

Latest Permian radiolarian fauna from Klaeng, eastern Thailand

Katsuo Sashida¹, Sirot Salyapongse², and Nikorn Nakornsri²

¹Institute of Geoscience, University of Tsukuba, Ibaraki, 305-8571, Japan

²Department of Mineral Resources, Rama VI, Bangkok 10400, Thailand
email: sashida@arsia.geo.tsukuba.ac.jp

ABSTRACT: A latest Permian radiolarian fauna is described from a chert-clastic sequence exposed at Khao Wang Chik, Klaeng, eastern Thailand. This fauna was recovered from a continuous siliceous sequence comprised of white to light gray siliceous shale, dark gray bedded chert, and dark gray siliceous shale. The fauna is composed of *Neoalbaillella optima*, *Albaillella levis*, *A. triangularis*, *Entactinia itsukaichiensis*, *Triaenosphaera minuta*, *Ishigaum trifustis*, *Nazarovella inflata*, *Triplanospongos musashiensis*, *Copicyntira akikawaensis* and others. These radiolarians represent the latest Permian *Neoalbaillella optima* Assemblage reported from Japan, Russian Far East, Philippines, south and southwestern China, and northern Thailand. The radiolarian-bearing sequence was probably deposited in the deep, pelagic environment of the Paleotethys Ocean. An overlying coarse-grained clastic sequence reflects an abrupt change in local depositional environment, possibly caused by the narrowing of the Paleotethys Ocean in Early Triassic time. Twenty-eight radiolarian species belonging to 15 genera are systematically investigated. One new genus, *Klaengspongos*, and four new species, *Triaenosphaera longispina*, *Ishigaum klaengensis*, *Pseudospongoprimum? fontainei*, and *Klaengspongos spinosus* are described.

INTRODUCTION

The largest mass extinction event of marine biota during the Phanerozoic era occurred at the Permian-Triassic (P/T) boundary (e.g., Erwin 1993). Most discussion of the extinction event at this boundary has analyzed the shallow marine sediments that accumulated on continental margins and yielded well-preserved fossils (e.g., Sweet et al. 1992). Conversely, deep-sea pelagic sediments that include the P/T boundary have been discovered in Japan (e.g., Yamakita 1987). Studies of these ancient deep-sea sediments indicate that Permian radiolarians also had a great extinction crisis at the end of Permian (Ishiga 1992; Yao and Kuwahara 1997). A Permian radiolarian biostratigraphy in the bedded chert sequences of the Tamba-Mino Terrane, central Japan, has been proposed by Ishiga and his colleagues (e.g., Ishiga et al. 1982; Ishiga 1990, 1991) using albaillellarians, which have a peculiar morphology and short stratigraphic range. Based on radiolarian diversity and lithostratigraphical characteristics, Kuwahara and Yao (1998) discussed marine environmental change during Late Permian time and concluded that the drastic faunal change in the latest Permian radiolarian fauna is strongly related to the environmental deterioration such as the development of overturn of an anoxia ocean near the end of the Permian. Their precise biostratigraphic work has revised Permian radiolarian biostratigraphy, especially the uppermost radiolarian zones (Kuwahara et al. 1998).

In March of 1998, we undertook a field survey in the Klaeng area, eastern Thailand, to determine the geologic age of the fine-grained clastic rocks there. In this area, almost continuous sequences composed of white to light gray siliceous shale, dark gray bedded chert, and dark gray siliceous shale and yielding uppermost Permian radiolarians, have been discovered at two sections in Khao Wang Chik, near Klaeng, eastern Thailand. The uppermost Permian radiolarian fauna is composed of well-known species representative of the *Neoalbaillella optima* Assemblage (Kuwahara et al. 1998). The lithological and

micropaleontological evidence in these sections provides significant data on radiolarian biostratigraphy near the P/T boundary and also on the depositional environment in the Paleotethys Ocean. Lithological characteristics of the sequence, the radiolarian fauna, and paleogeography are discussed by evaluating previous studies mainly from Japan. Twenty-eight radiolarian taxa, belonging to 15 genera are documented in this paper; four new species are described.

GEOLOGIC SETTING

Mainland Thailand consists of two principal continental blocks: the western Shan-Thai Block and eastern Indochina Block (Bunopas 1981) (text-fig. 1). The boundary between these two blocks is marked by two fold belts, the western Sukhothai and eastern Loei-Petchabun Fold Belts. The boundary between these two fold belts is further represented by a suture zone: the Nan-Uttaradit to the north and Sa or (Sra) Kaeo-Chanthaburi to the south. The Nan-Chanthaburi suture zone extends north to the Changning-Menglian belt in western Yunnan (Liu et al. 1991) and south to the Bentong-Raub suture zone in peninsular Malaysia (e.g., Hutchison 1975). The Klaeng area belongs to the Sukhothai Fold Belt. Bunopas (1992) recognized seven longitudinal stratigraphic belts, BS-1 to BS-5, and BI-6 to BI-7 from west to east, the first five of which cover the Shan-Thai Block in Thailand. The Klaeng area probably is within BS-4. According to Bunopas (1992), the following lithostratigraphic units are assigned as the Paleozoic and Mesozoic formations in the stratigraphic belt BS-4: the Sukhothai Group (Silurian to Devonian); the Dan Lan Hoi or Mae Tha Groups (Carboniferous); the Phrae and Chanthaburi Groups (Carboniferous to Triassic); the Ngao Group (Permian); the Lampang Group (Triassic); and the Lower Khorat Group (Jurassic).

These lithostratigraphic units, however, cannot be applied directly to this area because of the poor exposures and limited number of comprehensive geological studies. According to the

1:250,000 Geologic Map Sheet, Changwat Rayong, published by Department of Mineral Resources of Thailand (1984), the Carboniferous-Permian Ratburi Group is mapped around Khao Wang Chik. Salyapongse et al. (1997) also assigned the lithostratigraphic unit distributed in this area to the Carboniferous-Permian.

LITHOSTRATIGRAPHY

Latest Permian radiolarians were found in two sections: Section I located at an abandoned quarry, and Section II at a roadcut along National Road 344 (text-fig. 2). A sketch map of the outcrops and column showing the lithostratigraphy at both sections are shown in text-figures 2 and 3, respectively.

Section I

Rocks strike N65°W to N5°E and dip 65° to 85° east. On the basis of the sedimentary structures observed in the siliceous shale (text-fig. 4), this section consists of a northeast-upward sequence. The complete sequence could not be measured due to soil cover. The lowest rock unit is well bedded and consists of white to light gray siliceous shale with thin intercalations of clay. The siliceous shale beds are mostly 5 to 10cm thick and are composed of rare radiolarian tests, clay, and fine detrital quartz particles; the thin clay layers are typically less than 1 cm thick. The thickness of this unit is 6m. A dark gray to black bedded chert overlies the white to light gray siliceous shale unit. Pale and green or light gray cherts can be also seen in places. They are well bedded and about several centimeters thick intercalated with siliceous clay a few millimeters thick. The cherts are composed of abundant radiolarian tests with clay minerals and fine authigenic quartz grains. Several 10cm-thick layers of "brecciated chert" are present in the upper part of the chert unit. The "brecciated chert" consists of angular to subangular grains of chert and siliceous shale and of fine-grained opaque minerals in a microcrystalline quartz matrix (text-figure 4). Maximum diameter of most of the chert and siliceous shale grains, which have almost the same micro-lithological characteristics as mentioned above, is less than 1 mm. Sandstone grains are varied in shape, and maximum diameter rarely attains 2mm. The matrix contains fine-grained iron oxides in places. The thickness of the bedded chert unit including layers of "brecciated chert" is approximately 8m. Dark gray siliceous shale conformably overlies the bedded chert unit. This shale is thin bedded and composed of abundant radiolarian tests and minor sponge spicules within clay-sized matrix. Angular detrital quartz particles less than 20µm in diameter are also commonly scattered in this unit. Very fine grained sandstone layers are rarely intercalated in this siliceous shale. Gradation and cut and fill structures are commonly observed at the boundary between siliceous shale and sandstone layers (text-fig. 4). The thickness of the dark gray siliceous shale unit is estimated to be 2.5m. The contact with the overlying sandstone is not visible due to soil cover and vegetation, but we believe these units are in fault contact. This coarse-grained, massive, dark gray, arenite sandstone characteristically contains fragments of black shale with fine grains of quartz, plagioclase, and orthoclase.

