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Middle Permian Foraminifers of the Gozenyama Formation, Southern Kwanto Mountains, Japan

By

Fumio KOBAYASHI

2–6–4–1011, Yanagikubo, Higashi-kurume, Tokyo

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Abstract Twenty nine species assignable to twenty seven genera of late Middle Permian foraminifers are discriminated from the limestone blocks of the Gozenyama Formation (Upper Jurassic to Lower Cretaceous subduction complex) in the Kwanto Mountains, Chichibu Terrane, Japan. They are represented by characteristic occurrence of *Yabeina globosa* and *Colania larga*. Foraminiferal fauna of the Gozenyama Formation is nearly the same as that from the *Yabeina globosa* Zone of the Akasaka Limestone in the Mino Terrane, and is more closely related to that from the central part of the western Cordillera than that from Primorye of USSR, Northeast to South China and Southeast Asia.

Introduction

In the culminating time from the 1950's to early 1960's of the Japanese Late Paleozoic foraminiferal studies, many important contributions had been published. Consequently, the chronological distribution and fusulinacean zonation have been established for most of the Upper Paleozoic fossiliferous limestones (TORIYAMA 1967). Non-fusulinacean foraminifers, on the contrary, were rarely worked out at that time.

Rapidly increasing in recent years are the Mesozoic tectonic studies on the basis of such branches as paleomagnetism and radiolarian biostratigraphy in the mobile belts of East Asia including the Japanese Islands. In these studies, it has been clarified that Late Paleozoic fossil bearing limestones occur as exotic blocks in the Mesozoic sediments, and "Upper Paleozoic" strata are mostly referred to be Mesozoic in age. There are some heteropic fusulinacean faunas in the Japanese Late Paleozoic limestones, e.g. *Yabeina globosa* versus *Lepidolina multiseptata* in late Middle Permian. The anomalous occurrences of the Tethyan fusulinaceans in the western Cordilleran North America, reported by THOMPSON and WHEELER (1942), DOUGLASS (1967) and others are explained as allochthonous origin by MONGER and ROSS (1971), MONGER and IRVING (1980), CONEY *et al.* (1980) and OZAWA and KANMERA (1984). In other words, fusulinaceans as well as non-fusulinacean foraminifers provide available informations of paleobiogeographic reconstruction in relation to collision-accretion tectonics.

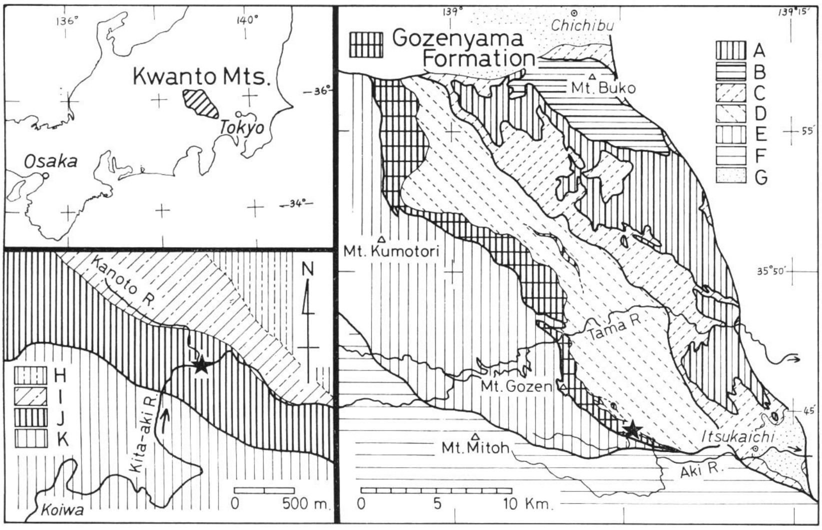
Fusulinaceans of the Kwanto Mountains in the Chichibu Terrane were collectively described by HUZIMOTO (1936) and later noted biostratigraphically or paleontologically by his co-workers. However, there are many limestones whose foraminiferal assemblages have been paleontologically undescribed. These limestones occasionally yield well-preserved foraminifers, including many non-fusulinacean foraminifers. The foraminiferal limestones in the area are implicative on account of their bearings on the paleobiogeography and tectonic development: (1) The Late Paleozoic foraminifers in the Chichibu Terrane are distributed in the most eastern side in East Asia, (2) The fusulinacean fauna of the terrane resembles closely that of the Ashio-Mino-Tamba Terrane, although two terranes are juxtaposed by the Median Tectonic Line, and (3) Faunal assemblages are closely related to those of the East Tethyan region and the central part of the western Cordillera. This paper concerns geologic occurrences and faunal assemblages of the Middle Permian foraminifers from the Gozenyama Formation, and presents systematic description.

All the described and referred materials used in the present work are stored in Department of Geology, National Science Museum, Tokyo. I am much indebted to Dr. Tomowo OZAWA, Hyogo University of Teacher Education, and Dr. Yasuji SAITO, National Science Museum, Tokyo, for their discussions.

Geologic setting

The Chichibu Terrane in the Kwanto Mountains is eastern extension of that of the Southwest Japan, although it is included into the Northeast Japan, as resulted from the Neogene tectionics. The terrane is occupied between the northern Sambagawa Metamorphic Terrane and the southern Shimanto Terrane. The main component of the terrane consists of subduction complexes of turbidity sediments and mélange, ranging from Early Jurassic to Early Cretaceous in age (OZAWA and KOBAYASHI, 1986). The latter is made up of exotic blocks with various lithologies, geologic ages, forms and sizes, chaotically embedded within sheared pellitic rocks. The Gozenyama Formation is distributed, as a narrow belt of one to three kilometers wide and about thirty five kilometers long, in the southern margin of the Chichibu Terrane in the Kwanto Mountains (Text-fig. 1). It is composed of predominant mélange and turbidity sediments of Late Jurassic to Early Cretaceous in age, showing imbricate structures generally striking northwestly to southeastly and steeply dipping northeastly. Exotic blocks consist of numerous amount of limestone, together with chert and basaltic rocks.

Limestone of the Gozenyama Formation can be petrographically as well as chronologically classified into three tpes. The first type is grey fine-grained micritic limestone, commonly accompanied with basalitic lava and basic pyroclastics. Nodular chert and regularly alternating beds of chert and limestone are also contained within limestone. This type of limestone is almost barren in megafossils, but, in places, containing abundant radiolarians replaced by carbonates. Late Triassic conodonts are rarely obtained from a few localities (KOIKE *et al.*, 1979). The second is dark grey to dark brown, bituminous "Torinosu"-type limestone interbedded within black calcareous shale. It yields such prolific megafossils as algae, echinoderms, sponges and



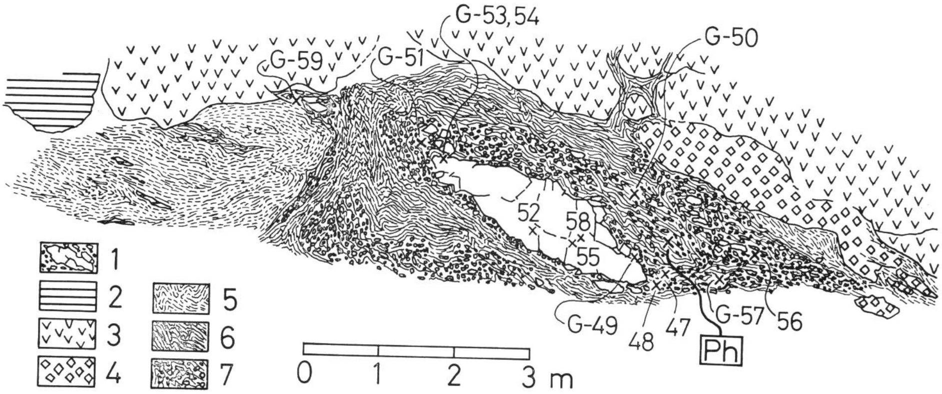
Text-fig. 1. Geologic map showing the distribution of the Gozenyama Formation in the Kwanto Mountains. Fossil locality is marked with an asterisk.
A: Takamizuyama Group, B: Hashidate Group, C: Musashi and Nishitama Groups, D: Tamagawa Group excluding the Gozenyama Formation, E, K: Ogouchi Group, F: Kobotoke Group, G: Neogene formations, H–J: Tamagawa Group; H: Unazawa Formation, I: Hikawa Formation, J: Gozenyama Formation.

gastropods. Geologic age is not exactly confirmed, but, presumably considered to be of Late Jurassic to Early Cretaceous age. The third is grey fossiliferous Middle Permian limestone, described in the next chapter.

Among the three, almost all huge blocks of limestones are those of the first type whose longer diameter is occasionally attaining more than several hundreds to thousands meters. Compared with frequent occurrence of the first type of limestones, the second and the third types are found in small blocks of less than five meters, sporadically scattered in this formation.

Occurrece of the Middle Permian Limestone

Takaoka (1954) reported the occurrence of the fusulinacean limestone from the following three localities: a roadside cliff of entrance of Tochiyori, a cliff about 800 meters east of Mt. Gozen, and the left bank near junction between the Kita-aki and Kanoto Rivers. The limestone block at the first locality was lost on the occasion of road enlargement works. Any additional fusulinaceans are not obtained from the second locality. The limestone locality from which foraminifers herein described is the same as the Takaoka's third one (Text-fig. 1).



Text-fig. 2, Occurrence of exotic blocks at the left bank near junction between the Kitaaki and Kanoto Rivers. 1: limestone, 2: chert, 3: massive lava, 4: pillow lava, 5: black shale, 6: pale green shale, 7: red brown shale containing abundant small limestone blocks. G-47 to -59 is foraminiferal localities. **Ph**, enclosed by square, is the location shown in Fig. 1 of Pl. 1.

Numerous small limestone blocks are chaotically embedded within pale green and red brown shales (Text-fig. 2; Pl. 1, fig. 1). The latter two partly grade into phyllitic black shale which contains exotic blocks of chert, basaltic rocks and Mesozoic limestones of various sizes and shapes.

Limestones show irregular outlines, range from three and half meters to several millimeters in their longer diameter, and are partly suffered from weak dolomitization. They are subdivided into such petrographic types as biosparite, biomicrite, oösparite, pelletoidal micrite and micrite. They are generally fossiliferous and contain foraminifers, algae, echinoderms, sponges, bryozoans, corals, gastropods, brachiopods and ostracodes. Most of them are considered to be late Middle Perminan in age. Some of limestones are composed of aggregation of different lithologies (Pl. 1, fig. 2). They rarely contain reddish brown very fine-grained micritic limestone (Pl. 1, figs. 3), or grey micritic limestone showing parallel lamination and graded bedding (Pl. 1, fig. 4). Both of them are preseumed to represent a debris of pelagic limestones. All limesone blocks abruptly disappear laterally as well as vertically.

Pale green and red brown shales are sheared and made highly foliated by complicated folding and faulting. Although limestone blocks of larger size are in fault contact with shales, densely concentrated smaller limestones within narrowly spaced shales give the rock conglomeratic appearence. They may be very easily misunderstood to be a limestone conglomerate with muddy matrix. Valanginian to Hauterivian radiolarians are extracted from the pale green shale (IGO *et al.*, 1984). Furthermore, any stratigraphic successions are never reserved throughout the Gozenyama Formation, in addition to the mentioned evidences. Therefore, the relationship between limestones and variegated shale is considered to be resulted not from sedimentological process but from tectonic one.

Foraminiferal Fauna

Twenty nine species assignable to twenty seven genera of foraminifers are discriminated from the seven limestone blocks of the mentioned locality (Table 1). Each limestone block is of late Middle Permian age, although slight differences in faunal assemblages and number of occurrence are recognizable.

Yabeina globosa (YABE) is the commonest among them. *Yabeina globosa*, besides many forms synonymous with *globosa*, has been described or reported from various

Table. 1. Foraminiferal assemblage in G-47 to -59, A: abundant, C: common, R: rare.

