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Late Paleozoic Radiolarians from the Guizhou and Guangxi Areas, China

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(With 2 Figures, 1 Table and 2 Plates)

Abstract

Late Paleozoic radiolarians were found from the Upper Paleozoic siliceous and clastic sediments on the Yangtze Platform in the Guizhou and Guangxi areas, South China. Three radiolarian faunas were preliminarily distinguished, namely, the late Carboniferous to early Permian fauna, the late Middle Permian fauna and the Late Permian fauna. The first fauna, represented by *Pseudoalbaillella u-forma* and *P.* cf. *annulata,* occurs in chert layers interbedded with limestone. The second, containing *Follicucullus scholasticus* and stauraxon polycystines, is from chert layers of the Gufeng Formation. The last fauna, characterized by *Albaillella triangularis, A. excelsa, A. levis* and *Neoalbaillella optima,* is from chert nodules within limestone of the Changxing Formation, from mudstone and chert of the Dalong Formation, and from their equivalents.

Key Words: Late Paleozoic, radiolarians, Yangtze Platform, Guizhou, Guangxi, Gufeng Formation, Changxing Formation, Dalong Formation

Introduction

During the last decade, research on Paleozoic radiolarians in China progressed steadily, which was briefly summarized by WANG (1991). Almost reports of the late Paleozoic radiolarians were from the Upper Paleozoic on and around the Yangtze Platform, except for an occurrence of Early Permian radiolarians, *Pseudoalbaillella* cf. *sakmarensis* (Kozur) and *Follicucullus*? spp., from eastern Inner Mongolia (YAO, 1991) and for a report of Middle Carboniferous radiolarians from the East Tianshan Mountain, Xinjiang (LIU, 1992). The Early Permian radiolarians, *Psuedoalbaillella* cf. *longicornis* Ishiga, Kito and Imoto and *P.* cf. *sakmarensis* (Kozur) were found from the Chahe district, Menglian, western Yunnan (WU and LI, 1989). The Middle Permian radiolarians have been obtained by WANG (1991) from the Gufeng Formation and its equivalents, which are widely distributed on the Yangtze Platform. SHENG and WANG (1985) distinguished two radiolarian assemblage zones, namely, the *Pseudoalbaillella scalprata-P. fusiformis* Zone and the *Hegleria mammifera* Zone in the Gufeng Formation from Longtan, Nanjing on the eastern part of the Yangtze Platform. The two zones may be compared with the Middle Permian *Pseudoalbaillella longtanensis* and *P. globosa* Zones proposed by ISHIGA

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(1990) (WANG, 1991). Late Permian radiolarians are also reported from South Shanxi, Northeast Sichuan, South Anhui, Hubei and Guangxi of South China. WANG (1991) reported two characteristic radiolarian assemblages of Late Permian age. The first assemblage, from Qinzhou of southeastern Guangxi, may be compared with the *Follicucullus bipartitus -F. charveti* Assemblage (ISHIGA, 1986) of early Late Permian age. The second, collected by Dr. LI from the upper Upper Permian in Nandan, Guangxi, includes *Neoalbaillella* spp.

The first author (YAO) of this paper has carried out cooperative research with the senior author (AN) on Paleozoic radiolarians of China and Japan since 1987. As a part of this cooperative research, we had the Monbusho International Scientific Research Program (no. 03041069), titled as "Environmental change and process of mass extinction of Paleozoic organisms in Yangtze Block during Late Paleozoic to Early Mesozoic time" in 1991. The investigators of this project were AN Tai-xiang, WANG Xinping (Department of Geology, Peking University), MAEJIMA Wataru, EZAKI Yoichi and YAO Akira (Department of Geosciences, Osaka City University). In the autumn of 1991, we surveyed the Upper Paleozoic and the lowest Mesozoic of the Guizhou and Guangxi areas on the Yangtze Platform, and collected rock samples for examination of radiolarian fossils from them. The junior author (YU) chemically treated the rock samples and picked up radiolarian remains from the treated samples.

In this paper, we submit a preliminary report on the occurrence of late Paleozoic radiolarians from the Guizhou and Guangxi areas of South China. The radiolarian biostratigraphy of the Upper Paleozoic and the paleontological description of radiolarian fossils will be published in other papers in the near future.

Geologic setting and Materials

The survey areas of the Guizhou and Guangxi provinces belong tectonostratigraphically to the Yangtze Block (South China Block), which is composed of the Proterozoic basement (the Yangtze Platform) and the Phanerozoic cover. The Paleozoic and Mesozoic sequences are well developed on the Yangtze Platform. These sequences are gently folded but the stratigraphic relationships among the stratigraphic units are well recorded.

