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Permian and Triassic radiolarians from the western Guangxi area, China

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Abstract

Five sections, namely the Shipao section of Xilin, the Wuzhuan section of Donglan, the Shanglao section of Napo, the Lingma section of Wuming and the Longtang section of Pingxiang, of the Permian-Triassic sequence were microbiostratigraphically examined in the western Guangxi, China. These sections are composed mainly of shallow marine sediments in the Jiangnan Terrane which are almost the same lithofacies as those on the Yangzi Platform.

Permian radiolarians were found from siliceous mudstones, cherts and tuffs of the Dalong Formation in the Shanglao section. The horizons that yielded the Permian radiolarians are correlated with the *Neoalbaillella ornithoformis* zone of Wujiapingian time. The Lingma section, which had been regarded as the Lower Triassic, contains the Permian-type radiolarians. The Shipao, Wuzhuan and Longtang sections yield the late Early Triassic radiolarians, and these horizons are correlated with the *Parentactinia nakatsugawaensis* zone of late Spathian time. No radiolarian fossils were found from the lower - middle Lower Triassic in the western Guangxi area.

Key-words: Permian, Triassic, radiolaria, Guangxi, Jiangnan Terrane, South China

Introduction

The greatest mass extinction between Permian and Triassic times is one of the important events of the Phanerozoic history. It is considered that the faunal analysis of radiolarian assemblages through the Permian to the Triassic indicates the actual conditions of the mass extinction in the marine plankton faunas. From this point of view, the Permian - Triassic continuous sequences of South China are required for radiolarian research.

The senior author (YAO Akira) has continued the Japanese-Chinese cooperative work by microbiostratigraphical and micropaleontological methods on the Paleozoic - Mesozoic of South China since 1991. From these works, firstly Yao et al. (1993) reported Late Paleozoic radiolarians from the Guizhou area on the Yangzi Platform and the Guangxi area in the Jiangnan Terrane. Secondly Yao and Kuwahara (1999a) reported Middle - Late Permian radiolarians from the north Sichuan area where is the northwestern margin of the Yangzi Platform, and Yao and Kuwahara (1999b, 2000) reported Permian and Triassic radiolarian assemblages from the Yangzi Platform. Thirdly Kuwahara et al. (2003, 2004) reported Late Permian radiolarians from the Laibin area, Guangxi in the Jiangnan Terrane. From these results, the Permian and Triassic radiolarian faunal features in South China have been cleared, and the radiolarian zones have

been correlated with those of Southwest Japan.

We did field survey as a part of cooperative work on November 2003 in the western Guangxi area (Fig. 1). We examined the sections of Permian - Triassic sequence and collected rock samples for radiolarian biostratigraphical and faunal analyses. Here we report the result of radiolarian occurrence and discuss its geological significance.

Geologic Setting

The Upper Paleozoic to Triassic marine strata extensively distribute in the Guangxi area (Bureau of Geology and Mineral Resources of Guangxi Region, 1985), where is situated on the western part of the Jiangnan Terrane (Fig. 1). The Jiangnan Terrane is regarded as the Caledonian Orogenic Belt which was formed to the south of the Yangzi Platform and amalgamated to the Yangzi Platform at Early Paleozoic time. Since Late Paleozoic time the Jingnan Terrane has the similar geohistory with the Yangzi Platform. The Permian to Middle Triassic strata in the Jiangnan Terrane are mainly characterized by carbonate rocks and clastic rocks deposited in the shallow sea environment.

The standard lithostratigraphy of the Permian units in the terrane are as follows in ascending order (Bureau of Geology and Mineral Resources of Guangxi Region, 1985): the Chuanshan Formation (the lower Lower Permian), the Qixia Formation (the upper Lower Permian), the Maokou Formation (the Middle Permian), the Wujiaping Formation (the lower Upper Permian), and the Changxing Formation (the upper Upper Permian). Except for the standard units, there are many lithostratigraphic units because they have different lithofacies from the standard units. The geologic age of these units is determined by many kinds of index fossils as fusulinaceans and conodonts from limestones, ammonites from mudstones, etc.

The standard lithostratigraphy of the Lower to Middle Triassic in the terrane are as follows in ascending order (Bureau of Geology and Mineral Resources of Guangxi Region, 1985): the Luolou Group (the Lower Triassic) and the Baifeng Formation (the lower Middle Triassic). The geologic age of these units is determined by index fossils as bivalves, ammonites, etc.

The stratigraphic relationship between the Permian and Triassic is conformable except for some sections in which the unconformity is recognized.

Study Sections

The five sections (Fig. 2) in this study are described as follows:

(1) Shipao section of Xilin

Xilin is the capital town of Xilin County. It is located in the northwestern marginal part of Guangxi Province and is about 390 km northwest of Nanning (Fig. 2). The