	G-47	G-48	G-49	G-50	G-51	G-52	G-53	G-54	G-55	G-56	G-57	G-58	G-59
1 *Tubertinina* sp.	R	R	R	R									
2 *Geinitzina* sp.	R		R		R		?	R					
3 *Pachyphloia ovata*	R		R		R	R	R	R	R			R	
4 *Palaeotextularia* sp.	R	R	R		R	R	R	R	?				
5 *Cribrogenerina* sp.	R		R		R	R	R	R			R	R	
6 *Tetrataxis* sp.	R		R	R	R						?		
7 *Abadehella coniformis*			R										
8 *Globival.* cf. *vonderschmitti*	R		R										
9 *Neoendothyra reicheli*	R		R										
10 *Kahlerina nautiloidea*	R	R	R	?	R	R	?	R	R	R			
11 *Bradyina*? sp.	R		R			R	R				R		
12 *Reichelina changhsingensis*	R	R	R										
13 *Sichotenella* sp.	?		R										
14 *Rauserella* sp.	R		R										
15 *Nankinella* sp.			R								?		
16 *Dunbarula cascadensis*	R	R	R		R								
17 *Paradoxiella* sp.	R												
18 *Chusenella andersoni*					C			R					
19 *Chusenella* sp.A	R	R	R		?	R							
20 *Pseudof.* cf. *padangensis*	C	?	R		R		R	R	?			?	
21 *Verbeekina verbeeki*					R			R					
22 *Neoschw. minoensis*	R	R	R										R
23 *Yabeina globosa* Form A	C	A	C		C	R	C	R	R	R			C
Form B	C	R	C		R			R				R	
Form C	R		R										
Form D	R	C	R		R		R	R					
Form E	R												
24 *Colania larga*			R										
25 *Agathammina* sp. A	R	R	R		R	R	R	R	R		R		
26 *Agathammina* sp. B	R	?	R		R						R		
27 *Orthovertella* ? sp.	R		R										
28 *Nodosaria* sp.			R										
29 *Pseudoglandulina* sp.	?		R										
30 Gen. et sp. indet.	R		R		R	R	R			R	R	R	

limestones in Japan, since YABE (1906) described from the Akasaka Limestone. Occurrence of this species in Japan, however, is very characteristic in the upper Middle Permian seamount limestones of the Ashio-Mino-Tamba and Chichibu Terranes (Jurassic to Early Cretaceous subduction complexes). Unidentified species of *Yabeina*, though neither described nor illustrated, is known from the Northern Kitakami Terrane (Jurassic to Early Cretaceous subduction complexes) by ONUKI (1969, p. 73). *Yabeina* is very few or entirely lacking in the contemporaneous shelf limestones of the Southern Kitakami and Kurosegawa (Silurian to Early and Cretaceous shelf facies) and Maizuru (Permian to Late Triassic shelf facies) Terranes and seamount limestones of the Yamaguchi Terrane (Permian subduction complexes including such gigantic limestone nappe as the Akiyoshi, Taishaku, Atetsu and Omi Limestones).

Outside Japan, the genus *Yabeina* is known from central Oregon (THOMPSON and WHEELER, 1942), northwestern Washington (THOMPSON *et al.*, 1950; SKINNER and WILDE, 1966), South China (CHEN, 1956), Laos (COLANI, 1924), Cambodia (TIEN, 1979), Pamir (LEVEN, 1967), Tunisia (SKINNER and WILDE, 1967) and Texas (SKINNER and WILDE, 1955). Among them, *Yabeina packardi* THOMPSON and WHEELER from central Oregon is considered to be synonymous with *Y. globosa*. Materials from Laos and South China are also probably identical with *Y. globosa*.

Colania larga (MORIKAWA and SUZUKI) is distinct from *C. kwangsiana* (LEE) and *C. douvillei* (OZAWA), which are widely distributed in East and Southeast Asia. Occurrence of this species from the Gozenyama Formation is the third record following those from the Akasaka Limestone (MORIKAWA and SUZUKI, 1961) and from San Juan Island, northwestern Washington (SKINNER and WILDE, 1966).

Neoschwagerina minoensis DEPRAT emend. OZAWA is a good stratigraphic indicator and characteristic species of the Ng Zone, associated with *Yabeina globosa* in the Akasaka Limestone (OZAWA, 1927). LEVEN (1967) also described this species from the upper Middle Permian (uppermost P_2m) of Pamir.

An association of genera *Verbeekina*, *Pseudofusulian*, *Chusenella* and some genera of Boultoniinae with *Yabeina globosa* or *Lepidolina multiseptata* (s.l.) is common in late Middle Permian limestones of Eurasia and western North America.

Verbeekina verbeeki (GEINITZ) is one of the commonest and most widespread species in Middle Permian time. Its geographic distribution extends from Yugoslavia (KOCHANSKY-DEVIDÉ and RAMOVŠ, 1955) through West, Central, Southeast and East Asia, to northwestern Washington (THOMPSON *et al.*, 1950).

Pseudofusulina padangensis (LANGE) is a well-known species in the upper Middle Permian of Southeast Asia (LANGE, 1925; GUBLER, 1935, etc.). The present materials are presumably identical with the original ones from the Padang Highland, Sumatra by LANGE (1925).

Chusenella is an endemic genus of Schwagerinidae, and is predominant in Southeast Asia and South China. Materials treated as *Chusenella* sp. A in this paper bear close resemblance to those from Southeast Asia (GUBLER, 1935, etc.) and South China (CHEN, 1956, etc.), while *C. andersoni* (THOMPSON, WHEELER and DANNER) is quite identical with original materials from western North America (THOMPSON *et al.*, 1950) and those from the Akasaka Limestone (MORIKAWA, 1958).

The genus *Dunbarula* of the Gozenyama Formation resembles *D. cascadensis* (THOMPSON, WHEELER and DANNER), originally assigned to the genus *Boultonia* by THOMPSON *et al.* (1950), and its junior synonym, *D. laudoni* SKINNER and WILDE from western North America, rather than materials from Eurasia.

Non-fusulinacean foraminifers provide, in general, insufficient informations available for faunal correlation and paleogeographic provincialism in comparison with fusulinacean foraminifers. Descriptive works of Middle Permian non-fusulinacean foraminifers in Japan and western North Anerica are very few in number. However, most of them in the Gozenyama Formation consist of common genera or species to those of the Middle Permian in Central South China (LIN, 1978), West South China (WANG, 1974), Indo-China (COLANI, 1924; TIEN, 1979), Sumatra (LANGE, 1925) and Xizang (WANG, 1982).

Almost all genera except for *Kahlerina* of the Gozenyama Formation are also yielded from the Upper Permian Ohguno Formation in the Kwanto Mountains. *Kahlerina* occurs restrictedly to the Middle Permian, but has wide geographic distribution from Yugoslavia (KOCHANSKY-DEVIDÉ and RAMOVŠ, 1955) to Primorye (SOSNINA, 1968). Although *Abadehella* was presumed to be stratigraphic indicator of the Upper Permian (OKIMURA *et al.*, 1975), the genus ranges down at least to the middle Middle Permian in Japan. In the southern Kwanto Mountains, it is associated with *Parafusulina japonica* (GÜMBEL).

On the basis of the mentioned specific assemblages as well as geographic and chronologic distribution, foraminiferal fauna of the Gozenyama Formation is nearly the same as that of the upper Middle Permian limestones in the Ashio-Mino-Tamba Terrane, represented by the Akasaka Limestone and other contemporaneous limestones in the Chichibu Terrane. Most of fusulinacean species from them are similar to those from both northwestern Washington to central Oregon and South China to Southesast Asia. Characteristic occurrence of *Yabeina globosa* and *Colanai larga* reveals that the Gozenyama fauna is more intimate to the former rather than the latter.

Systematic Description

Order Foraminiferida EICHWALD, 1830

Suborder Fusulinina WEDEKIND, 1937

Superfamily Endothyracea BRADY, 1884

Family Nodosinellidae RHUMBLER, 1895

Subfamily Tubertininae MIKLUKHO-MAKLAY, 1958

Genus ***Tubertinina*** GALLOWAY and HARLTON, 1928

Tubertinina sp.

(Pl.2, figs. 1–3)

Remarks: Attached test, rounded chamber and calcareous, granular and finely perforated wall of the present materials are assignable to the genus *Tubertinina*, although chamber arrangement is unknown. More detailed comparison is impossible, because they are based on randomly oriented thin sections.

Subfamily Nodosinellinae RHUMBLER, 1895
Genus ***Geinitzina*** SPANDEL, 1901
Geinitzina sp.
(Pl. 2, figs. 4, 5)

Descriptive remarks: Test sub-triangular, compressed, tapering, with distinct median longitudinal depression. Chambers broad, low, uniserially and rectilinearly arranged. Wall calcareous and translucent. The present materials are assigned into the genus *Geinitzina* by these morphologic characters. The present materials show close resemblance with *G. spandeli* LIPINA from the Changshing Limestone of the Chinese Upper Permian illustrated in ZHAO *et al.* (1981).

Genus ***Pachyphloia*** LANGE, 1925
Pachyphloia ovata LANGE
(Pl. 2, figs. 14–18, 24, 25, 27–30, 32)

1925 *Pachyphloia ovata* LANGE; Geol.-Mijinb. Genoot. Nederland, Kolon., Verhandl. Geol. Ser., vol. 7, p. 231, Pl. 1, figs. 24a, 24b.

Description: Test, compressed, asymmetrical oval in general outline, consisting of rectilinearly arranged, broad, low, strongly overlapping twelve chambers in maximum number. Length of 1 mm, width of 0.6 mm and thickness of 0.3 mm, approximately. Wall calcareous, with fibrous structure. Extremely thickened lamellar wall present in thin sections, cut at lateral margins of test. Aperture terminal and rounded.

Remarks: LOEBLICH and TAPPAN (1964) emphasize the taxonomic ambiguties between *Pachyphloia* and its related genera. Although numerous forms assigned into the genus have been proposed from the Tethys regions, their variation is mostly left uncertain. The present forms are believed to be identical with type species of this genus originally described from the Middle Permian limestone of Sumatra by LANGE (1925).

Family Palaeotextularidae GALLOWAY, 1933
Genus ***Palaeotextularia*** SCHUBERT, 1921
Palaeotextularia sp.
(Pl. 2, figs. 7, 8)

Descriptive remarks: Tapering test with rounded periphery and depressed sutural parts, composed of biserially coiled eight or more pairs of chambers. Wall thick, composed of double layers, outer thick granular calcite with dark calcareous materials and inner thinner dark calcareous with or without granular calcite. Although well-oriented specimens are not obtained, chamber arrangement of the present materials is related to that of *Palaeotextularia* with reference to stereographic diagram of textularid foraminifers revealed by CUMMINGS (1958).

Genus ***Cribrogenerina*** SCHUBERT, 1908
Cribrogenerina sp.
(Pl. 2, figs. 6, 19, 26)

Descriptive remarks: Test elongate coniform with depressed sutures, subdivided more than seven chambers, bordered by septal partitions. Chambers broad, low, rectilinear and uniserial in later stage, but obscure in initial stage. Septa concave, domed, with multiple openings. Wall calcareous and microgranular. The present materials are assignable into the genus *Criborgenerina* with reservation, because of lack of distinct uniserially arranged chambers of initial stage in thin sections. The present materials closely resemble many forms of *Cribrogenerina* described from the Chihsia and Maokou Limestones of Central South China by LIN (1978).

Family Textularidae GALLOWAY, 1933
Genus ***Tetrataxis*** EHRENBERG, 1854
Tetrataxis sp.
(Pl. 2, figs, 9–12)

Description: Test broadly conical with concave base and bluntly pointed apical end, 1.4–1.8 mm in diameter, 0.4–0.6 mm in height, of trochospirally coiled long and narrow many chambers. Ventral and dorsal surface more or less depressed at sutural parts. Apical angle approximately 110 degrees. Umbilical cavity broad and deep, attaining two-third to half of height of test.

Wall calcareous, composed of finely granular with fibrous layer on conical side, fibrous and alveolar on apertual side.