In the Guizhou and Guangxi areas (Fig. 1), the Middle Paleozoic clastic and calcareous facies are conformably overlain by the Upper Paleozoic. The Upper Paleozoic calcareous and clastic sediments are partly interbedded with siliceous layers and laterally change to siliceous facies in certain horizons. The boundary between the Permian and the Triassic in some sections is represented by the gradual change in lithology.

The three-fold subdivision of the Permian System has been recently generalized in South China (e.g., HUANG and CHEN, 1987; ZHOU *et al.*, 1987). The Mapingian and Longyinian or Changmoan Stages are referred to the Lower Permian, the Qixian and Maokouan Stages to the Middle Permian and the Wujiapingian and Changxingian Stages to the Upper Permian. These six stages were set up by a study of fusulinacean bio-

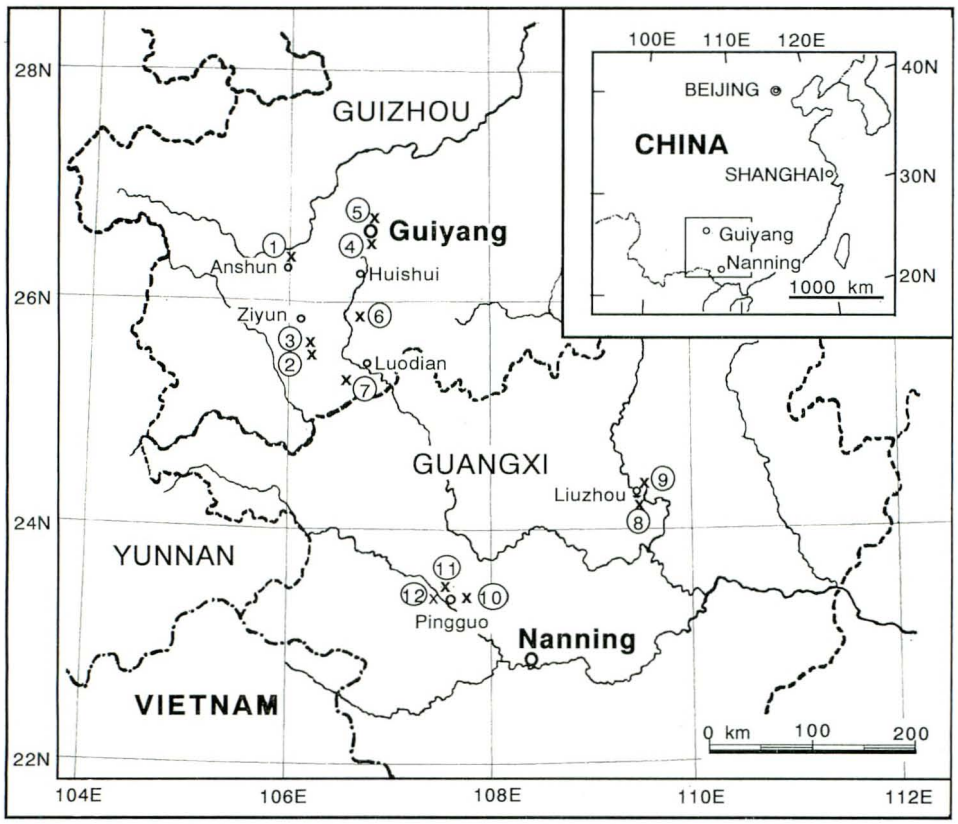

Fig. 1 Map showing the location of survey sections in the Guizhou and Guangxi areas, China.
1 Qiaozishan, 2 Maoshajing, 3 Shaiwa, 4 Taiciqiao, 5 Dulaying, 6 Duanshan, 7 Nashui, 8 Tongtianyan, 9 Niumuping, 10 Lingtang, 11 Taiping, 12 Guohualongiu.

stratigraphy in calcareous facies. The Gufeng Formation of siliceous facies is correlated to the Maokouan Stage, the Longtan Formation of clastic facies to the Wujiapingian Stage and the Dalong Formation of siliceous facies to the Changxingian Stage, respectively.

Survey sections are located in the Guizhou area (Sect. 1–6) and the Guangxi area (Sect. 7–12) (Fig. 1). Rock samples for examination of radiolarian fossils were collected from 207 points along the sections. The lithology of each rock sample is shown in Table 1. The stratigraphy of survey sections containing radiolarian remains, which basically depends on ZHANG Zhenghua *et al.* (1988), ZHANG Linxin *et al.* (1988), WANG *et al.* (1990) and "Stratigraphic Correlation Chart in China " (Nanjing Inst. Geol. Palaeont., Acad. Sinica, 1982), is as follws:

Section 1 (Fig. 2): Qiaozishan, 20 km north of Anshun, Guizhou. The Changxing Formation is composed of fossiliferous limestone, including chert nodules. The Dalong Formation (ca. 3 m thick) consists of laminated siliceous and calcareous mud-

Table 1 Occurrence of microfossils from the Guizhou and Guangxi areas, China.

