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Find of Permian Fossils from the Moribu Formation, Hida Mountains, Central Japan

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Abstract Lower Permian fossils including fusulinids and corals were found from the Moribu Formation, Hida Mountains, Central Japan. This is the first occurrence of reliable index fossils from the formation whose age remained hitherto unsettled.

Of the fossil collections four species of fusulinids are described.

The Moribu Formation is typically exposed along the Arakigawa (River Araki) and its tributary, north of Takayama City, Gifu Prefecture, Central Japan. It is overlain with angular unconformity by Cretaceous and Cenozoic terrestrial volcanics and underlain by a greenstone, the Arakigawa Formation, which contains limestone lenses bearing Lower Carboniferous fauna, but the precise age of the Moribu Formation remained hitherto unsettled because no reliable fossils for dating have been obtained.

Recently one of the authors (H. Y.) discovered Permian fossils from the Moribu Formation at two separate localities (Fig. 1) which represent the same stratigraphic horizon. The purpose of the present note is to report the occurrence of the fossils and to describe some fusulinids among them.

Acknowledgements: we wish to express our thanks to Professor K. Konishi of our Department for continuous encouragement and kind reading of the manuscript and to Dr. M. Kato of Hokkaido University for identification of corals.

The geology of the Arakigawa area has been already outlined by Isomi and Nozawa (1957), who considered the Moribu Formation to be Carboniferous despite lack of fossil evidence. The following description of the geology, therefore, will be chiefly given to the prime concern with fossils newly discovered.

The Moribu Formation is mainly composed of sandstone and shale with small

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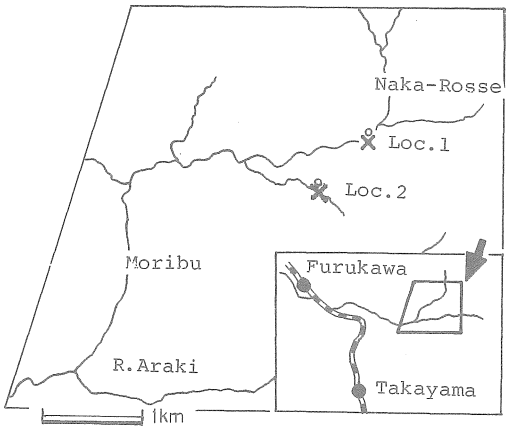

Fig. 1 Map showing fossil localities.

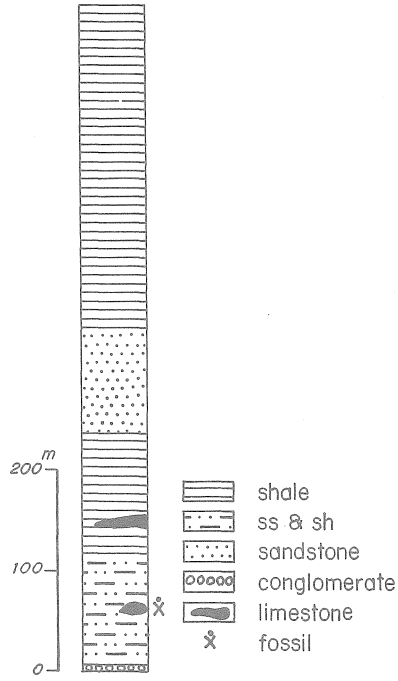

Fig. 2. Generalized columnar section of the Moribu Formation, showing the horizon of fossils.

amount of conglomerate and limestone, and trends northeastward and dips northwest steeply (more than 45°) in general. The total thickness exceeds 600 meters. Fossils newly found are contained in a limestone which exists at a horizon of about 60 meters above the base of the formation. Fig. 2 shows a generalized sequence of the formation and stratigraphic horizon of the fossils. The fossil-bearing limestone is conglomeratic and thinly to thickly bedded in a total thickness of, at least, 15 meters. A conglomerate with non-calcareous sandy matrix, 5 meters thick, interbeds with the limestone. Gravels in the limestone are the same as those of the conglomerate in rock type and texture; they are well-rounded, granule to fine pebble and chiefly volcanic and cherty rocks. Fossils are scattered sporadically in the pebbly limestone. The outer surface of almost all these remains is more or less worn out regardless to the kind of fossils. The outermost volutions of the fusulinids test, for example, are not well preserved in many of individuals. This suggests that the fossils may be transported from their habitat in some distance and buried together with other kind of gravels.