Remarks: The present materials differ from *Tetrataxis conica* EHRENBERG, type species of the genus, in larger apical angle and thinner wall, and from *T. minima* SCHELLWIEN in larger and broader conical test. *Tetrataxis* sp. resembles *Abadehella coniformis* OKIMURA and ISHII in wall thickness, size and shape of test and chamber arrangement, but easily distinguished from the latter by absence of platy septal partitions of the former.

Genus ***Abadehella*** OKIMURA and ISHII, 1975
Abadehella coniformis OKIMURA and ISHII
(Pl. 2, figs. 13, 20–23)

1975 *Abadehella coniformis* OKIMURA and ISHII; Mem. Fac. Sci. Kyoto Univ., Ser. Geol. Mineral., vol. 41, no. 1, p. 43, pl. 2, figs. 1–5, 7, 8 Pl. 3, fig. 2, Pl. 4, figs. 2–4.

Description: Test conical with concave base and bluntly pointed to rounded apical end, 1.0 mm in diameter, 0.6 mm in height in mature specimen, of trochospirally coiled broadly low many chambers. Dorsal surface rather smooth with obscure depressions at sutural parts. Ventral side deeply concave, irregularly wavy in its surface.

Chamber divided by platy septal partitions, resulting numerous chamberlets. Apical angle 80–100 degrees. Wall calcareous, of dark microgranular and fibrous layers. Septal wall cacareous and microgranular.

Remarks. The present materials closely resemble the original ones described from the Upper Permian Abadeh Formation, Iran and those from the Upper Permian Maizuru Group, Japan, in conical test with concave base, size, apical angle and development of platy septal partitions. *Tetrataxis planiseptata* by WANG (1974) from the Chinese Upper Permian is based on only one incomplete marginal transverse section. It is transferred into genus *Abadehella* by wall structure and weakly(?) developed platy septal partitions. However, detailed comparison with the present species is impossible.

Family Biseriamminidae CHERNYSHEVA, 1941

Genus ***Globivalvulina*** SCHUBERT, 1921

Globivalvulina sp. cf. ***G. vonderschmitti*** REICHEL

(Pl. 3, figs. 1–3)

Compare: 1945 *Globivalvulina vonderschmitti* REICHEL; Ecol. Geol. Helv., vol. 38, no. 2, p. 556, figs. 37a–e.

Descriptive remarks: Detailed morphologic characters of test are not exactly reconstracted, because the present materials are based on randomly-cut thin sections, most of which are not available for examination. However, hemispherical test, trochospirally to planispirally coiled, biserially arranged chambers, rapidly increasing their size and calcareous, microgranular wall are safely referable to the genus *Globivalvulina*. Test size of over 1 mm, rounded outline appeared in lateral sections and rapidly increasing chamber size in later stage are common between the present materials and the original ones described from the Upper Permian limestone of Greek by REICHEL (1945). More detailed comparison is impossible because of lack of equitorial sections.

Family Endothyridae BRADY, 1884

Subfamily Endothyrinae BRADY, 1884

Genus ***Neoendothyra*** REITLINGER, 1965

Neoendothyra reicheli REITLINGER

(Pl. 3, figs. 4, 5, 10)

1965 *Neoendothyra reicheli* REITLINGER; Akad. Nauk, USSR, Bop., Mikropaleont., vol. 9, p. 61, 62, Pl. 1, figs. 6–9.

Remarks: *Neoendothyra* was proposed by REITLINGER (1965) in its characteristic massive fillings at umbilical part of test, from the Lower Triassic Indskii Formation of Transcaucasia. Another diagnosis of test is almost the same as that of *Endothyra*. Except for larger test, this species is undistinguishable from *N. parva* (LANGE), originally described as *Nummulostegina*? *parva*, from the Middle Permian limestone of the Padang Highland, Sumatra by LANGE (1925).

Genus *Kahlerina* KOCHANSKY-DEVIDÉ and RAMOVŠ 1955
Kahlerina nautiloidea SOSNINA
(Pl. 3, figs. 6)

1968 *Kahlerina nautiloidea* SOSNINA; Minist. Geol. USSR (VESGEI), vol. 2, p. 102, 103, Pl. 27, figs. 1, 2.

Remarks: Any detailed comment can not be given on this species, as only one well-oriented specimen is obtained. However, among the described species, the present materials show striking resembleance to *Kahlerina nautiloidea* described from the lower half of the *Metadoliolina lepida* Zone of southern Primorye, USSR, by SOSNINA (1968) in umbilicate depression in axial part, number of whorl, general shape and size of test.

Subfamily Bradyininae REITLINGER, 1950
Genus *Bradyina* VON MÖLLER, 1878
Bradyina? sp.
(Pl. 2, figs. 31, 33)

Remarks: Planispirally coiled involute test with few chambers of the present forms suggests these belong to the genus *Bradyina*. However, there is little resemblance between the present forms and the Carboniferous typical *Bradyina* in test size, structure and thickness of wall.

Superfamily Fusulinacea VON MÖLLER, 1878
Family Ozawainellidae THOMPSON and FOSTER, 1937
Genus *Reichelina* ERK, 1941
Reichelina changhsingensis SHENG and CHANG
(Pl. 3, figs. 20–25, 28)

1958 *Reichelina changhsingensis* SHENG and CHANG; Acta Pal. Sinica, vol. 6, no. 2, p. 211, 212, Pl. 1, figs. 1–11.

Remarks: This species is the commonest *Reichelina* in East to Sutheast Asia. Any specifically significant disagreement are not recognizable between the present and the original Chinese Upper Permian materials. Detailed morphologic descriptions of each biocharacter are not given to avoid descriptive duplication between the present materials and the previously described ones.

Genus *Sichotenella* TUMANSKAYA, 1953
Sichotenella sp.
(Pl. 3, figs. 27, 29)

Description: Shell small, involute, lenticular to discoidal, with straight axis of coiling, broadly arched or straight lateral sides, bluntly pointed to rounded periphery and slightly umbilical poles; composed of four volutions, tightly coiled in inner three volutions and gradually increasing their height and loosely coiled in terminal one. Axial length 0.19 mm, median width 0.47 mm, giving form ratio 0.4: 1.

Proloculus minute, spherical and its diameter 0.04 mm. Radius vector from the first to the terminal volution, 0.04, 0.08, 0.13 and 0.27 mm, respectively. Wall thin, obscure in its structure, but, probably undifferentiated in inner volutions and of thin tectum and thicker translucent layer (partly similar to diaphanotheca). Septa, numerous, unfluted and loosely curved anteriorly. Dark calcareous deposits weakly developed in axial region. Chomata not observed.

Remarks: *Sichotenella* was originally described, *S. sutschanica* as type species, from South Ussuriy, USSR. TUMANSKAYA (1953) considered the present genus referable to the Fusulinidae on the basis of spirothecal structure. ROZOVSKAYA (1975) transferred the genus into Ozawainellidae and also considered *Chenella* MIKLUKHO-MAKLAY, 1959 and *Eostaffelloides* MIKLUKHO-MAKLAY, 1959 junior synonyms of *Sichotenella*.

Recently, many forms of "*Chenella*" have been described from the Chihsian to Maokouan limestones of East China (WANG and ZHANG, 1982). Among the Chinese materials, the present ones bear the closest resemblance to *Sichotenella changanchiaoensis* (SHENG and WANG) described from the Maokouan limestone of west Chekiang by SHENG (1962), but not those originally described by SHENG and WANG (1962).

Sichotenella appears to be distinguished from *Reichelina* in rapid increase of volume of the terminal coiled volution of the former, regardless of coiled or uncoiled mature stage.

Family Staffellidae MIKLUKHO-MAKLAY, 1949
Genus ***Nankinella*** LEE, 1933
Nankinella sp.

(Pl. 3, fig. 26)

Remarks: The present form is placed under the genus *Nankinella* by angular periphery and weakly replaced shell by calcite.

Family Schubertellidae SKINNER, 1931
Subfamily Boultoniinae SKINNER and WILDE, 1954
Genus ***Dunbarula*** CIRY, 1948
Dunbarula cascadensis (THOMPSON, WHEELER and DANNER)

(Pl. 3, figs. 30, 31; Pl. 4, figs. 12–19)

1950 *Boultonia cascadensis* THOMPSON, WHEELER and DANNER; Contr. Cushman Found. Foram. Research, vol. 1, p. 53, 54, Pl. 3, figs. 1–5.

Description: Shell small, fusiform, arched to broadly arched periphery and bluntly pointed poles. Mature specimens with 4 to 4.5 volutions, 0.75 to 0.98 mm in axial length and 0.31 to 0.58 mm in median width giving form ratio 1.7: 1 to 2.4: 1; first 2 to 3.5 volutions discoidal, coiled nearly at right angle to the later ones. Proloculus minute, approximately 20 to 30 microns.

Spirotheca thin, composed of tectum and inner translucent layer in outer volutions. Septa weakly fluted in axial region, closely spaced throughout shell, approximately 20 in number in the fourth volution. Tunnel low, less than one fourth as high as chambers. Tunnel angle about 40 degrees in the fourth volution. Chomata weakly and rudimentarily developed.

Remarks: The present materials agree in all essential features with *Dunbarula cascadensis* (THOMPSON, WHEELER and DANNER), originally assigned into the genus *Boultonia*, and *D. laudoni* SKINNER and WILDE, 1966. Both are from northwestern Washington, USA. It is almost impossible to distinguish *laudoni* from *cascadensis*. Hence, the former is considered to be junior synonym of the latter. Some of the present materials whose outer volution is loosely coiled show a slight resemblance to primitive forms of *Codonofusiella*, but, distinguished from the latter in indistinct uncoiled prolongation and weakly fluted septa.

Genus ***Paradoxiella*** SKINNER and WILDE, 1955

Paradoxiella sp. SADA and SKINNER

(Pl. 4, fig. 20)

1977 *Paradoxiella* sp. SADA and SKINNER; J. Paleont., vol. 51, no. 2, text-fig. 2 (not described).

Remarks: Only one vertically cut tangential section is obtained. Another materials are not available for comparison. Intensely fluted speta and uncoiled flared outer part of shell expanding from both sides of coiled inner volutions, as shown in thin sections, are very characteristic features of this specialized genus of Boultoniinae. The present materials are safely identical with *Paradoxiella* sp. illustrated from the Akasaka Limestone, Japan, by SADA and SKINNER (1977). Stratigraphic horizon is nearly the same between both materials.

Family Schwagerinidae DUNBAR and HENBEST, 1930

Genus ***Chusenella*** HSU, 1942

Chusenella andersoni (THOMPSON, WHEELER and DANNER)

(Pl. 9, figs. 7, 8)

1950 *Schwagerina andersoni* THOMPSON, WHEELER and DANNER; Contr. Cushman Found. Foram. Research, vol. 1, p. 55, 56, Pl. 4, figs. 1–5, Pl. 8, fig. 13.

Remarks: This species is diagnostic in arctely pointed poles throughout all volution, inflated median part of shell, tightly coiled in inner two to three volutions, dense axial filling and thick spirotheca of outer volutions. The original description by THOMPSON *et al.* (1950) was from Washington, USA and British Cloumbia, Canada, associated with *Yabeina cascadensis* (ANDERSON). The present materials are closely similar to the American materials and *Pseudofusulina royandersoni* THOMPSON, WHEELER and DANNER from the *Yabeina* Zone of the Akasaka Limestone, Japan, described by MORIKAWA (1958).

This species is placed under the genus *Chusenella* instead of *Schwagerina* in tightly coiled inner volutions and numerous volutions. However, fewer number of tightly coiled inner volutions and larger proloculus of this species are different from many forms of typical *Chusenella*, widely distributed in South China and Southeast Asia.

Chusenella sp. A

(Pl. 4, figs. 9, 10; Pl. 10, figs. 1, 3–5, 8)

Description: Shell fusiform to ventricose fusiform with sharply pointed poles. Axis of coiling nearly straight, but loosely curved in specimens. Periphery and lateral slope rounded, straight, convex, concave, or convex-concave in shape, and highly variable in specimens. The largest specimen consists of ten volutions and over 10.5 mm in length, 4.5(?) mm in width, giving form ratio 2.3: 1. Proloculus spherical, small and about 120 microns in diameter. Inner three to four volutions, elongate fusiform, tightly coiled, while, later ones loosely coiled and gradually increasing chamber height.

