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Paleozoic and Mesozoic complexes in the Yunnan area, China (Part 1) : Preliminary report of Middle - Late Permian radiolarian assemblages

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Abstract

Middle - Late Permian radiolarians were detected in the siliceous sediments of the Laba and Nanpihe Groups in the Changning-Menglian Terrane of the southwestern Yunnan area, China. These radiolarian assemblages contain albaillellarians, entactinarians and spumellarians. On the basis of the characteristic albaillellarian assemblages, seven radiolarian zones were distinguished. They are named the *Follicucullus monacanthus*, *Follicucullus scholasticus*, *Follicucullus charveti*, unnamed, *Albaillella excelsa*, *Albaillella levis* and *Neoalbaillella pseudogrypa* Zones, in ascending order. These zones were correlated with the Japanese radiolarian zones. They are useful for worldwide correlation in the Paleotethys and the Panthalassa regions.

Key Words: Middle - Late Permian, radiolarians, Changning-Menglian Terrane, Yunnan, Paleotethys.

Introduction

The Paleozoic - Mesozoic accretionary complexes and continental massives are distributed widely in the southwestern part of the Yunnan Province, China. These complexes and massives are grouped into several geological domains. One of these geological domains, the Changning-Menglian Terrane, is focused on in order to reconstruct the development of Paleotethys in Paleozoic - Mesozoic times. Radiolarian fossils are useful for geological age determination in such sedimentary complexes. Radiolarian research in the Paleozoic and Lower Mesozoic of the Yunnan area has been recently developed (e.g., Wu and Li, 1989; Feng, 1992; Feng and Liu, 1992, 1993). Because the geological structure of the Changning-Menglian Terrane is very complicated, the stratigraphy and tectonics were not completely known until now. The Changning-Menglian Terrane and the Lancangjiang Terrane extend over the Nan-Uttradit suture of Northern Thailand (Liu *et al.*, 1993). Very recently, the tectonic setting of the Laba Group in the Changning-Menglian Terrane has been newly reconstructed (Feng *et al.*, 1996). It is important to clarify the stratigraphy of the Paleozoic and Mesozoic complexes of the Changning-Menglian Terrane for understanding southeast Asian geology.

The authors (Yao and An) have carried out cooperative research concerning the Paleozoic-Mesozoic radiolarians of China and Japan since 1987. In 1994, the senior author (An) surveyed the southwestern Yunnan area in advance of the cooperative research. During December 1995 - January 1996, we surveyed the Changning-Menglian Terrane in the Yunnan area and collected rock samples. This paper deals preliminarily with the Middle - Late Permian radiolarian assemblages from the southwestern Yunnan area, China. The radiolarian assemblage zones are provisionally established, and these radiolarian zones are correlated with the Japanese ones.

Outline of Geology and Materials

The Paleozoic - Lower Mesozoic accretionary complexes and continental massives in the southwesten Yunnan area are zonally arranged in a N-S direction. These complexes and massives are divided into five geological domains, namely, the Baoshan Block, Gengma Block, Changning-Menglian Terrane, Lincang Block and Lancangjiang Terrane from west to east (Liu *et al.*, 1993). The Changning-Menglian Terrane is regarded as a suture zone formed by the closure of the Paleotethys during Early Mesozoic time (e.g., Liu *et al.*, 1993).

According to Liu *et al.* (1993), the Changning - Menglian Terrane is represented by the Nanduan Group