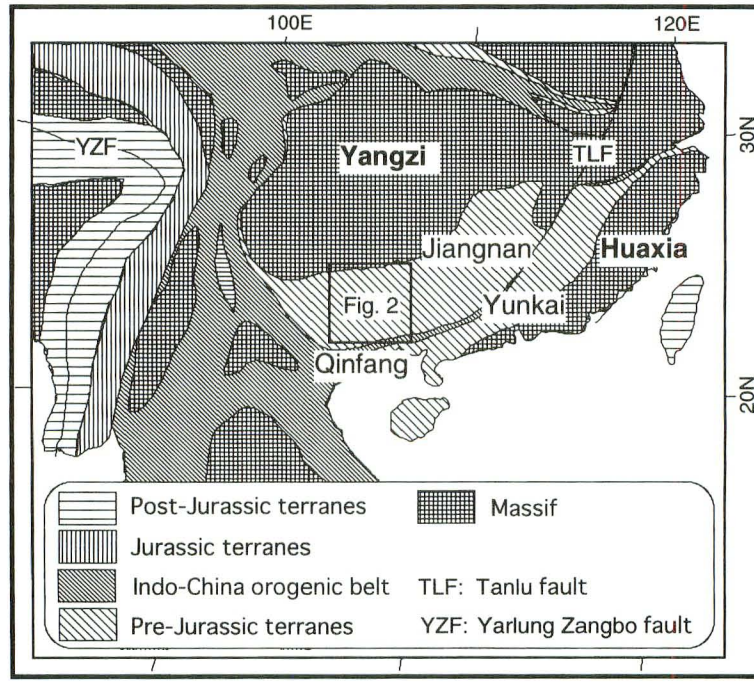

Fig. 1 Index map of the study area in South China.

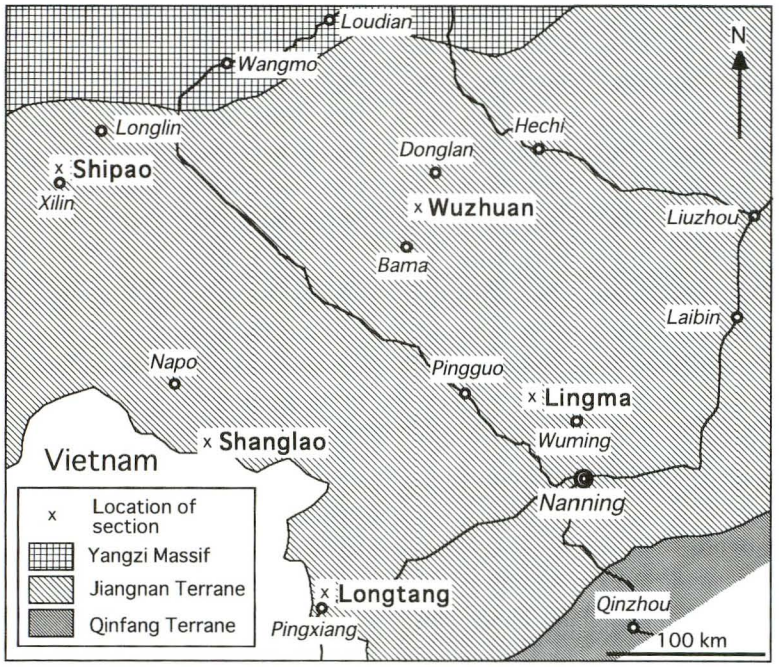

Fig. 2 Location of sections in the Jiangnan Terrane, the western Guangxi.

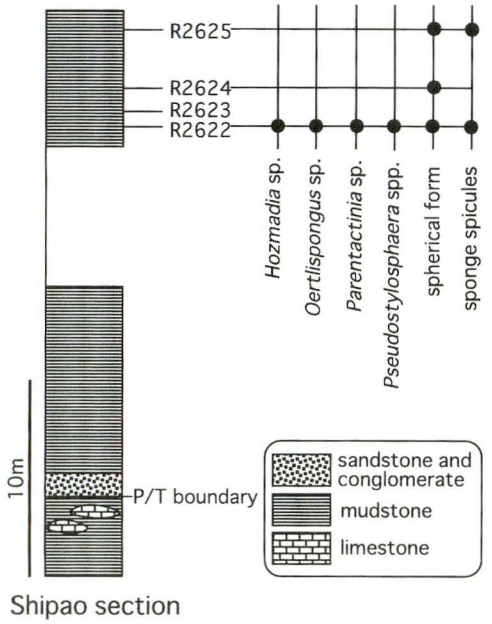

Fig. 3 Columnar section showing the horizons of radiolarian occurrence in the Shipao section.

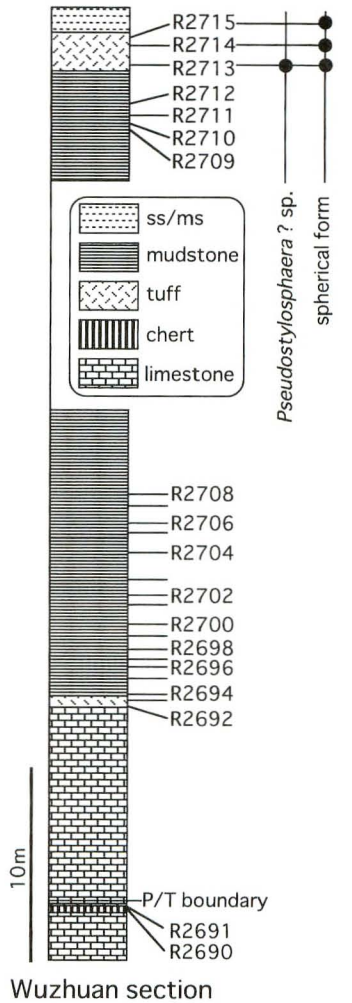

Fig. 4 Columnar section showing the horizons of radiolarian occurrence in the Wuzhuan section.