C	Sm	L	R	F	S	O
1	1	sm				
	2	chn	x		x	x
	3	chn			x	x
	4	chn			x	x
	5	ms	x	x	x	x
	6	ms				x
	7	ms	x			x
	8	ms				x
	9	chn			x	
	10	chn	x	x	x	x
	11	ms	x			
	12	ms				
	13	ms			x	x
	14	ms				
	15	ms				
	16	ms				
	17	ms				
	18	ms				
	19	sm		x		x
2	20	chn				
	21	chn				
	22	chn			x	
	23	chn				x
	24	chn	x			x
	25	chn				
	26	chn				
	27	chn				
	28	ms				
3	29	ms				
	30	chl				
	31	chl				
	32	chl				
	33	chl			x	
	34	ms				
	35	ms				
	36	chl				
	37	ms				
	38	sm				
	39	chn		x		
	40	chn				
	41	ms			x	
	42	ms		x		
	43	ms				
	44	chl			x	
	45	chl				
4	46	ms				
	47	chl				
	48	chn			x	x
	49	chl			x	
	50	chl				
	51	chl			x	x
	52	chl			x	x

C	Sm	L	R	F	S	O
4	53	ms			x	
	54	chl				
	55	chn				
5	56	chl			x	
	57	chl				
	58	chl				x
	59	ms				
6	60	ms				
	61	ms				
	62	ms				
	63	ms				
	64	ms				
	65	ms				x
	66	ms				
	67	ms				
	68	ms				
	69	sm				
	70	chn				
	71	chl				
	72	sm				
	73	chn	x			
	74	chl			x	
7	75	chl				
	76	chl				
	77	chl				
	78	chl				
	79	chl				
	80	chl				
	81	chl			x	
	82	chl			x	
	83	chl				
	84	chl				
	85	chl			x	
	86	chl			x	
	87	chl				
	88	chl				
	89	chl				
	90	chl				
	91	chl			x	x
	92	chn				
	93	chl				
	94	chl				
	95	chl				
	96	chl	x			
	97	chl	x			
	98	chl	x			
	99	chl				
	100	chl				
	101	chl				
	102	chl				
	103	chl	x			
	104	ms			x	

C	Sm	L	R	F	S	O
7	105	chl			x	
	106	chl			x	
	107	chl				
	108	chl				
	109	chl				
	110	ms				
	111	chl				
	112	chl			x	
	113	chl				
	114	chl				
	115	chl				
	116	chl			x	x
	117	chl				
	118	chn				
	119	chl			x	
	120	sm			x	
	121	chl	x		x	
	122	chl	x		x	
	123	chl				
	124	chl	x			
	125	chl				
	126	chl				
	127	chl				
	128	chl	x		x	
	129	chl				
	130	chl			x	
	131	chl	x		x	
	132	chl				
	133	ms	x			
8	134	chl	x			
	135	sm	x			
	136	sm				
	137	sm	x			
	138	chl				
	139	chl			x	x
9	140	sm				
	141	chl				
	142	chl				
	143	chl				
	144	chl				
	145	chn				
	146	chn				
	147	chl				
10	148	ms				
	149	sm	x			
	150	ms	x		x	
	151	ms				
	152	ms	x			
	153	ms			x	x
	154	chl	x			
	155	chl			x	
	156	chl	x			

C	Sm	L	R	F	S	O
10	157	chl				
	158	sm				
	159	sm				
	160	chn				
	161	chn				
	162	chl				
	163	chl				
	164	chl	x			
	165	chl				
	166	chl				
	167	chl				
11	168	chn				
	169	chl				
	170	chl			x	x
	171	chl				
	172	chl				x
	173	ms				
	174	sm				
12	175	ms				
	176	ms				
10	177	chl	x			
	178	chl				
	179	chl				
	180	chl			x	x
	181	chl				
	182	chl			x	
	183	chl		x		x
	184	chl				
	185	chl				
	186	chl			x	
	187	chl				
	188	chl				
	189	chl				
	190	chl			x	x
	191	chl				
	192	chl				
	193	chl				
	194	chl			x	x
	195	chl	x			
	196	chl	x		x	
	197	chl			x	x
	198	chl				
	199	chl				x
	200	chl				
	201	chl				
	202	chl				
	203	chl				
	204	chl				
	205	chl				
	206	chl				
	207	chl				

C-Section number; Sm-Rock sample number; L-lithology, ms-mudstone, sm-siliceous mudstone, chn-chert nodule, chl-chert layer; R-radiolarians, F-foraminifers, S-sponge spicule, O-ostracods.