Fossils collected are of foraminifers including fusulinid, coral, cephalopod, crinoid (stem) and others. The fusulinids are most abundant among them, though the obtained fossils are rather poor originally in quantity. The following is a list of the fusulinid and coral species discriminated at present.

Pseudofusulina vulgaris globosa (SCHELLWIEN and DYHRENFURTH)

P. fusiformis (SCHELLWIEN and DYHRENFURTH)
P. kraffti magna TORIYAMA
P. aff. *motoyoshiensis* MORIKAWA
P. spp.
Paraschwagerina sp.
Misellina sp.
Duplophyllum sp.
Yatsengia sp.

All of these species except one, *Duplophyllum* sp., were collected from Loc. 1.

The assemblage of fusulinids listed above is similar to that of the Upper Sakamotozawa Series (Kabayama Stage) (Minato et al., 1979) or the Upper Sakamotozawa Formation (Kanmera and Mikami, 1965) of the Kitakami massif, the *Pseudofusulina vulgaris* zone and the lower half of the *P. kraffti magna* zone of the Atetsu limestone (Nogami, 1961) and the *P. vulgaris* and the *P. ambigua* zone (Toriyama, 1958) or the *Pseudofusulina* zone (Hasegawa, 1963) of the Akiyoshi Limestone Group.

According to Kato (personal communication), moreover, two coral species, *Duplophyllum* sp. and *Yatsengia* sp., which are associated with the fusulinids, are identical or closely allied to those from the Upper Sakamotozawa Series. Although additional collection of fossils is needed for precise age assignment, there is no doubt that the Moribu Formation is referable to the later half of the Early Permian.

Description of Species

Genus *Pseudofusulina* DUNBAR and SKINNER, 1931

Pseudofusulina vulgaris globosa (SCHELLWIEN and DYHRENFURTH)

Pl. 1. Fig. 1

1909 *Fusulina vulgaris* var. *globosa* SCHELLWIEN and DYHRENFURTH, p. 164, 165, pl. 14, figs. 3–7.
1925 *Schellwienia vulgaris* var. *globosa*, OZAWA, p. 24, 25, pl.7, figs. 1, 2.
1927 *Schellwienia vulgaris* var. *globosa*, LEE, p. 67, pl. 9, fig. 12.
1936 *Pseudofusulina vulgaris* var. *globosa*, HUZIMOTO, p. 77, 78, pl, 12, figs. 1–7; pl. 14, figs. 1, 2.
1958 *Pseudofusulina vulgaris* var. *globosa*, TORIYAMA, p. 168–170, pl. 21, figs. 16–18; pl. 22, figs. 1–7.
1958 *Pseudofusulina vulgaris* var. *megaspherica* TORIYAMA, p. 170–172, pl. 22, figs. 8–17; pl. 23, figs. 1–3.
1958 *Pseudofusulina globosa* (DEPRAT) var. *exilis* TORIYAMA, p. 175–178, pl. 23, figs. 7–16; pl. 24, figs. 1–20.
1959 *Pseudofusulina vulgaris* var. *globosa*, IGO, p. 240–242, pl. 1, figs. 4–6; pl. 3, fig. 4
1961 *Pseudofusulina globosa*, MORIKAWA and ISOMI, p. 17, pl. 13, figs. 6–11.
1961 *Pseudofusulina vulgaris* var. *globosa*, KAWANO, P. 94–96, pl. 6, fig. 20; pl. 7, figs. 1–12.
1961 *Pseudofusulina vulgaris* var. *megaspherica*, KAWANO, p. 96–98, pl. 7, figs. 13–15; pl. 8, figs. 1–5.
1961 *Pseudofusulina* cf. *globosa* var. *exilis*, KAWANO, p. 98, 99, pl. 8, fig. 6
1961 *Pseudofusulina vulgaris globosa*, NOGAMI, p.212, 213, pl. 9, figs. 4–7.
1961 *Pseudofusulina globosa exilis*, NOGAMI, p. 214, 215, pl. 9, figs. 10–13.
1965 *Pseudofusulina vulgaris globosa*, KANMERA and MIKAMI, p. 297–298, pl. 51, figs. 4–9.