Shipao section is in the north of Xilin and at the road cutting (Fig. 8a) which connects Xilin with Longlin. The location coordinates of this section is 24°30.683′N, 105° 05.781′E. This section is composed of the Permian Sidazhai and Shaiwa Formations and the Triassic Shipao Formation. The strata of these formations strike generally N60° W and dip 40°S.

The Sidazhai and Shaiwa Formations consist mainly

of clastic rocks and volcaniclastic rocks. The sheet-like and dome-like basaltic rocks are observed as the intruded rocks in the lower part of the Shaiwa Formation. The blocks of limestone conglomerate are included in the uppermost horizon of the Shaiwa Formation. Rock samples for radiolarian research were collected from 5 horizons (R2617 to R2621) of the Shaiwa Formation.

The lowermost part of the Shipao Formation is composed of sandstone and conglomerate which directly cover the Shaiwa Formation. The sandstone and conglomerate of the Shipao Formation grade upward into mudstone which contains interbedded tuff layers. Siliceous mudstone samples were collected from 4 horizons (R2622 to R2625: Fig. 3) of the Shipao Formation.

(2) Wuzhuan section of Donglan

The Wuzhuan section is about 20 km southwest of Donglan which is the capital town of Donglan County, and about 205 km northwest of Nanning (Fig. 2). The section is at the road cutting. The road connects Bama with Donglan. The location coordinates of this section is 24° 21.799′N, 107°19.974′E. The section is composed of the Upper Permian Heshan Formation, the Lower Triassic Luolou Formation and the Middle Triassic Baifeng Formation. The strata of these formations trend northeast and dip west gently.

The Heshan Formation consists of clastics, tuff and limestone which contains thinly bedded chert layers. The limestone of the uppermost part of Heshan Formation contains fusulinacean fossils. Chert samples were collected from the uppermost horizons (R2690 and R2691) of this formation.

The Luolou Formation is composed of limestone, tuff and mudstone. The limestone (microbialite) of the lowest Luolou Formation covers directly the limestone of the uppermost Heshan Formation. The middle and upper parts of the Luolou Formation consist mainly of mudstone which contains interbedded tuff layers. This formation is covered conformably by the alternating beds of sandstone and mudstone of the Baifeng Formation (Fig. 8b). Tuff samples (R2692, R2693 and R2713 to R2715) and mudstone samples (R2694 to R2712) were collected from the middle and upper parts of the Luolou Formation (Fig. 4).

(3) Shanglao section of Napo

Napo is the capital town of Napo County. It is located in the western marginal part of Guangxi Province and is about 270 km west of Nanning (Fig. 2). The Shanglao section is to the south of Napo and at the road cutting. The location coordinates of this section is 23°19.246′N, 105°

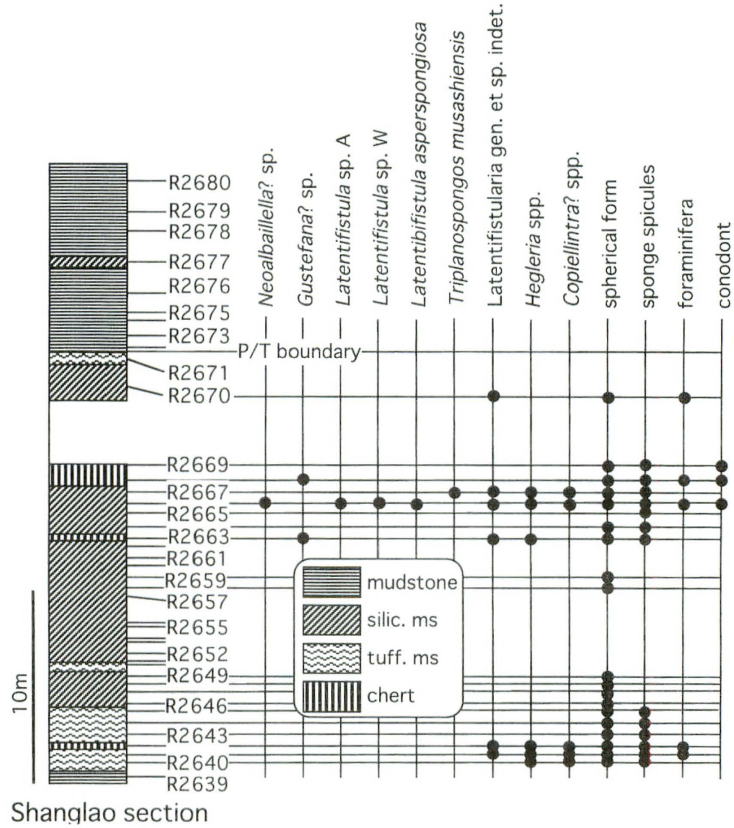

Fig. 5 Columnar section showing the horizons of radiolarian occurrence in the Shanglao section.

51.309′E. This section is composed of the Upper Permian Dalong Formation and the Lower Triassic Luolou Formation. The strata of these formations strike generally N20° W and dip 50°SW.

The Dalong Formation consists mainly of mudstone, tuffaceous mudstone and siliceous mudstone which contains bedded chert layers. The uppermost part of this formation is a thin layer of tuffaceous mudstone. Rock samples for radiolarian research were collected from 33 horizons (R2639 to R2671) of the Dalong Formation (Fig. 5).