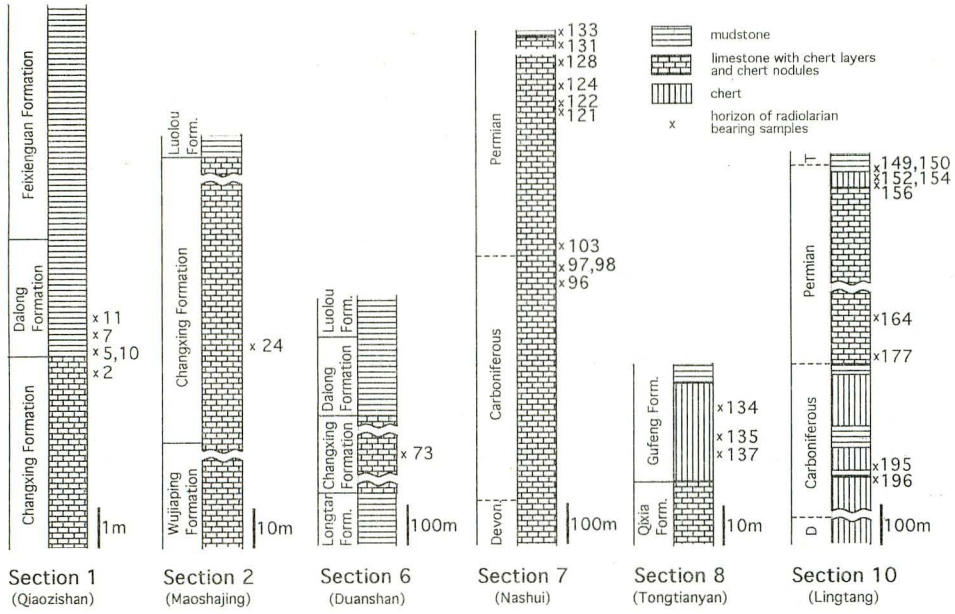

Fig. 2 Columnar sections showing the horizons of radiolarian bearing samples.

stone which abundantly yields the Late Permian ammonite *Pseudotirolites*. The lowermost part of the Lower Triassic Feixienguan Formation is represented by laminated, yellowish mudstone. Rock sample nos. 1–19.

Section 2 (Fig. 2): Maoshajing, 34 km southwest of Ziyun, Guizhou. The Wujiaping and Changxing Formations are widely distributed in this district, and are composed of thick limestone, including chert nodules sporadically. The Feixienguan Formation consists mainly of mudstone and fine sandstone in the lowermost part, and immediately covers the Changxing Formation. Rock sample nos. 20–28.

Section 6 (Fig. 2): Duanshan, 35 km south of Huishui, Guizhou. The Wujiaping, Changxing, Dalong Formations and the Lower Triassic Luolou Formation are successively developed along this section. Laminated mudstone of the Dalong Formation contains abundant Late Permian ammonites. The boundary clay layer (13 cm thick) is interbedded between the mudstone layers of the upper Upper Permian (the Dalong Formation) and the lower Lower Triassic (the Luolou Formation). Rock sample nos. 60–74.

Section 7 (Fig. 2): Nashui, 30 km southwest of Luodian, Guizhou. The Upper Devonian to the Upper Permian limestone layers are thick developed in this area. The limestone layers are frequently accompanied by chert layers. The Upper Carboniferous and Permian limestone yields fusulinaceans. Rock sample nos. 75–133.

Section 8 (Fig. 2): Tongtianyan, 20 km south of Liuzhou, Guangxi. In this section, chert layers of the Gufeng Formation immediately cover the limestone of the Qixia Formation. Rock sample nos. 134–139.

Section 10 (Fig. 2): Lingtang, 20 km northeast of Pingguo, Guangxi. The Upper

Devonian to the Lower Triassic crop out along this section. The Upper Devonian and the Carboniferous are composed mainly of tuffaceous chert and mudstone. The Permian consists of limestone, including chert nodules, in the lower and middle parts, and of chert and siliceous mudstone in the upper part. Rock sample nos. 148–167 and 177–207.

Rock samples were immersed in a 5% solution of hydrofluoric acid for 24 hours. Residues were obatined by using 35 to 200 mesh sieves. Radiolarians and other microfossils within the residue were picked up under a binocular microscope and mounted on a hole slide and on a sample holder of scanning electron microscope.