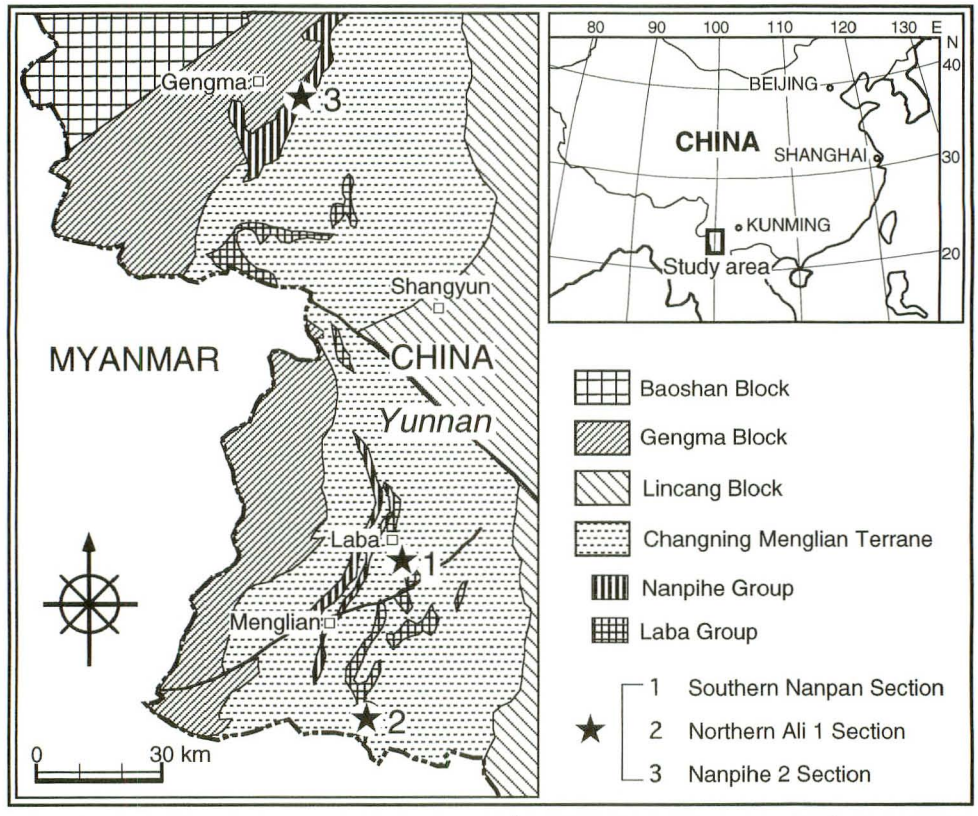

Fig. 1. Geological sketch map of the southwestern Yunnan area (modified form Liu *et al.*, 1993), showing the locality of study sections.

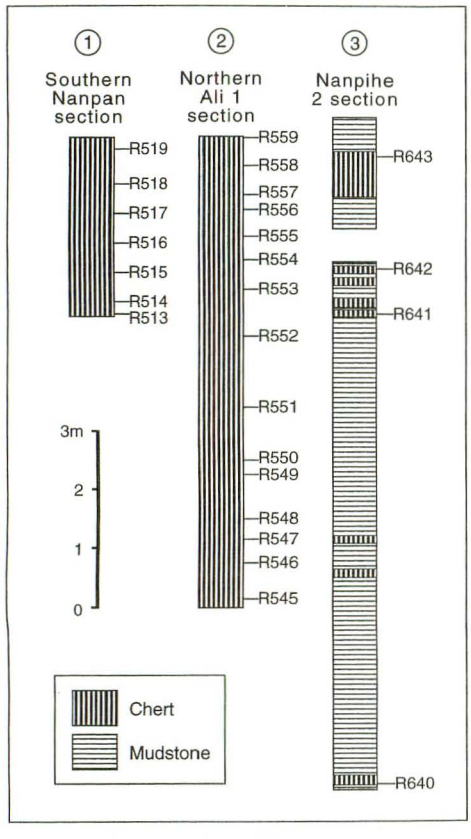

Fig. 2. Columns of the southern Nanpan, northern Ali 1, and Nanpihe 2 sections, showing the sampling horizons and sample numbers.

(Upper Devonian? - Upper Carboniferous), the Laba Group (Upper Carboniferous - Upper Permian), the Yiliu Formation (Carboniferous - Permian), the Muyinhe Formation (Lower - Middle Triassic) and the Nanpihe Group (Upper Devonian - Upper Permian). The Laba Group is composed of quartz sandstone, siltstone, purple mudstone, bioclastic marlstone and bedded tuffaceous - siliceous rocks. In the type section located in Nanpan Village, Lancang County, the Laba Group is estimated to be 1230 m thick. The Nanpihe Group consists of a melange facies, composed mainly of chert - greenstone blocks within a clastics matrix. This facies typically outcrops along the Nanpihe river, Gengma County. The siliceous, tuffaceous and pelitic rocks of these groups abundantly contain Late Paleozoic radiolarian fossils.

In this study, three sections (described below; Figs. 1, 2) of the Laba and Nanpihe Groups are examined, based on radiolarian biostratigraphy.

1. The southern Nanpan section

The southern Nanpan section is located south of Nanpan Village, Lancang County. The section consists of the upper part of the type section of the Laba Group, and is composed of pinkish tuffaceous chert beds. The thickness of the section is about 3 m, and the

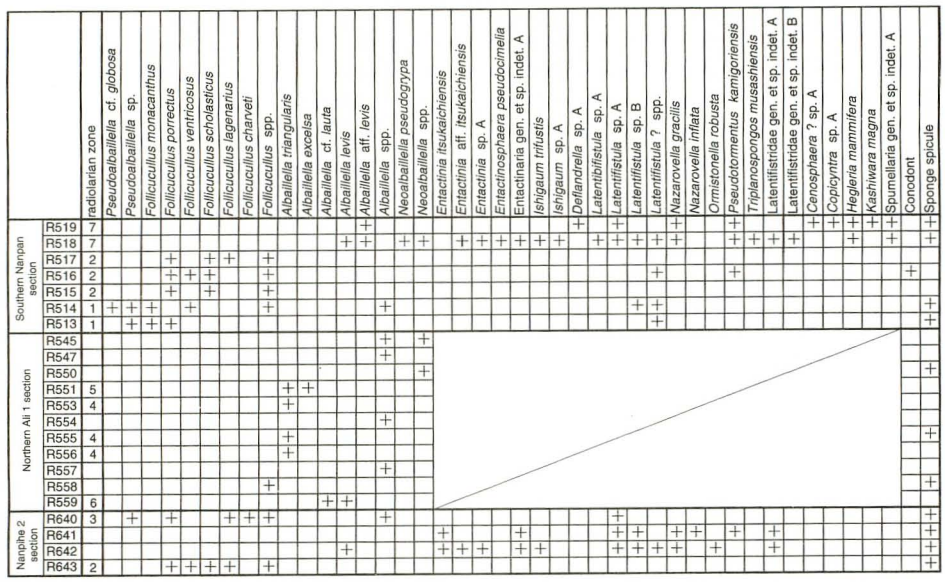

Fig. 3. List of the radiolarian species from the southern Nanpan, northern Ali 1, and Nanpihe 2 sections. The numbers of the radiolarian zones are 1:*Follicucullus monacanthus;* 2:*Follicucullus scholasticus;* 3:*Follicucullus charveti;* 4:unnamed; 5:*Albaillela excelsa;* 6:*Albaillella levis;* and 7:*Neoalbaillella pseudogrypa* Zones, respectively.