The lowermost part of the Luolou Formation is composted of mudstone which directly covers the Dalong Formation (Fig. 8c). The mudstone contains a thin siliceous mudstone layer. Rock samples were collected from 9 horizons (R2672 to R2680: Fig. 5) of the Luolou Formation.

(4) Lingma section of Wuming

The Lingma section is about 45 km northwest of Wuming which is the capital town of Wuming County, and about 80 km northwest of Nanning (Fig. 2). The section is at the road cutting. The road connects Wuming with Pingguo. The location coordinates of this section is 23°23.128′N, 107°54.722′E. Although the section was regarded as the Lower Triassic Luolou Formation on the basis of its lithologic feature, it is considered to be Permian due to the occurrence of Permian-type radiolarians in this study. The strata trend E-W and dip 30°S.

The section consists mainly of tuff, mudstone and siliceous mudstone. Rock samples were collected from 16 horizons (R2601 to R2616) of this formation (Fig. 6).

(5) Longtang section of Pingxian

The Longtang section is about 5 km north of Pingxiang which is the capital of Pingxiang City, and about 190 km southwest of Nanning (Fig. 2). The section is at the cliff of golden ore deposits quarry. The location coordinates of this section is 22°08.956′N, 106°46.252′E. The section is situated on the northwest side of a major fault zone, which strikes N20°E and dips 70°NW. The Lower Permian Qixia Formation is distributed on the southeast side of the fault zone.

The section mainly consists of the unnamed Lower Triassic tuff and mudstone. These strata strike generally N60°E and dip 65°NW. Rock samples were collected from 8 horizons (R2729 to R2736) (Fig. 7; Fig. 8d) and from one chert block (R2728) within fault breccia.

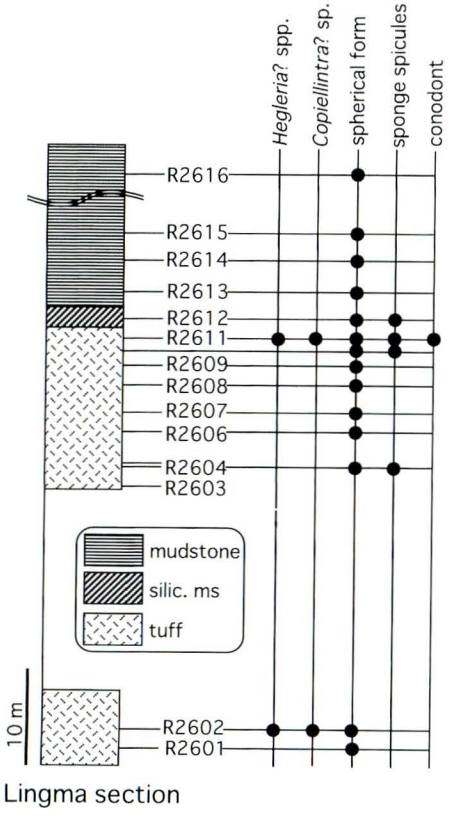

Fig. 6 Columnar section showing the horizons of radiolarian occurrence in the Lingma section.

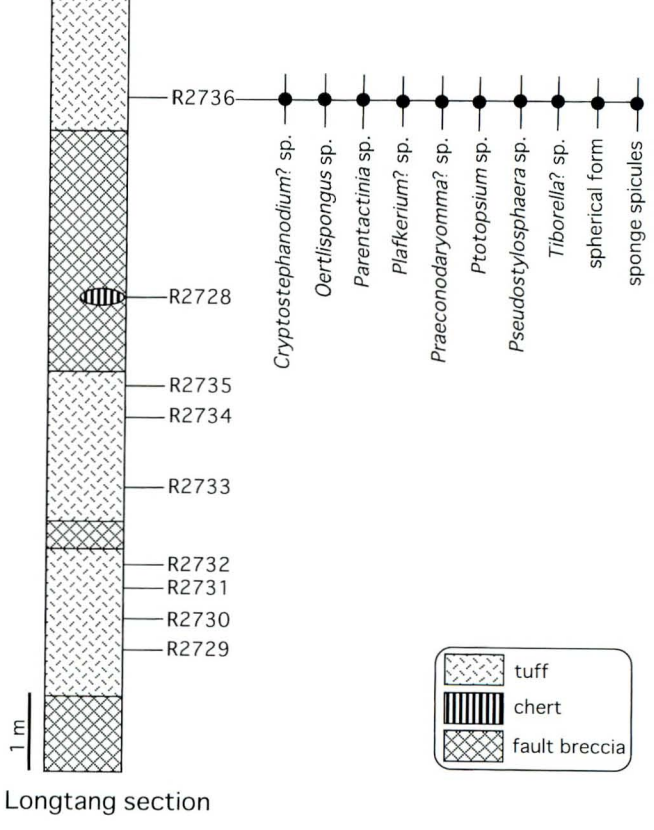

Fig. 7 Columnar section showing the horizon of radiolarian occurrence in the Longtang section.

Fig. 8 Photographs of the study area.
a: The Shipao section. The outcrop of the Lower Triassic Shipao Formation at the road cutting in the north of Xilin.
b: The Wuzhuan section. The boundary between the Lower Triassic Luolou Formation and the Middle Triassic Baifeng Formation.
c: The Shanglao section. The P/T boundary between the Permian Dalong Formation and the Triassic Luolou Formation.
d. The Longtang section. The Triassic clastic rocks with greenish fault brecciated zones.