Section II

Section II is located about 150m northwest of Section I and is an continuous sequence. The sequence measured in this section is as follows in ascending order; white to light gray siliceous shale (about 7m) dark gray bedded chert (12m); dark gray siliceous shale (2m); black carbonaceous mudstone (2.5m); dark gray siliceous shale (2.5m); thinly bedded fine-grained sand-

stone (3m); and coarse-grained massive sandstone (more than 10m). The lithological characteristics of the lowest white to light gray siliceous shale are almost the same as in Section I mentioned above. The upper part of this shale, however, intercalates thin layers of dark gray bedded chert in places. The overlying dark gray bedded chert and dark gray siliceous shale have also the same lithological characteristics of Section I. Thin (3 to 4cm) layers of white to light gray siliceous shale are rarely intercalated in the dark gray bedded cherts. The upper 30 cm of dark gray siliceous shale is thinly laminated and variegated; these beds are conformably overlain by black carbonaceous mudstone which is mostly massive and structureless and strongly weathered. Dark gray siliceous shale, whose lower portion of about 20cm is thinly laminated and variegated, conformably overlies the black carbonaceous mudstone. Lithologically, this dark gray siliceous shale is almost the same as that overlain by the black carbonaceous mudstone, but no radiolarians have been identified from this siliceous shale. Layers of fine-grained sandstone about several millimeters to 1cm thick are intercalated in the upper part of this siliceous shale. Thinly bedded fine-grained sandstone overlies dark gray siliceous shale. This arenitic, well sorted sandstone is light gray, and beds are 2 to 3cm thick. The overlying sandstone is coarse-grained, massive, and also arenitic. No fossils have been found in the sandstones in Section II. Although the radiolarian-bearing siliceous rock sequence in both sections is well correlated, the "brecciated chert" layers are not present in Section II.

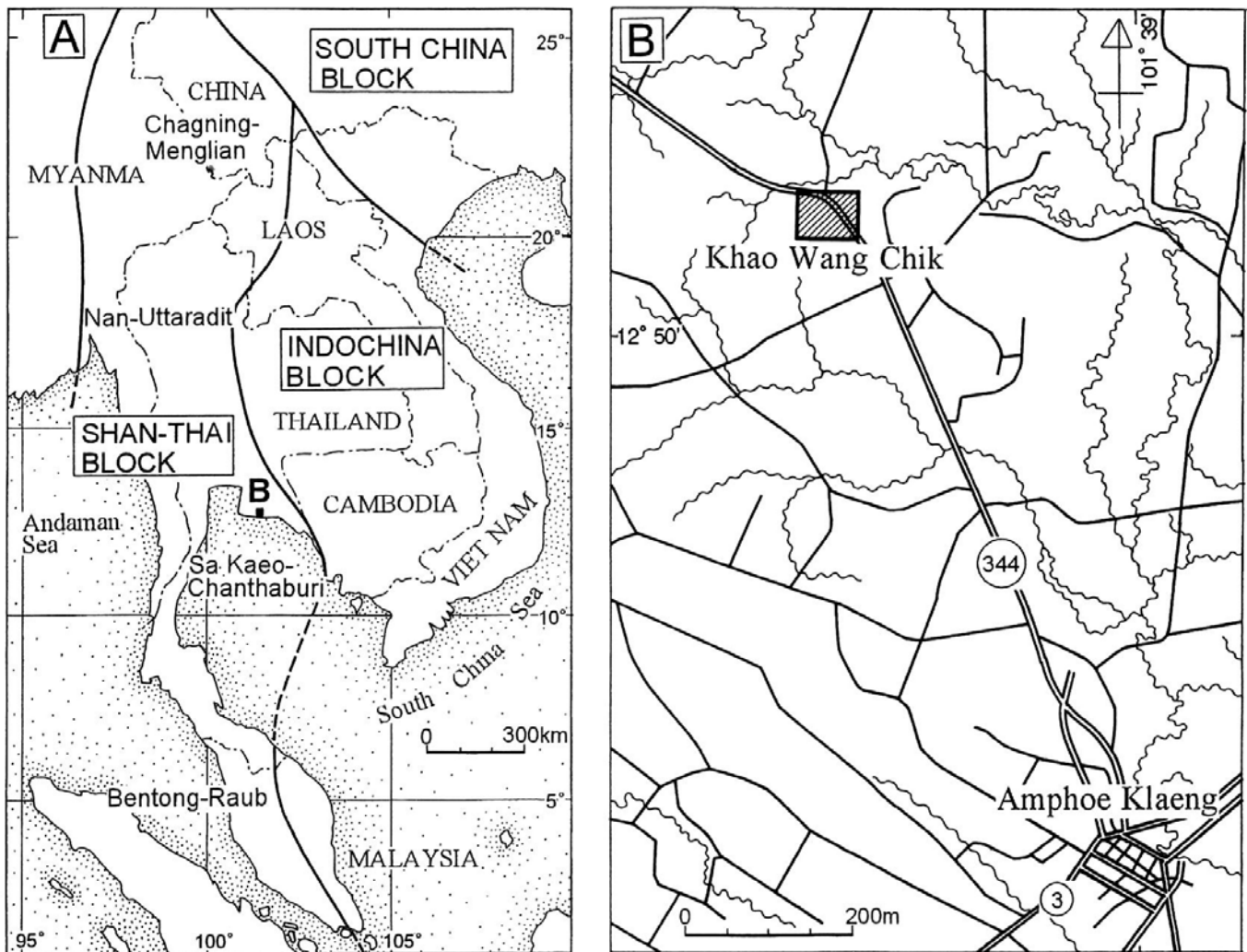
Comparison with the Uppermost Permian siliceous rock sequence of Japan

Since Yamakita (1987) first discovered the P/T boundary, defined by conodont biostratigraphy, in a continuous pelagic sedimentary sequence at the Tenjinmaru Section, Chichibu Terrane, eastern Shikoku, Japan, several sections that include the P/T boundary in the same lithologic units have been described from the Tamba-Mino Terrane, southwest Japan (e.g., Yamashita et al. 1991; Ishida et al. 1992; Kuwahara et al. 1991; Sugiyama 1992). All these units are allochthonous complexes of Jurassic age constituting disrupted melange. To sum up these lithological and biostratigraphical studies, the sequence including the P/T boundary consists of the following lithostratigraphy: Late Permian radiolarian-bearing gray bedded chert, siliceous shale (or claystone), black carbonaceous mudstone, alternating beds of chert and shale containing Early Triassic conodonts, and black to gray bedded chert. The P/T boundary defined by conodonts is placed at the base of black carbonaceous mudstone (e.g., Ishida et al. 1992; Ishiga 1992). The sequence below the black carbonaceous mudstone in the Section II in Khao Wang Chik is almost the same as that recognized in Japan.

The deep-sea pelagic sequences spanning the P/T boundary discovered in Japan may have been deposited somewhere in the western Panthalassa Ocean fairly remote from the land, as they are completely devoid of coarse-grained terrigenous clastics (Isozaki 1997). Radiolarian-bearing siliceous sedimentary rocks in both sections in Khao Wang Chik are also thought to have accumulated in a deep and pelagic environment in the Paleotethys Ocean around the end of Permian. However, drastic change occurred in the depositional basin, which is suggested by the stark lithological change from black carbonaceous mudstone to sandstone through dark gray siliceous shale.

