera (SCHWAGER) are consistent with the stratigraphic occurrence of these three species in Pamir (LEVEN, 1967). The present materials closely resemble the original ones from the Akasaka Limestone (OZAWA, 1927), whereas those from Pamir (LEVEN, 1967) have more-well developed primary transverse septula.

Occurrence: Locs. 7 (Pl. 6, figs. 1, 3, 4, 7–9, 13–17), 12 (Pl. 6, figs. 2, 5, 6, 10–12).

Neoschwagerina sp. A

Pl. 7, figs. 4–6; Pl. 12, figs. 1–4.

Remarks: The present un-named species is tentatively distinguished herein from *N. margaritate* in having larger proloculus. Further subdivision is possible on the basis of spirothecal thickness and shape of septula and parachomata. It is difficult to conclude wether the present un-named species represents the intraspecific variation of *N. margaritae* or it should be referable to an independant species.

Even if those referable to *N. margaritae* and *N.* sp. A are excluded, the conglomeratic limestones yield other forms of *Neoschwagerina* whose outer shell is mostly abraded. Some of them have similar appearences to those of *N. craticulifera* (SCHWAGER), *N. haydeni* DUTKEVICH and KHABAKOV or *N. minoensis* DEPRAT emend. OZAWA. However, further discussion on them is avoided, because they are represented by incomplete materials.

Occurrence: Locs. 6, 8 (Pl. 7, figs. 4, 5; Pl. 12, figs. 1–4), 9 (Pl. 7, fig. 6).

Subfamily Lepidolininae A. D. MIKLUKHO-MAKLAY, 1958

Genus ***Lepidolina*** LEE, 1933 emend. OZAWA, 1970

Lepidolina shiraiwensis (OZAWA)

Pl. 9, figs. 1–9; Pl. 10, figs. 1–7

1925 *Yabeina shiraiwensis* OZAWA; Jour. Coll. Sci., Imp. Univ. Tokyo, vol. 45, art. 6, p. 63, 64, Pl. 2, figs. 2b, 5c; Pl. 10, figs. 1, 2.

Remarks: This species was described from the uppermost part of the Akiyoshi Limestone by OZAWA (1925c). He noticed a close resemblance between this species and *Yabeina globosa* (YABE) except for larger proloculus of the former. Exact size of shell of the original specimens is uncertain because of abrasion of outer shells. TORIYAMA (1958) designated the lectotype for the specimen originally illustrated in Pl. 10, fig. 2 of OZAWA (1925c).

Before the proposal of *Y. shiraiwensis* OZAWA 1925, OZAWA (1922) proposed *Y. hayasakai* from the Omi Limestone for a neoschwagerinid with very large proloculus. The both species were described in the same year (OZAWA, 1925c). In contrast to many reports of the occurrence and description of *L. shiraiwensis* besides of *L. kumensis* KANMERA and *L. multiseptata* (DEPRAT) from various localities in Japan, materials from only the Omi Limestone were identified with *Lepidolina hayasakai* (IGO, 1960; HASEGAWA *et al*,. 1979). However, the illustrated specimens by IGO (1960) are quite similar to the lectotype specimen of *L. shiraiwensis*. *L. hayasakai* illustrated by HASEGAWA *et al.* (1979) resembles *L. shiraiwensis* illustrated by themselves from Yowara of Akiyoshi.

Based on a framework of septula, more advanced forms of *Lepidolina* than the lectotype specimen of *L. shiraiwensis* are described from the limestone blocks of the Inner Zone of Southwest Japan. They are identified with *Yabeina multiseptata shiraiwensis*, *Y. multiseptata multiseptata* and *Y. minuta* from the Taishaku Limestone by SADA and YOKOYAMA (1966). However, these three are conspecific and two illustrations by them assigned to *Y. elongata* (GUBLER) are undoubtedly microspheric forms of *Lepidolina multiseptata*. NOGAMI (1961b) showed many well-oriented specimens, which were referred to *Y. shiraiwensis*, *Yabeina* sp. A and *Y.* sp. B from the Atetsu Limestone, in addition to topotype specimens from Shiraiwa. As comprehensible from his description and his illustrations, *L. shiraiwensis* bears broad morphologic variation in prolocular size, development of septula and so on. *Y.* sp. A and *Y.* sp. B in NOGAMI (1961b) are considered to be represented by the microspheric forms of *L. shiraiwensis*, nevertheless they resemble *Yabeina globosa* (YABE) in their general appearences as indicated by NOGAMI.

OZAWA (1975) discussed the evolution of the species group of *Lepidolina multiseptata* (DEPRAT) on the basis of numerous materials mainly from Japan and Southeast Asia, among which many individuals from Omi are contained. According to OZAWA (1975), prolocular size of 292 individuals from Omi ranges from 0.176 to 0.640 mm, averaging 0.314 mm. Maximum number of axial septula between two adjacent septa of the tenth volution in 33 individuals ranges from 5 to 8. Secondary transverse septula first appears in the 2nd to 5th volution. These values are well concordant with those of the present materials. They are also applicable to those of IGO (1960) and HASEGAWA *et al.* (1979), so far as their illustrated specimens are concerned. OZAWA (1975) showed that the intrapopulational variation of each chracter in the Omi Limestone is statistically undistinguishable from that in Shiraiwa, where the lectotype specimen of *L. shiraiwensis* is designated.

Nevertheless, the difference of prolocular diameter, one of the most diagnostic characters of *Lepidolina* as indicated by OZAWA (1925c) and OZAWA (1975), is very significant statistically between *Yabeina hayasakai* (OZAWA, 1922) and numerous individuals assinged to *L. multiseptata* (DEPRAT) transient *shiraiwensis* OZAWA of OZAWA (1975). In order to know the distinct difference between *L. hayasakai* of OZAWA (1922, 1925c) and *L. shiraiwensis*, it is necessary to re-examine the size distribution of proloculus of original *L. hyasakai*.

Occurrence: Locs. 11 (Pl. 9, figs. 1–9; Pl. 10, figs. 1–5, 7), 13 (Pl. 10, fig. 6), 14.

Genus **Colania** LEE, 1933 emend. OZAWA, 1970

Colania douvillei (OZAWA)

Pl. 7, figs. 7–9; Pl. 8, figs. 1–8

1906 *Neoschwagerina globosa* YABE: DOUVILLÉ; Bull. Soc. Géol. France, Ser. 4, vol. 6, p. 182, Pl. 17; Pl. 18, figs. 1, 2.

Remarks: A derivation on the establishment of this species is noted in OZAWA (1925c, p. 56, 57). Later, TORIYAMA (1958) designated the lectotype specimen for the axial section originally illustrated in Pl. 18, fig. 1 of DOUVILLÉ (1906) from the limestone of Pong-Oua, Laos. This species had been mostly assigned to the genus *Neoschwagerina*, or unusually to the genus *Gifuella* (HONJO, 1959, etc.) before 1970 when OZAWA (1970a) emended the original generic diagnosis of *Colania* LEE, 1933.

Colania douvillei is widespread in Japan and has been described from various limestones of the middle Middle Permian in age. OZAWA (1970b) described this species from the Rat Buri Limestone, Thailand, and mentioned that "it is most reasonable and natural to separate the so-called *Neoschwagerina douvillei* from Japan from *Colania douvillei* from Southeast Asia as a distinct species" from the difference of limestone limestone lithology and others.

Occurrence: Locs. 9, 10 (Pl. 7, figs. 7–9; Pl. 8, figs. 1–8).

Subfamily Sumatrininae KAHLER and KAHLER, 1946

Genus **Sumatrina** VOLZ, 1904

Sumatrina "longissima" DEPRAT

Pl. 9, fig. 10; Pl. 10, figs. 8, 9; Pl. 11, figs. 1–9

1914 *Sumatrina longissima* DEPRAT; Mém. Serv. Géol. l'Indochine, vol. 3, fasc. 1, p. 36, 37, Pl. 5, figs. 1–6.

Remarks: This "species", originally described from Cambodia by DEPRAT (1914), would be seemingly distinguished from *S. annae* VOLZ, the type species of the genus from Sumatra, by larger and more elongate shell of the former than the latter. The two show a broad variation in many biocharacters as indicated by the later workers, and the taxonomic treatment of the two are diverse by workers. Although I am still uncertain wether the two are independent or not, the present materials are herein referred with reservation to *S. "longissima"* in consideration of the convenience use for a biostratigraphic application.

Occurrence: Locs. 6, 8 (Pl. 9, fig. 10; Pl. 11, figs. 4, 5), 9 (Pl. 11 figs. 1–3, 8), 11 (Pl. 10, figs. 8, 9; Pl. 11, figs. 6, 7, 9), 14.

Genus ***Afghanella*** THOMPSON, 1946

Afghanella ozawai HANZAWA

Pl. 5, figs. 22–25

1954 *Afghanella ozawai* HANZAWA; Japan. Jour. Geol. Geogr., vol. 24, p. 3–7, Pl. 1, figs. 1–6; Pl. 2, figs. 1–4.

Remarks: The first record of the occurrence of *Afghanella* in Japan is retrospected to the OZAWA's report under the name of *Yabeina minima* OZAWA in 1922 from the Akiyoshi Limestone without description. Specific and generic assignment of the original specimens was revised to *Neoschwagerina* (*Yabeina*) *schellwieni* (DEPRAT) in OZAWA (1925a), *Yabeina schellwieni* (DEPRAT) in OZAWA (1925c) in which the original specimens were described, and to *Cancellina schellwieni* (DEPRAT) in OZAWA (1927).

HANZAWA (1954) described *Afghanella ozawai*, collected from the *Neoschwagerina* Zone of the Akiyoshi, Taishaku and Atetsu Limestones. Although HANZAWA did not designate any types, he considered the original OZAWA's specimens from the Akiyoshi to be assignable to *A. ozawai*.