Methods

The rock samples were collected about 100 g per sample from the outcrop. They were immersed in a 5% hydrofluoric acid (HF) solution for 24 hours. After removing the HF solution, the residues were collected by using 35 and 200 mesh sieves. All samples were observed under transmitted light microscope and binocular microscope. In case of necessity, scanning photomicrographs were taken for some samples.

Radiolarian Assemblages

(1) Shipao section (Fig. 3)

The radiolarians from the R2622 sample of the Shipao section are identified as *Hozmadia* sp. (Pl. 2, fig. 1), *Oertlispongus* sp. (Pl. 2, fig. 3), *Parentactinia* sp. (Pl. 2, fig. 2) and *Pseudostylosphaera* spp. (Pl. 2, figs. 4-5). Radiolarian spherical forms and sponge spicules are found from the R2622, R2624 and R2625 samples. No radiolaria occurred from the Permian Shaiwa Formation (R2617 to R2621).

(2) Wuzhuan section (Fig. 4)

Pseudostylosphaera? sp. (Pl. 2, figs. 6-7) is found from the R2713 sample of the Wuzhuan section. Radiolarian spherical forms are contained in the R2713 to R2715 samples. No radiolaria occurred in the Permian Heshan Formation (R2690 and R2691) and the lower to middle Luolou Formation (R2692 to R2711).

(3) Shanglao section (Fig. 5)

The radiolarians from the R2640 to R2642 samples are identified as Latentifistularia gen. et sp. indet. (Pl. 1, figs. 10-11), *Hegleria* sp. (Pl. 1, fig. 12), *Copiellintra*? spp.

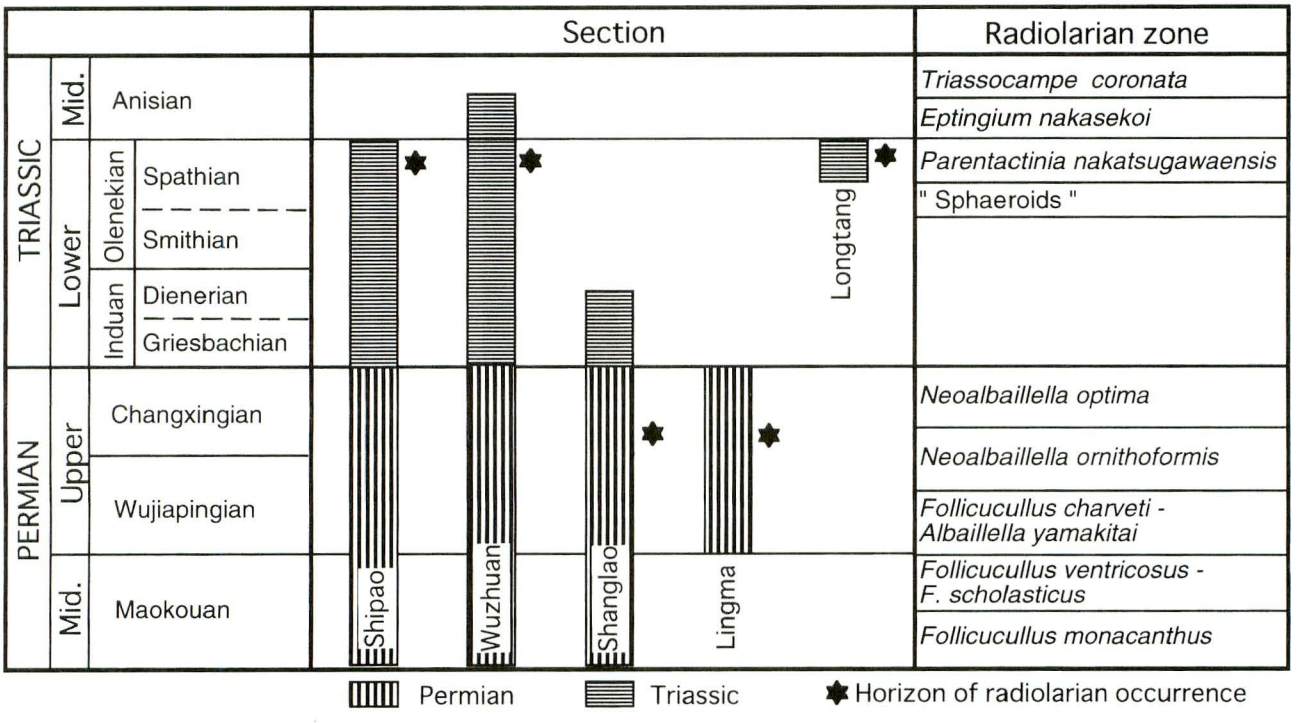

Fig. 9 Radiolarian biostratigraphic correlation of the sections in the western Guangxi with the radiolarian zones of Southwest Japan.

(Pl. 1, figs. 15-17) and spherical forms. The R2666 sample yields *Neoalbaillella*? sp. (Pl. 1, fig. 1), *Latentifistula* sp. A (Pl. 1, figs. 3-4), *L.* sp. W (Pl. 1, fig. 6), *L. asperspongiosa* Sashida and Tonishi (Pl. 1, fig. 5), *Hegleria* sp. (Pl. 1, fig. 12), *Triplanospongos musashiensis* Sashida and Tonishi (Pl. 1, fig. 8) and spherical forms (Pl. 1, fig. 19). The R2667 sample contains *Triplanospongos musashiensis* Sashida and Tonishi (Pl. 1, fig. 9). The R2670 sample from the uppermost horizon of Permian yields Latentifistularia gen. et sp. indet. and spherical forms. No radiolaria occurred from the R2673 to R2680 samples of the Triassic Luolou Formation.