RADIOLARIAN FAUNA AND AGE

Radiolarian specimens discussed in this paper were extracted from siliceous sedimentary rocks by using the method men-



TEXT-FIGURE 1

Index map: (A) Tectonostratigraphic terranes of Southeast Asia, showing the location of suture between the Shan-Thai and Indochina Blocks; map from Hada et al. (1999). (B) Index map showing the study area.

tioned by Sashida (1988). Stratigraphic distribution of radiolarians in the two sections is shown in text-figure 3. Radiolarian preservation in samples from Section I is much better than in those from Section II. Among the examined samples in Section I, sample KWC-1-9, a dark gray bedded chert, yielded the best preserved specimens.

Although radiolarian abundance is variable due to the state of preservation, all the examined samples seem to contain the same fauna based on composition and stratigraphic relationship. The fauna consists of well-known species such as, *Neobaillella optima*, *Albaillella triangularis*, *A. levis*, *Entactinia itsukaichiensis*, *Hegleria mammilla*, *Nazarovella gracilis*, *N. inflata*, *Triplanospogos musashiensis*, *Foremanhelenia triangularis*, and other representatives of the *Neobaillella optima* Assemblage established by Ishiga et al. (1982). Previously, the *Neobaillella optima* Assemblage has been reported from the Russian Far East (Rudenko and Panasenkov 1990), the Philippines (Cheng 1989; Tumanda et al. 1990), southern and southwestern China (e.g., Yao et al. 1993; Wang et al. 1994), and northern Thailand (Sashida et al. 1994).

Permian radiolarian biostratigraphy in Japan has been defined in bedded chert sequences mainly in the Tamba-Mino Terrane where Permian cherts are present as exotic blocks in the Jurassic accretionary complex (Ishiga et al. 1982; Ishiga 1990). Ishiga (1990) established 13 radiolarian assemblages or assemblage zones in the Upper Carboniferous to Upper Permian. These were defined by albaillellarians, which have a characteristic shell form and commonly short stratigraphic range. The upper Middle Permian to Upper Permian radiolarian assemblage zones are as follows in ascending order: *Follicucullus scholasticus*, *Neobaillella optima*, and *N. ornithoformis* Assemblage Zones. Kuwahara et al. (1998) reexamined Upper Permian radiolarian biostratigraphy in the bedded chert sections of the Gujo-hachiman and Neo areas in the Mino Terrane and revised the foregoing assemblage and zones as the *Follicucullus charveti-Albaillella* sp. F, *Neobaillella ornithoformis*, and *Neobaillella optima* Assemblage Zones. Reversal of the *Neobaillella optima* and the *N. ornithoformis* Zones was previously suggested by studies in northern Thailand (Sashida et al. 1994; 1998) and the Philippines (Tumanda et al. 1990). Sashida et al. (1994) recovered well-preserved radiolarians belonging to

the *Neobaillella optima* Assemblage from dark gray bedded cherts conformably overlain by black carbonaceous mudstone at Ban Huai Tin Tang about 100 km north of Chiang Mai, northern Thailand. Sashida et al. (1998) also pointed out that the first appearance of *Neobaillella ornithoformis* was earlier than that of *N. optima* at Busuanga Island in the Philippines, of which biostratigraphic work was conducted by Tumanda et al. (1990). The order of occurrence of *Neobaillella optima* and *N. ornithoformis* is similar in stratigraphic sections at the Sasayama Section in the Tamba Terrane and at Busuanga Island in the Philippines. However, we did not recover *Neobaillella ornithoformis* from siliceous sedimentary rock sequences in the present study at Khao Wang Chik.

There are no other index fossils to precisely date the radiolarian fauna from Kao Wang Chik. Only one conodont fragment (plate 2, figure 26) was found, in sample KWC-1-9; this specimen is probably a species belonging to *Neogondolella* that has long stratigraphic range from Permian to Middle Triassic. Therefore, we infer the age of the radiolarian fauna by employing previously presented radiolarian age assignments. The age of Upper Permian radiolarian zones has been discussed by Ishiga et al. (1982) and Blome and Reed (1992, 1995). Age assignment by Ishiga et al. (1982) is based on co-occurring conodonts and stratigraphic relationships of radiolarian faunas. According to Ishiga et al. (1982), *Neobaillella*-bearing cherts occupy stratigraphically higher levels than those of *Follicucullus*-bearing cherts in the bedded chert sequences in the Tamba Terrane. They further identified conodonts such as *Hindeodus minutus* (Ellison) and other unidentified species belonging to *Neogondolella*. Some of these neogondolellid specimens have a morphology similar to *Neogondolella orientalis* (Braskov and Koroleva), which indicates a Dzulfian (Late Permian) age. Blome and Reed (1992, 1995) dated radiolarian-bearing strata in Oregon and Nevada by adopting previously presented biostratigraphical investigations of ammonite, conodont, and radiolarian faunas from North America and Japan. We follow their age assignments herein and thus date the *Neobaillella optima* Assemblage as latest Permian, Changxingian stage in the Chinese sense (e.g., Sheng et al. 1984).

PALEOGEOGRAPHY IN THE KLAENG AREA DURING LATE PERMIAN TO TRIASSIC TIME

On the basis of radiolarian and fusulinacean biostratigraphy and granitoid dating, Hada et al. (1999) summarized the tectonics and paleogeography of the Sa Kao-Chanthaburi suture zone in eastern Thailand. They indicate the suture zone is composed of two parallel belts: a western chert-clastic belt (Chanthaburi Chert-Clastic Sequence), and an eastern belt of serpentinite melange (Thung Kabin Melange) that may occur as inferred-fault bounded packages. The boundaries between the Indochina Block and Thung Kabin Melange and between the Shan-Thai Block and Chanthaburi Chert-Clastic Sequence are equivocal. The Klaeng area is within the Shan-Thai Block. Previously, distinct Upper Permian lithologic units have not been reported from the Klaeng area except for the *Leptodus*-bearing shale near Khao Iphring (12°49' N, 101°48' E and 12°50'30" N, 101°48'10" E) (Salyapongse et al. 1997). Although the precise age of this shale is uncertain, a rather shallow depositional basin where *Leptodus* dwelled and a much deeper basin remote from land where radiolarian cherts accumulated were both present during Late to latest Permian time. Fontaine and Vachard (1981) reported the occurrence of Lower to Middle Triassic foraminifera-bearing limestone from Wat Suk Phrai Wan about 10km east of Klaeng. This limestone is rather thick and well

bedded and yielded *Meandrospira pusilla*, *Glomospira tenuifistula*, *G. facilis*, and other species that indicate Scythian to Anisian age. Furthermore, gray to black, thickly bedded limestones yielding Middle Triassic stromatolites and foraminifers crop out at an abandoned quarry at Khao Cha-ang On about 40 km north of Klaeng (Vachard and Fontaine 1988). Some identified fossils there are *Koivaella* sp., *Tubiphytes obscurus*, *Baccanella floriformis*, *Ladinella porata*, *Endothyranella* sp., and *Glomospirella* sp., which indicate a Ladinian age. Although unpublished, we discriminated poorly preserved Anisian to Ladinian radiolarians from red bedded chert distributed at Klaeng Hang Maeo about 25 km northeast of Klaeng. Sandstone conformably overlying the dark gray siliceous shale at Khao Wang Chik, some parts of the foraminifera-bearing limestones, red bedded chert, and sandstone are thought to be heterofacies.

In Early to Middle Triassic time, there were probably basins where cherts, coarse-grained clastics, and limestones accumulated. From bio- and lithostratigraphical evidence, it seems likely an abrupt change occurred in the depositional environment across the P/T boundary, from a deep pelagic ocean in the latest Permian to a shallower sea in the Triassic. This environmental change is believed to be due to the narrowing of the Paleotethys Ocean in the Early Triassic time. Farther to the east, the western belt of the suture zone in the Sa Kao-Chanthaburi area is characterized by alternating bedded chert and coarse clastic units, which are the product of an offscraped accretionary complex resulting from the convergence of the Paleotethys Ocean (Hada et al. 1999). The age of these bedded cherts is mostly Middle Triassic but extends rarely to the Upper Triassic.