thickness of one chert bed is 2-5 cm. Seven chert samples (R513-R519) were collected.

2. The northern Ali 1 section

The northern Ali 1 section, located near Ali Village, Menglian County, is composed of a bedded chert sequence, which is about 8 m thick. This chert sequence is regarded as a block within the melange of the Laba Group. The bedded cherts consist of rhythmically alternating grey - pinkish chert layers, 2-5 cm thick, interbedded with thin siliceous mudstone layers, 1-2 mm thick. Fifteen chert samples (R545-R559) were collected.

3. The Nanpihe 2 section

The Nanpihe 2 section is about 15 km southeast of Gengma, along the Nanpihe river, Gengma County. This section consists of alternating beds of grey, thin chert and reddish, thick mudstone. The geological sequence of this section is regarded as a block within the melange of the Nanpihe Group. Four chert samples (R640-R643) were collected.

Radiolarian fauna

For the past several years, Paleozoic and Lower Mesozoic radiolarian studies in the Yunnan area have progressed considerably. However, knowledge of the classification of Permian Entactinaria and Spumellaria is still meagre, in comparison with that of Albaillellaria. Except for the very characteristic species, specific identification is tentative.

As a result of the present examination, radiolarian fossils were detected from 22 rock samples of the three sections in the Changning-Menglian Terrane. A total of 18 genera and 36 species of Middle - Late Permian radiolarians are recognized (Fig. 3 and Plates 1-3). In addition, other microfossils occurring with radiolaria are also listed in Fig. 3. Radiolarian fossils are moderately well preserved in the southern Nanpan section and the Nanpihe 2 section, but are poorly preserved in the northern Ali 1 section. Therefore, only the Albaillellarian species were focused on in the northern Ali 1 section.

The Middle - Late Permian radiolarian faunas from the Changning-Menglian Terrane are characterized by albaillellarians, entactinarians and spumellarians. The composition of species is almost the same as that previously reported from the Middle to Upper Permian in the world. The albaillellarian genera *Albaillella, Follicucullus, Neoalbaillella* and *Pseudoalbaillella,* are characteristic taxa of the radiolarian biostratigraphy of the Middle - Upper Permian worldwide. The entactinarians (*Entactinia, Entactinosphaera* etc.) and the spumellarians (*Hegleria, Ishigaum, Latentifistula, Nazarovella, Triplanospongos* etc.) are some of the major component species in Middle - Late Permian faunas all over the world. An endemic species for this area has not yet been detected.

The occurrence of a fauna characterized by diversified stauraxon spumellarians and very rare albaillellarians is worth noting. Such a fauna occurs in

R642 of the cherty intercalation in mudstone, in the Nanpihe 2 section. Stauraxon spumellarians occur exclusively both in the number of species and in the individual abundance of each species. A preliminary study of faunal composition indicates that stauraxon spumellarians form nearly 70 per cent in individual abundance. Spherical spumellarians and entactinarians are not common. In the other samples from the Nanpihe 2 and southern Nanpan sections, the abundance of stauraxon spumellarians range from several to 20 per cent. A more accurate faunal analysis will be carried out in the future.

Radiolarian assemblage zone

On the basis of the characteristic albaillellarian assemblages, six radiolarian assemblage zones and one unnamed zone are provisionally set up herein. They are the *Follicucullus monacanthus, Follicucullus scholasticus, Follicucullus charveti,* unnamed, *Albaillella excelsa, Albaillella levis* and *Neoalbaillella pseudogrypa* Zones, in ascending order. The characteristic species of each assemblage are divided into the diagnostic species (restricted to one assemblage) and the common species (occurring in adjacent assemblages also).

1. *Follicucullus monacanthus* Assemblage Zone

Composition of radiolarian assemblage: The diagnostic species of this zone is *Follicucullus monacanthus* Ishiga and Imoto. The common species are *Follicucullus porrectus* Rudenko, *Follicucullus ventricosus* Ormiston and Babcock and *Pseudoalbaillella* cf. *globosa* Ishiga and Imoto.

Age: late Middle Permian.

Occurrence: Chert of the lower part of the southern Nanpan section (R513 and R514).

2. *Follicucullus scholasticus* Assemblage Zone

Composition of radiolarian assemblage: The diagnostic species is *Follicucullus scholasticus* Ormiston and Babcock. The common species are *Follicucullus porrectus, Follicucullus ventricosus,* and *Follicucullus lagenarius* Rudenko.