Material: Single axial section. GKZ02101. Ultimate volution has been broken up.

Description: Shell large, thickly fusiform with gently convex lateral slopes and bluntly pointed poles. Actual shell-size of the specimen of 5 volutlons is not known,but shell of 4.5 volutions is about 6mm long and 4.3mm thick, giving form ratio of 1.4.

Proloculus spherical, with outside diameter of 0.35mm. Shell expands rapidly, especially from the third volution. It retains nearly the same axial profile throughout growth. Radius vectors of the first to forth volution 0.36, 0.72, 1.25, and 2.0mm, respectively. Height of each chamber is almost equal throughout length.

Spirotheca thick, consisting of tectum and coarsely alveolar keriotheca. Its thickness of the first to fourth volution 0.04, 0.06, 0.10 and 0.15mm, respectively. Septal fluting strong and rather regular, commonly reaching nearly to tops of chambers.

Chomata not observable. Phrenotheca well develops.

Remarks: The present specimen is referable to *Pseudofusulina vulgaris globosa* (SCHELLWIEN and DYHRENFURTH) of the *P. vulgaris* group in shell size and shape, and mode of expansion. But it differs from the lectotype of the subspecies designated by Toriyama (1958) in having more intensely and regularly fluted septa in inner volutions. The present from is not distinguishable from a form of *Pseudofusulina globosa exilis* TORIYAMA from the Atetsu limestone illustrated by Nogami (1961, pl. 9, fig. 10), who has suggested that *P. globosa exilis* may be consubspecific with *P. vulgaris globosa.* Kanmera and Mikami (1965) are also of the same opinion. We follow them.

Pseudofusulina kraffti magna TORIYAMA

Pl. 1, Fig.2

1958 *Pseudofusulina kraffti* var. *magna* TORIYAMA, p. 178-181, pls. 25, 26.

1959 *Pseudofusulina kraffti* var. *magna*, IGO, p. 244, pl. 1, fig. 8; pl. 3, fig. 3.

1961 *Pseudofusulina kraffti magna*, NOGAMI, p. 216, 217, pl. 10, figs. 1-4.

Material : Axial section of an imperfect shell. GKZ02102.

Description : Shell of 8.5 volutions large, short subcylindrical with bluntly rounded poles. Median part of each volution straight to somewhat depressed, though the depression is strengthend by the secondary deformation. Actual shell-size is not measured because of very poor preservation of last volution, but it is estimated to attain 6.5mm long and 5.8mm wide or more.

Proloculus 0.36mm in outside diameter. Shell expands uniformly and height of the first half to the seventh and a half volution 0.08, 0.10., 0.19, 0.22, 0.26, 0.36 and 0.48mm, respectively.

Spirotheca composed of tectum and moderately coarse keriotheca, with thickness of 0.10-0.12mm in outer whorls. Septa rather thin, intensely and narrowly fluted.

Axial filling very heavy. Chomata not present.

Remarks : The present specimen is closely allied to *Pseudofusulina kraffti magna* TORIYAMA from the Akiyoshi Limestone Group, type locality of the subspecies, illustrated by Toriyama (1958) and recently by Hasegawa (in Minato et all, 1979) in important

characters. But it differs from the latter in having slightly thinner septa, heavier axial filling and smaller proloculus.

It is also distinguishable from *P. kraffti norikurensis* IGO in shell shape. The present form is possible to be a new subspecies of *P. kraffti* group, but we now treat it as consubspecific with *P. kraffti magna* until sufficient materials are obtained.

Pseudofusulina fusiformis (SCHELLWIEN and DYHRENFURTH)

Pl. 1, Figs 3,4.

1909 *Fusulina vulgaris* var. *fusiformis* SCHELLWIEN and DYHRENFURTH, p. 165–168, pl. 15, figs. 1–3.

1948 *Pseudofusulina fusiformis*, THOMPSON, pl. 12, fig. 3.

1955 *Pseudofusulina fusiformis*, MORIKAWA, p. 98, 99, pl. 13, figs. 1–7.

1955 *Pseudofusulina huecoensis*, MORIKAWA, p. 96–98, pl. 13, figs. 8–11.

1959 *Pseudofusulina fusiformis*, IGO, p. 246, 247, pl. 3, fig. 5.