The lithological setting of the Triassic shallow marine limestones and clastics and the deep and pelagic cherts and clastic sequences on the Shan-Thai Block to the Paleotethys Ocean is almost the same as that recognized in southern peninsular Thailand and northwestern peninsular Malaysia (Sashida et al. 1999). The closure of the Paleotethys Ocean is estimated to have occurred in the Late to latest Triassic, as suggested by Hada et al. (1999), Sashida and Igo (1999), and others.

SYSTEMATIC PALEONTOLOGY

The paleontological work was undertaken by K. Sashida, who takes full responsibility for the taxonomy presented in this paper. All specimens described are deposited in the Institute of Geoscience, University of Tsukuba, and have the prefix IGUT.

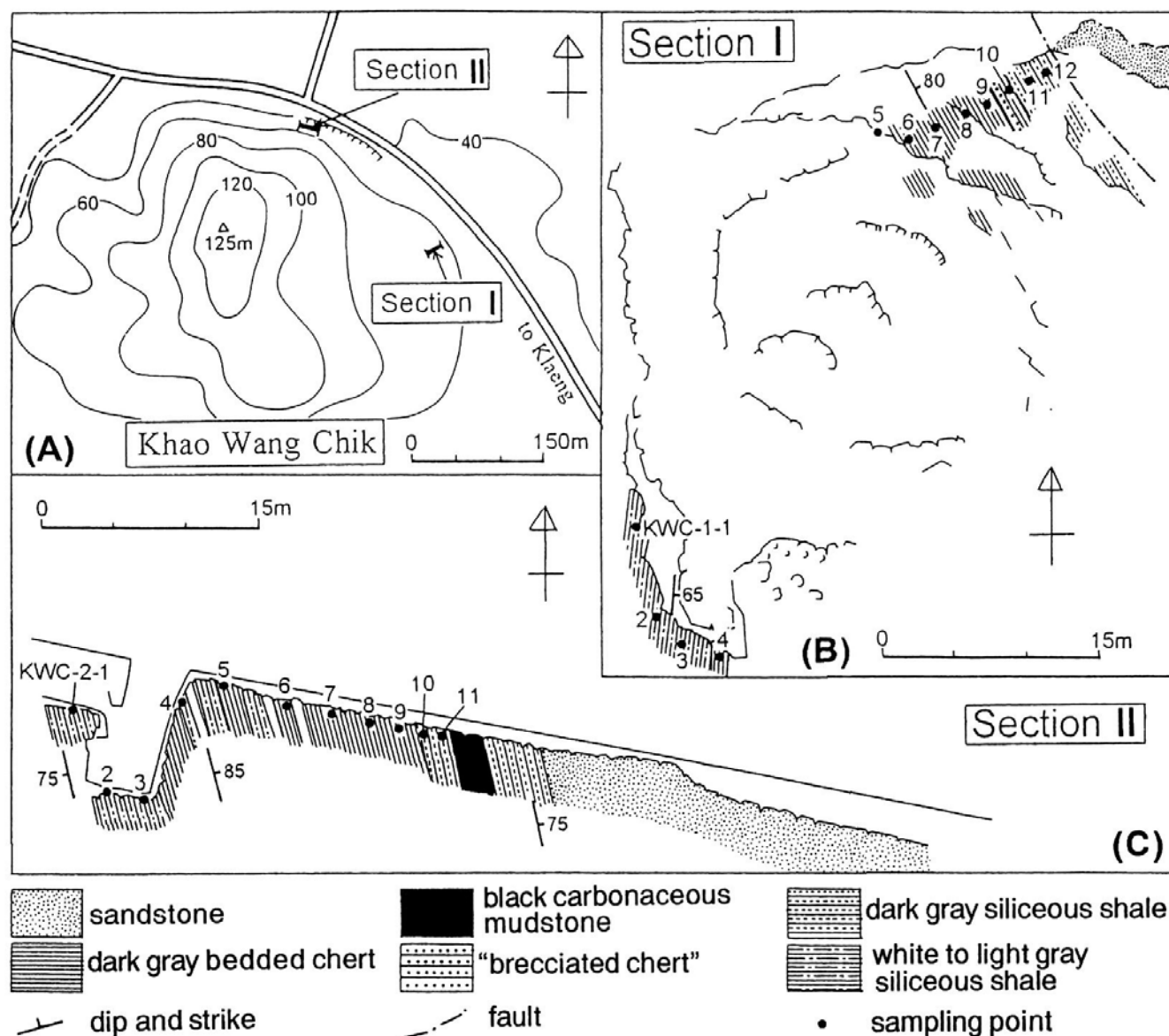
Order POLYCYSTINA Ehrenberg 1838; emend. Riedel 1967
Suborder ALBAILLELLARIA Deflandre 1952; emend.
Holdsworth 1969
Family ALBAILLELLIDAE Deflandre 1952; emend.
Holdsworth 1977

Genus *Neobaillella* Takemura and Nakaseko 1981
Type species: *Neobaillella ornithoformis* Takemura and Nakaseko 1981

Range: Upper Permian (Wuchiapingian to Changxingian).

Occurrence: Japan, North America, peninsular Malaysia, Thailand, New Zealand, Philippines, south and southwestern China, Russian Far East.

Neobaillella optima Ishiga, Kito and Imoto
Plate 1, figures 1-4



TEXT-FIGURE 2

Index map showing the location of sections studied (A). Sketch map showing the sampling sites along Section I (B) and Section II (C).

Neobaillella sp. B TAKEMURA and NAKASEKO 1981, p. 213, pl. 34, figs. 4, 5. - NISHIZONO 1996, pl. 2, fig. 13.

Neobaillella optima ISHIGA, KITO and IMOTO 1982, p. 16, pl. 1, figs. 1-5. - NISHIZONO et al. 1982, pl. 2, fig. 8. - WAKITA 1983, pl. 5, figs. 1-3. - TUMANDA et al. 1990, pl. 2, fig. 17. - RUDENKO and PANASENKO 1990, p. 120, 121, pl. 11, fig. 4. - KUWAHARA et al. 1991, fig. 4-4. - YAO et al. 1993, pl. 2, fig. 9. - WANG et al. 1994, p. 186, pl. 4, figs. 1-3. - KUWAHARA and YAO 1998, pl. 1, fig. 24.

Neobaillella sp. cf. *N. optima* ISHIGA, KITO and IMOTO, CHENG 1989, p. 139, pl. 4, figs. 13-16; pl. 5, figs. 1-3.

Neobaillella sp., CHENG 1989, p. 139, pl. 5, fig. 4.

? *Neobaillella* sp. cf. *N. ornithoformis* TAKEMURA and NAKASEKO, ISHIDA et al. 1992, pl. 1, fig. 3.

Remarks: Our specimens are well preserved and have the diagnostic characters of *Neobaillella optima*, such as a long conical shell with ladder-shaped wings.

Occurrence: Upper Permian (Changxingian). Japan, Philippines, Russian Far East, northern and eastern Thailand.

Neobaillella ? sp.

Plate 1, figure 5

Remarks: Illustrated specimen is characterized by a cylindrical shell which probably consists of a pseudothorax and pseudoabdomen, with a conical apical horn and bars perpendicular to the rods. This form has a swollen apical cone (apex of shell) and may belong to the S type of *Neobaillella*, which represents a part of the "dimorphic pairs" of Ishiga (1991). Previously, the S type of *Neobaillella* has been reported from the Tamba Terrane of southwest Japan as *Neobaillella* sp. A Takemura and Nakaseko 1981 and from the Yunnan area of south China as *Neobaillella* sp. of Kuwahara, Yao and An 1997. *Neobaillella* sp. A Takemura and Nakaseko 1981 differs from *Neobaillella* ? sp. of the present study by having strongly inflated apical portion, which resembles a "temple bell". Although the outer shell features of *Neobaillella* ? sp. resemble *Neobaillella* sp. of Kuwahara, Yao and An 1997, precise com-

parison is not possible because of the poor preservation of the specimens.