The present materials are rarely yielded from the the crinoidal micritic limestone in association with *Parafusulina* sp. cf. *P. kaerimizensis*. They are identical with *A. ozawai* in development of septula, prolocular size and others. This species shows a broad variation especially in prolocular size among the materials from Kaerimizu, in which two specimens with large shell are illustrated in this paper for the purpose of comparison of the Omi materials.

Occurrence: Loc. 5 (Pl. 5, figs. 22, 23).

Concluding Remarks

Forty-six species belonging to thiry-three genera of Middle Permian foraminifers are distinguished in the Omi Limestone, as listed in Table 1. Most of the identified fusulinacean species are well-known in Japan as well as outside of Japan. However,

Table 1. Permian foramirifers from the Omi Limestone. The numbers are corresponding to those in the index map.

	Locality													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Tubertinina spp.			X				X		X		X	X		X
Geinitizina sp.							X							
Pachyphloia ovata Lange						X	X	X	X	X	X		X	
Climacammina valvulinoides Lange	X		X	X	X									
C. sp.												X	X	
Tetrataxis sp.			X					X	X	X	X			
Abadehella coniformis Okimura & Ishii								X	X					X
Globivalvulina cyprica Reichel							X	X	X		X	X		
G. sp. cf. *G. vonderschmitti* Reichel							X	X	X		X	X		
Endothyra sp.	X													
Neoendothyra reicheli Reitlinger										X				
Kahlerina pachytheca Kochansky-Devidé & Ramovš						X		X	X		X		X	X
K. globiformis Sosnina											X			
K. sp. A													X	
K. sp. B							X							
Nankinella sp. cf. *N. kotakiensis* (Fujimoto & Kawada)					X						X		?	
Pseudoendothyra spp.					X			X	X	X	X			
Mesoschubertella sp.							X							
Neofusulinella simplex (Lange)			X				X					X		
Dunbarula schubertellaeformis Sheng	?		?		?	X	X	X			X	X		X
D. sp. A								X	X	X				
D. sp. B													X	
Minojapanella elongata Fujimoto & Kanuma	X				X									
Chusenella sp.										X	?			
Parafusulina sp. cf. *P. kaerimizensis* (Ozawa)	X	X	X	X	X									
Pseudofusulina padangensis (Lange)										X	X		X	
P.? sp. cf. *P. crassa* (Deprat)						X		X	X					
Verbeekina verbeeki (Geinitz)								X			X			X
Misellina ovalis (Deprat)							X					X		
Pseudodoliolina ozawai Yabe & Hanzawa	X		X	X	X									
P. pseudolepida (Deprat)						X		X	X	X			X	X
Neoschwagerina margaritae Deprat						X		X	X					
N. simplex Ozawa							X					X		
N. sp. A						X		X	X					
Lepidolina shiraiwensis (Ozawa)											X		X	X
Colania douvillei (Ozawa)									X	X				
Sumatrina "longissima" Deprat						X		X	X		X			X
Afghanella ozawai Hanzawa					X									
Agathammina sp. A						X	X	X	X	X	X	X	X	
A. sp. B							X				X			
Baisalina hunanica Lin											X			
Orthovertella sp.							X					X		
Calcitornella sp.							X				X	X		X
Calcivertellinae gen. et sp. indet.	X						X				X			
Nodosaria sp.												X		
Frondicularia sp.											X			

stratigraphic distribution of them and biostratigraphic zonation of the Middle Permian limestones are unknown mainly due to complicated geological structure.

Among the Middle Permian fusulinacean species from the Omi Limestone, index species for biostratigraphic divisions and useful for regional correlation are; *Parafusulina* sp. cf. *P. kaerimizensis*, *Pseudodoliolina ozawai*, *Neoschwagerina simplex*, *Neoschwagerina margaritae*, *Verbeekina verbeeki*, *Colania douvillei* and *Lepidolina shiraiwensis*, with reference to OZAWA (1925c, 1927), KANMERA (1954, 1963), KOBAYASHI (1957), TORIYAMA (1958, 1975), MORIKAWA (1958, 1960), HONJO (1959), NOGAMI (1961a, 1961b), SHENG (1963), LEVEN (1967), OZAWA (1970a, 1975), LYS and LAPPARENT (1971), CHOI (1973), TORIYAMA and KANMERA (1979) and TIEN (1979). Details on their geographic distribution and association with other species are excluded, since they have been mentioned in the above literature. Fusulinacean biostratigraphy in Japan until 1966 had been summarized in TORIYAMA (1967).

The results of the present observation and literature survey on the Middle Permian fusulinaceans from Omi and other localities are;

(1) The genus *Yabeina* has been considered to occur in the upper Middle Permian limestones throughout Japan. However, it is entirely absent in the Yamaguchi Belt of the Inner Zone of Southwest Japan and Omi Limestone as well as the Maizuru Belt. It is also probably lacking or very rare in the Southern Kitakami Mountains and the Kurosegawa Belt of Southwest Japan. To put them in different terms, *Yabeina* is exclusively found in the limestones of sea mount origin in the Jurassic to Lower Cretaceous subduction complexes.

(2) Distribution of Sumatrininae in Japan is restricted to the Yamaguchi and Maizuru Belts and the Omi Limestone.

(3) Middle Permian fusulinacean assemblage of the Omi Limestone in addition to that from the Yamaguchi and Maizuru Belts is more intimately related to that of Southeast Asia than that of rest of Japan on special emphasis on the occurrence of Sumatrininae.

(4) The occurrence of *Neoschwagerina simplex* from the Omi Limestone reveals that the local faunal provincialism in early Middle Permian is not so prominent than previously thought (NOGAMI, 1961b; KANMERA, 1963; TORIYAMA, 1967; OZAWA, 1970a).

In conclusion, it can be said that the Middle Permian fusulinaceans from the Omi Limestone is alsmost identical with those from the huge limestone blocks in the Inner Zone of Sourhwest Japan.

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Explanation of Plates 1–13

Plate 1

Figs. 1–6. *Tubertinina* spp. 1–3: longitudinal sections; 4–6: lateral sections. 1–3, 5, 6: Loc. 11; 4: Loc. 7. Slide No.: 4091, 4096, 4081, 4202, 4104, 4094. ×54.

Figs. 7–15. *Pachyphloia ovata* LANGE, 7–11, 15: lateral sections; 12–14: transverse sections. 7–9, 11, 12: Loc. 7; 10: Loc. 9; 13: Loc. 10; 14, 15: Loc. 11. Slide No.: 4193, 4192, 4188, 4169, 4193, 4204, 4116, 4106, 4098. ×36.

Fig. 16. *Neoendothyra reicheli* REITLINDER. longitudinal section. Loc. 10. Slide No. :4215. ×45.

Figs. 17, 18. *Climacammina valvulinoides* LANGE. 17: longitudinal axial section; 18: longitudinal section. 17: Loc, 1; 18: Loc. 5. Slide No. :4039, 4059. ×18.

Fig. 19. *Geinitzina* sp. lateral section. Loc. 7. Slide No. :4202. ×54.

Figs. 20–22. *Tetrataxis* sp. 20, 21: lateral sections; 22: horizontal section. 20, 22: Loc. 10; 21: Loc. 11. Slide No. :4221, 4080, 4221. 20, 22: ×27; 21: ×18.

Figs. 23, 24. *Abadehella coniformis* OKIMURA and ISHII. lateral sections. 23: Loc. 9; 24: Loc. 8. Slide No. :4165, 4155. ×32.

Figs. 25, 27, 28. *Globivalvulina* sp. cf. *G. vonderschmitti* REICHEL. lateral sections. 25: Loc. 11; 27, 28: Loc. 7. Slide No. :4104, 4204, 4203. 25: ×27; 27, 28: ×36.

Fig. 26. *Endothyra* sp. lateral section. Loc. 1. Slide No. :4037. ×27.

Figs. 29–32. *Globivalvulina cyprica* REICHEL. lateral sections. 29: Loc. 8; 30: Loc. 11; 31, 32: Loc. 7. Slide No. :4153, 4103, 4185, 4187. ×36.

Figs. 33–35. *Kahlerina globiformis* SOSNINA. 33, 35: median sections; 34: lateral section. Loc. 11. Slide No. :4084, 4107, 4104. ×27.

Plate 2

Figs. 1–4. *Kahlerina pachytheca* KOCHANSHV-DEVIDÉ and RAMOVŠ. 1, 2: nearly axial sections; 3: axial section; 4: lateral section. Loc. 11. Slide No. :4094, 4086, 4079, 4103. ×27.

Fig. 5. *Kahlerina* sp. A. tangential section. Loc. 13. Slide No. :4074. ×36.

Fig. 6. *Kahlerina* sp. B. median section. Loc. 7. Slide No. :4188. ×36.

Figs. 7–12. *Agathammina* sp. A. 7, 9, 10, 11: longitudinal sections; 8, 12: lateral sections. 7, 8, 12: Loc. 11; 9: Loc. 6; 10: Loc. 7; 11: Loc. 13. Slide No. :4102, 4098, 4209, 4189, 4074, 4098. 7, 8, 11, 12: ×36; 9: ×27; 10: ×45.

Figs. 13, 14, 16, 17. *Calcitornella* sp. 13: longitudinal section; 14, 16, 17: lateral sections. 13, 14: Loc. 11; 16, 17: Loc. 7. Slide No. :4101, 4095, 4193, 4191. 13, 17: ×54; 14, 16: ×36.

Figs. 15, 22. *Agathammina* sp. B. lateral(?) sections. 15: Loc. 7; 22: Loc. 11. Slide No. :4196, 4102. ×36.

Figs. 18, 19. *Baisalina hunanica* LIN. 18: transverse section; 19: lateral section. Loc. 11. Slide No. :4095, 4101. ×36.

Figs. 20,21. *Orthovertella* sp. 20: nearly longitudinal section; 21: lateral section. 20: Loc. 12; 21: Loc. 7. Slide No. :4125, 4196. ×54.

Figs. 23, 24. Calcivertellinae gen. et sp. indet. 23: lateral section; 24: longitudinal section. 23: Loc. 7; 24: Loc. 11. Slide No. :4204, 4101. ×36.

