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Permian radiolarians from the Global boundary Stratotype Section and Point for the Guadalupian -Lopingian boundary in the Laibin area, Guangxi, China

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Abstract

Moderately well preserved radiolarians were found from siliceous rocks of the Heshan Formation, in Laibin, Guangxi, China. The horizons of radiolarian occurrence are the lower part of Wuchiapingian of the Global boundary Stratotype Section and Point (GSSP) defining the base of the Lopingian Series. The radiolarian assemblage from the basal part of the Wuchiapingian includes *Foremanhelena triangula, Latentifistula similicutis, Raciditor scalae, Ishigaum trifustis,* and *Triplanospongos* cf. *angustus*. Although no Albaillellaria species have been detected, this assemblage corresponds to that of the *Follicucullus charveti - Albaillella yamakitai* assemblage zone of Southwest Japan. The absence of Albaillellaria in this assemblage may indicate that the siliceous rocks of the Heshan Formation were deposited in the shallower water depth.

Key-words : Late Permian, Wuchiapingian, radiolaria, GSSP, Laibin, South China

1. Introduction

Stratotypes and type localities for a stratigraphic unit are fundamental and important in stratigraphy. International Stratigraphic Guide, Second Edition by Salvador (1994) states, "The concept of a stratigraphic unit is based on properties or attributes of the rocks such as lithology, fossil content, magnetic polarity, and age or time span. The type section or type locality of such a unit, therefore, constitutes the standard of reference on which the concept of the unit is based (4.A.2)". For requirements for stratotypes (type sections), "In the case of global choronostratigraphic units (e.g., systems, series, stages) it has been recommended that the definition should place emphasis in the selection of the boundary-stratotype of its lower boundary; its upper boundary is defined as the lower boundary of the overlying unit. The term "Global boundary stratotype section and point (GSSP)" has been proposed for these standard boundary-stratotypes of units of the Global Chronostratigraphic Scale (4.C.1)".

Recently, the Penglaitan section, Laibin, Guangxi Zhuang's Autonomous Region, China, was approved as the GSSP defining the base of the Wuchiapingian Stage and the base of Lopingian Series of the Permian System by ISSC (2004) (Figs. 1-2). The nearby Tieqiao (Rail-Bridge) section becomes a supplementary reference section. The base of the Wuchiapingian Stage coincides with the first appearance (FAD) of conodont *Clarkina postbitteri postbitteri* (Mei and Wardlaw (1998)) and with the beginning of a transgressive phase that terminated the regional expression of a major global sea-level lowstand.

These sections have been researched in various views. For their stratigraphic significance, conodonts have been examined and discussed eagerly by many researchers (e.g., Mei et al., 1998; Wang et al., 1998). Other fossils,

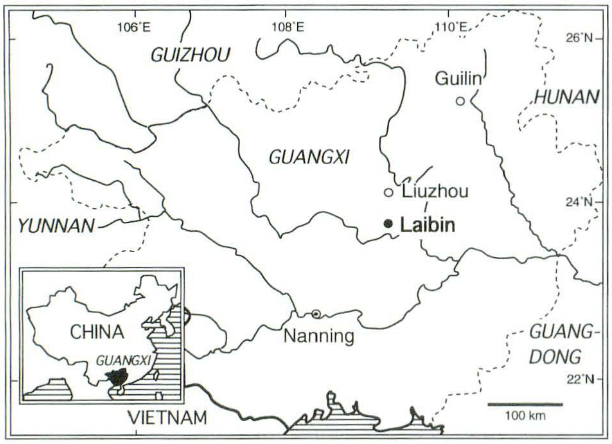

Fig. 1 Index map of the Laibin area.

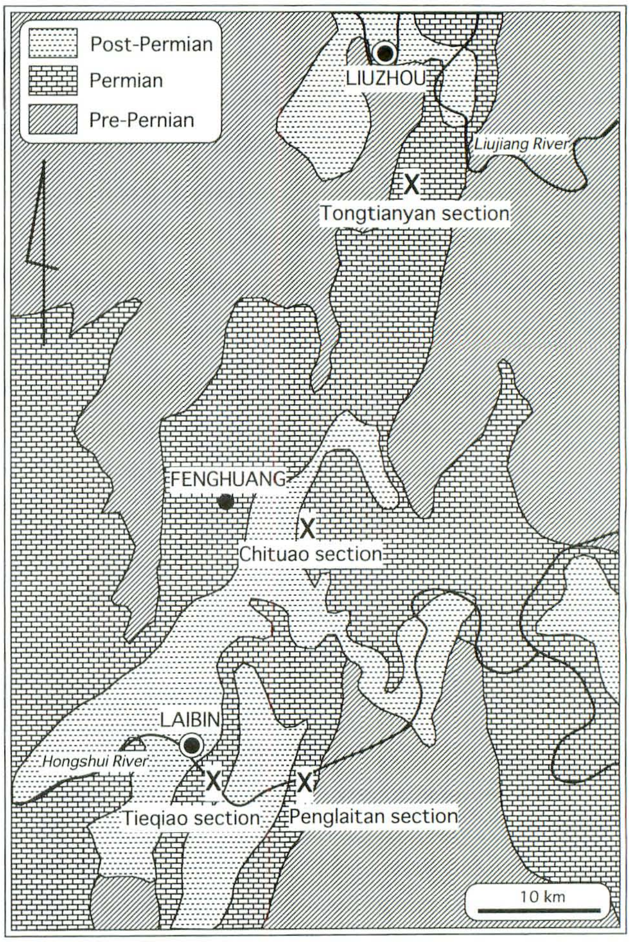

Fig. 2 Geological sketch map of the Laibin and its adjacent area, showing the location of the study sections (based on Jin et al., 1994: modified from Kuwahara et al., 2004).

including foraminifera and ammonites, were also researched biostratigraphically (Sha et al., 1990). Moreover, lithostratigraphy, magnetostratigraphy, chemostratigraphy and isotopic-dating also were applied to these sections as introduced by Jin et al. (2001).