Spirotheca very thin and rugose in inner tightly coiled volutions, but, beyond which, it thickened rapidly, corrugated, mostly over 100 microns in its thickness, in thicker part, and composed of tecum and alveolar keriotheca.

Septa closely spaced throughout shell, weakly fluted in inner volutions, but intensely and rather irregularly fluted throughout shell in outer ones. Tunnel narrow, about one-third as high as chamber. Chomata weakly developed in inner volutions, but absent in outer ones. Axial filling well-developed in axial and polar regions.

Remarks: Numerous forms referable to *Chusenella* have been described from China, Southeast Asia, Japan and western North America. The following materials are considered to be more or less related to the present ones: *Pseudofusulina cambodgiensis* GUBLER, 1935; *C. conicocylindrica* CHEN, 1956; *Schwagerina compacta* (WHITE) by SHENG, 1963, not the original Texas materials; and *C. absidata* WANG, SHENG and ZHANG, 1981. However, specific identification of the present materials would be left future problem unitl variation of the original as well as topotype speciemens is fully examined.

Genus *Pseudofusulina* DUNBAR and SKINNER, 1931
Pseudofusulina sp. cf. *P. padangensis* (LANGE)

(Pl. 10, figs. 2, 6, 7, 9–14)

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

Remarks: Taxonomic assignment and disagreement in interpretation of variation of this species are highly diverse among fusulinid paleontologists, such as OZAWA 1927), GUBLER (1935), STEWART (1963) and KAHLER and KAHLER (1966). These confusuing circumstances would be due to the original description by LANGE (1925) who established this species based on incomplete materials and pointed out the similarity of this species to *Parafusulina japonica* (GÜMBEL).

However, microscopic observation of non-oriented, besides oriented, numerous thin sections shows that the present materials are roughly identical with the original ones. Among the described materials asigned to *padangensis*, the present ones are the closest to the TIEN (1979)'s ones, associated with *Lepidolina multiseptata*, which came from the Sisophon Limestone, Cambodia, where some of GUBLER's *padangensis* were originated.

Family Verbeekinidae STAFF and WEDEKIND, 1910

Subfamily Verbeekininae STAFF and WEDEKIND, 1910

Genus ***Verbeekina*** STAFF, 1909

Verbeekina verbeeki (GEINITZ)

(Pl. 4, fig. 8; Pl. 9, fig. 6)

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

Remarks: Verbeekinids is very few in number from the Gezenyama Formation, and only one incomplete axial section is obtained. The present material is nearly identical with the topotype specimens from the Padang Highland, Sumatra, restudied by THOMPSON (1936).

Family Neoschwagerinidae DUNBAR and CONDRA, 1928

Subfamily Neoschwagerininae DUNBAR and CONDRA, 1928

Genus ***Neoschwagerina*** YABE, 1903

Neoschwagerina minoensis DEPRAT emend. OZAWA

(Pl. 4, figs. 7, 11; Pl. 8, figs. 3, 7, 8; Pl. 9, fig. 1)

1914 *Neoschwagerina craticulifera* var. *minoensis* DEPRAT; Mem. Survice Geol. l'Indochine. vol. 3, pt. 1, p. 27, Pl. 7, figs. 9, 10.

Remarks: This species is charateristic in its occurrence from the *Yabeina globosa* Zone in Japan, as insisted by OZAWA (1927) who gave emended diagnosis for DEPRAT's original description. The present materials are quite identical with those by previous authors.

Genus ***Yabeina*** DEPRAT, 1914

Yabeina globosa (YABE)

(Pl. 4, figs. 1–6; Pl. 5, figs. 1–6; Pl. 6, figs. 1–10; Pl. 7, figs. 1–10; Pl. 8, figs. 1, 2, 4–6)

1906 *Neoschwagerina globosa* YABE; J. Coll. Sci., Imp. Univ. Tokyo, vol. 21, art. 5, p. 4, Pl. 1, fig. 4, Pl. 3, fig. 1.

Remarks: Although this species is well-known and has been described from various limestones, especially in Japan, intraspeciefic variation of this species has not been fully worked out. YABE (1906)'s original description was based on insuficient materials from the Akasaka Limestone, Japan. Later, independent specific names, evidently assignable to the genus *Yabeina*, *inouyei*, *katoi*, *ozawai* and *igoi* were proposed by DEPRAT (1914), OZAWA (1927), HONJO (1959) and MORIKAWA and SUZUKI (1961), respectively, from the same limestone. However, intraspecific variation as well as interspecific disparity among the five has been left unresolved.

Five forms of *Yabeina*, mentioned below, are discriminated through a careful observation of diagnostic characters. More than 1,000 thin-sectioned individuals, including approximately 50 exact axial and sagittal sections, are prepared to examine the variation of them. However, the subdivision is insisted to be provisional solely for the sake of convenience of description. Selected biocharacters are; thickness of spirotheca, shape and degree of development of septula, first appearence of secondary transverse septula and prolocular size.

Form A (Pl. 4, figs. 1–3; Pl. 5, figs. 1–6; Pl. 6, figs. 1–10). Spirotheca thick. Septula stout. Primary transverese and axial septula elongate triangular to irregular in shape, well-developed throughout shell except for endothyroidly coiled embryonic volutions. Secondary transverse septula first appeared in the fifth to the seventh volution, increasing their number ontogenetically.

Form B (Pl. 7, figs. 1–5). Different from Form A in thinner spirotheca and relatively slender septula in inner vlutions, but, similar to Form A in outer volutions.

Form C (Pl. 4, fig. 5; Pl. 7, figs. 6–8, 10). Different from Forms A and B in larger proloculus. Secondary transverse septula first appeared in the fifth to sixth volution.

Form D (Pl. 4, fig. 4; Pl. 7, fig. 9; Pl. 8, figs. 1, 2, 4, 5). Similar to Form A, but differs in less well-developed secondary transverse septula and relatively thin spirotheca in early stage. Ontogenetic change whether early stage continues until the fifteenth volution or entirely lacking except for endothyroidly coiled embryonic volutions is variable in individuals.

Form E (Pl. 4, fig. 6; Pl. 8, fig. 6). Very diagnostic in minute proloculus, succeeded by neoschwagerinid fusiform shell in inner six volutions. Subsequent rounded fusiform volutions with thin spirotheca, long and exceedingly slender primary transverse septula, and very short, but definitely discernible even in inner volutions, secondary transverse septula. Beyond the eighteenth volution, general features on septula and parachomata are similar to those of Form B and early stage of Form D.

The above-described five forms are not specifically independent, but merely express intraspecific variation, because many transitional forms are recognizable among them, and all of these forms are observable within the same limestone sample. Form E is very few number and is unknown in its actual shell size and morphologic features of outermost volutions, because of abrasion. It is highly probable that Form E represents the microspheric generation. Closely related variation of various biocharacters of the present materials is also recognizable among the topotype specimens of *Yabeina globosa* from the Akasaka Limestone. Although *Yabeina inouyei* DEPRAT, 1914 is designated as the type species of the genus (THOMPSON, 1948), *inouyei* is junior synonym of *globosa*.

Besides *inouyei*, at least, the following species are also presemed to be synonymous with *globosa*: *Neoschwagerina katoi* OZAWA, 1927; *Yabeina kaizensis* HUZIMOTO, 1936; *Yabeina packardi* THOMPSON and WHEELER, 1942; *Yabeina packardi shimensis* YAMAGIWA and ISHII, 1958; *Yabeina omurensis* YAMAGIWA and ISHII, 1958 and *Yabeina* *kanmerae* IGO, 1964.

Subfamily Lepidolininae MIKLUKHO-MAKLAY, 1958 emend. OZAWA, 1970
Genus ***Colania*** LEE, 1933 emend. OZAWA, 1970
Colania larga (MORIKAWA and SUZUKI)
(Pl. 9, figs. 2–5)

1961 *Neoschwagerina larga* MORIKAWA and SUZUKI; Sci. Rep,, Saitama Univ., Ser. B, p. 57, 58, Pl.8, fig. 3, Pl. 19, figs. 1–6.

Description: Shell large, ellipsoidal fusiform in shape, with rounded to bluntly pointed poles and straight axis of coliling. Mature specimens of 17 to 18 volutions, over than 11.5 mm in length and 6.3 mm in maximum median width. Form ratio about 1.8: 1. Proloculus subspherical and of approximately 180 to 220 microns in longer diameter. Inner two to three volutions more or less variable in shape, succeeding ones nearly the same in shape and slowly expanding outerwardly.

Spirotheca very thin compared with chamber height, composed of tectum and fine alveolar keriotheca. Septa slender, numerous and widely spaced. Adjacent septa are inserted vertically by primary and secondary transverse septula and laterally by axial septula, resulting regularly arranged mesh-work structure.

Primary transverse septula slender, numerous, well-developed and connected with rather slender parachomata. Secondary transverse septula, short, poorly developed, commonly one, rarely two, in number between adjacent primary transverse septula, first appeared in the sixth volution. Axial septula, numerous and present even in inner volutions.

Remarks: The present materials are identical with those from the Akasaka Limestone, originally described as *Neoschwagerian larga* by MORIKAWA and SUZUKI (1961), and also safely identical with those from San Juan Island, northwestern Washington, described as *Neoschwagerina insularis* by SKINNER and WILDE (1966). The Japanese and American materials are almost undistinguishable in each other by important essential biocharacters. In thin spirotheca, slender septula and relatively large proloculus, this species is referable to the genus *Colania* rather than *Neoschwagerina*.

Suborder Miliolina DELANGE and HÉROUARD, 1896
Superfamily Miliolacea EHRENBERG, 1839
Family Fisherinidae MILLETT, 1898
Subfamily Cyclogyrinae LOEBLICH and TAPPAN, 1961
Genus ***Agathammina*** NEUMAYR, 1887
Agathammina sp. A
(Pl. 3, figs. 7–9, 11?)

Description: Test subglobular to oval, consisting of spherical proloculs, followed by non-septate undivided tubular chamber coiled streptospirally as *Glomospira* with sutural depressions throughout growth. Diameter of tube gradually increasing. Wall thick, smooth, imperforate, of dark microgranular calcite.

Remarks: The present form is easily distinguished from *Glomospira* in not agglutinated wall, and from *Hemigordius* in streptospiral tubular chamber throughout growth. Thick calcareous wall and mode of coiling of the present materials are common to those of *Baisalina*. However, *Baisalina* is distinguishable from *Agathamina* by short septal partitions ("pseudosepta" by REITLINGER, 1965).

Agathammina sp. B

(Pl. 3, figs. 15, 18, 19)

Remarks: The present form is tentatively separated from *Agathammina* sp. A in thinner wall.

Genus **Orthovertella** CUSHMAN and WATERS, 1928

Orthovertella? sp.

(Pl. 3, fig. 12)

Remarks: Variously-oriented more specimens are necessary to compare with the described species from USA, Australia, *etc.* (e.g. CUSHMAN and WATERS, 1928; CRESPIN, 1958). Small test, streptospirally coiled undivided tubular chamber and smooth, calcareous, imperforate wall of the present form are presumably assignable into the genus *Orthovertella*. The present form showing no attached nature of test would not be referable to *Calcitornella*. Generic assignment of the Xizang (Tibet) material by WANG (1982, p. 19, Pl. 4, fig. 27) is questionable.

Suborder Rotaliina DELANGE and HÉROUARD, 1896

Superfamily Nodosariacea EHRENBERG, 1838

Family Nodosariidae EHRENBERG, 1838

Subfamily Nodosariinae EHRENBERG, 1838

Genus **Nodosaria** LAMARK, 1812

Nodosaria sp.

(Pl. 3, figs. 13, 14)

Remarks: Rectilinearly arranged rounded chambers and wall structure, of inner thin dark structureless and outer thick transparent, radially laminated, finely perforate, of the present materials are safely referable to the genus *Nodosaria*.