Fig. 25. *Frondicularia* sp. longitudinal section. Loc. 11. Slide No. :4095. ×36.

Fig. 26. *Nodosaria* sp. longitudinal axial section. Loc. 12. Slide No. :4130. ×36.

Figs. 27–30. *Nankinella* sp. cf. *N. kotakiensis* (FUJIMOTO and KAWADA). 27–29: tangential sections; 30: parallel section. 27, 29, 30: Loc. 11; 28: Loc. 5. Slide No.: 4078, 4062, 4107, 4103. 27, 29, 30: ×36; 28: ×27.

Plate 3

Figs. 1, 2. *Pseudoendothyra* spp. 1: axial section; 2: tangential section. Loc. 11. Slide No. :4105, 4098, ×36.

Figs. 3–9. *Dunbarula schubertellaeformis* SHENG. 3–5, 9: oblique sections; 6: parallel section; 7: axial section; 8: tangential section. 3, 8: Loc. 8; 4–7, 9: Loc. 11. Slide No. :4154, 4101, 4079, 4103, 4079, 4150, 4104. ×36.

Figs. 10–13. *Neofusulinella simplex* (LANGE). 10: nearly sagittal section; 11: axial section; 12: oblique section; 13: tangential section. 10: Loc. 7; 11–13: Loc. 3. Slide No. :4188, 4046, 4046, 4045. 10: ×36; 11–13: ×45.

Figs. 14, 15. *Mesoschubertella* sp. tangential sections. Loc. 7. Slide No. :4196, 4198. ×36.

Fig. 16. *Dunbarula* sp. B. axial section. Loc. 13, Slide No. :4073. ×36.

Figs. 17–22. *Minojapanella elongata* FUJIMOTO and KANUMA. 17–22: oblique sections. Loc. 1. Slide No. :4038, 4041, 4040, 4039, 4035, 4035. ×27.

Figs. 23–28. *Dunbarula* sp. A. 23,24, 27: oblique sections; 25, 28: tangential sections; 26: sagittal section. 23–27: Loc. 10; 28: Loc. 9. Slide No. :4221, 4221, 4221, 4117, 4222, 4171. ×45.

Figs. 29(?), 30. *Pseudofusulina*? sp. cf. *P. crassa* (DEPRAT). 29: sagittal section; 30: axial section. Loc. 8. Slide No. :4139, 4138. ×9.

Figs. 31, 32. *Pseudofusulina padangensis* (LANGE). oblique sections. Loc. 10. Slide No. :4222, 4215. ×9.

Fig. 33. *Chusenella* sp. tangential section. Loc. 10. Slide No. :4225. ×9.

Figs. 34, 35. *Parafusulina* sp. cf. *P. kaerimizensis* (OZAWA). axial sections. 34: Loc. 2; 35: Loc. 1. Slide No. :4044, 4037. ×9.

Plate 4

Figs. 1–13. *Parafusulina* sp. cf. *P. kaerimizensis* (OZAWA). 1, 4, 5, 7–10: axial sections; 2, 3: tangential sections; 6, 11–13: sagittal sections. 1, 2, 4–6: Loc. 3: 3, 9, 10, 12, 13: Loc. 5; 7, 8: Loc. 1; 11: Loc. 4. Slide No. :4045, 4048, 4058, 4046, 4047, 4049, 4034, 4041, 4059, 4061, 4050, 4060, 4052. ×9.

Plate 5

Figs. 1–12. *Misellina ovalis* (DEPRAT). 1–3, 9–12: axial sections; 4–6, 8: sagittal sections; 7: tangential section. 1, 3–11: Loc. 7; 2, 12: Loc. 12. Slide No. :4197, 4126, 4195, 4198, 4200, 4201, 4196, 4194, 4199, 4198, 4205, 4129. 1a–6a, 7–12: ×9; 1b–6b: ×36.

Figs. 13–17. *Pseudodoliolina ozawai* YABE and HANZAWA. 13, 15: tangential sections; 14: oblique section; 16, 17: parallel sections. Loc. 5. Slide No. :4055, 4056, 4059, 4060, 4057. ×10.

Figs. 18–21. *Pseudodoliolina pseudolepida* (DEPRAT). 18: axial section; 19, 20: tangential sections; 21: sagittal section. 18, 19: Loc. 8; 20: Loc. 6; 21: Loc. 13. Slide No. :4140, 4143, 4210, 4071. ×9.

Figs. 22–25. *Afghanella ozawai* HANZAWA. 22, 24: sagittal sections; 23: tangential section; 25: axial section. 22, 23: Loc. 5; 24, 25: Kaerimizu, Akiyoshi. Slide No.: 22 (4052), 23 (4051). ×10.

Plate 6

Figs. 1–17. *Neoschwagerina simplex* OZAWA. 1, 2, 5, 6, 8–10, 13, 14: axial sections; 3, 4, 7, 12, 15, 16: sagittal sections; 11: tangential section; 17: parallel section. 1, 3, 4, 7–9, 13–17: Loc. 7; 2, 5, 6, 10–12: Loc. 12. Slide No.: 4183, 4123, 4189, 4184, 4125, 4124, 4186, 4192, 4191, 4127, 4126, 4128, 4185, 4190, 4187, 4193, 4188. 1a–4a, 5–17: ×9; 1b–4b: ×36.

Fig. 18. *Pseudodoliolina pseudolepida* (DEPRAT). parallel section. Loc. 9. Slide No. :4167. ×9.

Plate 7

Figs. 1–3. *Neoschwagerina margaritae* DEPRAT. axial sections. 1, 2: Loc. 8; 3: Loc. 6. Slide No. :4135, 4136, 4209. ×9.

Figs. 4–6. *Neoschwagerina* sp. A. 4, 5: axial sections; 6: sagittal section. 4, 5: Loc. 8; 6: Loc. 9. Slide No. :4145, 4144, 4172. ×9.

Figs. 7–9. *Colania douvillei* (OZAWA). sagittal sections. Loc. 10. Slide No. :4227, 4212, 4223. ×9.

Plate 8

Figs. 1–8. *Colania douvillei* (OZAWA). 1–5, 8: axial sections; 6: sagittal section; 7: tangential section. 1–6: megalospheric forms; 7, 8: microrpheric forms. Loc. 10. Slide No. :4217, 4218, 4216, 4214, 4224, 4214, 4213, 4213. ×9.

Plate 9

Figs. 1–9. *Lepidolina shiraiwensis* (OZAWA). 1, 2, 7–9: axial sections; 3–6 sagittal sections. 1–8: megalospheric forms; 9: microrpheric form. Loc. 11. Slide No. :4077, 4078, 4088, 4089, 4087, 4085, 4083, 4082, 4084. 1a–3a, 4–9: ×9; 1b–3b: ×36,

Fig. 10. *Sumatrina*"*longissima*" DEPRAT. axial section. Loc. 8. Slide No. :4142. ×9.

Plate 10

Figs. 1–7. *Lepidolina shiraiwensis* (OZAWA). 1–6: axial sections; 7: sagittal section 1–5, 7: Loc. 11; 6: Loc. 13. Slide No.: 4084, 4081, 4079, 4076, 4080, 4072, 4086. ×9.

Figs. 8, 9. *Sumatrina "longissima"* DEPRAT. axial sections. Loc. 11. Slide No. :4099, 4094. ×9.

Plate 11

Figs. 1–9. *Sumatrina "longissima"* DEPRAT. 1, 3–7: axial sections; 2, 8, 9: sagittal sections. 1–3, 8: Loc. 9; 4, 5: Loc. 8; 6, 7, 9: Loc. 11. Slide No. :4169, 4168, 4165, 4146, 4137, 4097, 4096, 4166, 4092. 1a, 2a, 3–9: ×9; 1b, 2b: ×36.

Figs. 10–14. *Verbeekina verbeeki* (GEINITZ). 10: axial section; 11, 12, 14: oblique sections; 13: tangential section. 10, 14: Loc. 14; 11, 13: Loc. 8; 12: Loc. 11. Slide No. :4229, 4144, 4149, 4145, 4230. 10a, 11–14: ×9; 10b: ×54.

Plate 12

Figs. 1–4. *Neoschwagerina* sp. A. 1–3: axial sections; 4: sagittal section. Loc. 8. Slide No. :4147, 4150, 4151, 4148. ×9.

Fig. 5. Conglomeratic limestone containing various forms of *Neoschwagerina*, *Sumatrina "longissima"* and the pebble of the Asselian limestone bearing "*Pseudoschwagerina*" *miharanoensis* AKAGI. Loc. 8. Slide No. :4150. ×3.6.

Figs. 6, 7. Conglomeratic *Lepidolina shiraiwensis* limestone. 6: Loc. 13; 7: Loc. 11. Slide No. :4074, 4109. ×3.6.

Fig. 8. *Colania douvillei* limestone. Loc. 10. Slide No. :4212. ×3.6.