Occurrence: Upper Permian (Changxingian). Eastern Thailand.

Genus *Albaillella* Deflandre 1952; emend. Holdsworth 1966; emend. Ormiston and Lane 1976

Type species: *Albaillella paradoxa* Deflandre 1952

Occurrence: Devonian to Upper Permian (upper Famennian to Changxingian). Japan, North America, Europe, south China, northern and eastern Thailand, peninsular Malaysia.

Albaillella triangularis Ishiga, Kito and Imoto 1982
Plate 1, figures 6-10, 13

Albaillella triangularis ISHIGA, KITO and IMOTO 1982, pl. 2, figs. 8-11. - WAKITA 1983, pl. 6, fig. 8. - CARIDROIT et al. 1985, pl. 1, fig. 1. - ISHIGA 1985, p. 13, pl. 2, figs. 13-19. - YOSHIDA and MURATA 1985, pl. 2, figs. 9, 10. - CARIDROIT and DE WEVER 1986, p. 58, 59, figs. 1-5. - ISHIGA and MIYAMOTO 1986, pl. 64, fig. 13. - WU and LI 1989, pl. 1, fig. 14. - TUMANDA et al. 1990, pl. 2, fig. 18. - RUDENKO and PANASENKO 1990, p. 120, pl. 10, figs. 10, 11. - KUWAHARA et al. 1991, figs. 4.1, 4.2. - ANDO et al. 1991, pl. 9, fig. 9. - KUWAHARA and SAKAMOTO 1992, pl. 3, figs. 5-6. - YAO et al. 1993, pl. 1, fig. 3. - WANG and LI 1994, p. 205, pl. 1, fig. 17. - WANG et al. 1994, p. 185, pl. 4, figs. 9, 10. - SASHIDA et al. 1995, p. 51, figs. 10.18-10.20. - NISHIZONO 1996, pl. 2, fig. 8. - YU 1996, pl. 1, fig. 10. - KUWAHARA 1997, pl. 1, fig. 9. - KUWAHARA et al. 1997, pl. 1, fig. 16.

Albaillella sp. cf. *A. triangularis* ISHIGA, KITO and IMOTO, CHENG 1989, p. 138, pl. 5, figs. 6-9, 11-12. - BLOME and REED 1992, p. 362, fig. 9.10. - BLOME and REED 1995, p. 59, pl. 1, fig. 6.

Imotoella triangularis (Ishiga, Kito and Imoto 1982), KOZUR 1999, pl. 2, fig. 13.

Remarks: This species has a triangular shell with a ridged H-frame. Most of our specimens lack the H-frame due to the poor preservation, but in other respects such as transverse bands and triangular shell shape, they agree with this species.

Occurrence: Upper Permian (Wuchiapingian to Changxingian). Japan, North America, Philippines, Russian Far East, south and southwestern China, northern and eastern Thailand, peninsular Malaysia.

Albaillella levis Ishiga, Kito and Imoto 1982
Plate 1, figures 11, 12, 14, 15

Albaillellidae gen. et sp. indet. TAKEMURA and NAKASEKO 1981, pl. 34, fig. 10.

Albaillella levis ISHIGA, KITO and IMOTO 1982, p. 17, pl. 3, figs. 1-4. - KOJIMA 1982, pl. 3, figs. 5, 6. - WAKITA 1983, pl. 6, figs. 5, 6. - SASHIDA and TONISHI 1985, pl. 7, figs. 5, 6. - YOSHIDA and MURATA 1985, pl. 2, figs. 11, 12. - NOBLE and RENNE 1990, pl. figs. 12-15. - TUMANDA et al. 1990, pl. 2, fig. 24. - RUDENKO and PANASENKO 1990, p. 119, pl. 10, figs. 5-9. - ISHIDA et al. 1992, pl. 1, fig. 4. - KUWAHARA and SAKAMOTO 1992, p. 40, pl. 3, figs. 8, 9, 12. - FENG and LIU 1993, p. 555, pl. 4, figs. 7, 8. - YAO et al. 1993, pl. 1, figs. 6, 8. - WANG et al. 1994, p. 184, pl. 4, figs. 11-13. - SASHIDA et al. 1995, figs. 10.16, 10.17, 10.21. - BLOME and REED 1995, p. 58, 59, pl. 1, fig. 3. - NISHIZONO 1996, pl. 2, fig. 11. - KUWAHARA 1997, pl. 1, fig. 6. - KUWAHARA et al. 1997, pl. 1, fig. 19.

Albaillella sp. C of ISHIGA and IMOTO, NISHIZONO et al. 1982, pl. 2, fig. 6.

Albaillella sp. cf. *A. levis* ISHIGA, KITO and IMOTO, CHENG 1989, p. 138, pl. 1, figs. 5-7; pl. 2, figs. 1-4. - ANDO et al. 1991, pl. 9, fig. 10. - BLOME and REED 1995, p. 59, pl. 1, figs. 1, 2, 4, 7-11.

? *Albaillella levis* ISHIGA, KITO and IMOTO, WU and LI 1989, pl. 1, fig. 10.

Imotoella levis (Ishiga, Kito, and Imoto 1982), KOZUR 1999, pl. 2, fig. 9.

? *Imotoella* cf. *I. levis* (Ishiga, Kito and Imoto 1982), KOZUR 1999, pl. 2, figs. 7, 8.

Remarks: More than 50 incomplete specimens were examined. Length and shape of the ventral wing are variable in examined specimens. Some of specimens (e.g., plate 1, figures. 11, 14) have a wing that is almost as long as the height of the shell.

Occurrence: Upper Permian (Wuchiapingian to Changxingian). Japan, Philippines, Russian Far East, peninsular Malaysia, northern and eastern Thailand, North America, south and south-western China.

Suborder SPUMELLARIA Ehrenberg 1875

Family ENTACTINIIDAE Riedel 1967

Subfamily ENTACTINIINAE Riedel 1967; emend. Nazarov 1975

Genus *Triaenosphaera* Deflandre 1973; emend. Gourmelon 1987

Type species: *Triaenosphaera sicarius* Deflandre 1973.

Occurrence: Upper Devonian to Upper Permian. Alaska, north-west Europe, Japan, eastern Thailand.

Triaenosphaera minutus Sashida and Tonishi 1988

Plate 1, figure 16

Triaenosphaera minutus SASHIDA and TONISHI 1988, p. 530, figs. 8.1-8.6. - KUWAHARA and YAO 1998, pl. 3, fig. 87.

Remarks: *Triaenosphaera minutus* differs from other species of *Triaenosphaera* by having a smaller spherical shell with larger pores, fewer pores, and shorter major spines. The illustrated specimen compares well with the holotype and paratypes from Itsukaichi, central Japan.

Occurrence: Upper Permian (Wuchiapingian to Changxingian). Japan, eastern Thailand.