Occurrence of radiolarians

Some of the rock samples (nos. 1–207) from the Upper Paleozoic of the Guizhou and Guangxi areas on the Yangtze Platform contain microfossils, such as radiolarians, foraminifers, sponge spicules and ostracods (Table 1). Radiolarian fossils were obtained from 29 rock samples of 6 sections. Their horizons are shown in the columnar section (Fig. 2). Among them, albaillellarian radiolarians were identified as follows:

No. 11 (Sect. 1) from the Dalong Formation: *Follicucullus scholasticus* Ormiston and Babcock, 1979 (Pl. 1, fig. 1) and *Albaillella excelsa* Ishiga, Kito and Imoto, 1982 (Pl. 1, fig. 2).

No. 24 (Sect. 2) from the Changxing Formation: *Albaillella triangularis* Ishiga, Kito and Imoto, 1982 (Pl. 1, fig. 3).

No. 73 (Sect. 6) from the Changxing Formation: *Albaillella excelsa* Ishiga, Kito and Imoto, 1982 (Pl. 1, figs. 4 and 5).

No. 98 (Sect. 7) from the Carboniferous: *Pseudoalbaillella* sp. (Pl. 1, fig. 10).

No. 103 (Sect. 7) from the Permian: *Pseudoalbaillella* cf. *u-forma* Holdworth and Jones, 1980 (Pl. 1, fig. 11).

No. 124 (Sect. 7) from the Permian: *Albaillella* cf. *levis* Ishiga, Kito and Imoto, 1982 (Pl. 1, fig. 6).

No. 128 (Sect. 7) from the Permian: *Albaillella excelsa* Ishiga, Kito and Imoto, 1982 (Pl. 1, fig. 9).

No. 133 (Sect. 7) from the Permian: *Albaillella excelsa* Ishiga, Kito and Imoto, 1982 (Pl. 1, fig. 7) and *A. levis* Ishiga, Kito and Imoto, 1982 (Pl. 1, fig. 8).

No. 137 (Sect. 8) from the Gufeng Formation: *Follicucullus scholasticus* Ormiston and Babcock, 1979 (Pl. 2, fig. 2) and *Pseudoalbaillella*? sp. (Pl. 2, fig. 4).

No. 154 (Sect. 10) from the Permian?: *Pseudoalbaillella* sp. (Pl. 2, figs. 6 and 7).

No. 156 (Sect. 10) from the Permian: *Neoalbaillella optima* Ishiga, Kito and Imoto, 1982 (Pl. 2, fig. 9).

No. 164 (Sect. 10) from the Permian: *Follicucullus scholasticus* Ormiston and Babcock, 1979 (Pl. 2, fig. 8).

No. 177 (Sect. 10) from the Permian or Carboniferous: *Pseudoalbaillella* cf. *u-forma* Holdworth and Jones, 1980 (Pl. 2, fig. 10) and *P.* cf. *annulata* Ishiga, 1984 (Pl. 2, fig. 11).

Samples from Section 8 of the Gufeng Formation yield stauraxon polycystines such as *Nazarovella* sp. (no. 134; Pl. 2, fig. 1) and *Latentifistula* sp. (no. 137; Pl. 2, fig. 3), and spumellarian radiolaria (no. 135; Pl. 2, fig. 5).

Age of radiolarian fauna

The Late Paleozoic radiolarian fauna is characterized by some albaillellarian genera (*Albaillella, Pseudoalbaillella, Neoalbaillella* and *Follicucullus*) and stauraxon polycystines. NAZAROV and ORMISTON (1986) recognized 15 zones of stauraxon polycystines for the Upper Paleozoic. ISHIGA (1986) set up 13 zones based on albaillellarians for the Upper Carboniferous to Permian of Japan.

On the basis of their specific compositions and ranges, the Late Paleozoic radiolarians from South China now under investigation are preliminarily divided into three faunas, namely the late Carboniferous to early Permian fauna, the late Middle Permian fauna, and the Late Permian fauna.

1. The late Carboniferous to early Permian radiolarian fauna

This radiolarian fauna contains *Pseudoalbaillella u-forma* and *P.* cf. *annulata*. In Sect. 7, *Pseudoalbaillella* sp. is obtained from sample of no. 98 which cocurs in the *Triticites* Zone of the uppermost Carboniferous. This horizon (no. 98) may be correlated with the *Pseudoalbaillella nodosa* or *P. bulbosa* Zones of ISHIGA (1986). The radiolarian fauna from the middle part (sample of no. 177) of the Lingtang section (Sect. 10) containing *Pseudoalbaillella* cf. *u-forma* and *P.* cf. *annulata* is similar to the fauna of *P. u-forma* m. I Zone of ISHIGA (1986). The concurrent range of *P. u-forma* and *P. annulata* is restricted to latest Carboniferous and/or earliest Permian in age. The horizon of no. 177 may correspond to the boundary part between the Carboniferous and the Permian. The horizon of no. 103 in Sect. 7, which is equivalent to the *Pseudofusulina* Zone of the upper Lower Permian, yields *Pseudoalbaillella* cf. *u-forma*. It may be correlated with the *Albaillella sinuata* Zone of ISHIGA (1986) only on the basis of age estimation by fusulinaceans.