Sha et al. (1990) illustrated some spherical radiolarians from the Tieqiao section in the plate XX and XXI of their comprehensive work. Shang (2003) reported siliceous microfossils including radiolarians from the Upper Changhsingian in Tieqiao section. However, there was no radiolarian report from the Penglaitan section.

In March 2003, we made a field survey in Guangxi area, and collected samples from both sections for radiolarian biostratigraphic research. We could find radiolarian remains from the Wuchiapingian interval of the both sections. Here we introduce these radiolarians from the Laibin area and discuss the comparison with other Late Permian assemblages from South China and Southwest Japan.

2. Geologic outline

2.1 Geologic outline of study area

The late Paleozoic to Triassic marine strata are distributed in the Laibin area, Guangxi, China. These strata are the deposits of the Jiangnan Basin, between the Yangzi and Cathaysia cratons (Jin et al., 2001). Lower Cretaceous nonmarine red beds and Quaternary sediments are unconformably overlying these late Paleozoic to Triassic strata. The Permian strata are well exposed along the banks of the Hongshui River (Fig. 2). Structurally, these strata are folded by a southward plunging syncline, called the Laibin syncline. The Penglaitan section is sited on the eastern limb of the syncline, and on the southern bank of the Hongshui River near the Penglaitan Islet. The Tieqiao section is sited on the western limb of the syncline, and on the northern bank of the river.

Sha et al. (1990) described the lithostratigraphy and biostratigraphy of the Tieqiao section in Laibin, in their book of comprehensive research on Permian in Guizhou-Guangxi area. The Permian strata are divided into the Maping, Qixia, Maokou, Wujiaping, and Dalong formations in ascending order, by them. Jin et al. (1994) pointed out that the strata of Wuchiapingian age are traditionally called the Heshan Formation in eastern Guangxi including the Laibin area. Lithostratigraphy of Permian strata is roughly the same between the eastern limb and western limb of the syncline.

Based on Jin et al. (1998, 2001), the lithostratigraphy of the Maokou and Heshan formations are as follows. The Maokou Formation is divided into 5 members from I to V, and composed of carbonate siltstone and sandstone, radiolarian chert, carbonate mudstone, massive carbonate deposits, cherty carbonate mudstone and sandstone, massive limey sandstone and siltstone. The Member V, the uppermost member of the Maokou Formation is called Laibin Limestone, which is massive limestone of pale purple in color.

The Heshan Formation overlies this massive limestone. This formation is composed of black cherty limestone in the lower part and white bioclastic carbonate in the upper part at Tieqiao section, while it is composed mostly of chert and lenticular limestone at Penglaitan section. The lithostratigraphic boundary between Maokou and Heshan formations is defined by the lowest appearance of black cherty limestone.

As the GSSP, the base of Wuchiapingian stage lies within the uppermost part of the Member V of the Maokou Formation. The base is approved at the base of bed 6K/115 in the Member V of the Maokou Formation of the Penglaitan section (Fig. 3.1-2), with the first appearance of *Clarkina postbitteri postbitteri*. In the Tieqiao section, the base also lies within the uppermost part of the Maokou Formation.

2.2 Study sections

At the Penglaitan section, we measured an interval of 15 m thickness of the uppermost Maokou Formation and that of 24 m thickness of the lowermost Heshan Formation. The uppermost 15 m of Maokou Formation is mainly composed of limestone. Its lower half contains intercalated thin chert, and its upper half is thick-bedded limestone. The lowermost part of the Heshan Formation is composed of black chert, mudstone, and calcareous mudstone (Figs. 3.3-6 and 4). An Ammonite fossil was detected from the Heshan Formation (Fig. 3.5). We collected 14 chert samples from the Maokou Formation and 48 chert samples from the Heshan Formation.

At the Tieqiao section, we measured an interval of 11 m thickness of the lowermost Heshan Formation, and collected 15 chert samples (Fig. 5). The lowermost 5 m of the Heshan Formation is alternating beds of limestone and cherty rock. Next 6 m is also alternating beds of siliceous rock and limestone, but siliceous rocks are predominant.

3. Materials and Methods

Cherty rocks were collected for radiolarian research. Each rock sample weighed from 100 to several hundred grams. Rock samples were immersed in diluted hydrofluoric acid (5%) in 24 hours. Residues are collected using 36 and 200 mesh sieves. To get enough residues, the HF treatment is repeated upto a maximum of ten times. The residues were observed under binocular microscope. Radiolarian fossils were picked up for scanning microscope (JSM5500) and to take photos.

Radiolarian content is low and is ill-preserved, except for a few horizons. Sponge spicules, conodonts, bryozoans, ostracodes, foraminiferans, and other unidentified bioclasts are also seen in the residues by hydrofluoric treatment. Sponge spicules are predominant generally.

4. Fossil assemblages

4.1 Penglaitan section

In 14 samples from the uppermost Maokou formations at Penglaitan section, no radiolarian fossils were detected. Sponge spicules, non-fusulinid foraminiferans, ostracodes, bryozoans, fish teeth and unidentified bioclasts were obtained.

Radiolarian fossils were found from 31 samples of 48 samples collected from the lowermost Heshan Formations (Figs. 3.3-5, 4). Moderately well to identifiably preserved radiolarians were recognized from 6 samples (R2231, R2222, R2214, R2210, R2200, R2190: Fig. 4), as mention below, and figured in Plates 1-2.