(4) Lingma section (Fig. 6)

The R2602 and R2611 samples yield *Hegleria*? spp. (Pl. 1, figs. 13-14) and *Copiellintra*? sp. (Pl. 1, fig. 17). All rock samples (R2601 to R2616) from the Lingma section contain radiolarian spherical forms.

(5) Longtang section (Fig. 7)

The R2736 sample yields *Cryptostephanodium*? sp. (Pl. 2, fig. 15), *Oertlispongus* sp. (Pl. 2, figs. 13 and 21), *Parentactinia* sp. (Pl. 2, fig. 16), *Plafkerium*? sp. (Pl. 2, figs. 12 and 14), *Praeconocaryomma*? sp. (Pl. 2, fig. 18), *Protopsium* sp. (Pl. 2, fig, 16), *Pseudostylosphaera* sp. (Pl. 2, figs. 11 and 19), *Tiborella*? sp. (Pl. 2, fig. 20), radiolarian spherical forms (Pl. 2, fig. 22) and sponge spicules. No radiolarians were found in other samples (R2729 to R2735) of this section.

Discussion

(1) Geologic age of radiolarian assemblages

The radiolarian assemblage from the Dalong Formation of the Shanglao section (Fig. 5) is represented by the species of Permian time. The range of genus *Neoalbaillella* is restricted to the Upper Permian (e.g. Kuwahara et al., 1998). *Latentibifistula asperspongiosa* Sashida and Tonishi and *Triplanospongos musashiensis* Sashida and Tonishi are characteristic species of the Upper Permian (Kuwahara and Yao, 2001). Based on these data, the radiolarian assemblage from the Shanglao section is considered as belonging to the Upper Permian.

The radiolarian assemblages from the Lingma section is represented by *Hegleria*? spp. and *Copiellintra*? sp. (Fig. 6). As the occurrence of these species is restricted to the Permian, the radiolarian assemblage is considered to be of the Permian.

The radiolarian assemblages from the Shipao, the Wuzhuan and the Longtang sections commonly include the species of *Pseudostylosphaera* (Figs. 3, 4 and 7). The occurrence of these species is restricted to the upper Lower

- Middle Triassic (Sugiyama, 1997). The Shipao and the Longtang sections yield *Oertlispongus* sp. and *Parentactinia* sp. which are also characteristic species of the upper Lower Triassic (Sashida, 1991; Sugiyama, 1997). Based on these species, the radiolarian assemblages from three sections are considered to be of the upper Lower Triassic.

(2) Correlation of radiolarian zones

The horizons of R2666 in the Shanglao section yield *Latentibifistula asperspongiosa* Sashida and Tonishi (Fig. 5). This species is a characteristics of the *Neoalbaillella ornithoformis* zone in the Gujo-hachiman section of Southwest Japan (Kuwahara and Yao, 2001). *Triplanospongos musashiensis* Sashida and Tonishi, which is a characteristic species of the *Neoalbaillella ornitoformis* zone and the *Neoalbaillella optima* zone in Southwest Japan (Kuwahara and Yao, 2001), is found from the horizon of R2667. Based on these data, these horizons of the Shanglao section are correlated with the *Neoalbaillella ornithoformis* zone.

The horizon of R2622 in the Shipao section (Fig. 3) and the horizon of R2736 in the Longtang section (Fig. 7) yield the radiolarian species of late Early Triassic time. The combination of radiolarian species from two sections is similar to the fauna of late Spathian time reported from Southwest Japan by Sugiyama (1997). Based on these data, the horizons of R2622, R2736 and additionally R2713 (Wuzhuan section; Fig. 4) are correlated with the *Parentactinia nakatsugawaensis* zone defined by Sugiyama (1997).

(3) Permian - Triassic radiolarian faunal change

The Late Permian radiolarian faunal feature in the Shanglao section is represented by the assemblage of small numbered species. Especially Albaillellaria is restricted to only one species as shown in Fig. 5, and the individual number of albaillellarian species is very small. This feature on the radiolarian diversity is widely observed on the Yangzi Platform. Yao and Kuwahara (1999a, b, 2000) reported the Middle - Late Permian radiolarian assemblages from Sichuan, Guizhou and Guangxi Provinces, and discussed the Permian radiolarian faunal difference between South China and Southwest Japan. By adding the feature of the Shanglao section to the already known features (Yao and Kuwahara, 1999a, b, 2000), it is inferred that the Late Permian radiolarians in the South China represent the low latitudinal and shallow marine fauna.

The lower - middle Lower Triassic in the Wuzhuan section and the Shanglao section do not entierly contain radiolarian remains (Figs. 4 and 5). This feature is the same as other sections on the Yangzi Platform reported by Yao and Kuwahara (1999a, b, 2000). From this feature, it is inferred that almost all the Late Permian radiolarians were extinct at the end of Permian time in South China, and the radiolarian recovery had not progressed during early to middle Early Triassic time.

The upper Lower Triassic in the Shipao section and the Wuzhuan section contain radiolarians which are the characteristic species of the *Parentactinia nakatsugawaensis* zone. This feature is also the same as other sections on the Yangzi Platform reported by Yao and Kuwahara (1999b, 2000).