2. The late Middle Permian radiolarian fauna

This radiolarian fauna from the Gufeng Formation of Sect. 8 contains *Follicucullus scholasticus, Pseudoalbaillella*? sp., *Nazarovella* sp., *Latentifistula* sp. and spumellarian radiolaria. WANG (1991) reported a large number of radiolarian species belonging to *Psuedoalbaillella, Follicucullus* and stauraxon polycystines from the Gufeng Formation, and estimated the age of radiolarian fauna as Maokouan (late Middle Permian). On the basis of WANG (1991) and the age of first occurrence of *Follicucullus scholasticus*, the horizon of no. 137 may correspond to the uppermost Middle Permian. The horizon of no. 164 in Sect. 10, which yields only *Follicucullus scholasticus*, may be aslo the uppermost Middle Permian.

3. The Late Permian radiolarian fauna

This radiolarian fauna is characterized by *Albaillella triangularis, A. excelsa, A. levis* and *Neoalbaillella optima*. It is found from the Changxing Formation (no. 24 in Sect. 2 and no. 73 in Sect. 6), the equivalent to the Changxing Formation (nos. 124, 128 and 133 in Sect. 7), the Dalong Formation (no. 11 in Sect. 1) and the equivalent to the Dalong Formation (no. 156 in Sect. 10). On the basis of stratigraphic range of *Albaillella triangularis* and *A. excelsa* sited by ISHIGA (1986), the horizon of no. 24 is correlated with the upper part of *Follicucullus scholasticus* Zone and/or the *Neoalbaillella optima* Zone, and the *N. ornithoformis* Zone. The horizon of nos. 124 to 133 in Sect. 7 may be correlated with the *N. ornithoformis* Zone because of co-occurrence of *A. excelsa* and *A. levis*. The radiolarian species, *A. excelsa* and *F. scholasticus* from the Dalong Formation (no. 11 in Sect. 1) belong to the fauna of the boundary part between the *N. optima* Zone and the *N. ornithoformis* Zone. The siliceous mudstone of the same horizon abundantly contains the Late Permian ammonite *Pseudotirolites*. The horizon of no. 156, containing *N. optima* in Sect. 10, corresponds to the *N. optima* Zone and/or the *N. ornithoformis* Zone.

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Plate 1

Fig. 1 *Follicucullus scholasticus* Ormiston and Babcock, rock sample no. 11, Sect. 1, x100.

Fig. 2 *Albaillella excelsa* Ishiga, Kito and Imoto, rock sample no. 11, Sect. 1, x175.

Fig. 3 *Albaillella triangularis* Ishiga, Kito and Imoto, rock sample no. 24, Sect. 2, x250.

Figs. 4-5. *Albaillella excelsa* Ishiga, Kito and Imoto, rock sample no. 73, Sect. 6, x175.

Fig. 6 *Albaillella* cf. *levis* Ishiga, Kito and Imoto, rock sample no. 124, Sect. 7, x250.

Fig. 7 *Albaillella excelsa* Ishiga, Kito and Imoto, rock sample no. 133, Sect. 7, x175.

Fig. 8 *Albaillella levis* Ishiga, Kito and Imoto, rock sample no. 133, Sect. 7, x250.

Fig. 9 *Albaillella excelsa* Ishiga, Kito and Imoto, rock sample no. 128, Sect. 7, x175.

Fig. 10 *Pseudoalbaillella* sp., rock sample no. 98, Sect. 7, x175.

Fig. 11 *Pseudoalbaillella* cf. *u-forma* Holdworth and Jones, rock sample no. 103, Sect. 7, x175.