Sample R2231 is gray siliceous mudstone, collected from the 1.4 m horizon above the boundary between the Maokou and Heshan formations, and the 2 m horizon above the Guadalupian-Lopingian boundary. R2231 is sponge spicule-rich rock, and the spicules are minute in size. By using sieves, radiolarian tests could be concentrated into residue, with small amount of sponge spicules, fragments of conodont, ostracodes, and foraminifera. This sample contains 18 radiolarian forms and is most diversified. *Foremanhelena triangula* De Wever and Caridroit (Pl. 1, Fig. 1) is detected characteristically, but there were only 2 specimens. *Raciditor gracilis* (De Wever and Caridroit) (Pl. 1, Figs. 11-12, 15), *Raciditor scalae* (De Wever and Caridroit) (Pl. 1, Fig. 13), *Latentifistula similicutis* Caridroit and De Wever (Pl. 1, Figs. 2-3), *Latentifistula* aff. *similicutis* Caridroit and De Wever (Pl. 1, Fig. 4) are common. *Gustefana obliqueannulata* Kozur (Pl. 1, Fig. 9) and *Ishigaum*? sp. (Pl. 1, Fig. 7) occur in little amounts. *Hegleria mammilla* (Sheng and Wang) (Pl. 2, Fig. 1) is dominant. *Entactinia*? sp. A (Pl. 2, Fig. 5), *Cenosphaera*? sp. A (Pl. 2, Fig. 12), *Cenosphaera*? sp. B (Pl. 2, Fig. 13) and radiolarians of ellipsoidal forms [Form A (Pl. 2, Fig. 18) and Form B (Pl. 2, Fig. 19)] are common. *Orbiculiforma*? sp. A (Pl. 2, Fig. 16) , *Spongotripus*? sp. A (Pl. 2, Fig. 21), *Staurolonche*? sp. A (Pl. 2, Fig. 23) and *Staurolonche*? sp. C (Pl. 2, Fig. 22) rarely occur.

Sample R2222 is nodular chert and is the 8.1 m horizon above the Guadalupian-Lopingian boundary. Conodonts, foraminiferans, and sponge spicules also occur

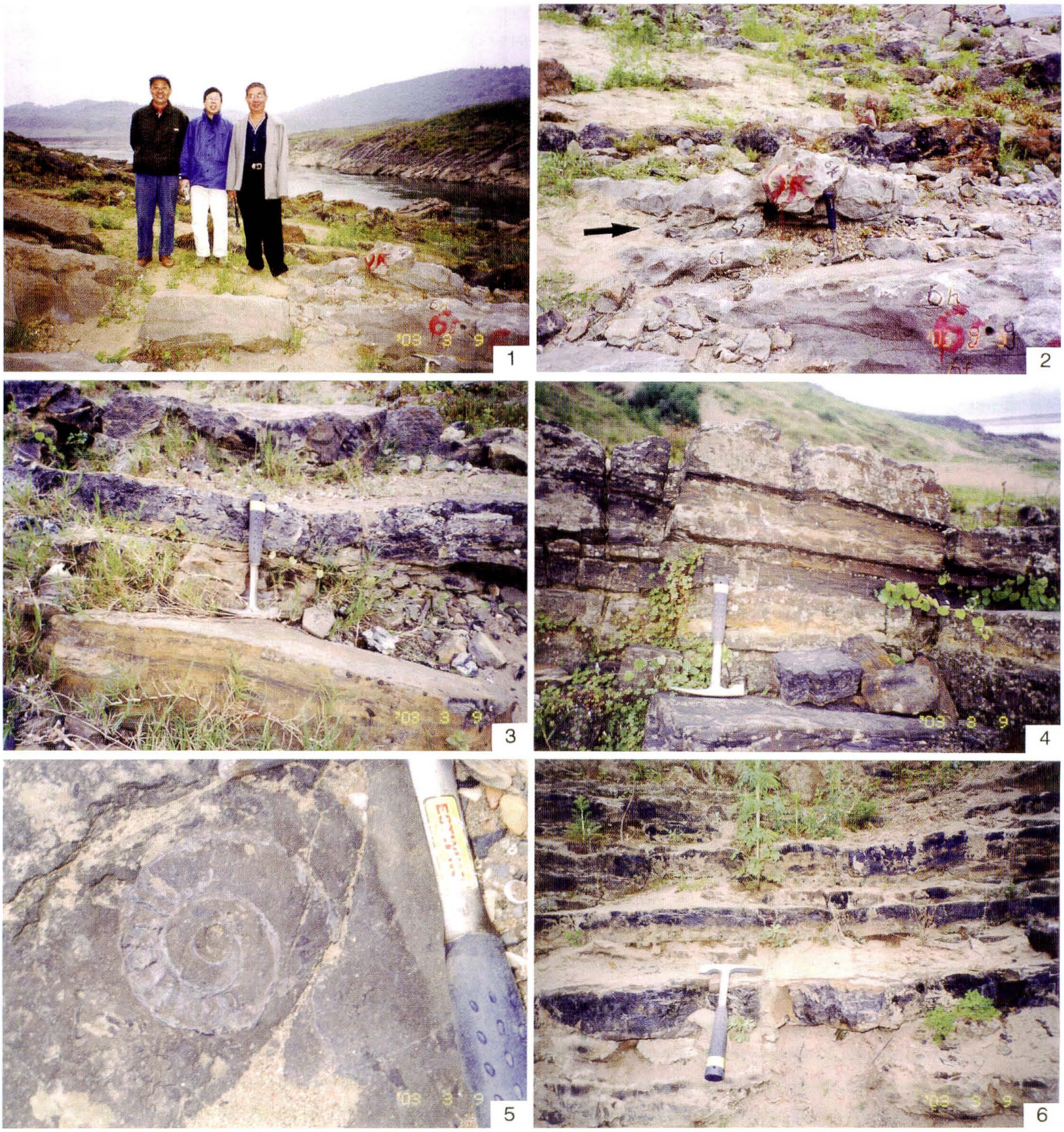

Fig. 3 Photographs of the Penglaitan section, Laibin, China.