Age: latest Middle Permian - earliest Late Permian (early Wujiapingian)?

Occurrence: This zone occurs in the middle part of the southern Nanpan section (R515, R516 and R517), consisting of chert. A chert intercalation in mudstone of the Nanpihe 2 section (R643) is also assigned to this zone. The occurrence of the *Follicucullus scholasticus* assemblage in the stratigraphic level number 11 of the Nanpan section, and the so-called "pseudo-Laba Formation" in the Xiaolaba district (Feng and Liu, 1992) are regarded as corresponding to this zone. Dx-252 in the Ali district and D-270 in the Chahe district (Wu and Li, 1989) can probably be correlated with this zone.

Correlation: A part of the strata containing the *Follicucullus* assemblage (Liu *et al.*, 1993) may be the equivalent of this zone.

Remarks: *Follicucullus scholasticus* was first described from the Guadalupian Lamar limestone (Ormiston and Babcock, 1979). In Japan, the *Follicucullus scholasticus* assemblage occurs in the *Lepidolina kumaensis* fusulinid zone (Ishiga, 1986). Kozur (1993) re-investigated the type locality of *Follicucullus ventricosus* and *Follicucullus scholasticus* and other localities of Lamar limestone. He indicated that the fauna is accompanied by Dzhulfian conodonts. Kozur and Mostler (1989) placed the *Follicucullus ventricosus - Ishigaconus* (=*Follicucullus*) *scholasticus* Assemblage Zone over the *Follicucullus monacanthus* Zone, and placed it under the *Follicucullus charveti - Imotoella triangularis* Zone. However, Kozur (1993) regards that his *Follicucullus ventricosus - Ishigaconus scholasticus* Assemblage Zone overlies the *Follicucullus charveti - Follicucullus porrectus* Assemblage Zone. Considering the above information, the age of this *Follicucullus scholasticus* Assemblage Zone seems to be still debatable.

3. *Follicucullus charveti* Assemblage Zone

Composition of radiolarian assemblage: *Follicucullus charveti* Caridroit and De Wever is the diagnostic species of this zone. *Follicucullus porrectus* and *Follicucullus lagenarius* occur as the common species.

Age: early Late Permian (Wujiapingian)

Occurrence: Chert intercalation in mudstone of the Nanpihe 2 section (R640).

4. Unnamed zone

Composition of radiolarian assemblage: This zone is characterized by the abundant occurrence of *Albaillella triangularis* Ishiga, Kito and Imoto.

Age: middle Late Permian (late Wujiapingian - early Changxingian).

Occurrence: Bedded chert of the northern Ali 1 section (R553, R555 and R556).

Remarks: The *Albaillella excelsa* Assemblage Zone (described below) is overlain by this zone. This zone characterized only by *Albaillella triangularis*, and, therefore, it is impossible to define as an assemblage zone.

5. *Albaillella excelsa* Assemblage Zone

Composition of radiolarian assemblage: The diagnostic species of this zone is *Albaillella excelsa* Ishiga, Kito and Imoto. *Albaillella triangularis* is the common species.

Age: late Late Permian (Changxingian).

Occurrence: Bedded chert of the northern Ali 1 section (R551). This assemblage zone corresponds to Dx-286 and, probably, to Dx-287 of Wu and Li (1989) from the eastern Ali district.

Correlation: A part of the strata containing the *Neoalbaillella ornithoformis* Assemblage (Liu *et al.*, 1993) is a possible equivalent of this zone.

6. *Albaillella levis* Assemblage Zone

Composition of radiolarian assemblage: This zone is characterized by the assemblage of *Albaillella levis* Ishiga, Kito and Imoto as the common species and *Albaillella* cf. *lauta* Kuwahara as the diagnostic species.

Age: late Late Permian (Changxingian).

Occurrence: Bedded chert of the northern Ali 1 section (R559).

Correlation: Some strata containing the *Neoalbaillella ornithoformis* assemblage (Liu *et al.*, 1993) may be the equivalent to this zone.

7. *Neoalbaillella pseudogrypa* Assemblage Zone

Composition of radiolarian assemblage: This zone is characterized by *Neoalbaillella pseudogrypa* Sashida and Tonishi and *Albaillella* aff. *levis* as the diagnostic species. The common species is *Albaillella levis*.

Age: late Late Permian (Changxingian).

Occurrence: Chert of the upper part of the southern Nanpan section (R518 and R519).

Discussion

(1) Correlation of radiolarian zones between the Yunnan area and Japan

From the upper Middle - Upper Permian of the Laba and Nanpihe Groups in the southwesten Yunnan area, seven radiolarian zones are distinguished, namely, the *Follicucullus monacanthus, Follicucullus scholasticus, Follicucullus charveti*, unnamed, *Albaillella excelsa, Albaillella levis* and *Neoalbaillella pseudogrypa* Zones, in ascending order. These zones are correlated with the Japanese radiolarian zones based on the occurrence of characteristic albaillellarian species (Fig. 4). The *Albaillella excelsa* Assemblage Zone of the northern Ali 1 section corresponds to the lower part of the *Neoalbaillella ornithoformis* Zone because *Albaillella excelsa* is restricted in its occurrence to the *Neoalbaillella*