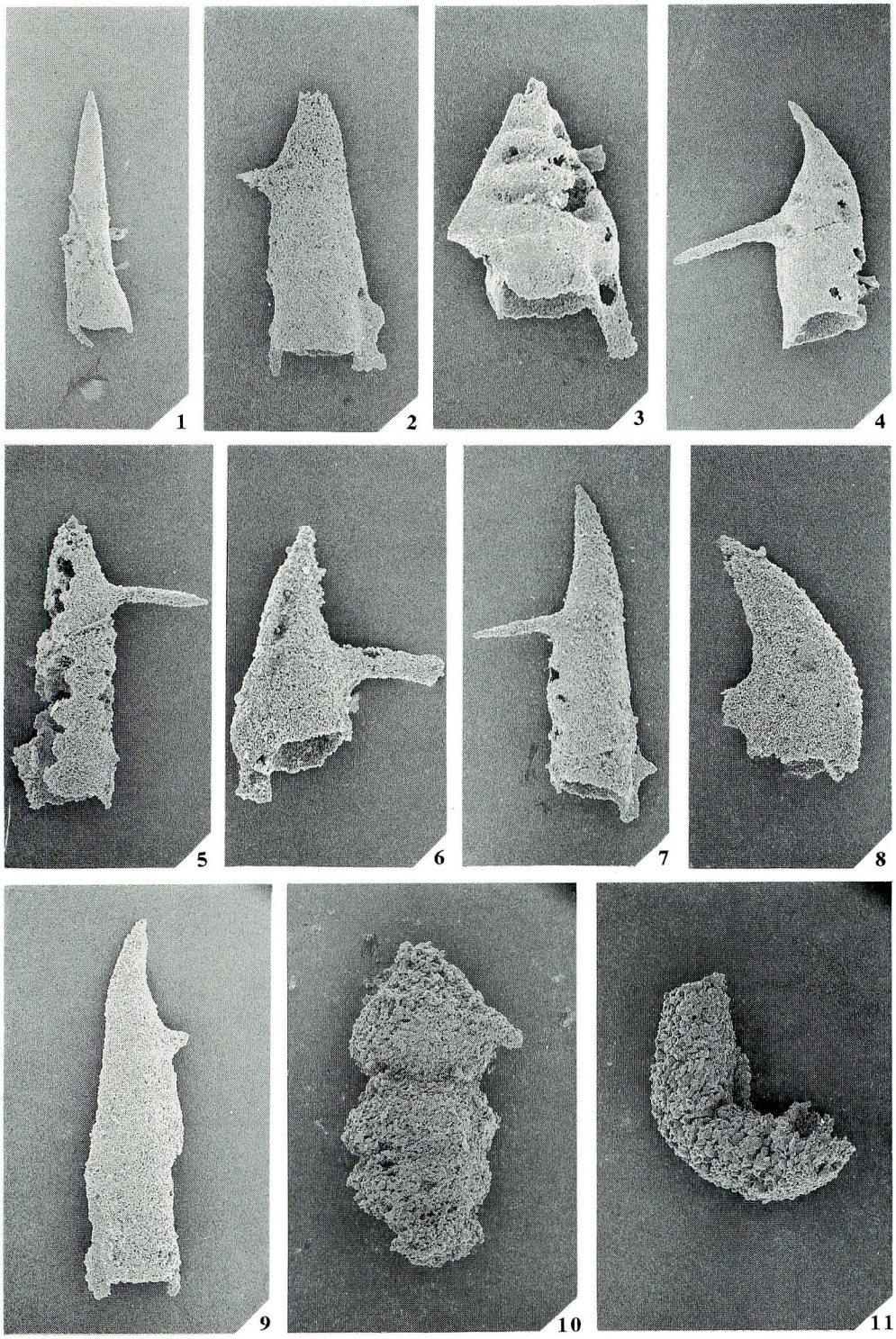
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Plate 2

Fig 1 *Nazarovella* sp., rock sample no. 134, Sect. 8, x250.

Fig. 2 *Follicucullus scholasticus* Ormiston and Babcock, rock sample no. 137, Sect. 8, x175.

Fig. 3 *Latentifistula* sp., rock sample no. 137, Sect. 8, x175.

Fig. 4 *Pseudoalbaillella*? sp., rock sample no. 137, Sect. 8, x175.

Fig. 5 Spumellaria, rock sample no. 135, Sect. 8, x175.

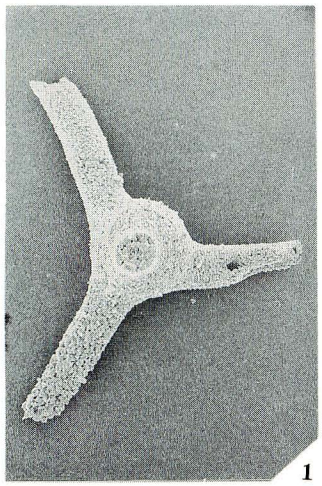
Figs. 6-7. *Pseudoalbaillella* sp., rock sample no. 154, Sect. 10, x175.

Fig. 8 *Follicucullus scholasticus* Ormiston and Babcock, rock sample no. 164, Sect. 10, x100.

Fig. 9 *Neoalbaillella optima* Ishiga, Kito and Imoto, rock sample no. 156, Sect. 10, x250.

Fig. 10 *Pseudoalbaillella* cf. *u-forma* Holdworth and Jones, rock sample no. 177, Sect. 10, x175.