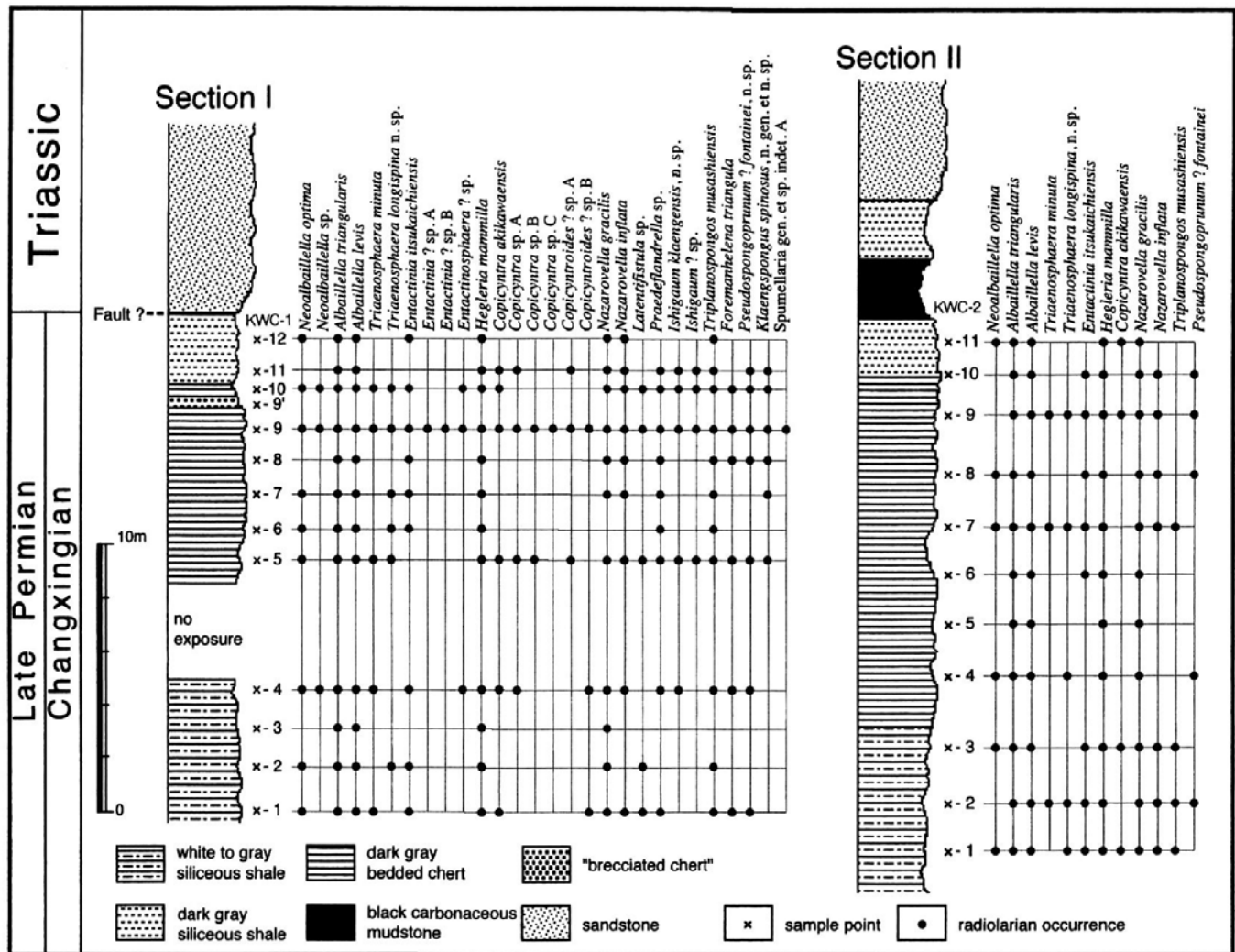
Triaenosphaera longispina Sashida n. sp.

Plate 1, figures 17-23

Diagnosis: *Triaenosphaera* with long, thin, three-bladed major spines.

Description: The spherical shell has four major spines. The cortical shell is composed of small pore frames with well-developed nodes or needle-like spines at vertices. These needle-like spines are long and almost two-thirds the length of the major spines. Pentagonal to hexagonal pore frames are usually dominate. Thirty-five to 40 pores are present on the outer surface of a hemisphere. Four major spines are disposed tetrahedrally, spines have three narrow longitudinal ridges alternating with three wide longitudinal grooves. The length of three major spines making the base of the tetrahedron is generally equal. The fourth major spine is shorter, approximately two-thirds length of others. The distal end of major spines is acute and needle-like. Three-bladed thin internal tetrahedral spicules are continuous with major spines at the inner surface of shell.

Remarks: Specimens are incompletely preserved. *Triaenosphaera longispina* is similar to *Triaenosphaera ? leherissei* Gourmelon 1987 described from the Early Carboniferous of France. *Triaenosphaera longispina* is distinguished from *T. ? leherissei* by having thinner major spines and from *T. minutus* by possessing long, thin, major spines and needle-like spines on the outer surface of the shell.



TEXT-FIGURE 3

Lithostratigraphic column and stratigraphic distribution of radiolarians in Section I and Section II.

Etymology: Latin *longus*, long and *spina*, spine or thorn.

Measurements (in μm): Diameter of shell, 95 to 120 (average 105); length of major spines, 160 to 210 (average 180); diameter of pores, 2 to 12 (average 10); length of the longest needle-like spines, 105 to 146 (average 115); number of pores on hemisphere, 35 to 40 (average 37); averages based on 18 specimens.

Types: Holotype, Plate 1, figure 19, sample KWC-1-9, IGUT-KSET5496; paratypes: Plate 1, figure 17, sample KWC-1-9, IGUT-KSET5520; Plate 1, figure 18, sample KWC-1-9, IGUT-KSET5498; Plate 1, figure 20, sample KWC-1-9, IGUT-KSET5516; Plate 1, figure 21, sample KWC-1-9, IGUT-KSET5497.

Occurrence: Upper Permian (Changxingian). Eastern Thailand.

Genus *Entactinia* Foreman 1963

Type species: *Entactinia herculea* Foreman 1963

Occurrence: Silurian to Lower Triassic. Worldwide.

Entactinia itsukaichiensis Sashida and Tonishi 1985

Plate 1, figures 24-26

Entactinia itsukaichiensis SASHIDA and TONISHI 1985, p. 9, 10, pl. 1, figs. 1-10. - ISHIGA 1990, pl. 1, fig. 1. - BLOME and REED 1992, p. 369, figs. 11.2-11.5. - FENG and LIU 1993, p. 558, pl. 5, figs. 10, 11. - JASIN et al. 1995, p. 82, pl. 1, figs. 1, 2. - BLOME and REED 1995, pl. 1, figs. 25, 26. - KUWAHARA et al. 1997, pl. 2, fig. 4. - KUWAHARA and YAO 1998, pl. 2, fig. 59. - FENG et al. 1998, p. 239, figs. 3c, 3d.

Remarks: Completely preserved specimens of this species have never been reported. Although our specimens are poorly preserved, they have the characteristic features of *Entactinia itsukaichiensis*, such as a small spherical shell having thorny by-spines and three-bladed main spines. Illustrated specimens have rather wider and more robust main spines compared with the holotype and paratypes of this species.

Occurrence: Upper Permian (Wuchiapingian to Changxingian). Japan, south China, North America, peninsular Malaysia, eastern Thailand.

Entactinia ? sp. A

Plate 2, figures 12, 13

Remarks: Several poorly preserved specimens were examined. Although the internal shell structure has not been detected, these forms are tentatively included in *Entactinia*. *Entactinia* ? sp. A is distinguished from *Entactinia itsukaichiensis* by having a larger spherical shell and thinner and shorter three-bladed main spines.

Occurrence: Upper Permian (Changxingian). Eastern Thailand.

Entactinia ? sp. B

Plate 3, figure 5

? *Entactinia* ? sp. F, KUWAHARA and YAO 1998, pl. 2, fig. 66.

Remarks: The skeleton of this species consists of a spherical cortical shell with very small rudimentary needle-like spines. The shell is composed of hexagonal pore frames with circular pores. Although we examined several poorly preserved specimens attributable to this species, no specimens having distinct major spines have been encountered. The generic position of this species is tentative.

Occurrence: Upper Permian (Changxingian). Japan, eastern Thailand.

Genus *Entactinosphaera* Foreman 1963

Type species: *Entactinosphaera esostrongyla* Foreman 1963

Remarks: *Entactinosphaera* is distinguished from *Entactinia* Foreman by having two or more spherical shells.

Occurrence: Upper Devonian to Lower Triassic. Worldwide.

Entactinosphaera ? sp.

Plate 2, figure 19

Remarks: Several poorly preserved specimens were examined. The illustrated specimen has a spherical shell with three sturdy major spines, triradiate in cross section. The outer shell resembles that of *Entactinosphaera* sp. reported from peninsular Malaysia by Sashida *et al.* (1995) but differs from this species by having sturdy and long conical major spines. The generic position of this species is uncertain.