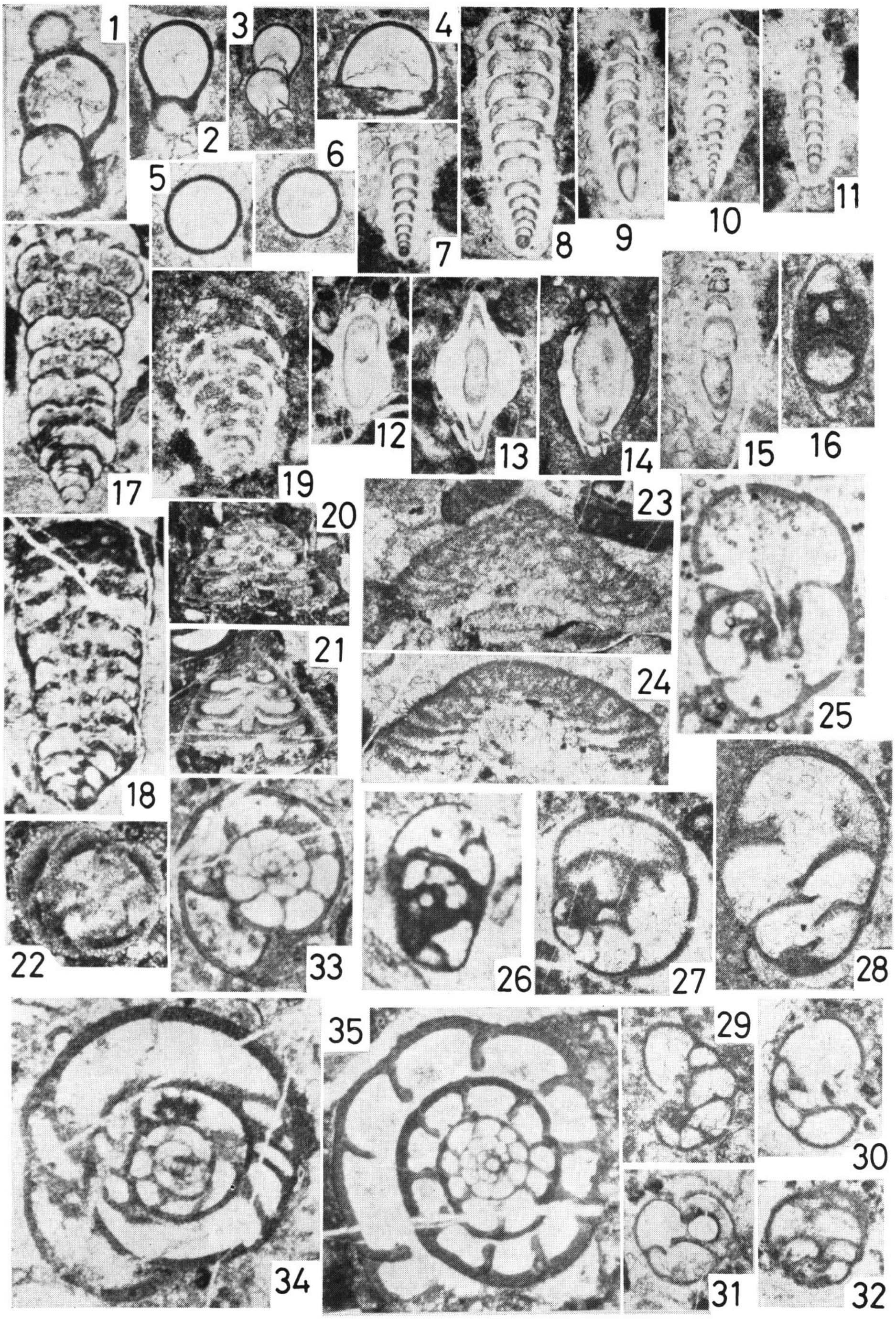
Plate 13

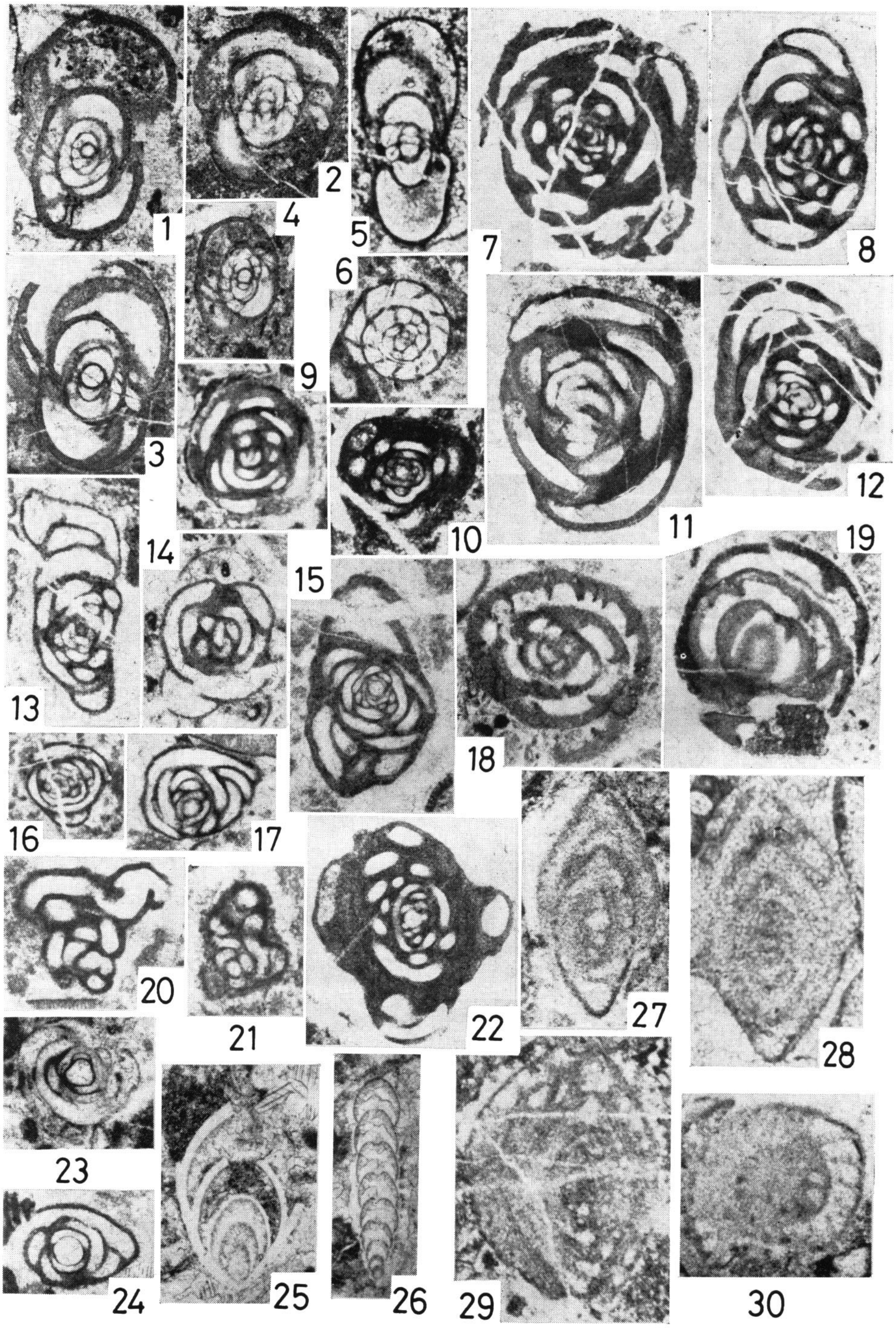
Figs. 1, 2. *Parafusulina* sp. cf. *P. kaerimizensis* limestone. 1: Loc. 4; 2: Loc. 5. Slide No. :4050, 4060. ×3.6.

Fig. 3. Conglomeratic *Lepidolina shiraiwensis* limestone. Loc. 11. Slide No. :4108. ×3.6.

Figs. 4, 5. Conglomeratic limestone containing varied bioclasts and free specimens of fusulinaceans of different ages. Fig. 4 contains *Pseudofusulina* sp. of Sakmarian in age. Fig. 5 contains the pebble of oölitic limestone bearing *Endothyra* sp. of Late Viséan to Early Serpukhovian in age and *Triticites ozawai* TORIYAMA of Gzhelian in age. 4: Loc. 9; 5: Loc. 8. Slide No. :4171, 4156. ×3.6.

Figs. 6, 7. Bioclastic limestone containing *Neoschwagerina simplex* OZAWA and *Misellina ovalis* (DEPRAT), both of which are considered to be re-worked. Loc. 7. Slide No. :4207, 4206. ×3.6.