Genus **Pseudoglandulina** CUSHMAN, 1929

Pseudoglandulina sp.

(Pl. 3, figs. 16, 17)

Description: Test subconiform with greatest width at base of terminal chamber, tapering, consisting of large globular proloculus followed by uniserially and rectilinearly arranged four chambers gradually increasing their height and width, with sutural depressions. Wall calcareous, of inner thinner microgranular and outer thicker dark translucent or transparent perforate layers.

Remarks: The present forms are similar to *Pseudoglandulina conica* MIKLUKHO-MAKLAY described by LIN (1978) from the Upper Permian of Central South China in general shape of test and chamber arrangement, but the former is over three times larger than the latter in test size.

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Explanation Plates 1–10

Plate 1

Fig. 1. Enlarged photograph shown in part of Text-fig. 2.

Fig. 2. Late Middle Permian limestone composed of aggregation of different lithologies. G-59. ×3.4.

Fig. 3. Late Middle Permian limestone containing reddish brown very fine-grained micritic limestone fragment. G-49. ×4.5.

Fig. 4. Late Middle Permian limestone containing grey micritic limestone fragment showing parallel lamination and graded bedding. G-49, ×4.5.

Plate 2

Figs. 1–3. *Tubertinina* sp. lateral sections. All from G-49. 1: ×45; 2, 3: ×80. Slide No.: 3419, 3455, 3398.

Figs. 4, 5, *Geinitzina* sp. 4: longitudinal section, 5: lateral section. both from G-49. ×45. Slide No.: 3428, 3444.

Figs. 6, 19, 26. *Cribrogenerina* sp. lateral sections. 6: G-52; 29: G-57; 26: G-54. 6, 26: ×15, 19: ×25. Slide No.: 3579, 3606, 3594.

Figs. 7, 8. *Palaeotextularia* sp. lateral sections. 7: G-52; 8: G-47. 7: ×15, 8: ×25. Slide No.: 3576, 3480.

Figs. 9–12. *Tetrataxis* sp. 9, 11, 12: longitudinal sections, 10: lateral section, All from G-49. 9, 11, 12: ×35; 10: ×25. Slide No.: 3415, 3460, 3453, 3452.

Figs. 13, 20–23. *Abadehella coniformis* OKIMURA and ISHII. 13, 23: longitudinal sections, 20, 21: apertural sections, 22: lateral section. All from G-49. ×45. Slide No.: 3414, 3452, 3410, 3441, 3431.

Figs. 14–18, 24, 25, 27–30, 32. *Pachyphloia ovata* LANGE. 14: longitudinal section; 15, 16, 18: transverse sections; 17, 24, 25, 27–30, 32: lateral sections. All from G-49 except for 14: G-47. All ×45 except for 27, 29: ×35. Slide No.: 3487, 3442, 3447, 3403, 3421, 3408, 3426, 3457, 3395, 3415, 3441, 3415.

Figs. 31, 33. *Bradyina*? sp. nearly axial sections. both from G-49. ×45. Slide No.: 3408, 3424.

Plate 3

Figs. 1–3. *Globivalvulina* sp. cf. *G. vonderschmitti* REICHEL. lateral sections. All from G-49. 1, 2: ×35, 3: ×45. Slide No.: 3428, 3423, 3450.

Figs. 4, 5, 10. *Neoendothyra reicheli* REITLINGER. 4: nearly axial section; 5, 10: lateral sections. All from G-49. ×45. Slide No.: 3421, 3445, 3406.

Fig. 6. *Kahlerina nautiloidea* SOSNINA. tangential section. G-49. ×15. Slide No.: 3433.

Figs. 7–9, 11?. *Agathammina* sp. A. 7: lateral transverse section, 8: nearly longitudinal section, 9, 11: lateral sections. 7: G-49, 8: G-51, 9: G-52, 11: G-47. 7: ×35, 8, 11: ×25, 9: ×45. Slide No.: 3456, 3569, 3577, 3482.

Fig. 12. *Orthovertella*? sp. lateral section. G-49. ×45, Slide N.: 3448.

Figs. 13, 14. *Nodosaria* sp. longitudinal sections. Both from G-49. ×45. Slide No.: 3395, 3411.

Figs. 15, 18, 29. *Agathammina* sp. B. lateral sections. 15: G-49; 18, 19: G-51, 15: ×37, 18, 19: ×45, Slide No.: 3423, 3568, 3566.

Figs. 16, 17. *Pseudoglandulina* sp. 16: longitudinal section, 17: lateral section. Both from G-49, ×35. Slide No.: 3429, 3412.

Figs. 20–25, 28, *Reichelina changhsingensis* SHENG and CHANG. 20, 22–25, 28: axial sections, 21: oblique section. All from G-49. Slide No.: 3408, 3411, 3456, 3452, 3428, 3459, 3453.

Fig. 26. *Nankinella* sp. tangential section. G-49. ×45. Slide No.: 3449.

Figs. 27, 29. *Sichotenella* sp. 27: axial section, 29: parallel section. Both from G-49. 27: ×100, 29: ×45. Slide No.: 3401, 3401.

Figs. 30, 31. *Dunbarula cascadensis* (THOMPSON, WHEELER and DANNER). axial sections. both from G-49. ×45, Slide No.: 3395, 3437.

Plate 4

Figs. 1–11, Enlarged photographs showing inner structure of shell. All ×20.

Figs. 1–3, *Yabeina globosa* (YABE) Form A. 1, 2: axial sections. 3: sagittal section. 1 and 3 are same as figs. 4 and 5 of Plate 5. 2 from G-47, Slide No.: 3482.

Fig. 4, *Yabeina globosa* (YABE) Form D. axial section. same as fig. 1 of Pl. 8.

Fig. 5. *Yabeina globosa* (YABE) Form C. axial section. same as fig. 10 fo Pl. 7.

Fig. 6. *Yabeina globosa* (YABE) Form E. axial section. same as fig. 6 of Pl. 8.

Figs. 7, 11. *Neoschwagerina minoensis* DEPRAT emend. OZAWA. axial sections. 7 and 11 are same as fig. 7 of Pl. 8 and fig. 1 of Pl. 9.

Fig. 8. *Verbeekina verbeeki* (GEINITZ). axial section. same as fig. 6 of Pl. 9.

Figs. 9, 10. *Chusenella* sp. A. axial sections. 9 and 10 are same as figs. 5 and 3 of Pl. 10.

Figs. 12–19, *Dunbarula cascadensis* (THOMPSON, WHEELER and DANNER). 12–14: axial sections, 15–19: sagittal sections. All from G-49 except for 15 and 18: G-47. ×45. Slide No.: 3428, 3428, 3420, 3488, 3454, 3454, 3482, 3444.

Fig. 20. *Paradoxiella* sp. SADA and SKINNER. tangential section. G-47. ×30, Slide No.: 3486.

Plate 5

Figs. 1–6. *Yabeina globosa* (YABE) Form A, 1–4: axial sections, 5, 6: sagittal sections. 1: G-47; 2, 6: G-48; 3–5: G. 49. ×10. Slide No.: 3500, 3532, 3405, 3392, 3399, 3529.

Plate 6

Figs. 1–10. *Yabeina globosa* (YABE) Form A. 1–3, 5–8, 10: axial sections; 4, 9: sagittal sections. 1, 2, 4–6, 10: G-47; 3, 7, 8: G-48; 9: G-49. ×10. Slide No.: 3481, 3495, 3535, 3498, 3497, 3496, 3492, 3536, 3410, 3530.

Plate 7

Figs. 1–5. *Yabeina globosa* (YABE) Form B. 1, 2, 5: axial sections; 3, 4: sagittal sections. All from G-49 except for 4: G-47. ×10. Slide No.: 3394, 3396, 3413, 3501, 3395.

Figs. 6–8, 10. *Yabeina globosa* (YABE) Form C. 6, 8, 10: axial sections, 7: sagittal section. 6, 7, 10: G-49, 8: G-47. ×10. Slide No.: 3407, 3411, 3490, 3415.

Fig. 9. *Yabeina globosa* (YABE) Form D. axial section. G-48. ×10. Slide No.: 3533.

Plate 8

Figs. 1, 2, 4, 5, *Yabeina globosa* (YABE) Form D. 1, 5: axial sections; 2, 4: sagittal sections. 1: G-49; 2, 4: G-47; 5: G-48. ×10. Slide No.: 3393, 3494, 3489, 3531.

Figs, 3, 7, 8. *Neoschwagerina minoensis* DEPRAT emend. OZAWA. axial sections. 3: G-48; 7, 8: G-49. ×10, Slide No. 3534, 3419, 3434.

Fig. 6. *Yabeina globosa* (YABE) Form E. axial section. G-47. ×10. Slide No.: 3480.

Plate 9

Fig. 1. *Neoschwagerina minoensis* DEPRAT emend. OZAWA. axial section. G-49. ×10. Slide No.: 3398.

Figs. 2–5. *Colania larga* (MORIKAWA and SUZUKI). 2, 3: axial sections, 4: sagittal section, 5: tangential section. All from G-49. ×10, Slide N.: 3403, 3412, 3395, 3404.

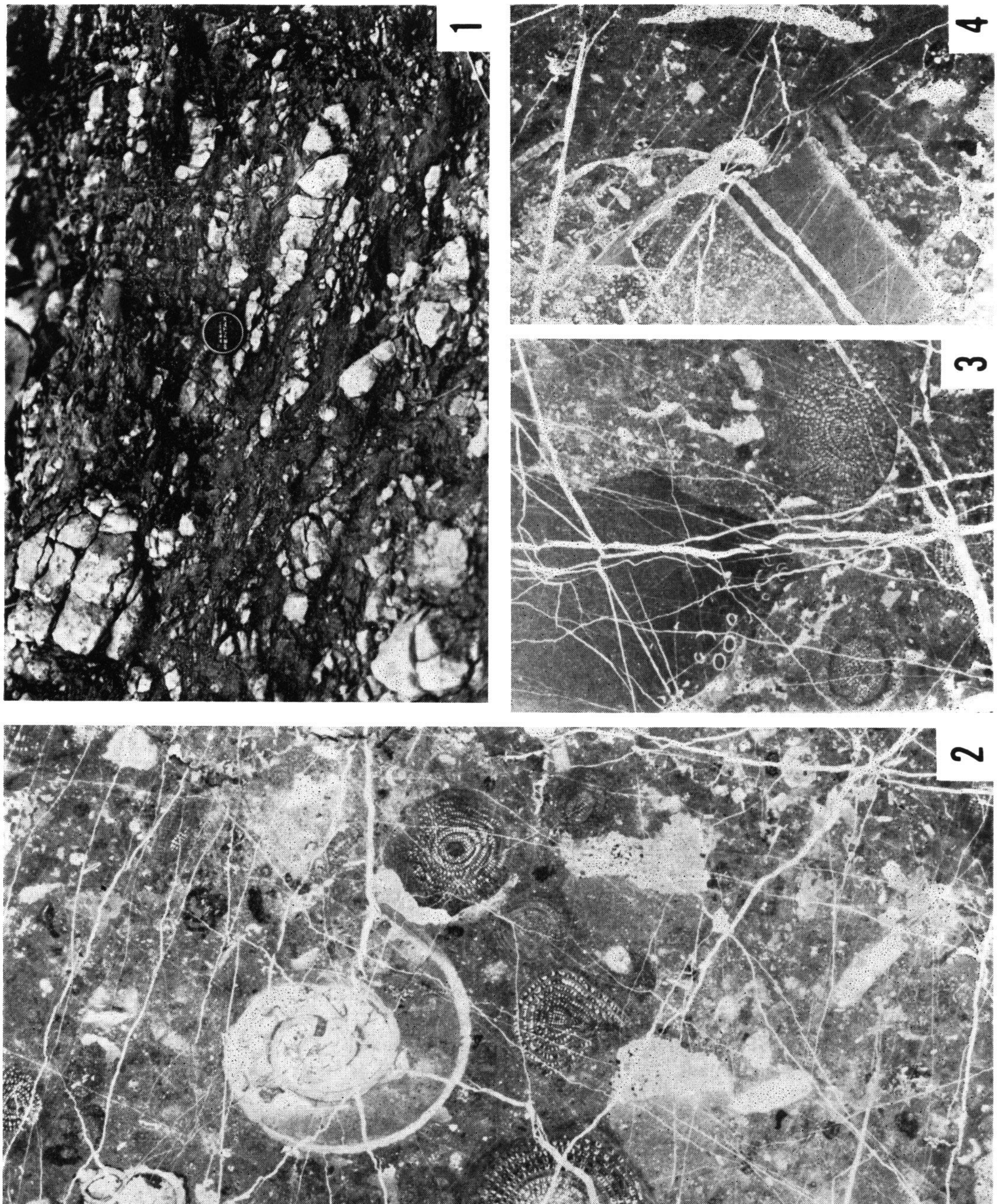
Fig. 6, *Verbeekina verbeeki* (GEINITZ). axial section. G-51. ×10. Slide No.: 3563.