Although there are some differences of radiolarian faunal features between South China and Southwest Japan, it is recognized that the radiolarian faunal change in both regions shows the same tendency through Permian to Triassic time. It is inferred that the end-Permian mass extinction caused serious damage to the radiolarian fauna, and the recovery began at late Early Triassic time in both regions.

Acknowledgements

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Plate 1

Fig. 1 *Neoalbaillella*? sp., R2666
Fig. 2 *Gustefana*? sp., R2668
Figs. 3-4 *Latentifistula*? sp. A, R2666
Fig. 5 *Latentifistula asperspongiosa* Sashida and Tonishi, R2666
Figs. 6-7 *Latentifistula* sp. W, 6:R2666, 7:R2667
Figs. 8-9 *Triplanospongos musashiensis* Sashida and Tonishi, 8:R2666, 9:R2667
Figs. 10-11 Latintifistullaria gen. et sp. indet., 10:R2666, 11:R2667
Figs. 12-14 *Hegleria* spp., 12:R2640, 13-14:R2611
Figs. 15-17 *Copiellintra*? sp., 15:R2642, 16:R2641, 17:R2602
Figs. 18-20 Radiolaria, spherical form, 18:R2667, 19:R2666, 20:R2611
Figs. 21-22 Sponge spicule, 21:R2642. 22:R2640
Fig. 23 Foraminifera, Gen. et sp. indet., R2642
Fig. 24 Foraminifera, *Langella*? sp., R2670
Fig. 25 Conodont, R2611

Figs. 1-12, 15-16, 18-19, 21-24: Shanglao section
Figs. 13-14, 17, 20, 25: Lingma section