1. The authors, YAO Jianxin (left), YAO Akira (center), and LI Jiaxiang (right) on GSSP for the Guadalupian /Lopingian boundary.
2. The boundary between the Maokou Formation and the Heshan Formation. The base of the Wuchiapingian stage is at the base of 6K/115 in the Maokou Formation. The base is indicated by a black arrow.
3. Gray mudstone and black chert of the lowermost Heshan Formation. The sampling horizon of sample R2229 is showing near the hammer grip. The hammer is 27 cm for scale.
4. Black chert and mudstone of the Heshan Formation. Hammer top indicating the sampling horizon of sample R2189.
5. Ammonite fossil, which occurs in the near horizon of sample R2188.
6. Alternating beds of black chert and mudstone of the Heshan Formation at 80 m above the lithostratigraphic boundary of the Maokou and Heshan formations.

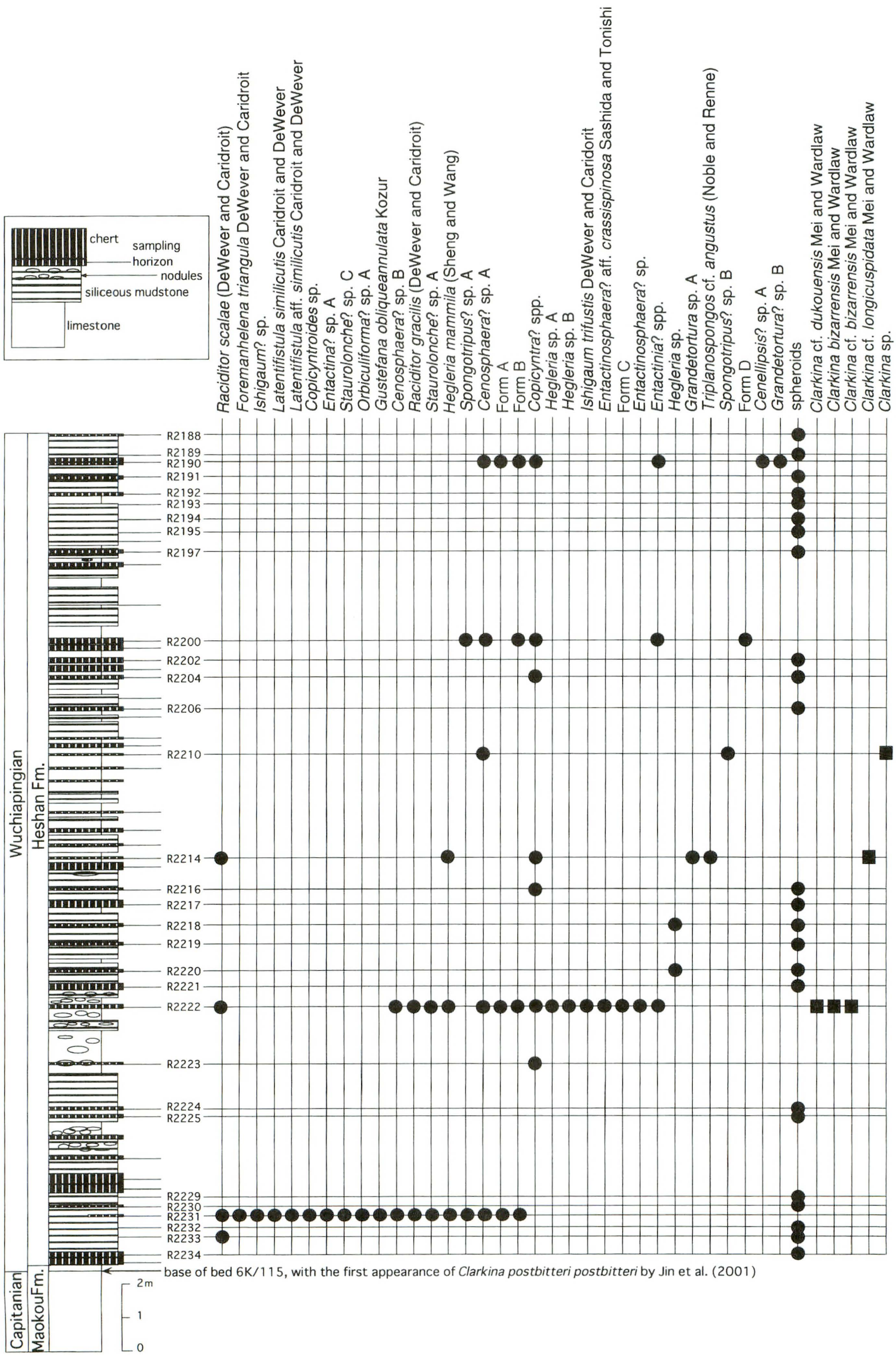

Fig. 4 Column of the Penglaitan section of the GSSP for the Guadalupian /Lopingian boundary, with radiolarian occurrence.