Figs. 7, 8. *Chusenella andersoni* (THOMPSON, WHEELER and DANNER). 7: axial section, 8: sagittal section. Both from G-51. ×10. Slide No.: 3564, 3565.

Plate 10

Figs. 1, 3–5, 8. *Chusenella* sp. A. 1, 3–5: axial sections, 8: parallel section. 1, 4: G-47; 3, 5, 8: G-49. ×10. Slide No.: 3491, 3400, 3499, 3422, 3433.

Figs. 2, 6, 7, 9–14. *Pseudofusulina* sp. cf. *P. padangensis* (LANGE). 2, 6, 9, 14: sagittal sections; 7, 10–13: axial sections. All from G-49 except for 10: G-47. ×10. Slide No.: 3431, 3432, 3420, 3428, 3493, 3426, 3421, 3401, 3429.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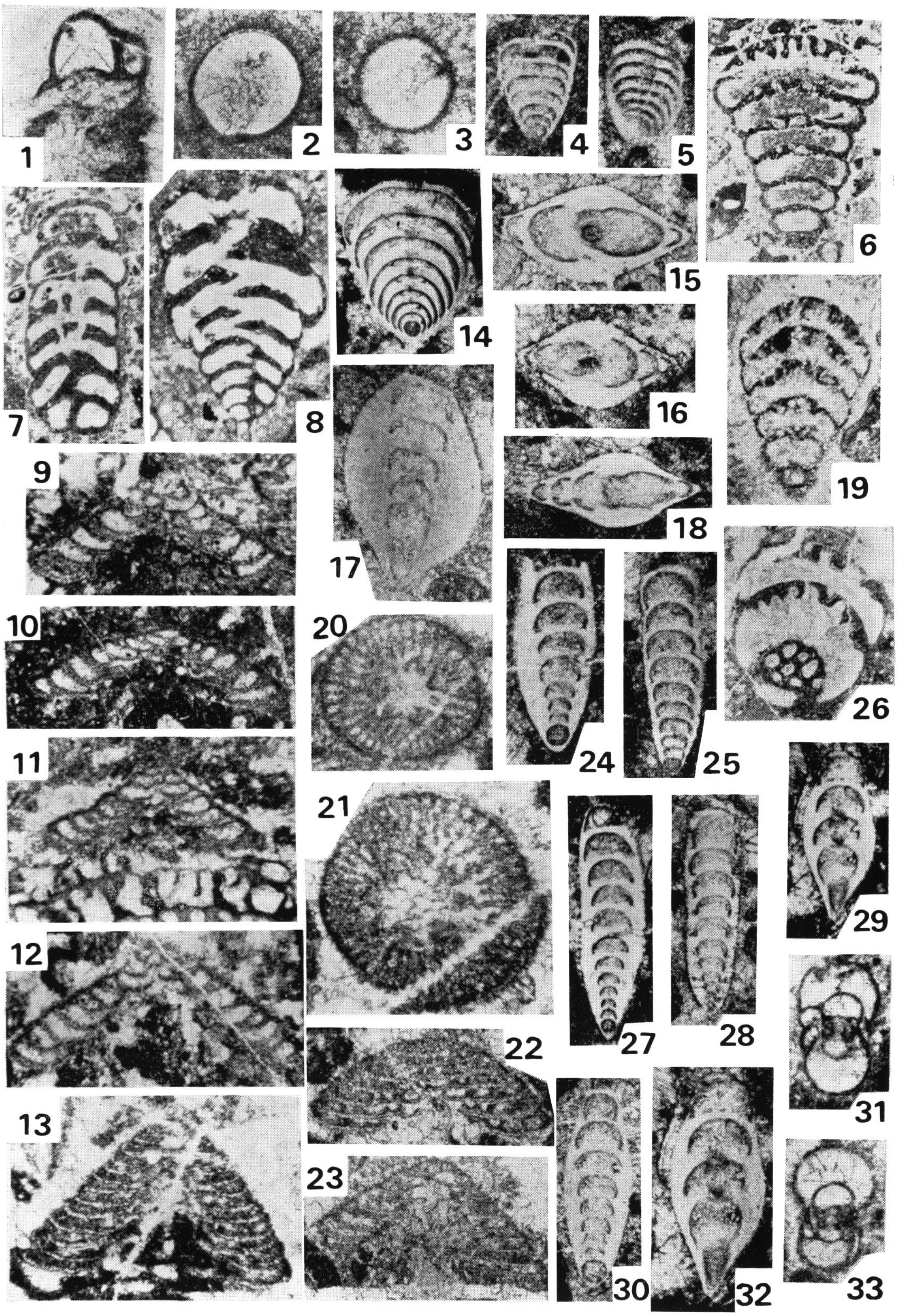
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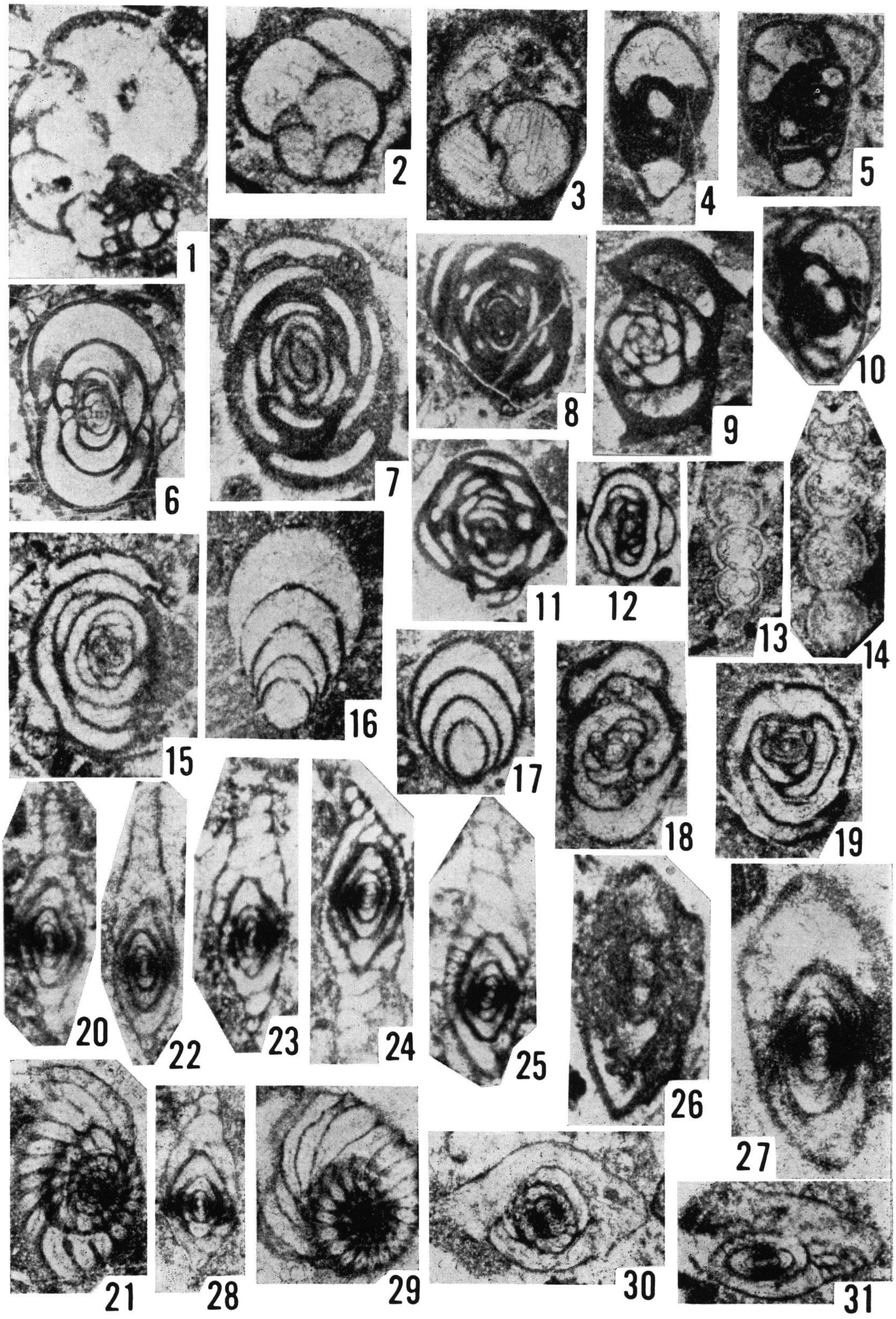
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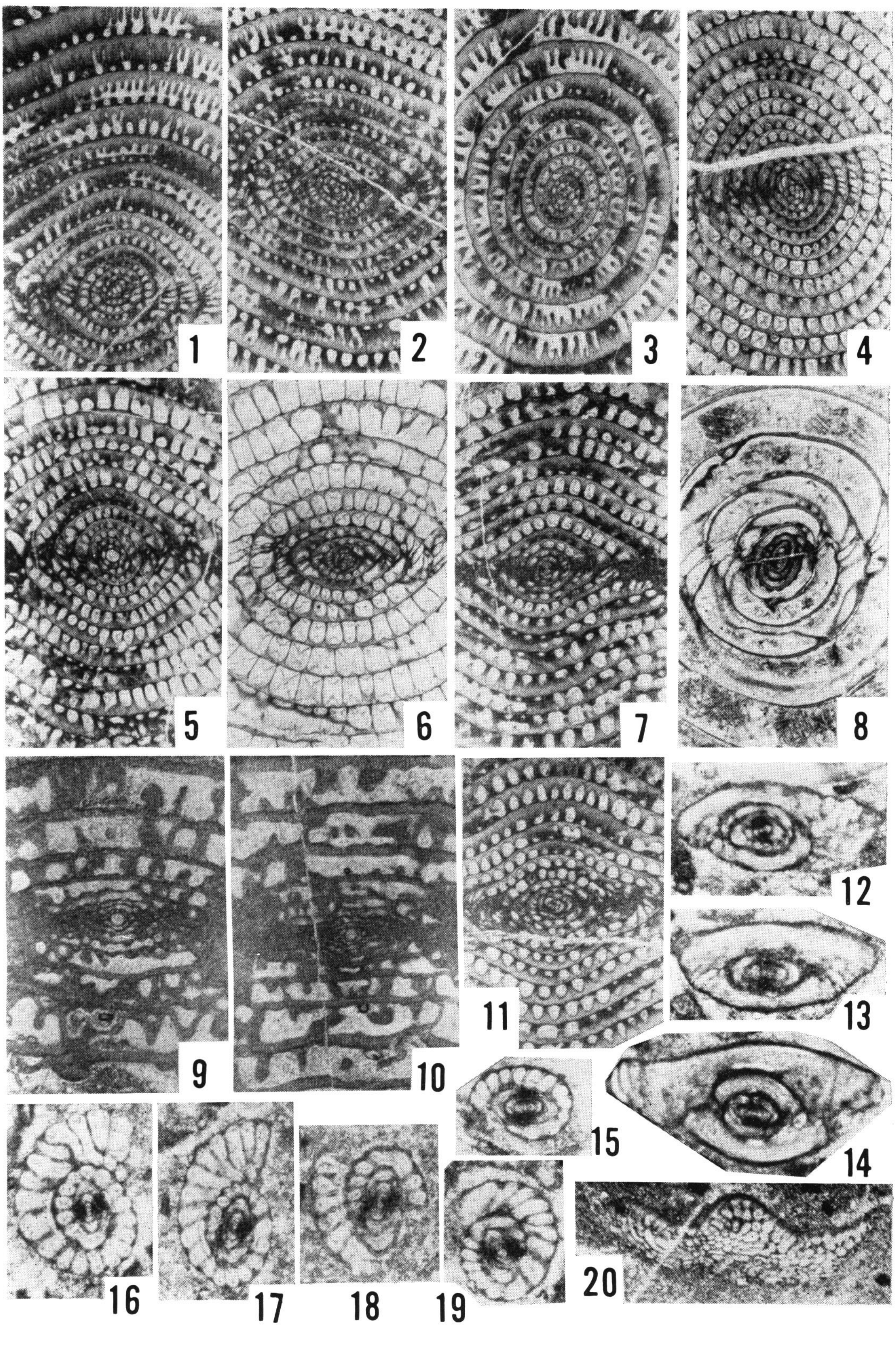
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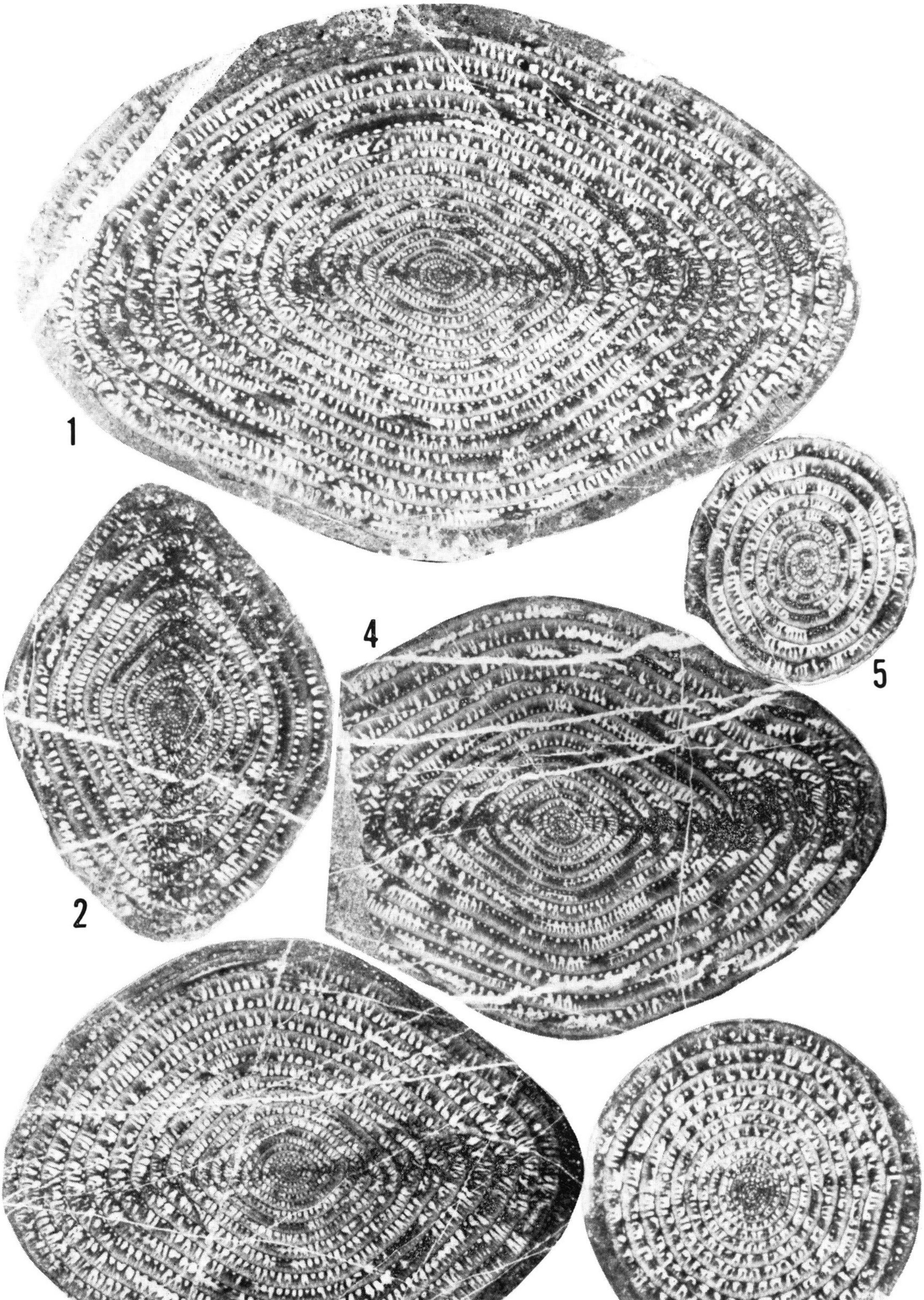