Fig. 11 *Pseudoalbaillella* cf. *annulata* Ishiga, rock sample no. 177, Sect. 10, x175.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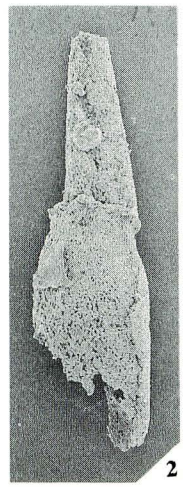
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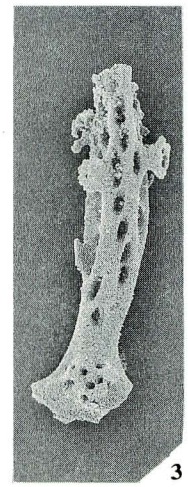
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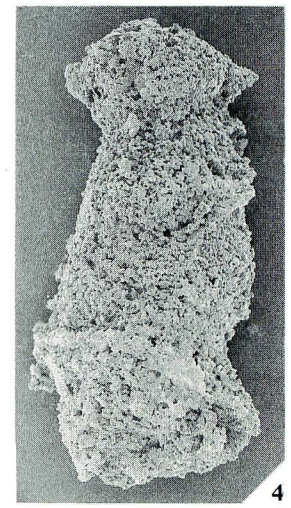
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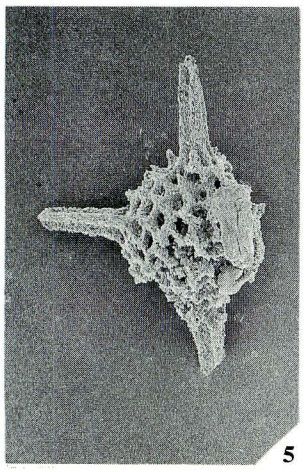
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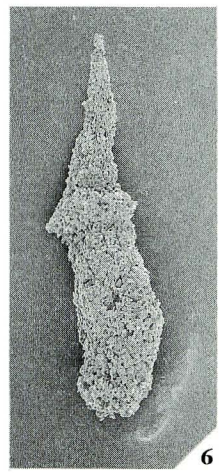
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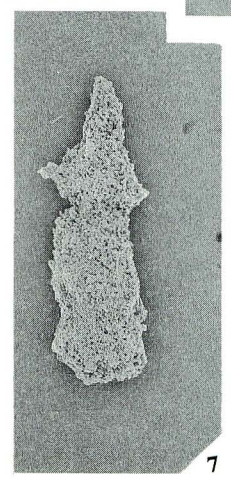
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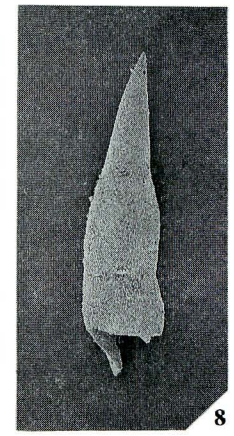
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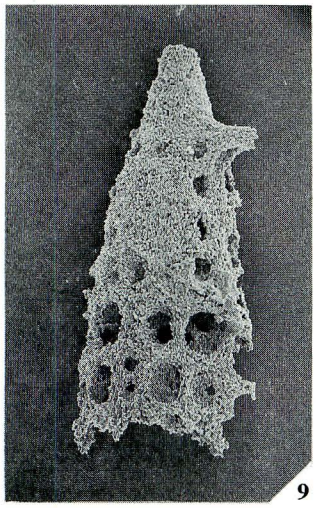
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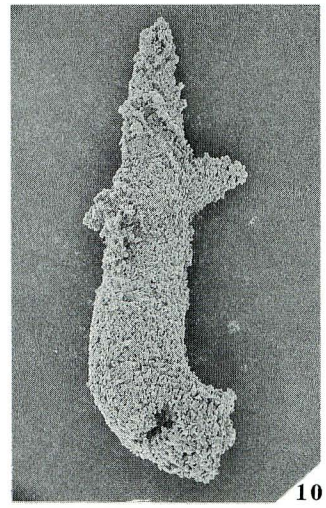
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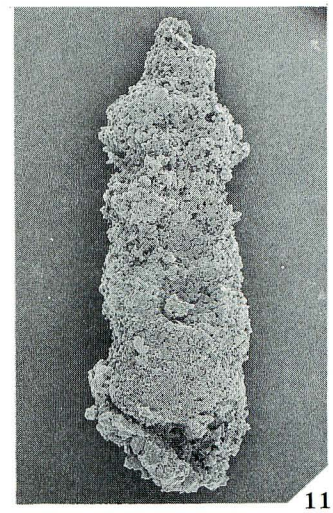
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