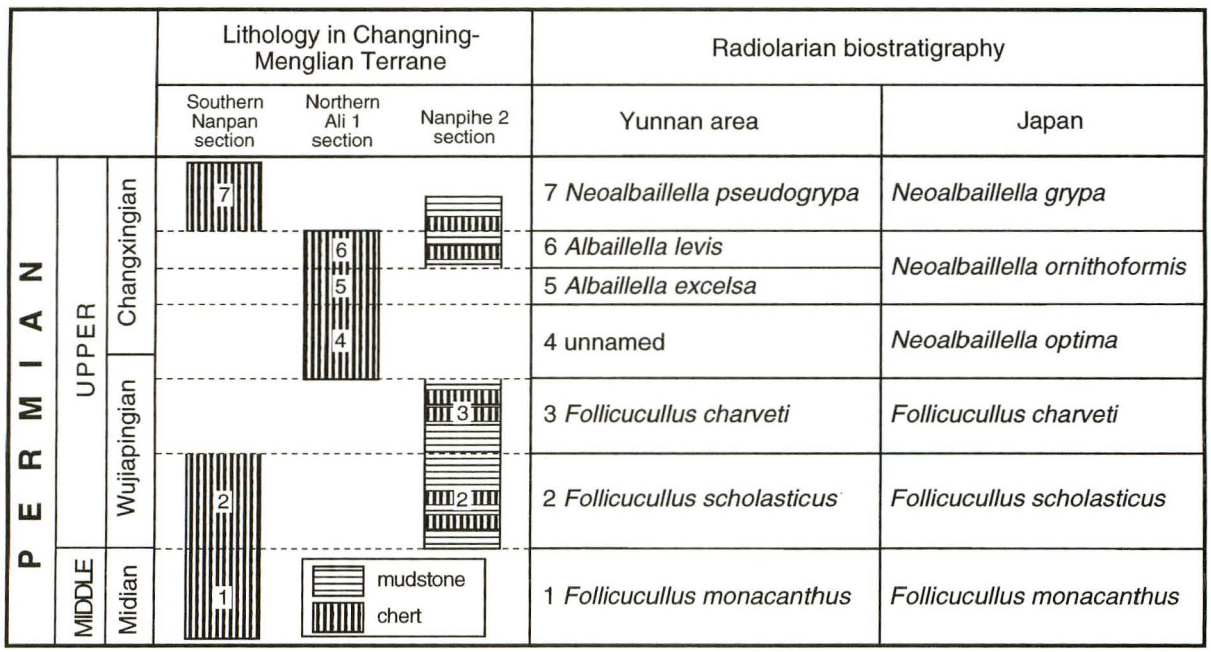

Fig. 4. Correlation of study sections of the Changning-Menglian Terrane, on the basis of the radiolarian biostratigraphy.

ornithoformis Zone in Japan. The *Albaillella levis* Assemblage Zone of the northern Ali 1 and Nanpihe 2 sections is characterized by the occurrence of *Albaillella levis*. In Japan, *Albaillella levis* is most abundant in the *Albaillella levis* Abundance Zone (Kuwahara, 1997), which is within the *Neoalbaillella ornithoformis* Zone. From this fact, the *Albaillella levis* Assemblage Zone is correlated with the upper part of the *Neoalbaillella ornithoformis* Zone in Japan.

The radiolarian-bearing sediments of the Laba and Nanpihe Groups were deposited on the Paleotethys region during Late Paleozoic time (e.g., Wu and Li, 1989; Feng and Liu, 1992; Liu *et al.*, 1993). On the other hand, the Upper Paleozoic chert sequence of southwest Japan is regarded as derived from pelagic sediments formed under the low-latitude area in the Panthalassa oceanic basin. According to the Permian plate-tectonic reconstruction (Scotese and Langford, 1995), the Tethyan continental fragments comprising the Tarim, North China, South China and Indochina blocks formed a north-south partition between Paleotethys and Panthalassa. On the basis of different lithofacies between both regions and among the sections within the southwestern Yunnan area, the sedimentary environments of radiolarian bearing sediments are thought to be different. Nevertheless, the Permian radiolarian assemblages are similar to one another in specific composition. This fact indicates that the Middle - Upper Permian radiolarian zones are useful for worldwide correlation in the Paleotethys and the low-latitude Panthalassa regions.

(2) Sedimentary rates of the radiolarian siliceous rocks in the Changning-Menglian Terrane

In the southern Nanpan section, the upper Middle Permian *Follicucullus monacanthus* Assemblage Zone to the upper Upper Permian *Neoalbaillella pseudogrypa* Assemblage Zone were recognized in the chert beds of the Laba Group. Four radiolarian zones between the *Follicucullus scholastics* and the *Neoalbaillella pseudogrypa* Assemblage Zones seem to be absent in this section (Fig. 4). The time interval of this section is estimated to be from approximately several million years to ten million years, based on Harland *et al.* (1990) and Klein and Beauchamp (1994). The thickness of this section is about 3 m. Taking into account the absence of the four zones, the mean thickness of one assemblage zone is about 1 m. The sedimentary rate still seems very low and the same as that of bedded chert in Japan.