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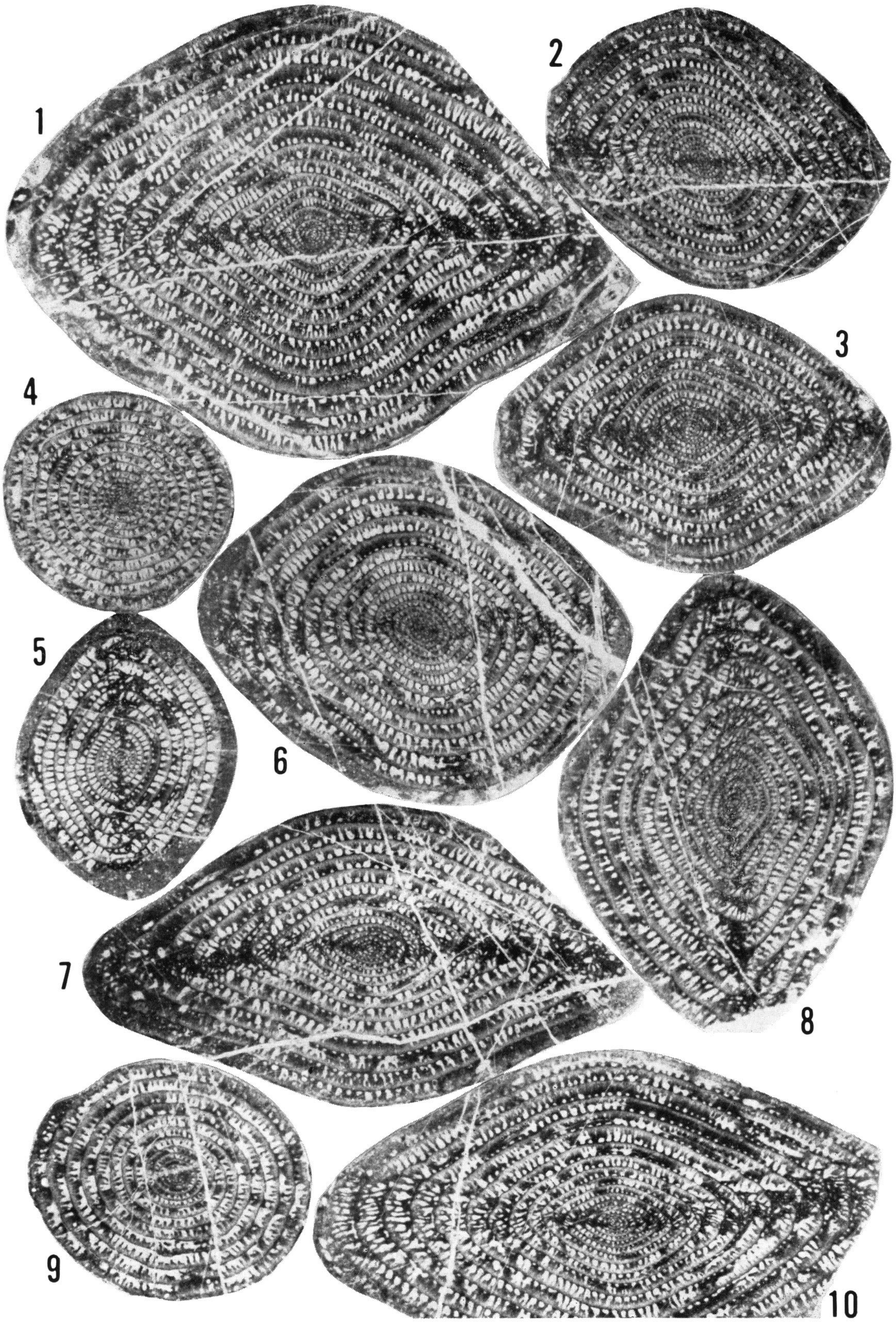
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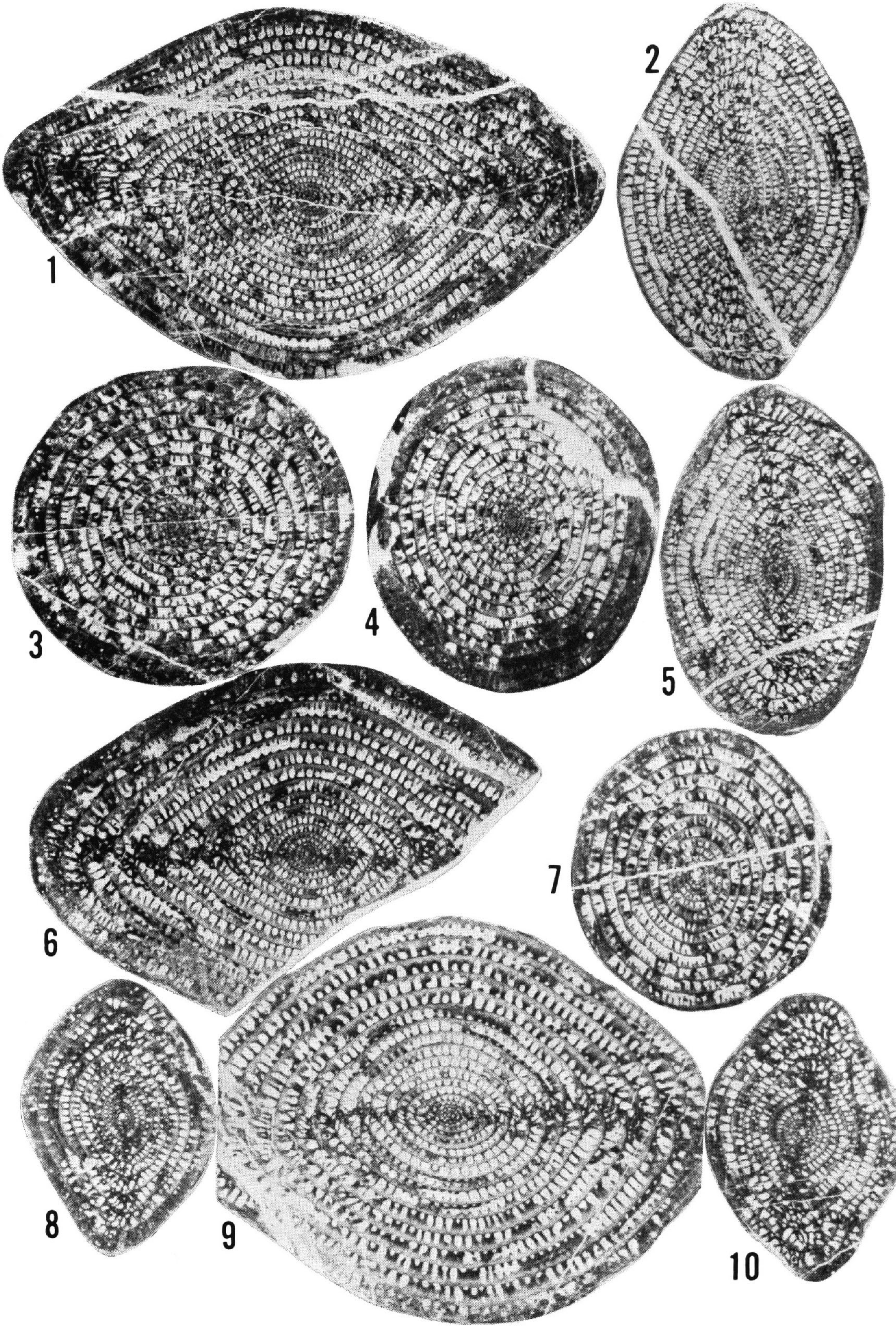
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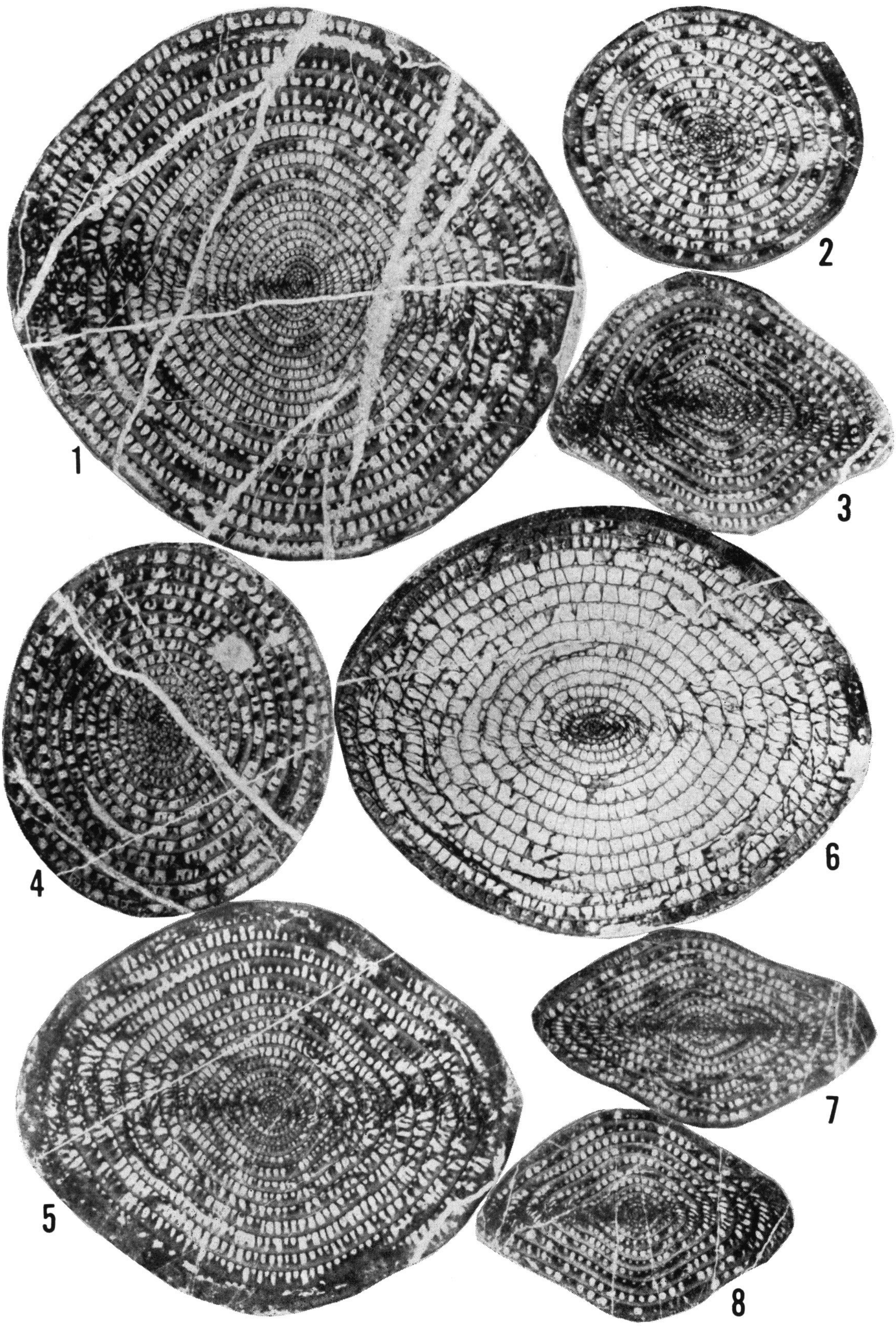