1961 *Pseudofusulina fusiformis*, MORIKAWA and ISOMI, p. 19, 20, pl. 7, figs. 11, 12; pl. 8, figs. 12, 13; pl. 10, figs. 1–10, pl. 11, figs. 1–10; pl. 12, figs. 1–10 ; pl. 13, fig. 5.

?1962 *Schwagerina fusiformis*, SUYARI, p.26, pl. 8, figs. 7–9.

1965 *Pseudofusulina fusiformis*, KANMERA and MIKAMI, p. 301, 302, pl. 52, figs. 1–6.

1973 *Pseudofusulina fusiformis*, CHOI, p.46, 47, pl. 9, figs. 1–3, pl. 11, fig. 4.

Material : An Axial section (slightly oblique) and a centered oblique section. Preservation of last volutions is imperfect in both specimens. GKZ02103, 02104.

Description : Shell large, elongate fusiform with narrowly rounded poles. Mature shell of 6 volutions attains 10mm or more in lengh and 3.5mm in width.

Proloculus spherical, with outside diameter 0.30 to 0.33mm. Proloculus wall thin. Shell expands uniformly. Height of volutions of the first to fifth volution in a specimen (GKZ02103) 0.10, 0.15, 0.22, 0.34 and 0.34mm, respectively. The first volution subspherical. Radius vectors of the first to the sixth volution 0.27–0.28, 0.42–0.46, 0.64–0.68, 0.98–1.0, 1.32–1.4 and 1.65mm, respectively.

Spirotheca thick, consisting of tectum and coarsely alveolar keriotheca. Thickness of spirotheca in the first to fifth volution 0.04, 0.06, 0.06–0.08, 0.10–0.14, and 0.18–0.2mm, respectively. Septal fluting rather weak in central part, but strong and irregular in lateral and polar regions.

Axial filling occurs in inner volutions.

Remarks : The present form agrees well with *Pseudofusulina fusiformis* (SCHELLWIEN and DYHRENFURTH) in essential characters including mode of septal fluting and rate of expansion of shell. Only difference is in prolocular size; proloculus of the Moribu form is somewhat smaller than that of many of species hitherto referred to this species.

Pseudofusulina aff. *motoyoshiensis* MORIKAWA

Pl. 2, Figs. 1–8

1973 *Parafusulina motoyoshiensis*, CHOI, p.56, 57, pl. 4, figs. 1–3, ?6; pl. 10, fig. 6.

Compaired with

1960 *Pseudofusulina motoyoshiensis* MORIKAWA, p. 283, 284, pl. 47, figs13–18.

Material: Seven nearly axial sections and a tangential section. GKZ02107-02114. Many of the specimens are more or less secondarily compressed normal to the axis of coiling. In addition, their outer whorls have been poorly preserved.

Description: Shell large, elongate fusiform with straight to slightly curved axis of coiling. Poles rather pointed. Mature individuals of 6 to 6.5 volutions are 10mm or more in length and 2mm or more in width. Ratio of half length to radius vector of the fifth volution in less compressed four specimens 4.0 to 4.7.

Proloculus spherical, moderate in size with outside diameter 0.17 to 0.23mm. Shell expands slowly and uniformly as a whole, though inner one or two volutions more tightly coiled. Radius vectors of the first to fifth volution 0.12-0.17, 0.18-0.28, 0.25-0.42, 0.42-0.63 and 0.63-0.96mm, respectively. Height of volutions of the first to fifth volution 0.3-0.6, 0.5-0.11, 0.7-0.16, 0.13-0.23 and 0.19-0.33mm, respectively.

Spirotheca relatively thin, consisting of tectum and coarsely alveolar keriotheca. About 4 alveoli present in a distance of 100 microns of keriotheca in outer volutions.- Thickness of spirotheca in the first to the fifth volution of a typical form 0.02, 0.03, 0.05, 0.07, and 0.09mm, respectively.

Septa weakly fluted in median portion, especially in outer volutions, but rather strongly and irregularly in lateral and polar regions. Cuniculi not observable.

Axial filling occurs weakly in some specimens. Chomata absent.

Remarks: The present specimens are diagnostic in large, elongate fusiform shell, relatively thin spirotheca, weak septal fluting in central part of volution and absence of cuniculi.