The horizons (R553, R555 and R556) of the bedded chert sequence of the Laba Group yield *Allbaillella triangularis*, which occurs between the *Albaillella excelsa* Assemblage Zone (R551) and the *Albaillella levis* Assemblage Zone (R559). The order of occurrence of these radiolarian zones is not consistent with that of the Japanese zones. Therefore, a repetition of bedded cherts by folding or faulting is predicted in the section. The real thickness of the bedded chert is considered to be thinner than the apparent thickness. The sedimentation rate of this bedded chert is also considered to be very low.

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* In Chinese.

** In Chinese with English abstract.

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Plate 1

1. *Pseudoalbaillella* cf. *globosa* Ishiga and Imoto, R514.

2. *Pseudoalbaillella* sp., R640.

3-4. *Follicucullus monacanthus* Ishiga and Imoto, 3: R513; 4: R514.

5. *Follicucullus porrectus* Rudenko, R643.

6-7. *Follicucullus ventricosus* Ormiston and Babcock, 6-7: R516.

8. *Follicucullus scholasticus* Ormiston and Babcock, R643.

9-10. *Follicucullus lagenarius* Rudenko, 9: R517; 10: R640.

11-12. *Follicucullus charveti* Caridroit and De Wever, 11-12: R640.

13-15. *Follicucullus* spp., 13: R640; 14-15: R643.

16. *Albaillella triangularis* Ishiga, Kito and Imoto, R555.

17. *Albaillella excelsa* Ishiga, Kito and Imoto, R551.

18. *Albaillella* cf. *lauta* Kuwahara, R559.

19. *Albaillella levis* Ishiga, Kito and Imoto, R559.

20. *Albaillella* aff. *levis* Ishiga, Kito and Imoto, R519.

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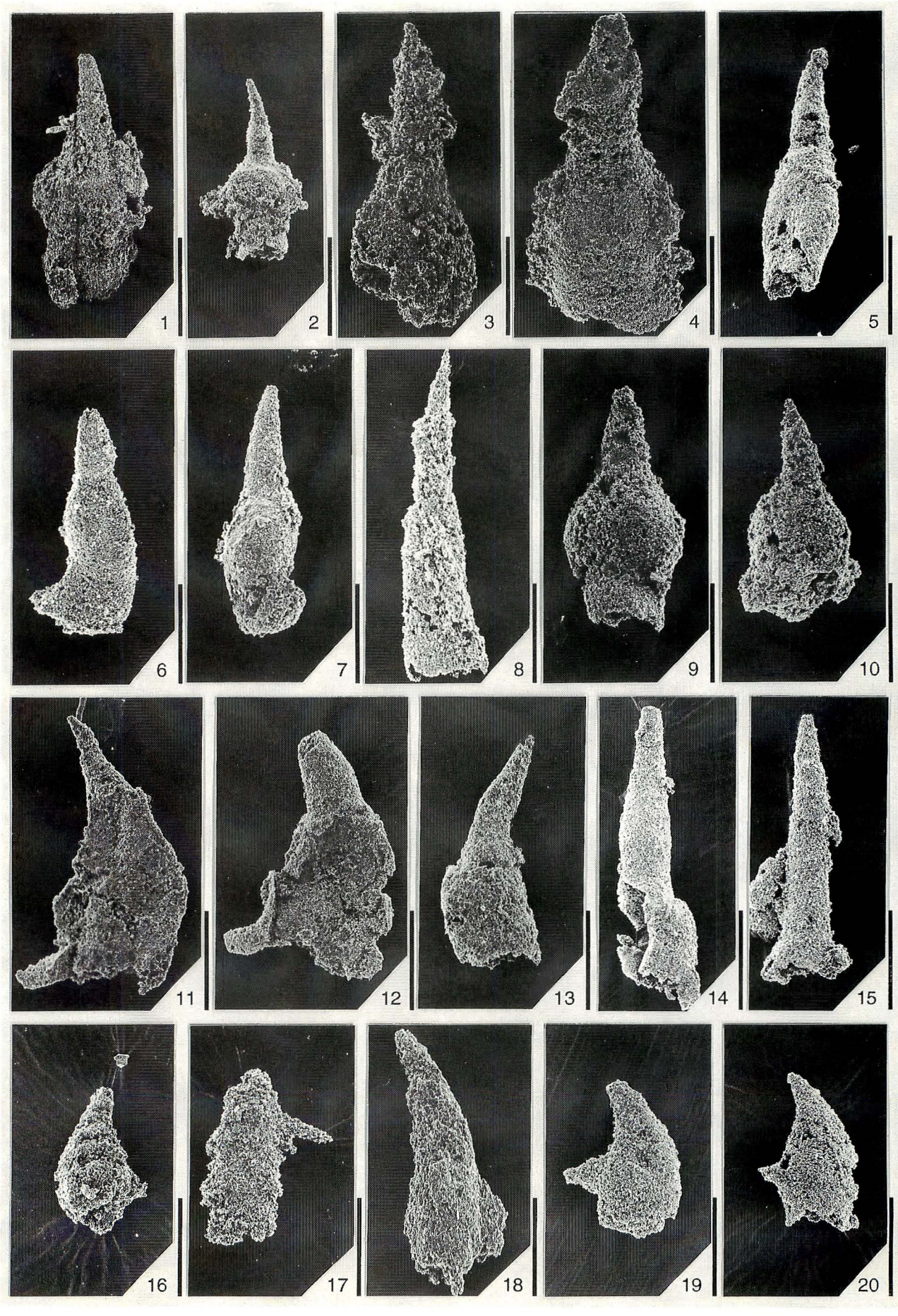
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Plate 2

1-2. *Neoalbaillella pseudogrypa* Sashida and Tonishi, 1-2: R518.