Plate 1

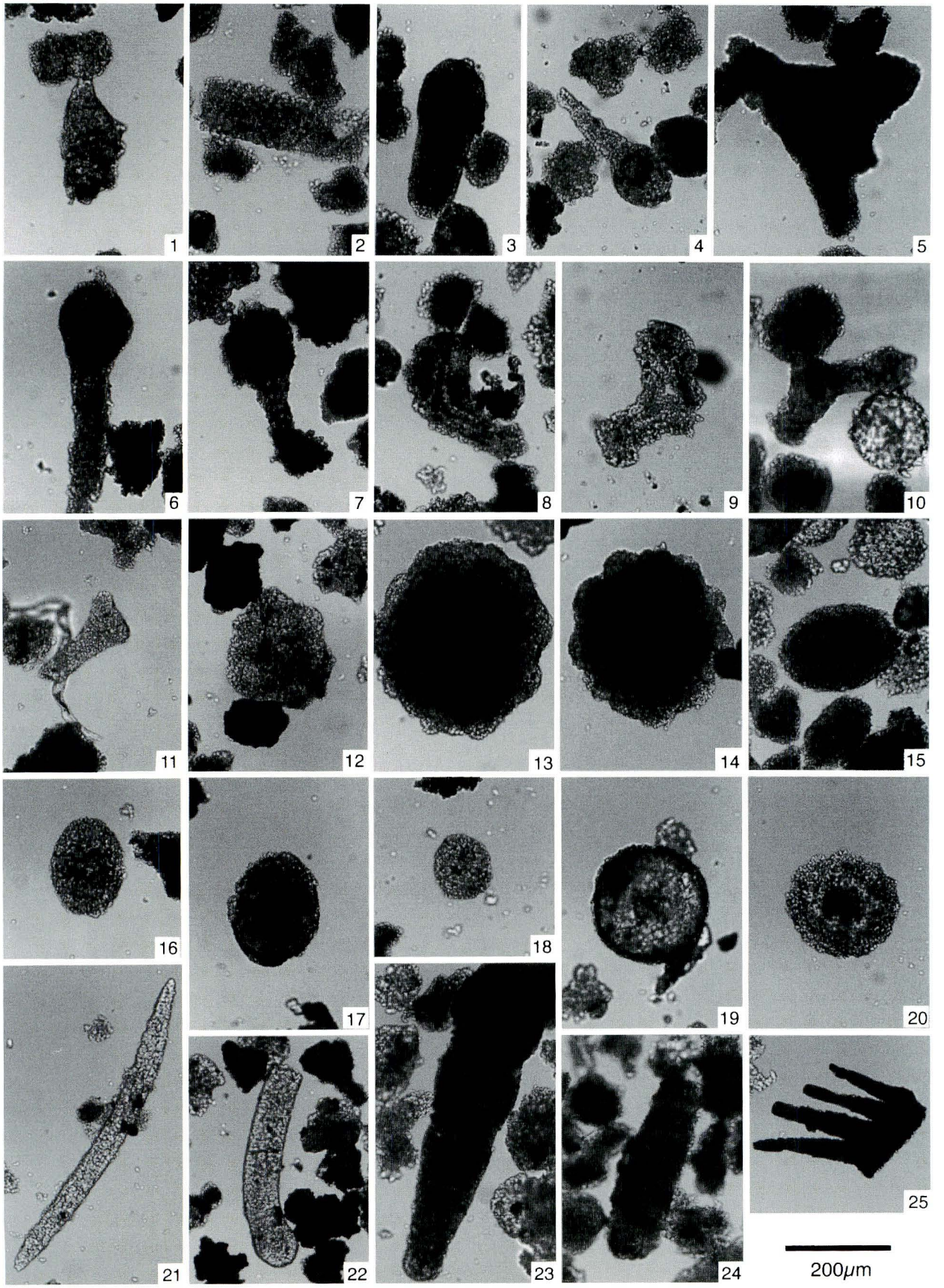
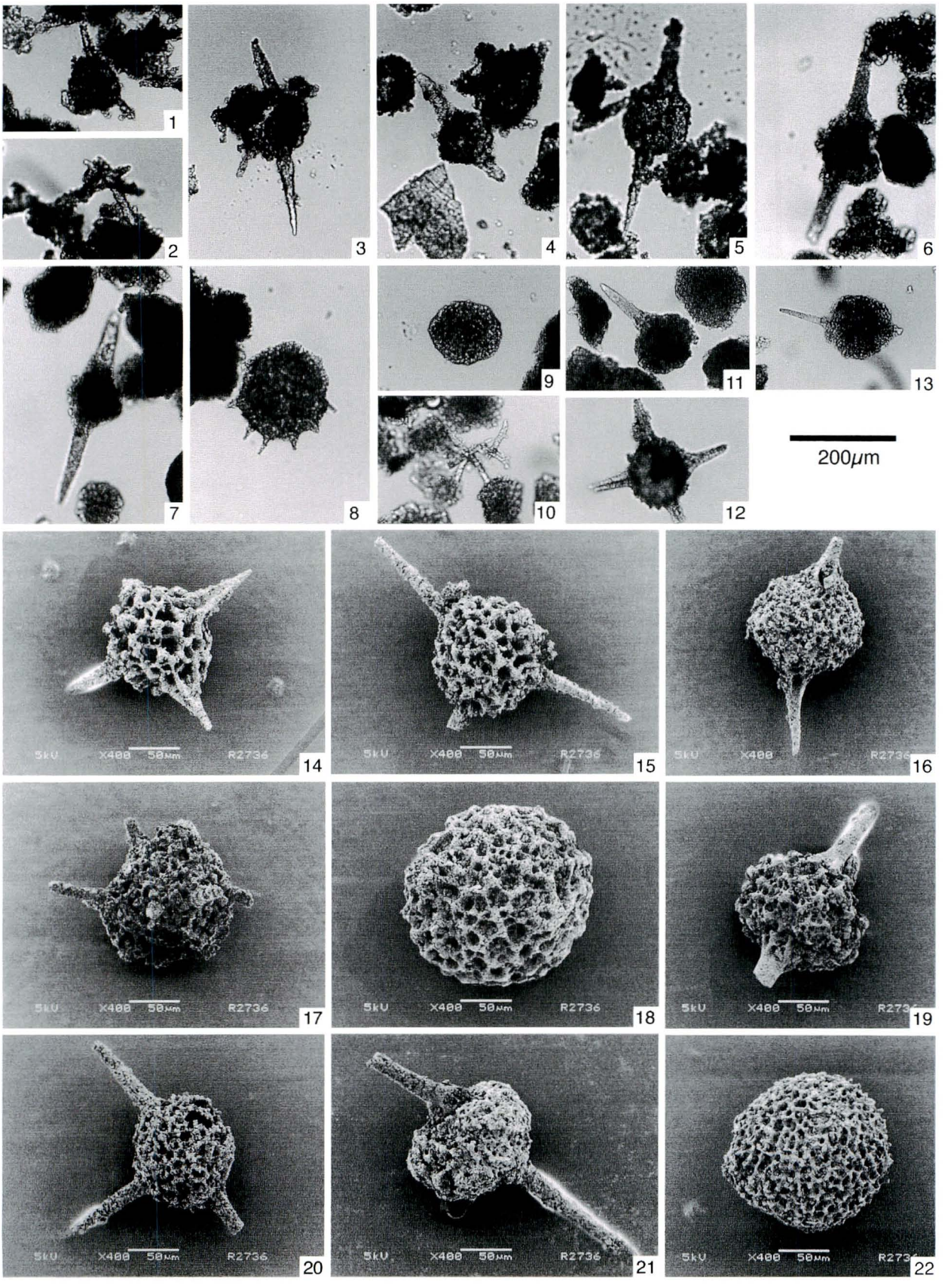


Plate 2

Fig. 1 *Hozmadia* sp., R2622
Fig. 2 *Parentactinia* sp., R2622
Fig. 3 *Oertlispongus* sp., R2622
Figs. 4-5 *Pseudostylosphaera* spp., R2622
Figs. 6-7 *Pseudostylosphaera*? sp., R2713
Figs. 8-9 Radiolaria, spherical form, 8:R2713, 9:R2714
Fig. 10 *Parentactinia*? sp. R2736
Fig. 11 *Pseudostylosphaera* sp., R2736
Fig. 12 *Plafkerium*? sp., R2736
Fig. 13 *Oertlispongus* sp., R2736
Fig. 14 *Plafkerium*? sp., R2736
Fig. 15 *Cryptostephanodium*? sp., R2736
Fig. 16 *Protopsium* sp., R2736
Fig. 17 *Triassospongosphaera* sp., R2736
Fig. 18 *Praeconocaryomma*? sp., R2736
Fig. 19 *Pseudostylosphaera* sp., R2736
Fig. 20 *Tiborella*? sp., R2736
Fig. 21 *Oertlispongus* sp., R2736
Fig. 22 Radiolaria, spherical form, R2736

Plate 2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200μm
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