Occurrence: Upper Permian (Changxingian). Eastern Thailand.

Genus *Hegleria* Nazarov and Ormiston 1985

Type species: *Hegleria mammifera* Nazarov and Ormiston 1985

Remarks: The status of this genus has been discussed by Blome and Reed (1992) and Wang and Li (1994); their discussions are followed herein.

Occurrence: Middle to Upper Permian. Worldwide.

Hegleria mammilla (Sheng and Wang)

Plate 3, figures 1-4, 6

Phaenicosphaera mammilla SHENG and WANG 1985, p. 179, 180, pl. 3, figs. 1-8. - KOZUR and KRAHL 1987, p. 365, 366, fig. 7a. - WANG 1993a, pl. 2, figs. 1-6. - WANG 1993b, p. 466, pl. 2, figs. 13-16. - XIAN and ZHANG 1998, pl. 5, figs. 18, 19.

Hegleria mammifera NAZAROV and ORMISTON 1985, p. 22, 23, pl. 6, figs. 3-5. - NOBLE and RENNE 1990, p. 387, pl. 1, figs. 9, 10. - WANG 1991 pl. 3, figs. 5-7. - KUWAHARA *et al.* 1997, pl. 3, figs. 17, 18.

Hegleria mammilla (Sheng and Wang) BLOME and REED 1992, p. 369, figs. 11.10—11.13. - WANG *et al.* 1994, p. 189, 190, pl. 2, figs.

17, 18. - WANG and LI 1994, p. 209, 210, pl. 1, figs. 22, 23. - WANG and QI 1995, pl. 5, figs. 1-12. - BLOME and REED 1995, p. 59, pl. 1, figs. 27, 28. - JASIN *et al.* 1995, p. 82, pl. 1, fig. 4. - FENG *et al.* 1998, p. 240, figs. 3f-3h, 3k. - WANG and LUO 1998, pl. 5, figs. 16, 17.

Remarks: The basic skeleton of this species is composed of a spherical cortical shell with numerous nodes or mammae on the surface and two medullary shells. Internal shells are connected with each other and the outer spherical shell by many radial beams. In the above listed specimens, there seems to be wide variation in the development of mammae. Previously, specimens with pronounced spines on the center of mammae were discussed by Nazarov and Ormiston (1985), Wang and Li (1994), and Wang and Qi (1995). Wang and Li (1994) and Wang and Qi (1995) insisted that the development of mammae with a spine at the center of each mammae depended on the state of preservation. Our specimens of *Hegleria mammilla* have a larger number of mammae, but they are less developed.

Occurrence: Permian (Asselian to Changxingian). Worldwide.

Subfamily ASTROENTACTINIINAE Nazarov and Ormiston 1985

Genus *Copicyntra* Nazarov and Ormiston 1985

Type species: *Copicyntra acilaxa* Nazarov and Ormiston 1985.

Occurrence: Upper Carboniferous to Upper Permian. Southern Urals of Russia, Japan, North America, northern and eastern Thailand, Philippines.

Copicyntra akikawaensis Sashida and Tonishi 1988

Plate 2, figures 20, 21; Plate 3, figure 10

Copicyntra akikawaensis SASHIDA and TONISHI 1988, p. 530-531, figs. 7.14-7.17. - TUMANDA *et al.* 1990, pl. 2, fig. 11. - FENG and LIU 1993, pl. 5, figs. 1, 2. - WU and XIAN 1994, pl. 1, figs. 14, 15. - KUWAHARA and YAO 1998, pl. 1, fig. 43.

Remarks: *Copicyntra akikawaensis* differs from other species of the genus *Copicyntra* by having rod-like external spines. Our illustrated specimens have external spines whose proximal part is three bladed (plate 2, figures 20, 21); these forms are included in *Copicyntra akikawaensis*. The specimen illustrated on Plate 3, figure 10 seems to have more sturdy and conical spines; this may be due to preservation.

Occurrence: Upper Permian (Wuchiapingian to Changxingian). Japan, southern and eastern Thailand.

Copicyntra sp. A

Plate 3, figure 9

Remarks: This species differs from *Copicyntra akikawaensis* by having fewer external spines.

Occurrence: Upper Permian (Changxingian). Eastern Thailand.

Copicyntra sp. B

Plate 3, figures 13, 15

Remarks: Several poorly preserved specimens of this species were examined. The presence of several internal concentric shells was observed in one specimen (plate 3, figure 13). This species is distinguished from *Copicyntra akikawaensis* by having needle-like external spines. The outer shell features of this species slightly resemble those of *Copicyntra cuspidata* Nazarov and Ormiston 1985. The latter species is different from

the former species in having three-bladed and slightly twisted external spines.

Occurrence: Upper Permian (Changxingian). Eastern Thailand.

Copicyntra sp. C

Plate 3, figure 14

Remarks: This species differs from *Copicyntra* sp. B by having a larger shell and longer, three-bladed spines.

Occurrence: Upper Permian (Changxingian). Eastern Thailand.

Genus *Copicyntroides* Nazarov and Ormiston 1985

Type species: *Copicyntroides asteriformis* Nazarov and Ormiston 1985

Occurrence: Upper Permian (Wuchiapingian to Changxingian). North America, Japan, eastern Thailand.

Copicyntroides ? sp. A

Plate 2, figure 14

Remarks: The shell is inflated and discoidal and has eight sturdy, conical three-bladed spines around the equatorial belt. The outer surface of the shell is spongy. Both long and short spines are present; the length of short spines is one-half to two-thirds that of long spines. The internal shell structure was not detected. Therefore, the generic position of this species is tentative. Outer shell features of *Copicyntroides* ? sp. A are similar to those of *Copicyntroides asteriformis* Nazarov and Ormiston. *Copicyntroides* ? sp. A, however, is distinguished from *Copicyntroides asteriformis* by having sturdy conical equatorial spines.

Occurrence: Upper Permian (Changxingian). Eastern Thailand.

Copicyntroides ? sp. B

Plate 3, figure 11

Remarks: Several poorly preserved specimens were examined. The internal shell structure is unknown. This species somewhat resembles *Copicyntroides* ? sp. A but differs by having four long, sturdy, equatorial spines. This species is tentatively included in genus *Copicyntroides*.

Occurrence: Upper Permian (Changxingian). Eastern Thailand.

Superfamily LATENTIFISTULIDEA Nazarov and Ormiston 1983

Family LATENTIFISTULIDAE Nazarov and Ormiston 1983

Genus *Nazarovella* De Wever and Caridroit 1984

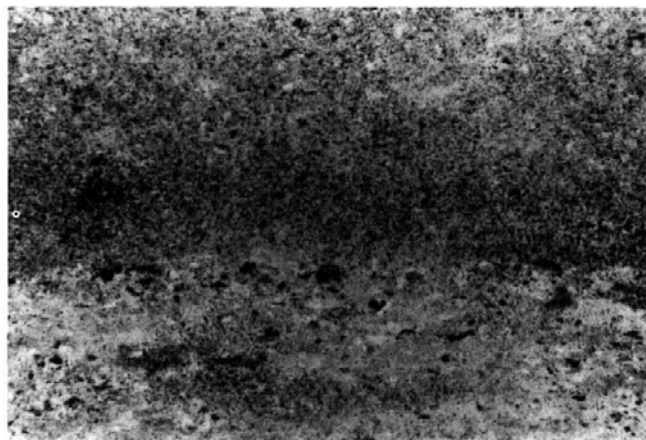
Type species: *Nazarovella gracilis* De Wever and Caridroit 1984

Occurrence: Lower to Upper Permian (Sakmarian to Changxingian). Worldwide.