3. *Neoalbaillella* sp., R518.

4. *Entactinia itsukaichiensis* Sashida and Tonishi, R642.

5. *Entactinia* aff. *itsukaichiensis* Sashida and Tonishi, R642.

6. *Entactinia* sp. A, R642.

7-8. *Entactinosphaera pseudocimelia* Sashida and Tonishi, 7-8: R518.

9. Entactinaria gen. et sp. indet A, R641.

10. *Ishigaum trifustis* De Wever and Caridroit, R642.

11. *Ishigaum* sp. A, R518.

12. *Deflandrella* sp. A, R519.

13-14. *Latentibifistula* sp. A, 13-14: R518.

15. *Latentifistula* sp. A, R519.

16-17. *Latentifistula* sp. B, 16: R641; 17: R642.

18-20. *Latentifistula*? spp., 18-20: R518.

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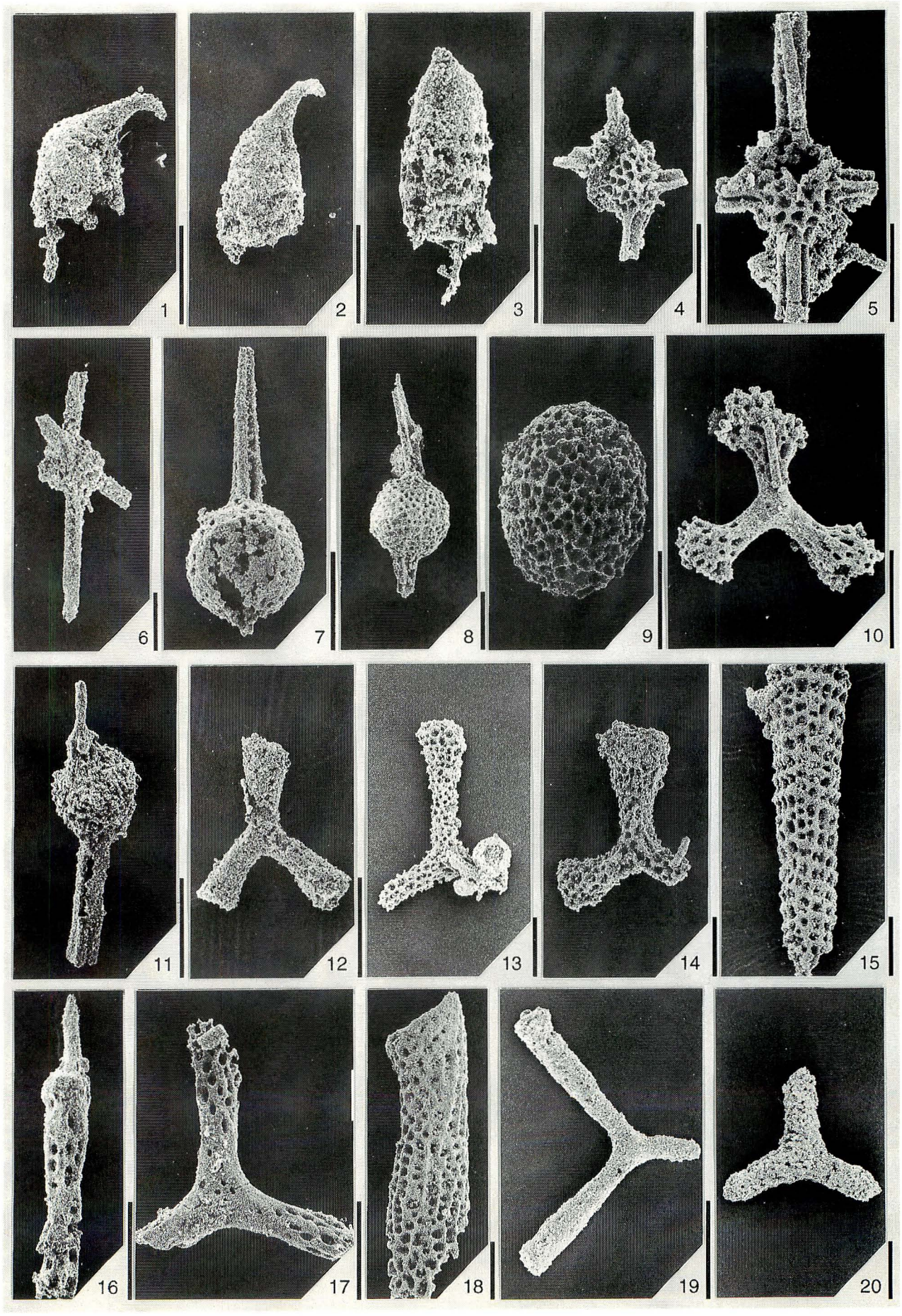
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Plate 3

1-2. *Nazarovella gracilis* De Wever and Caridroit, 1: R518; 2: R642.