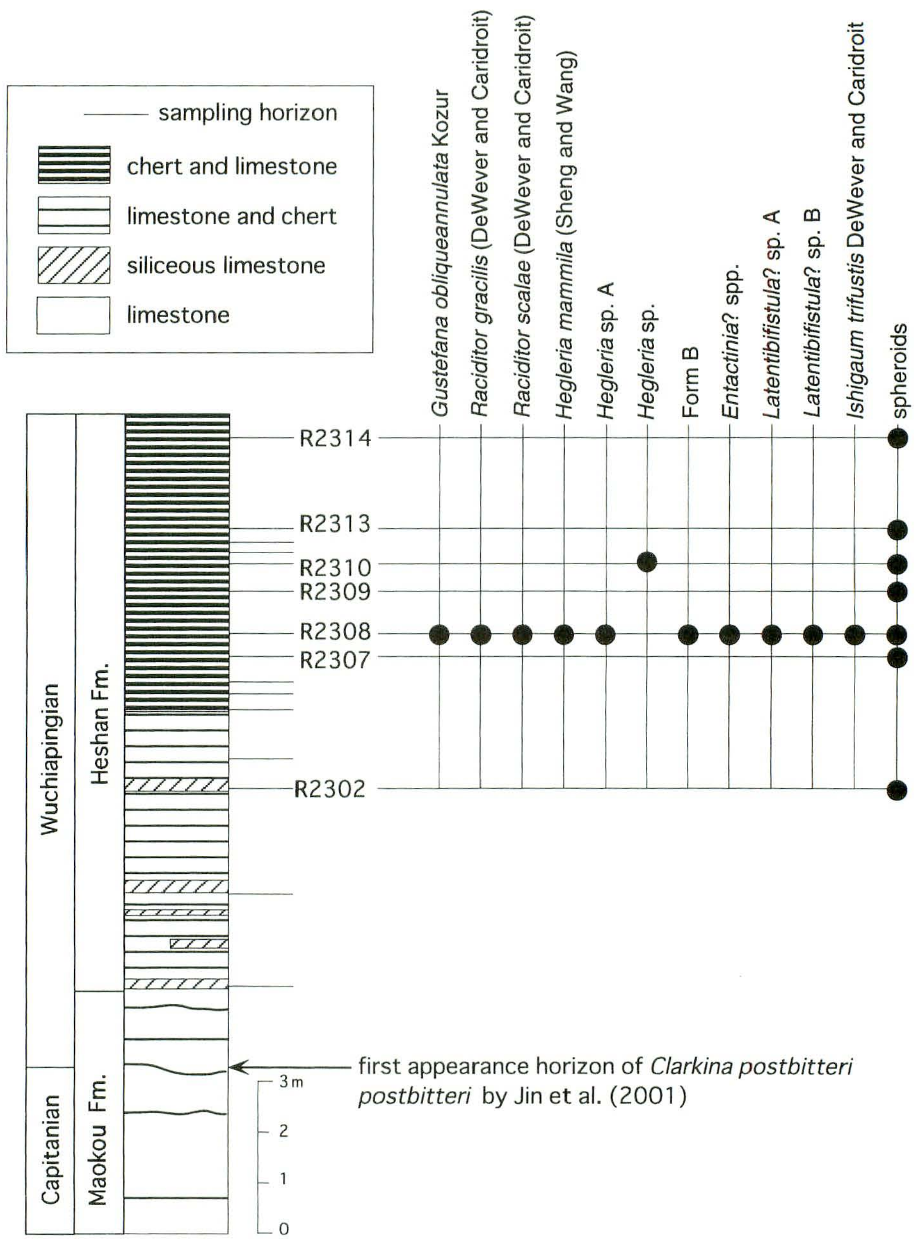

Fig. 5 Column of the Tieqiao section of the GSSP for the Guadalupian /Lopingian boundary, with radiolarian occurrence.

with radiolarian fossils. Sample R2222 bears 16 forms of radiolarians. This sample is characterized by the occurrence of *Ishigaum trifustis* De Wever and Caridroit (Pl. 1, Fig. 6), although the abundance is low. *Hegleria mammilla* (Pl. 2, Fig. 2) and *Staurolonche*? sp. A dominantly occur. Common species are *Entactinosphaera*? aff. *crassispinosa* Sashida and Tonishi (Pl. 2, Fig. 6), *Entactinia*? spp. (Pl. 2, Fig. 7), *Hegleria* sp. A (Pl. 2, Fig. 3), *Hegleria* sp. B (Pl. 2, Fig. 4), *Cenosphaera*? sp. A, *Cenosphaera*? sp. B, Form A, and Form B. Rare species are *Entactinosphaera*? sp. (Pl. 2, Fig. 17) and *Pentaspongodiscus*? sp. A (Pl. 2, Fig. 24). Co-existing conodont fossils are *Clarkina bizarrensis* Mei and Wardlaw (Fig. 6.2), *Clarkina* cf. *bizarrensis* Mei and Wardlaw (Fig. 6.3) and *Clarkina* cf. *dukouensis* Mei and Wardlaw (Fig. 6.1).

Sample R2214 is thin chert, which was collected from the 12.4 m horizon above the Guadalupian-Lopingian boundary. In sample R2214, radiolarian abundance is low, and radiolarian preservation is rather poor. Fossils found together are sponge spicules and conodonts. Five radiolarian forms and one conodont form were recovered. *Triplanospongos* cf. *angustus* (Noble and Renne) (Pl. 1, Fig. 8), *Raciditor scalae*, and *Grandetortura* sp. A (Pl. 2, Fig. 9) are detected, however only one specimen each. *Hegleria mammilla* and *Copicyntra* sp. (Pl. 2, Fig. 8) are