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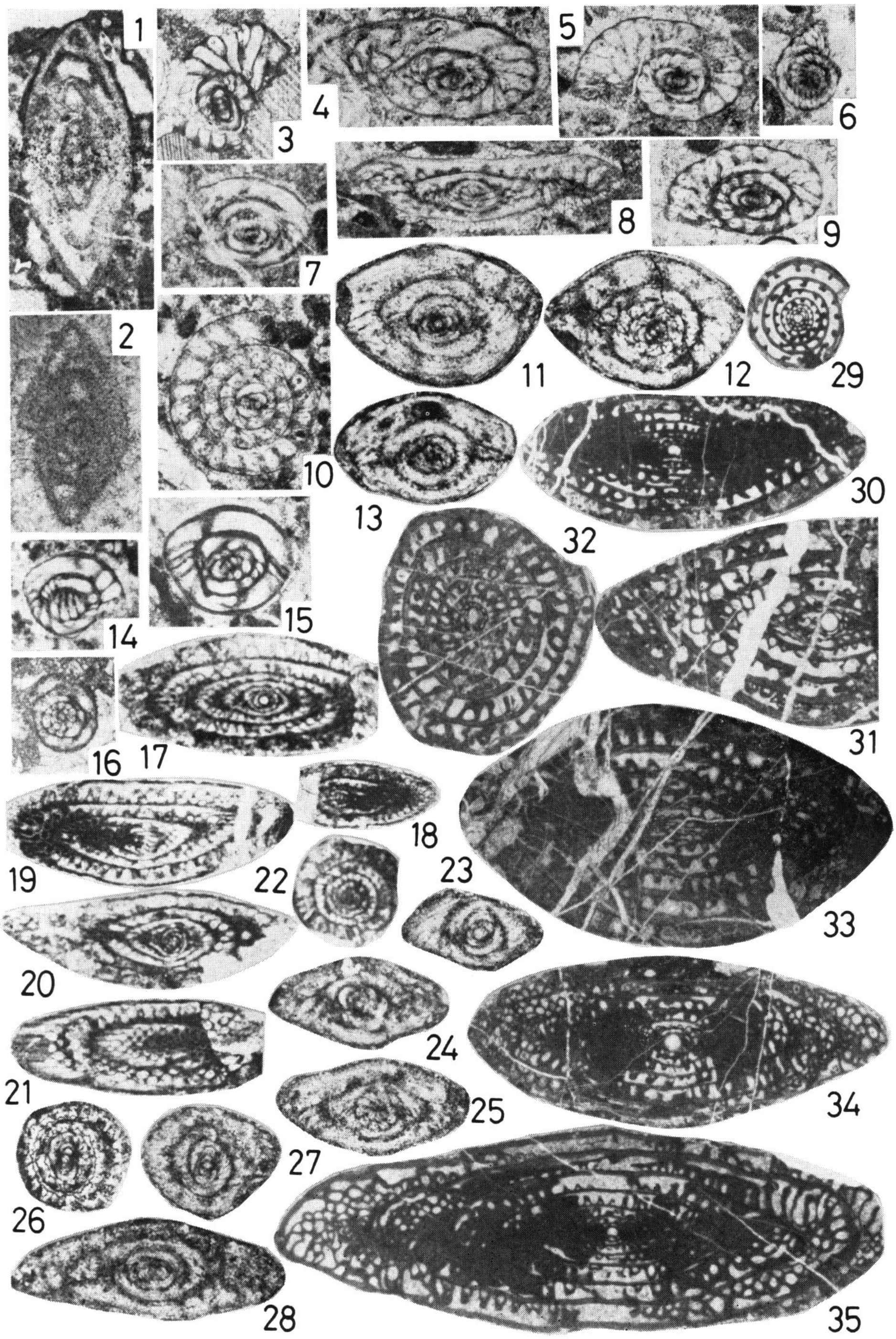
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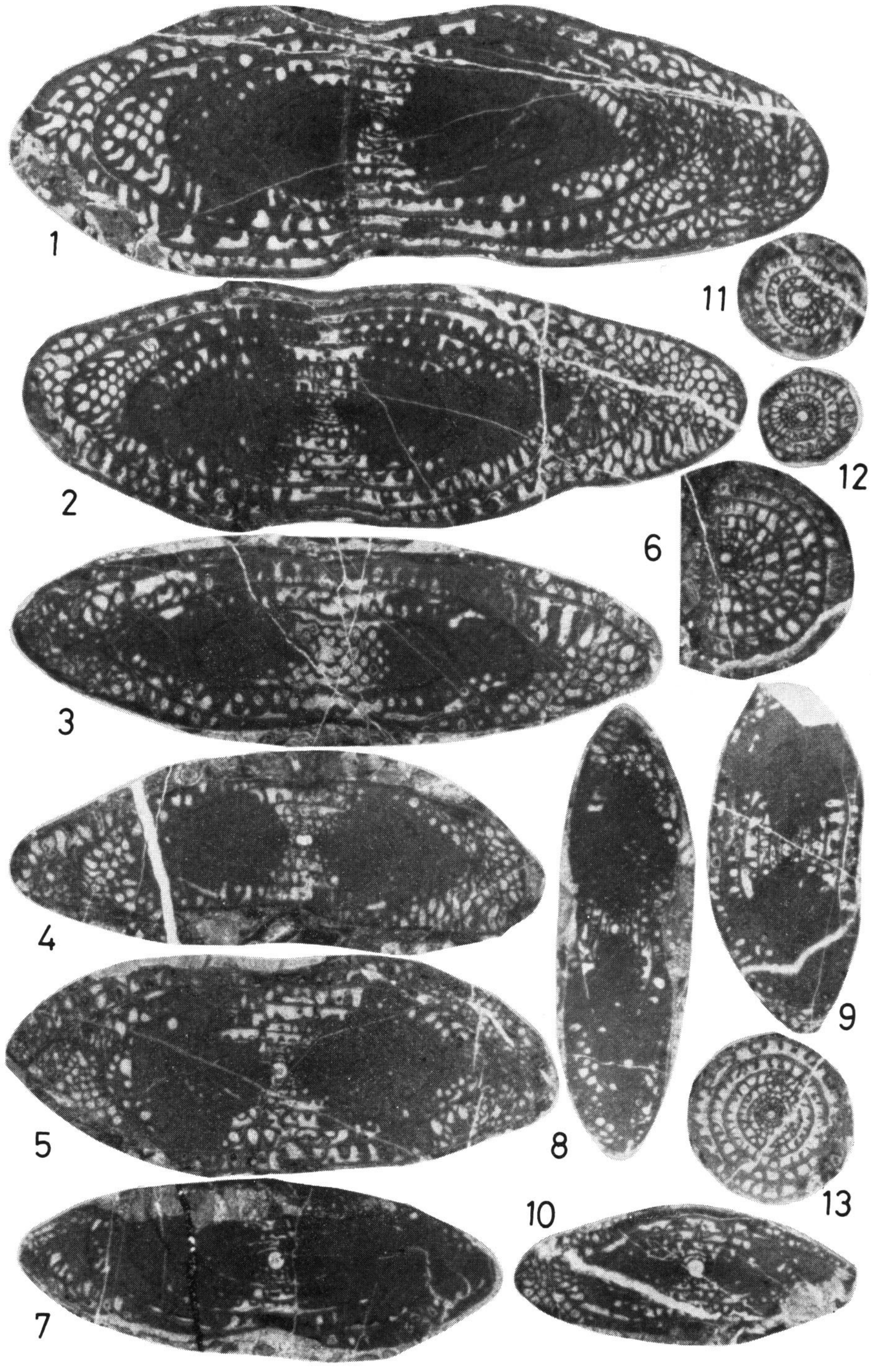
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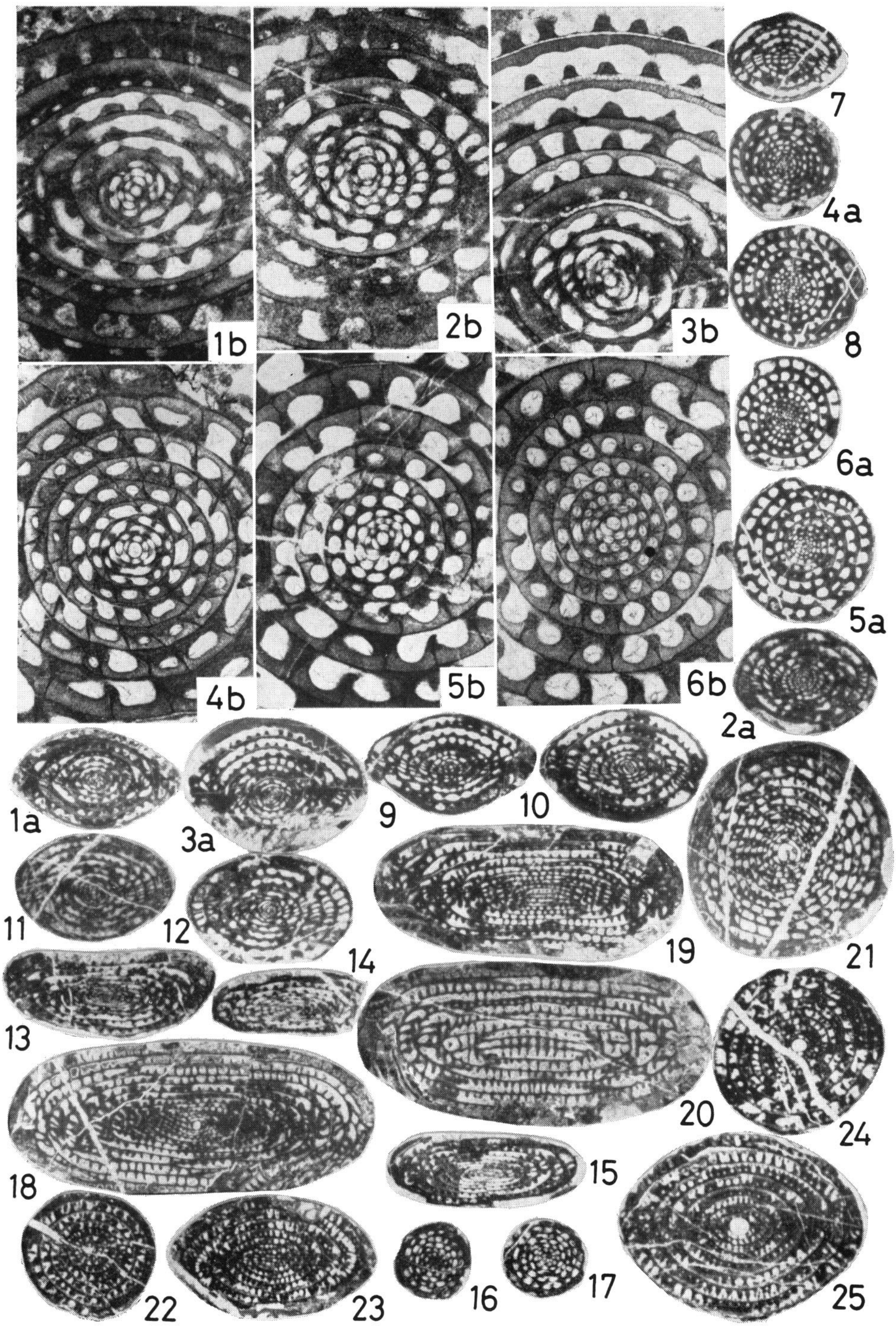