3. *Nazarovella inflata* Sashida and Tonishi, R641.

4. *Ormistonella robusta* De Wever and Caridroit, R642.

5-6. *Pseudotormentus kamigoriensis* De Wever and Caridroit, 5: R641; 6: R518..

7-9. *Triplanospongos musashiensis* Sashida and Tonishi, 7-9: R518.

10-11. Latentifistridae gen. et sp. indet. A, 10: R518; 11: R642.

12. Latentifistridae gen. et sp. indet. B, R518.

13-14. *Cenosphaera*? sp. A, 13-14: R519.

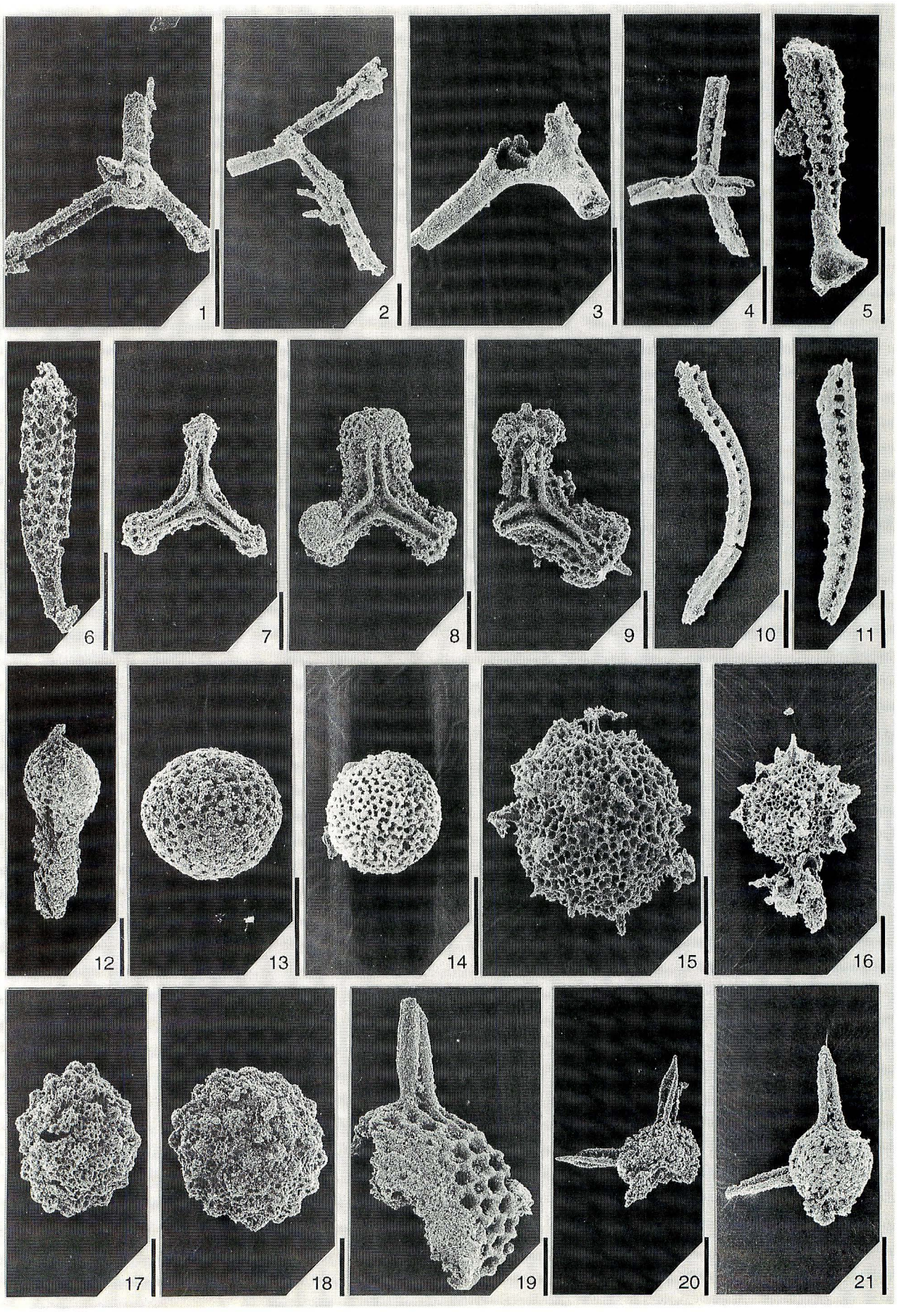
15-16. *Copicyntra* sp. A, 15-16: R519.

17-18. *Heglaria mammifera* Nazarov and Ormiston, 17: R518; 18: R519.

19. *Kashiwara magna* Sashida and Tonishi, R519.

20-21. Spumellaria gen. et sp. indet. A, 20: R518; 21: R519.

Scale bar = 100 μm.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