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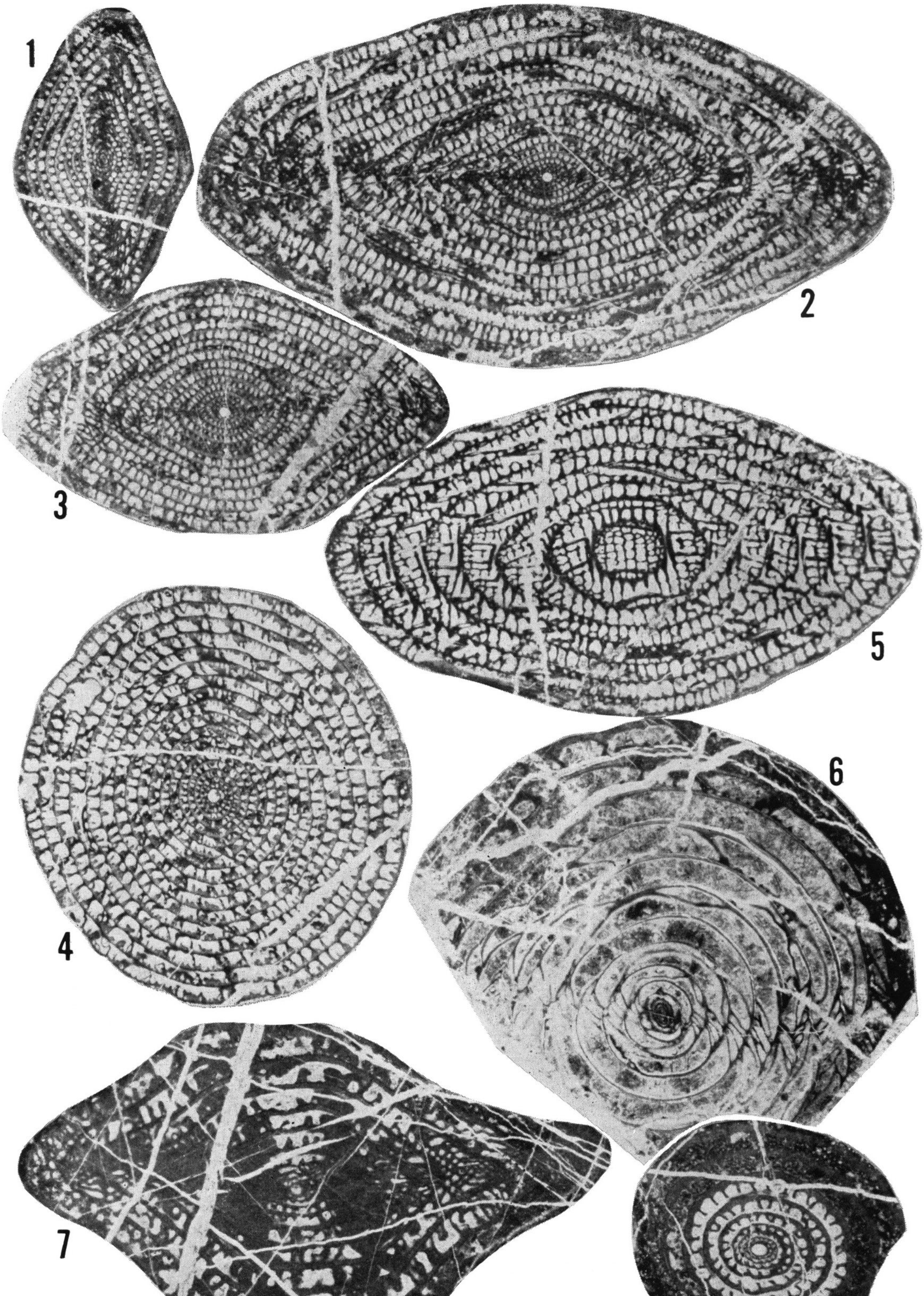
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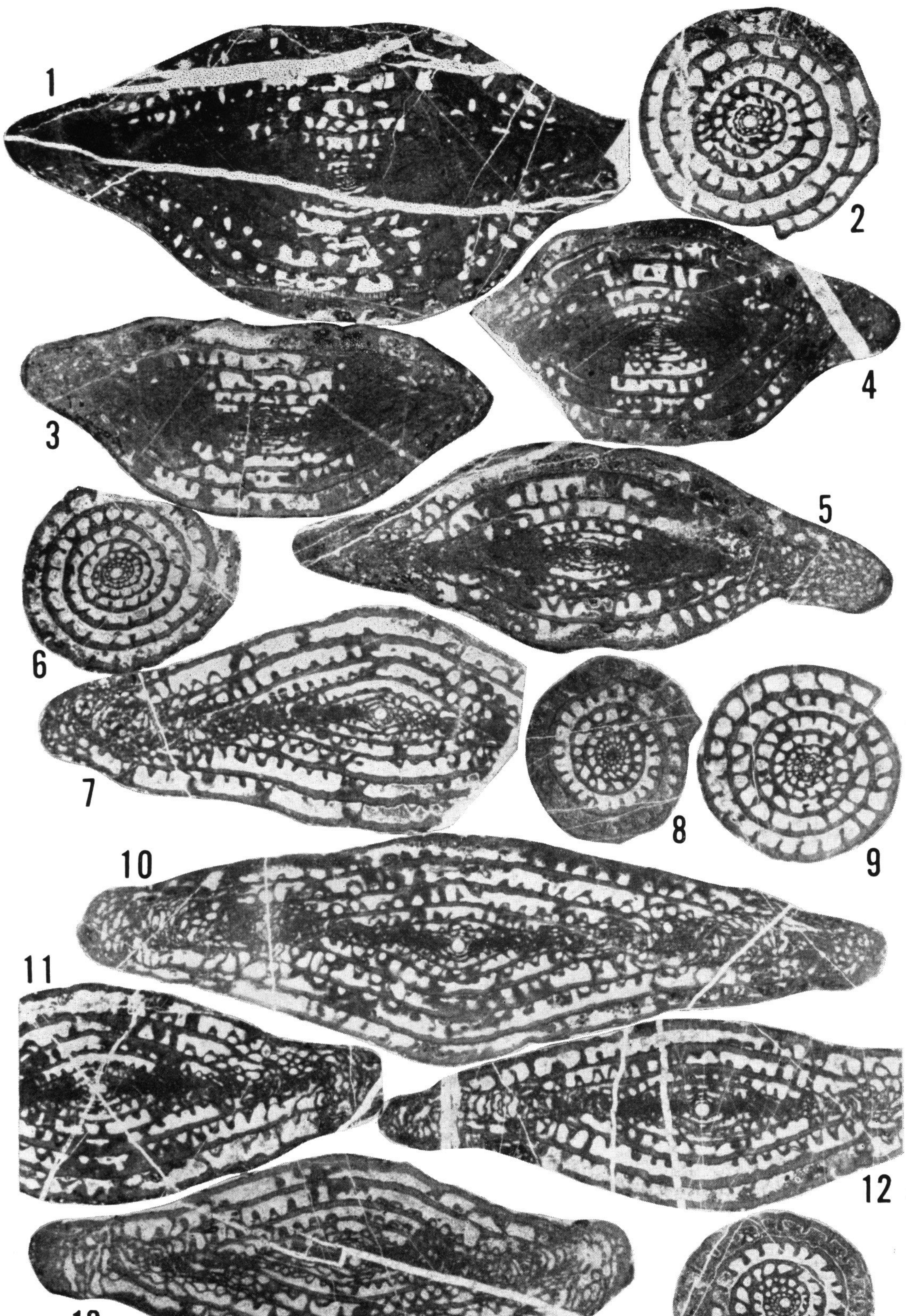
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