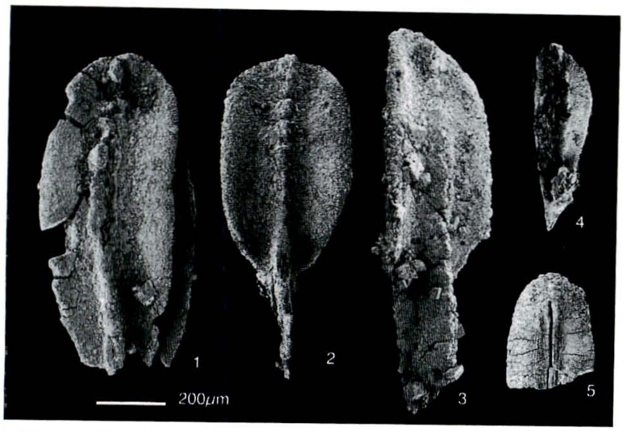

Fig. 6 Scanning photomicrographs of Wuchiapingian (Late Permian) conodonts from the Penglaitan section, Laibin, Guangxi, China, 1: *Clarkina* cf. *dukouensis* Mei and Wardlaw from R2222; 2: *Clarkina bizarrensis* Mei and Wardlaw from R2222; 3: *Clarkina* cf. *bizarrensis* Mei and Wardlaw from R2222; 4: *Clarkina* cf. *longicuspidata* Mei and Wardlaw from R2214; 5: *Clarkina* sp. from R2210.

common. Co-occuring conodont is *Clarkina* cf. *longicuspidata* Mei and Wardlaw (Fig. 6.4).

Sample R2210 is black mudstone. Sponge spicules, foraminiferans, ostracodes, radiolarians and conodont, *Clarkina* sp.? (Fig. 6.5), were recovered. *Spongotripus*? sp. B (Pl. 2, Fig. 20) and *Cenosphaera*? sp. A were detected, although the abundance of radiolarians is very low.

Sample R2200 is black chert. Sponge spicules, foraminiferans, and ostracodes also occur with radiolarians. The radiolarian preservation is poor. The 6 forms detected are mainly spherical and spheroidal forms, as *Cenosphaera*? sp. A, Form D (Pl. 2, Fig. 15) and Form B.

Sample R2190 is black chert. Sponge spicules, foraminiferans, and ostracodes are also recovered with radiolarians. Preservation of shell surfaces of radiolarians is poor, but internal structures are preserved in some specimens (Pl. 2, Figs. 10-11). *Grandetortura*? sp. B (Pl. 2, Figs. 10-11), which has coiled internal skeleton were recovered abundantly. *Hegleria mammilla* is also abundant. *Cenellipsis*? sp. A (Pl. 2, Fig. 14) is common. Totally 7 forms were detected.

4.2 Tieqiao section

Radiolarians were recovered from 7 samples of collected 14 samples (Fig. 5). The preservation of radiolarians on 6 samples are poor, and the assemblages are composed of only spheroids. We found moderately preserved radiolarian assemblage from the sample R2308, the horizon of which is 7 m above the boundary between the Maokou and Heshan formations, and 8.5 m above the Guadalupian-Lopingian boundary.

In sample R2308, *Hegleria mammilla* is frequent. There are representatives of *Raciditor scalae* (Pl. 1, Fig. 14), *Latentibifistula*? sp. A (Pl. 1, Fig. 16), *Latentibifistula*? sp. B (Pl. 1, Fig. 17), *Ishigaum trifustis* (Pl. 1, Fig. 5), *Raciditor gracilis*, and *Gustefana obliqueannulata* (Pl. 1, Fig. 10).

The radiolarian assemblages from the Heshan Formation are characterized by Latentifistularia. These are *Raciditor scalae, Foremanhelena triangula, Latentifistula similicutis, Ishigaum trifustis, Triplanospongos* cf. *angustus* etc. These assemblages are also characterized by abundant occurrences of *Hegleria mammilla* and spherical radiolarians with spongy test. No Albaillellaria was found at all from the both section.

5. Discussion

5.1 Radiolarian age

Permian radiolarian biostratigraphy of Southwest Japan (e.g., Ishiga, 1986), one of the standard Permian radiolarian zonation, was mainly established by pelagic bedded cherts, which are allocthonous blocks in the Jurassic accretionary complex. These bedded cherts are composed mostly of radiolarian test and sponge spicules with a few conodonts. Dating of the radiolarian zones is based on co-existing conodonts, although the occurrences of conodonts are sporadic and the frequency is low. Therefore, age determination of radiolarian zones from Southwest Japan may still be vague in some parts. In this study, we can recover the characteristic radiolarians from the GSSP for the Guadalupian-Lopingian boundary. The radiolarians from the lower Heshan Formation at Penglaitan and Tieqiao sections are certainly assigned to early Wuchiapingian age. These radiolarians are important for dating other radiolarian assemblages, which are already reported.

In the Penglaitan section, the preservation of radiolarians is limited, but the specific composition may show some faunal change through the section (Fig. 4). The sample R2231, which is collected from the 2 m horizon above the boundary between the Guadalupian-Lopingian, is characterized by *Foremanhelena triangula, Latentifistula similicutis, Raciditor gracilis* and *Raciditor scalae*. The sample R2222, which sites the 8.1 m horizon above the Guadalupian-Lopingian boundary, contains *Raciditor scalae, Raciditor gracilis* and *Ishigaum trifustis* characteristically. The sample R2214, which is the 12.4 m horizon above the Guadalupian-Lopingian boundary, contains *Triplanospongos* cf. *angustus*. In the Tieqiao section, sample R2308, which sites the 8.5 m horizon above the Guadalupian-Lopingian boundary, contains *Raciditor scalae, Raciditor gracilis* and *Ishigaum trifustis* etc. Therefore the horizons of sample R2222 and sample R2308 may be correlative by their similarity of the composition with the stratigraphic position.