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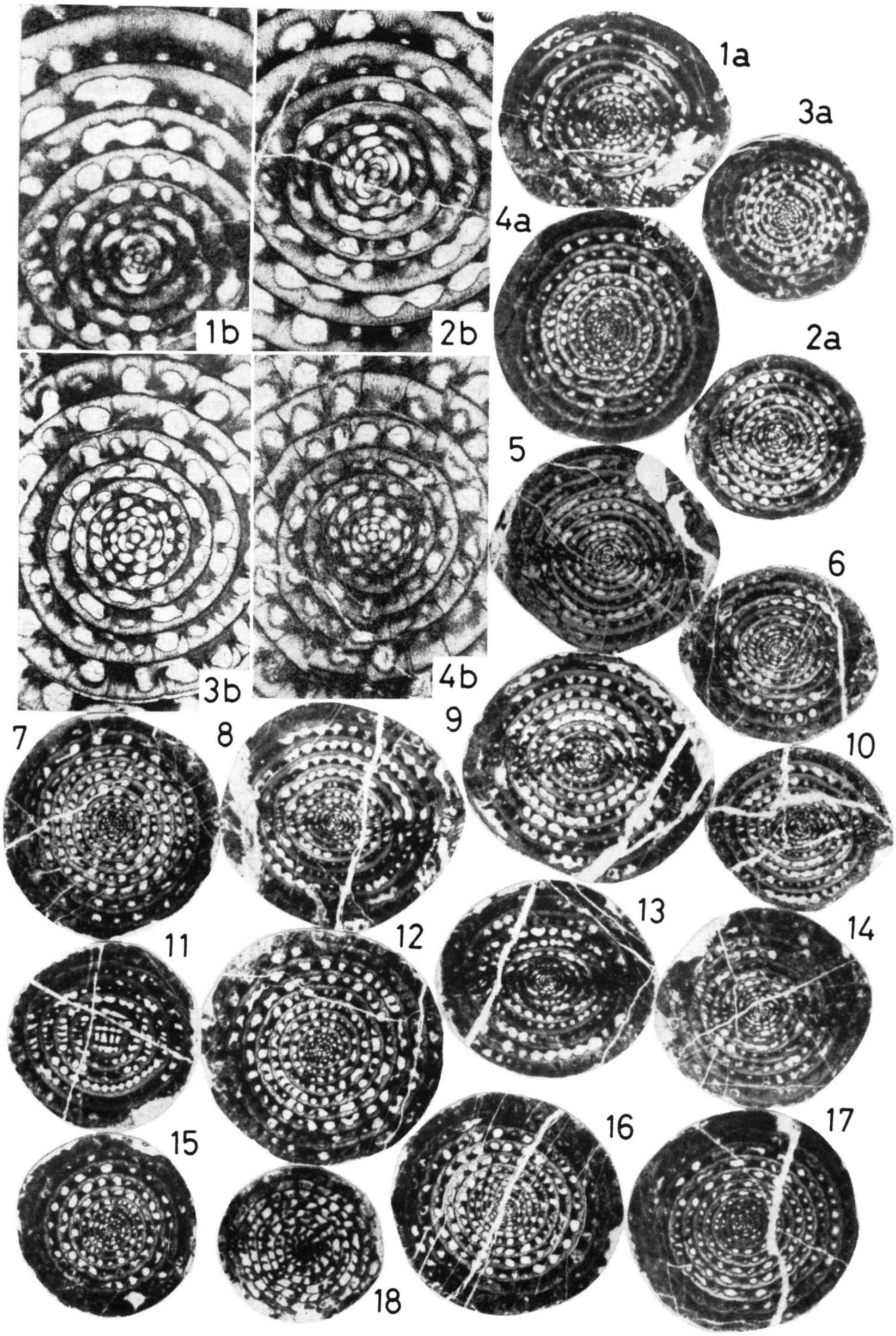
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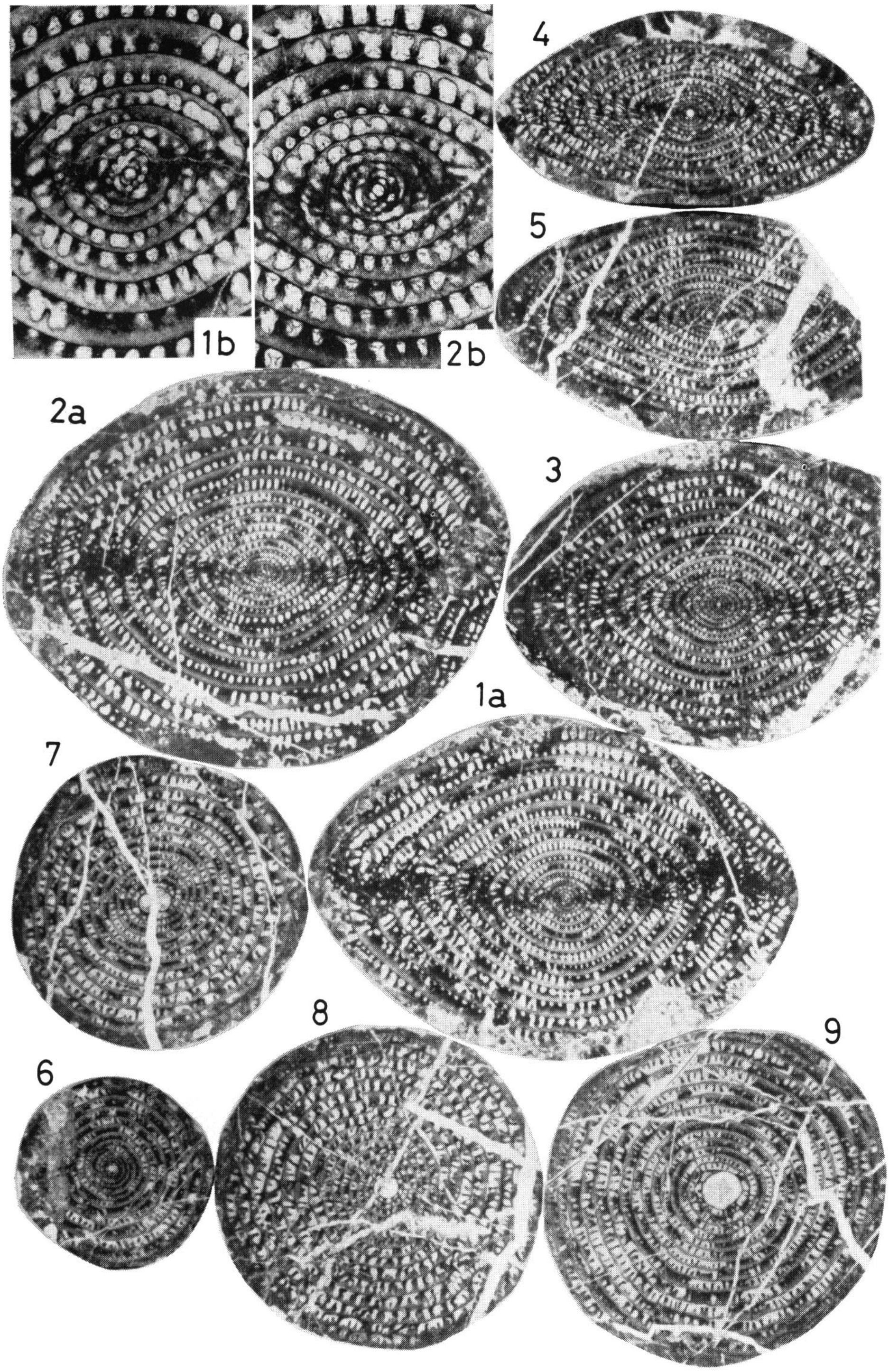
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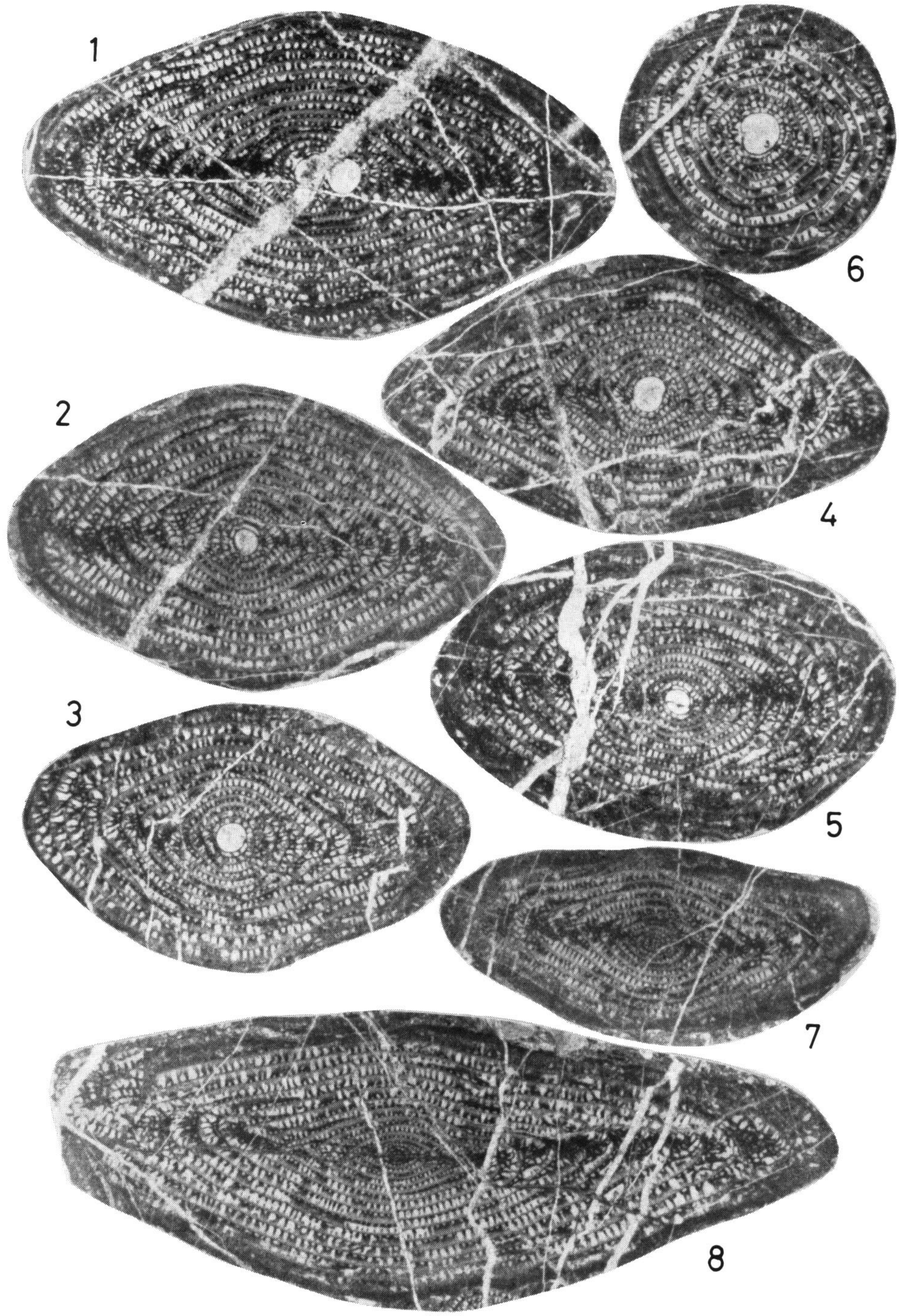