They agree well with the specimens referred to *Parafusulina motoyoshiensis* (MORIKAWA) by Choi (1973, not 1970) from Setamai district, southern Kitakami Mountains, in essential features mentioned above.

Pseudofusulina motoyoshiensis, which was transferred to genus *Parafusulina* by Choi (1970), was originally described by Morikawa (1960) from Iwaizaki, southern Kitakami Mountains.

The Setamai and Moribu specimens slightly differ from the Iwaizaki specimens in having slightly larger shell and less intensely fluted septa. The first two forms are likely distinguished from the last as a different subspecies.

Parafusulina motoyoshiensis of Choi (1970) from Imo, southern Kitakami Mountains, may be a different species because it has large shell, more numbers of volution and strong septal fluting compared with the type specimens of the species. Final determination of these questions, however, will be reserved until additional material becomes available.

Measurements of *Pseudofusulina* aff. *motoyoshiensis* MORIKAWA (in mm.)

Sp.	Pl. 2 Fig.	No. vol.	Prol.	Radius vector 1	2	3	4	5	6	Half length 1	2	3	4	5	6
1	1	6	.20×.31	.15	.22	.37	.60	.84	1.1±	.48	1.00	1.65	2.50	3.95	5.20
2	2	6.5	.21×.31	.14	.19	.29	.42	.63	—	.38	.70	1.48	2.23	3.10	4.20
3	3	6	.23×.31	.15	.22	.36	.57	—	—	.37	1.12	2.18	3.00	4.20	—
4	4	6	.20×.29	.15	.26	.40	.63	.96	—	.40	1.05	1.75	2.80	3.80	—
5	5	6.5	.17×.26	.12	.18	.25	.42	.61	—	.42	.76	1.78	2.55	3.45	4.35
6	6	6	.22×.38	.17	.28	.42	.60	.82	—	.60	1.15	1.65	2.55	3.60	—
7	8	5.5	.28×.32	.19	.35	.55	.81	1.10		.65	1.40	2.30	4.10	4.90	

Sp.	Rg. no. GKZ	Half length/radius vector 1	2	3	4	5	6	Thickness of spirotheca 1	2	3	4	5	6
1	02107	3.2	4.5	4.5	4.2	4.7	4.7	.02	.03	.05	.07	.09	—
2	02108	2.7	3.7	5.1	5.3	4.9		.01	.01	.03	.04	.07	—
3	02109	2.1	5.1	6.1	5.3			.01	.03	.04	.07	—	—
4	02110	2.7	4.0	4.4	4.4	4.0		.01	.02	.04	.08	.10	—
5	02111	3.5	4.2	7.1	6.1	5.7		.02	.03	.04	.04	.08	—
6	02112	3.5	4.1	3.9	4.3	4.4		.02	.03	.04	.07	.08	—
7	02114	3.4	4.0	4.2	5.1	4.5		.02	.03	.05	.06	.10	

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PLATES

Explanation of Plate 1

Figs. 1- 4 ×10. Fig. 5 ×40

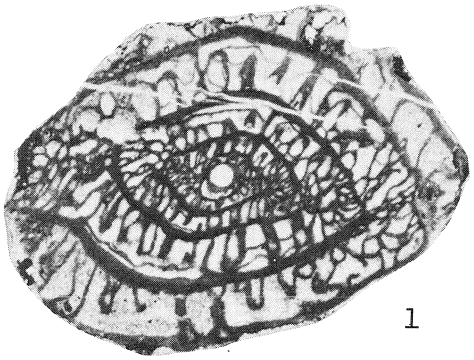
Fig. 1. *Pseudofusulina vulgaris globosa* (SCHELLWIEN and DYHRENFURTH)
Slightly oblique axial section. GKZ02101.

Fig. 2, *Pseudofusulina kraffti magna* TORIYAMA
Axial section. GKZ02102.

Figs. 3, 4. *Pseudofusulina fusiformis* (SCHELLWIEN and DYHRENFURTH)
3, Slightly oblique axial section. GKZ02103.
4, Centered oblique section. GKZ02104.

Fig. 5. *Misellina* sp. (Only illustration without description)
Tangential section. GKZ02115.