Although these assemblages do not include any albaillellarians, it could be compared with that of the *Follicucullus charveti* – *Albaillella yamakitai* Assemblage Zone (Kuwahara et al., 1998; Kuwahara, 1999) from the Gujo-hachiman bedded chert section in the Mino Terrane, Southwest Japan. *Foremanhelena triangula, Latentifistula similicutis, Raciditor gracilis* and *Raciditor scalae* are characteristically found from the *Follicucullus charveti* - *Albaillella yamakitai* Assemblage Zone and equivalent zone (e.g., Caridroit and De Wever, 1986; Ishiga, 1985; Kuwahara and Yao, 2001; Kuwahara et al., 2003; Sun et al., 2002; Tumanda et al., 1990). *Triplanospongos angustus* may be considered to be a younger component, which occurs at the upper part within the *Follicucullus charveti* – *Albaillella yamakitai* Assemblage Zone, based on the composition of the assemblage (Noble and Renne, 1990) and its stratigraphic distribution (Kuwahara, unpublished data).

Based on the above comparison of the assemblage, the *Follicucullus charveti* – *Albaillella yamakitai* Assemblage Zone is assigned to the Wuchiapingian, however its accurate base and top are still unclear. The stratigraphic position of the lower *Follicucullus scholasticus* – *Follicucullus ventricosus* Assemblage Zone had been discussed (eg., Ishiga, 1991; Kozur, 1993). Kuwahara et al. (1998) assigned the age of the lower *Follicucullus scholasticus* – *Follicucullus ventricosus* Assemblage Zone to late Middle Permian – early Late Permian. Yao et al. (2001) made correlations between conodont and radiolarian zones in Gujo-hachiman section, Southwest Japan, and the conodont *Clarkina liangshanensis* zone of early Wuchiapingian was correlated to the radiolarian *Follicucullus scholasticus* – *Follicucullus ventricosus* and *Follicucullus charveti* – *Albaillella yamakitai* assemblage zones. In this study, the Wuchiapingian radiolarian assemblage could be assigned to that of the *Follicucullus charveti* – *Albaillella yamakitai* assemblage zone, and the lower *Follicucullus scholasticus* – *Follicucullus ventricosus* Assemblage Zone may be better assigned to late Middle Permian.

5.2 Significance of the assemblage

The assemblages from the Penglaitan and Tieqiao sections do not contain any Albaillellaria. The assemblages are also characterized by *Hegleria mammilla* and spherical radiolarians with spongy test. These features seem to indicate the paleoenvironment where radiolarians had been.

Mei et al. (1998) remarked that the depositional site of the Penglaitan and Tieqiao sections is between a carbonate platform and a northerly-trending narrow basin during the Guadalupian. ISSC (2004) stated that the Guadalupian-Lopingian boundary level herein coincides with the beginning of a transgressive phase. The limestone in the uppermost part of the Maokou Formation clearly indicates shallower water than the lowermost part of the Heshan Formation. In early Wuchiapingian age, the paleodepth increased and cherty deposits accumulated to make the lowermost Heshan Formation. However, the presence of carbonate rocks in the Heshan Formation shows that the paleodepth is not very deep as the basin center.

Wuchiapingian radiolarians were reported from the adjacent areas. The Chituao section (Kuwahara et al., 2003) is about 20 km north of the study sections. The Chituao section is composed of mainly chert with manganese layers, and had been called Gufeng Formation. The section can be correlated with the Heshan Formation because of its radiolarian assemblage. The distinctive feature of the assemblage is the presence of Albaillellaria in the Chituao section. Moreover, the Tongtianyan section (Kuwahara et al., 2004) is about 30 km north to the Chituao section. The Tongtianyan section comprises of chert and mudstone. Here, Albaillellaria occurs in limited horizons, although Latentifistularia and other spherical radiolarians occur in many horizons. Cherty sediments in the Chituao and Tongtianyan sections indicate rather deep paleodepth than that of the Penglaitan and Tieqiao sections.

Based on the variations of lithologies and radiolarian faunas among sections in the Laibin area, there is a possibility that Albaillellaria may prefer rather deepwater depth. The radiolarian assemblage with absence of Albaillellaria may indicate the shallower water depth. *Hegleria mammilla* and spherical radiolarians with spongy test may prefer shallower depth than Albaillellaria.

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Plate 1. Scanning photomicrographs of Wuchiapingian (Late Permian) radiolarians from the Penglaitan and Tieqiao sections, Laibin, Guangxi, China.

Fig. 1: *Foremanhelena triangula* De Wever and Caridroit, from R2231, Penglaitan.
Figs. 2-3: *Latentifistula similicutis* Caridroit and De Wever, from R2231, Penglaitan.
Fig. 4: *Latentifistula* aff. *similicutis* Caridroit and De Wever, from R2231, Penglaitan.
Figs. 5-6: *Ishigaum trifustis* De Wever and Caridroit, Fig. 5 from R2308, Tieqiao; Fig. 6 from R2222, Penglaitan.
Fig. 7: *Ishigaum*? sp., from R2231, Penglaitan.
Fig. 8: *Triplanospongos* cf. *angustus* (Noble and Renne), from R2214, Penglaitan.
Figs. 9-10: *Gustefana obliqueannulata* Kozur, Fig. 9 from R2231, Penglaitan; Fig.10 from R2308, Tieqiao.
Figs. 11-12, 15: *Raciditor gracilis* (De Wever and Caridroit), from R2231, Penglaitan.
Figs. 13-14: *Raciditor scalae* (De Wever and Caridroit), Fig. 13 from R2231, Penglaitan; Fig. 14 from R2308, Tieqiao.
Fig. 16: *Latentibifistula*? sp. A, from R2308, Tieqiao.
Fig. 17: *Latentibifistula*? sp. B, from R2308, Tieqiao.