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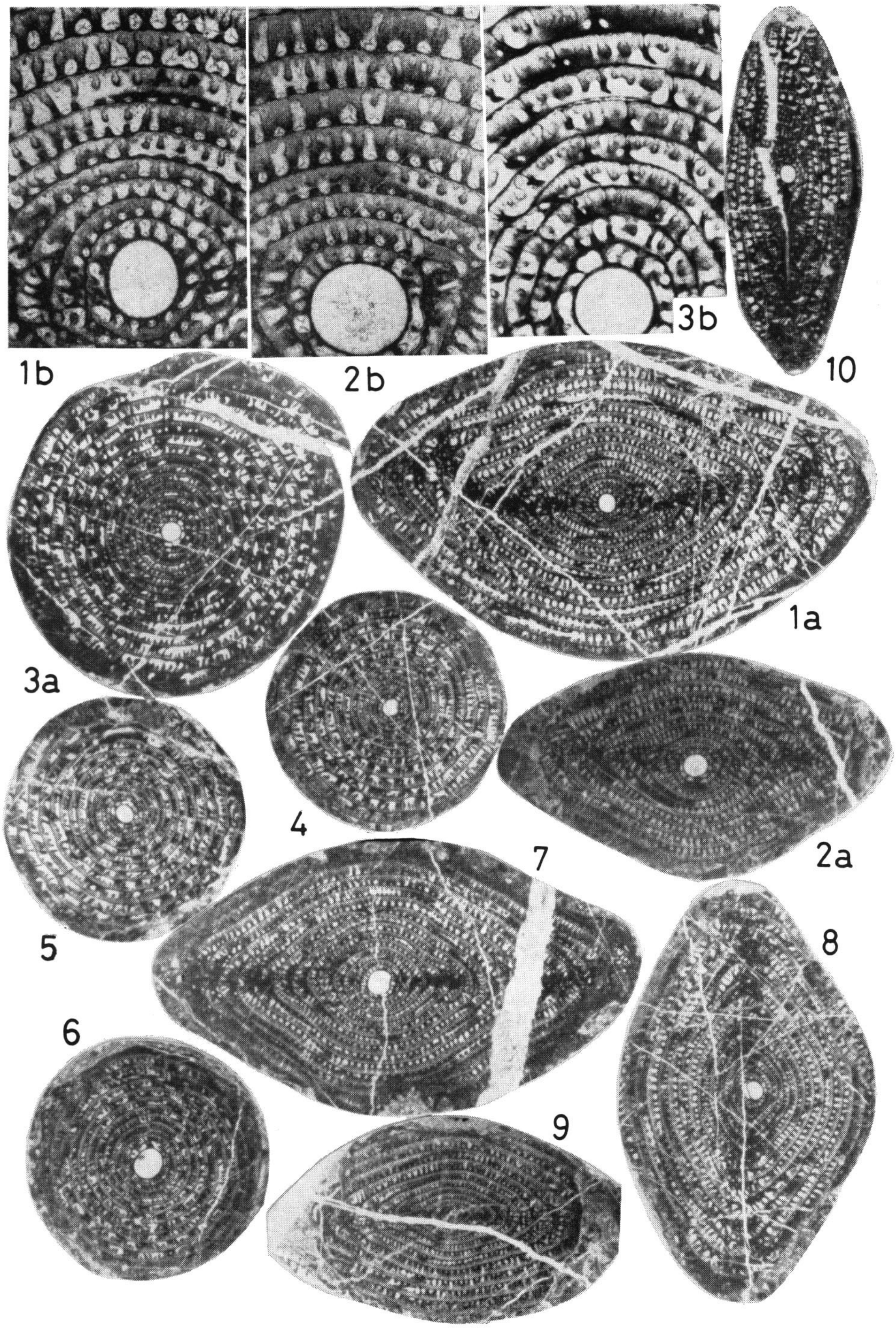
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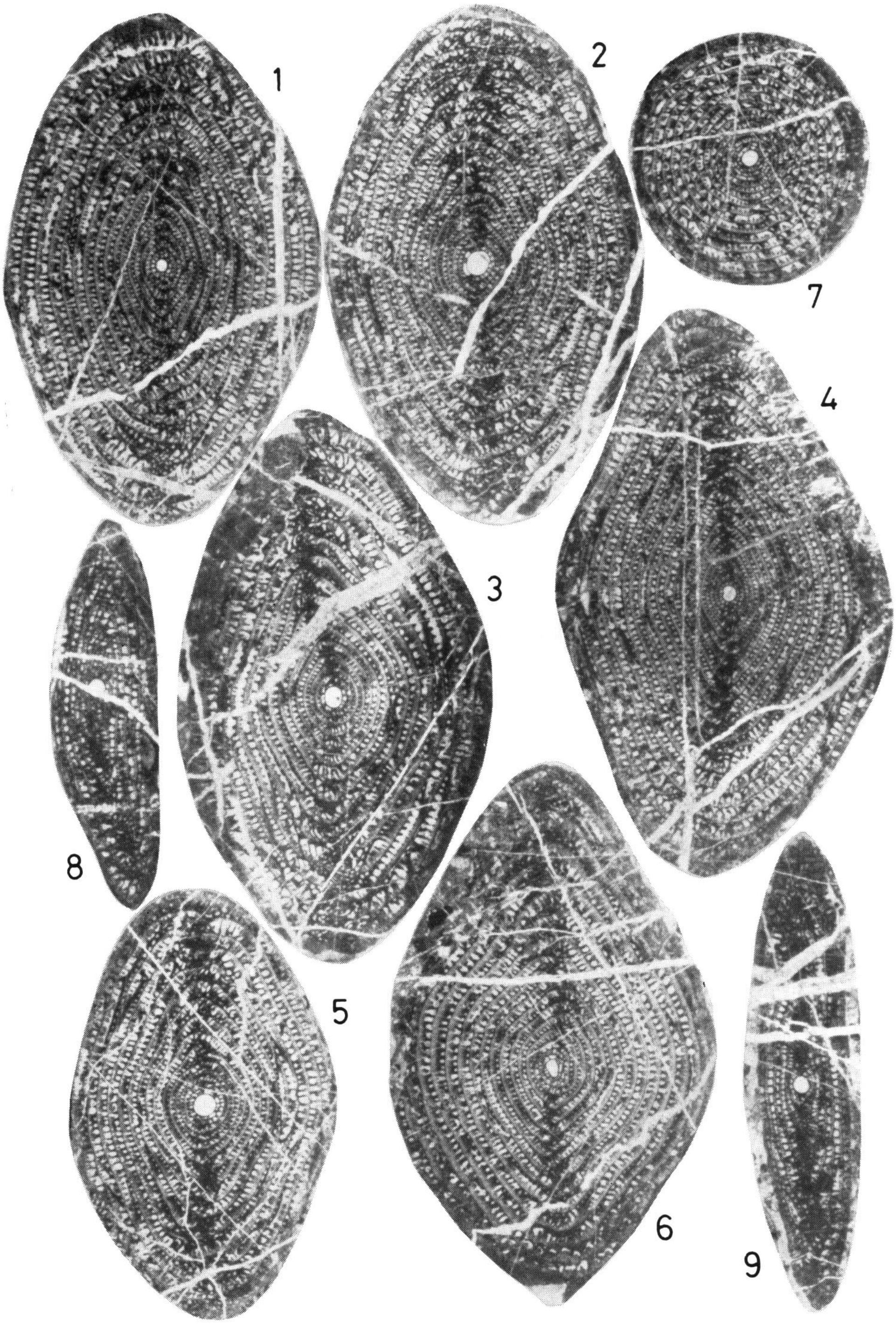
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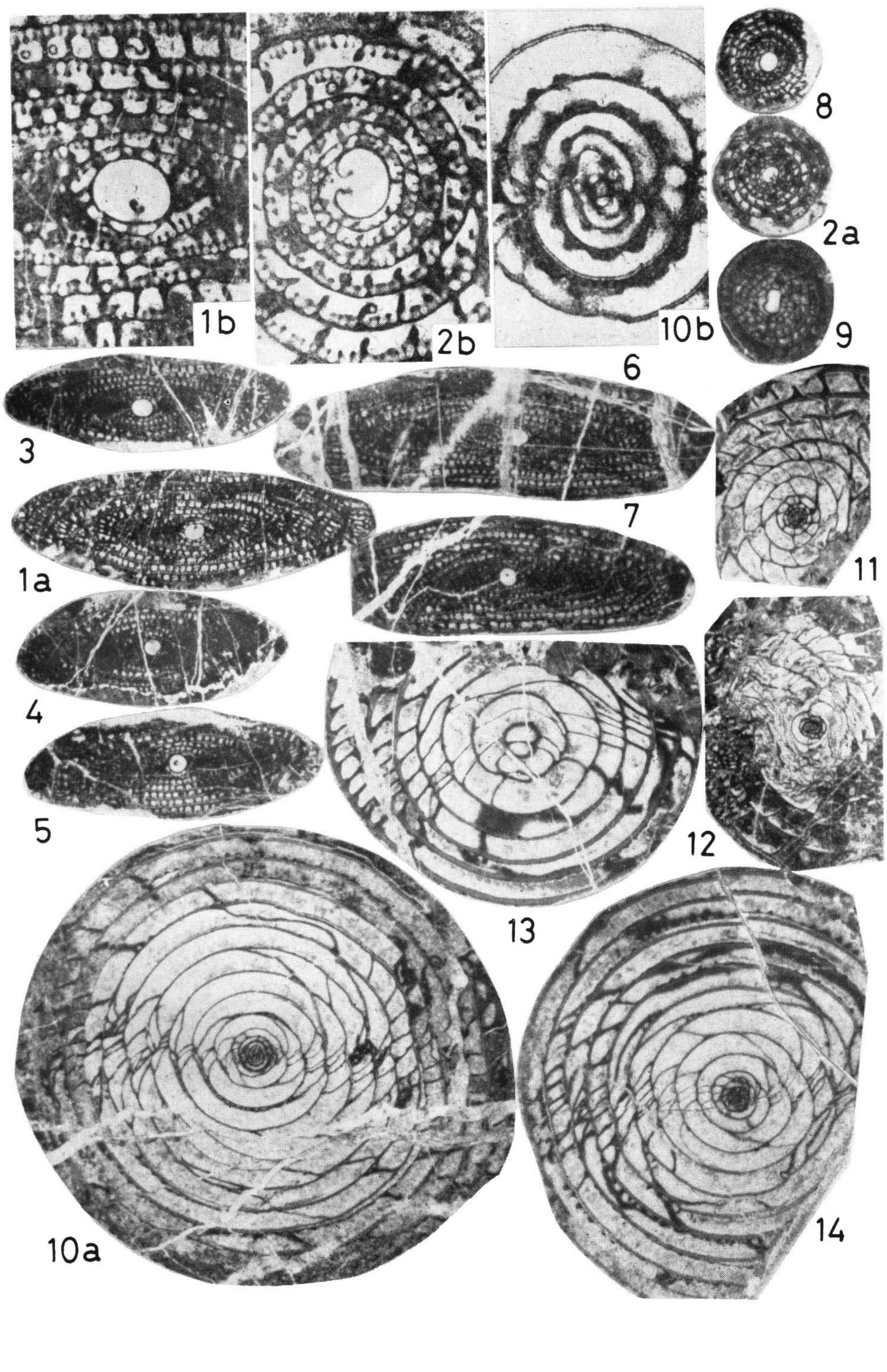