Plate 1



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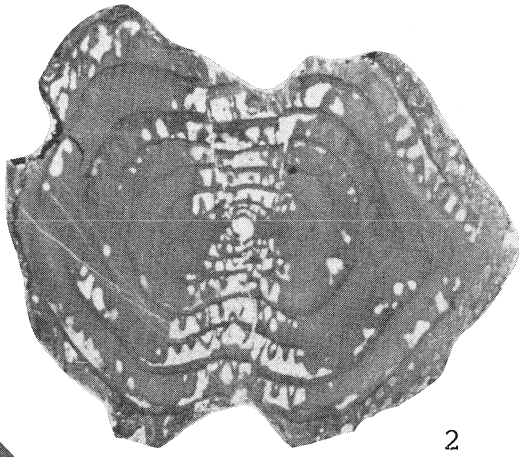

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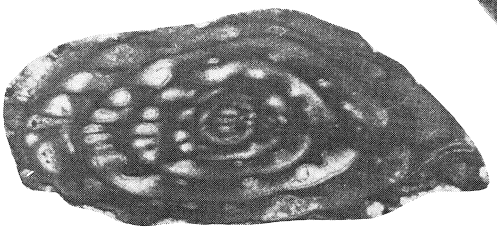

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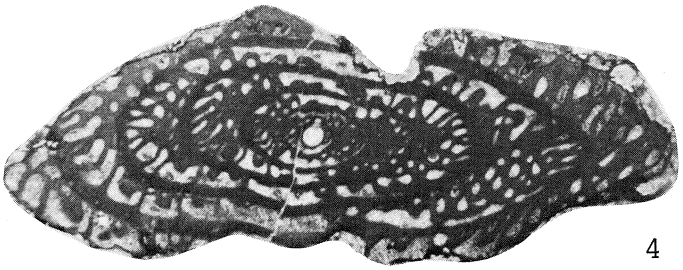

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Explanation of Plate 2
All figures ×10

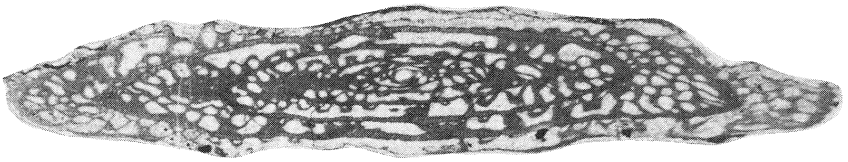
Figs. 1- 8. *Pseudofusulina* aff. *motoyoshiensis* MORIKAWA

1- 6. Slightly oblique axial sections; GKZ02107, 02108, 02109, 02110, 02111 and 02112, respectively.

7. Tangential section; GKZ02113.

?8. Axial section, GKZ02114.

Plate 2



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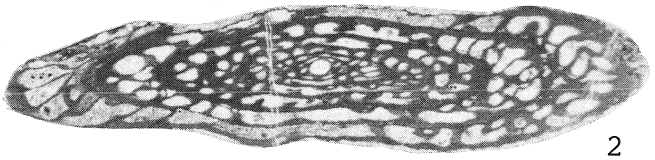

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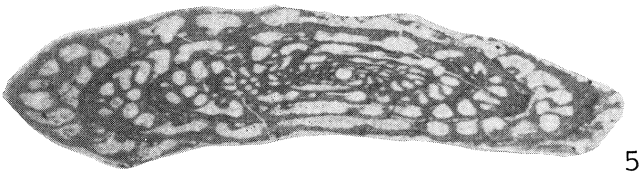

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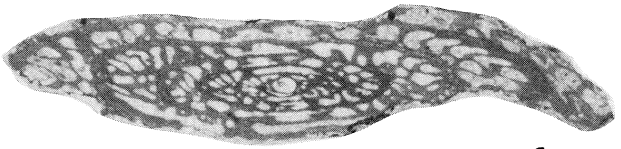

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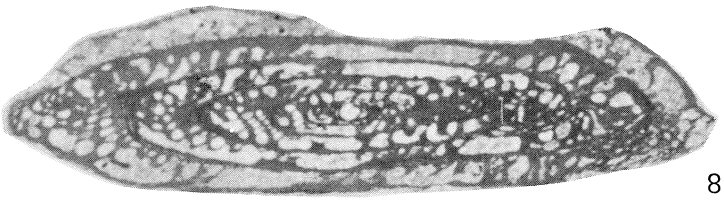

8