Plate 1

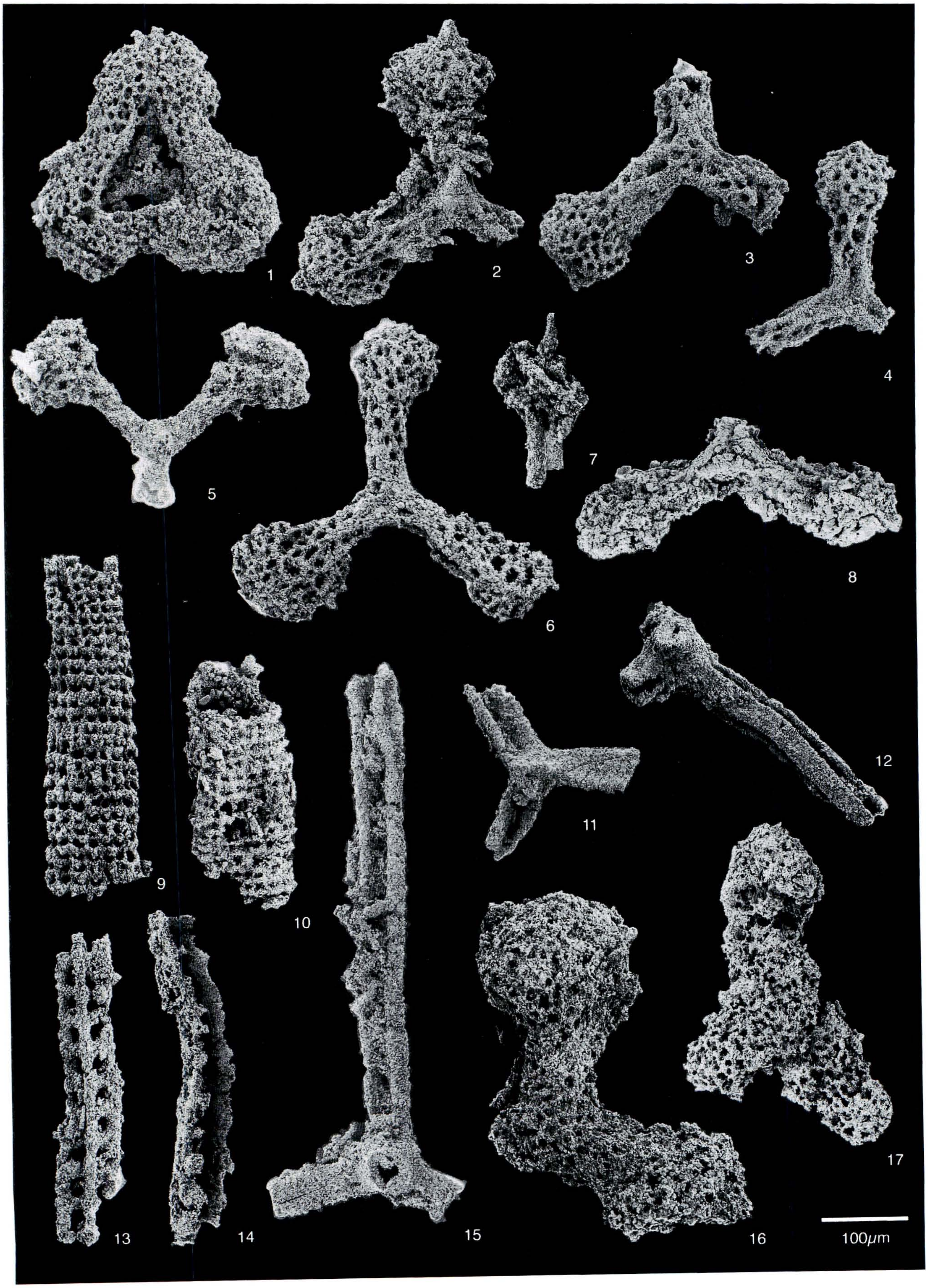

Plate 2. Scanning photomicrographs of Wuchiapingian (Late Permian) radiolarians from the Penglaitan section, Laibin, Guangxi, China.

Figs. 1-2: *Hegleria mammilla* (Sheng and Wang), Fig. 1 from R2231; Fig. 2 from R2222.
Fig. 3: *Hegleria* sp. A, from R2222.
Fig. 4: *Hegleria* sp. B, from R2222.
Fig. 5: *Entactinia*? sp. A, from R2231.
Fig. 6: *Entactinosphaera*? aff. *crassispinosa* Sashida and Tonishi, from R2222.
Fig. 7: *Entactinia*? sp., from R2222.
Fig. 8: *Copicyntra*? sp., from R2214.
Fig. 9: *Grandetortura* sp. A, from R2214.
Figs.10-11: *Grandetortura*? sp. B, from R2190.
Fig. 12: *Cenosphaera*? sp. A, from R2231.
Fig. 13: *Cenosphaera*? sp. B, from R2231.
Fig. 14: *Cenellipsis*? sp. A, from R2190.
Fig. 15: Form D, from R2200.
Fig. 16: *Orbiculiforma*? sp. A, from R2231.
Fig. 17: *Entactinosphaera*? sp., from R2222.
Fig. 18: Form A, from R2231.
Fig. 19: Form B, from R2231.
Fig. 20: *Spongotripus*? sp. B, from R2210.
Fig. 21: *Spongotripus*? sp. A, from R2231.
Fig. 22: *Staurolonche*? sp. C, from R2231.
Fig. 23: *Staurolonche*? sp. A, from R2231.
Fig. 24: *Pentaspongodiscus*? sp. A, from R2222.

Plate 2