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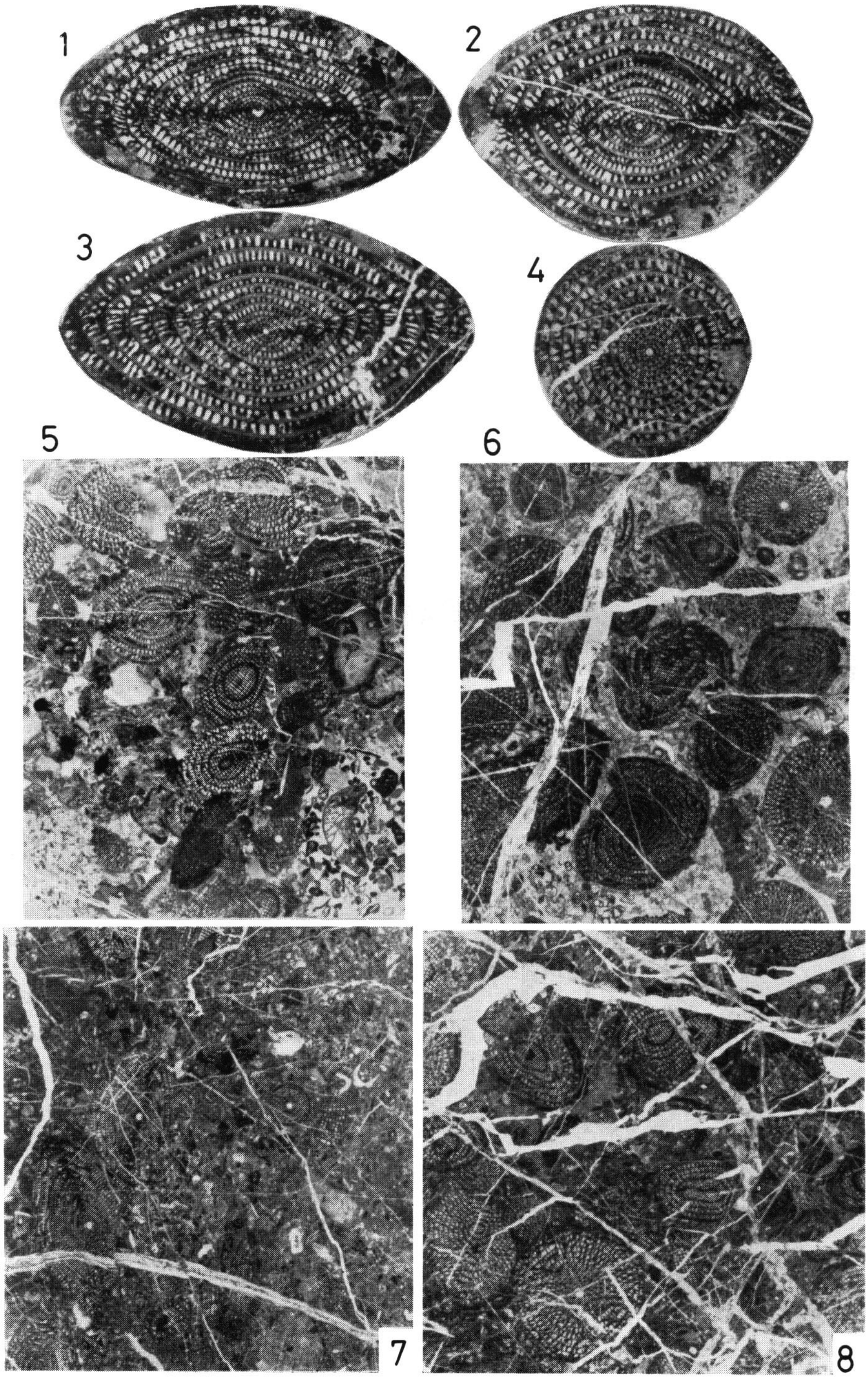
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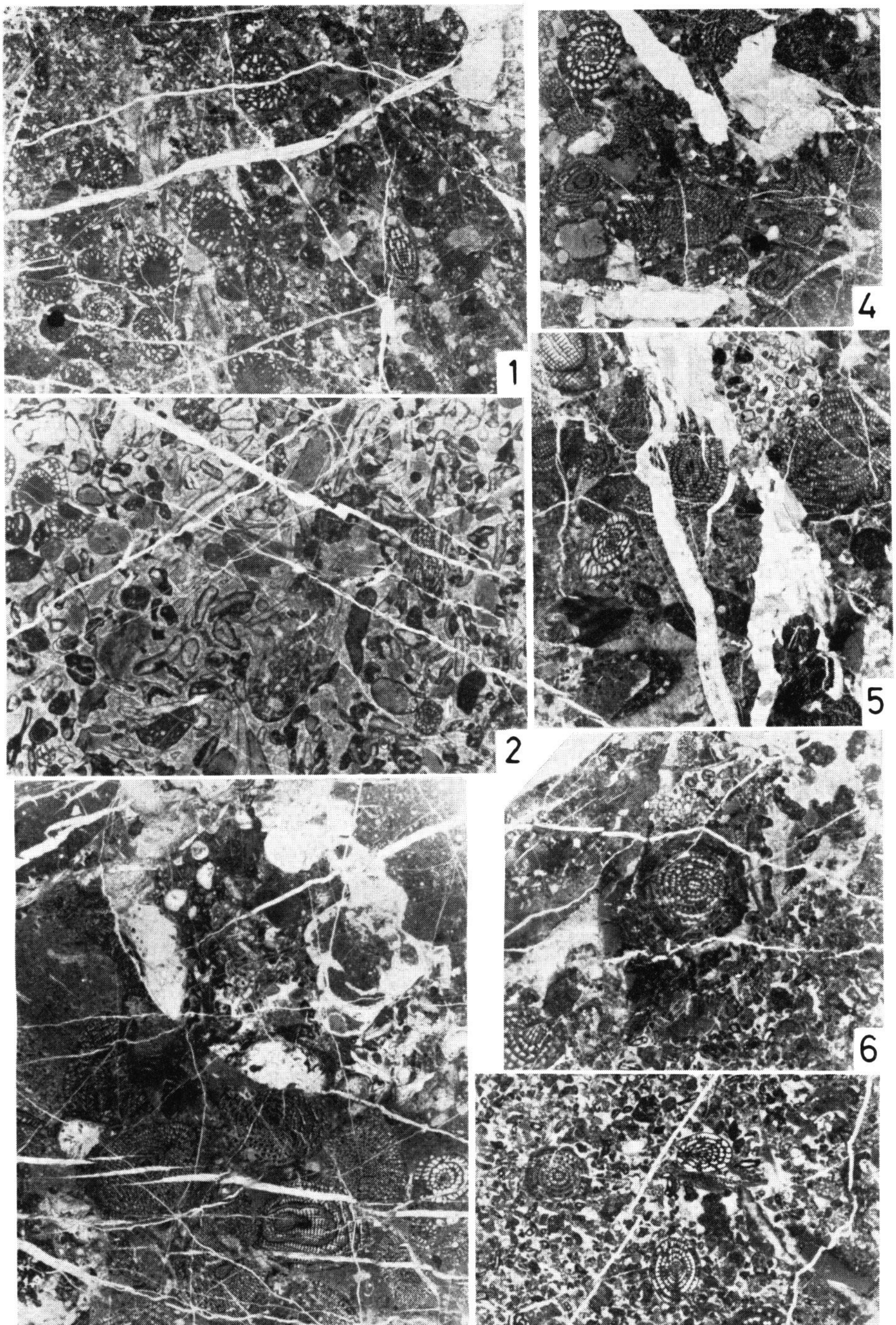
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