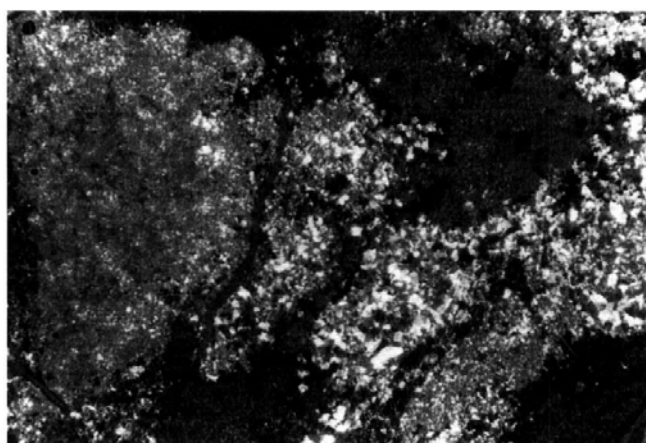
Nazarovella gracilis De Wever and Caridroit 1984

Plate 2, figure 11

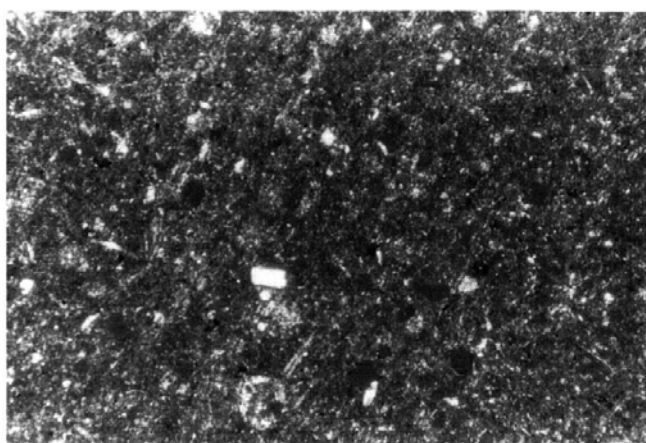
Nazarovella gracilis DE WEVER and CARIDROIT 1984, p. 101, pl. 1, figs. 14, 15, 17. - ISHIGA 1985, pl. 2, figs. 22, 23. - NAKA and ISHIGA 1985, pl. 1, figs. 14, 15. - YAMAKITA 1987, pl. 1, figs. 12, 13. - ISHIGA and MIYAMOTO 1986, pl. 64, fig. 16. - SASHIDA and TONISHI 1986, p. 10, pl. 3, figs. 10-12, pl. 4, fig. 7. - CARIDROIT and DE WEVER 1986, p. 82, 83, pl. 4, figs. 9-15. - MIYAMOTO and TANIMOTO 1986, pl. 1, figs. 12, 13. - TUMANDA et al. 1990, pl. 1, fig. 27. - BLOME and REED 1992, p. 375, figs. 13.9, 13.10. - WANG 1993a, p. 451, 452, pl. 4, figs. 15, 16. - WANG 1993b, p. 464, pl. 2,



1



2



3

TEXT-FIGURE 4

Photomicrographs of thin-section samples, 1: dark gray siliceous shale (sample KWC-1-12) showing sedimentary structures such as gradation and cut and fill. Open nicol. 2: "Brecciated chert" (sample KWC-1-10'). Crossed nicol. 3: White to light gray siliceous shale (sample KWC-1-3). Fragments of radiolarians and sponge spicules as well as fine quartz grains, are contained in the matrix. Crossed nicols. Scale bar indicates 500µm.

figs. 5, 6. - FENG and LIU 1993, pl. 6, fig. 14. - SASHIDA et al. 1995, p. 54-56, figs. 11-17, 19. - KUWAHARA and YAO 1998, pl. 4, fig. 118. - XIAN and ZHANG 1998, pl. 5, fig. 5. - KUWAHARA 1997, pl. 3, figs. 1, 2. - KOZUR 1999, pl. 2, fig. 16.
Nazarovella spp. CHENG 1989, pl. 2, fig. 12.
Nazarovella ? sp. B ISHIGA and SUZUKI 1984, pl. 1, figs. 17-20.
Nazarovella cf. *gracilis* DE WEVER and CARIDROIT, WANG and LI 1994, p. 206, pl. 2, figs. 4, 5, 7, 8. - WU et al. 1994, pl. 3, fig. 9.

Remarks: *Nazarovella gracilis* is a well-known species but completely preserved specimens have never been reported. Our illustrated specimen is also not complete, but it has the distinctive features of this species: long, simple, grooved arms.

Occurrence: Lower to Upper Permian (Sakmarian to Changxingian). Japan, Philippines, south China, peninsular Malaysia, northern and eastern Thailand, North American.

Nazarovella inflata Sashida and Tonishi 1986

Plate 2, figures 9, 10

Nazarovella inflata SASHIDA and TONISHI 1986, p. 10, 11, pl. 4, figs. 1.6, 1.10-1.12. - TUMANDA et al. 1990, pl. 1, figs. 20. - WANG 1991, pl. 4, fig. 2. - WANG and LI 1994, p. 205, 206, pl. 2, figs. 1-3, 6. - WANG et al. 1994, p. 190, pl. 3, figs. 15, 16. - SASHIDA et al. 1995, p. 55, figs. 11-15, 16. - KUWAHARA et al. 1997, pl. 3, fig. 3. - WANG and LUO 1998, pl. 4, figs. 4-7.

Nazarovella spp. CHENG 1989, pl. 2, figs. 10, 11.
 unidentified ? latentifistulid BLOME and REED 1992, fig. 13.21.

Remarks: This species differs from *Nazarovella gracilis* De Wever and Caridroit 1984 by possessing cylindrical rays and a tetrahedron-shaped shell.

Occurrence: Upper Permian (Wuchiapingian to Changxingian). Japan, south and southwestern China, Philippines, peninsular Malaysia, northern and eastern Thailand, North American.

Genus *Latentifistula* Nazarov and Ormiston 1983

Type species: *Latentifistula crux* Nazarov and Ormiston 1983

Occurrence: Upper Carboniferous to Upper Permian. World-wide.

Latentifistula sp.

Plate 2, figure 23

Remarks: This species has three, thin, long rays with spindle-shaped spongy meshwork and long needle-like terminal spines. Rays attain 750µm and basically consist of a bundle of three thin rods with bars perpendicular to rods. A small dome-like protrusion is present at the center of rays.

Occurrence: Upper Permian (Changxingian). Eastern Thailand.

Genus *Praedeflandrella* Kozur and Mostler 1989

Type species: *Praedeflandrella* Kozur and Mostler 1989

Occurrence: Upper Permian (Wuchiapingian to Changxingian). Worldwide.

Praedeflandrella sp.

Plate 2, figure 8

Remarks: This species resembles *Praedeflandrella* sp. described by Sashida et al. (1995) from peninsular Malaysia. However, the Malaysian specimen has a shell whose radial rays are approximately at 120 degrees from each other, whereas the angles between these rays are more irregular.

Occurrence: Upper Permian (Changxingian). Eastern Thailand.

Genus *Ishigaum* De Wever and Caridroit 1984

Type species: *Ishigaum trifustis* De Wever and Caridroit 1984

Occurrence: Upper Permian (Wuchiapingian to Changxingian). Japan, peninsular Malaysia, North America, south and southwestern China, Philippines, northern and eastern Thailand.

Ishigaum klaengensis Sashida n. sp.

Plate 2, figures 1, 2

Ishigaum obesum De Wever and Caridroit, KUWAHARA and YAO 1998, pl. 3, fig. 94.

Diagnosis: *Ishigaum* with oval or fan-shaped spongy structures.

Description: The shell consists of triradial rays with oval or fan-shaped spongy structures at their distal end. Three hollow rays diverge at an angle of about 120 degrees from their junction. Hollow rays are cylindrical, and the diameter increases gradually toward the periphery. Distal parts of rays are covered by a fine spongy meshwork whose external form is ellipsoidal, fan shaped, or rounded. Terminal spines are short and conical. Circular or oval pores are present at distal tips of hollow rays.

Remarks: *Ishigaum obesum* De Wever and Caridroit differs from *Ishigaum klaengensis*, n. sp. by having shorter rays on which wrinkles are present longitudinally. This new species is very similar to *Ishigaum* sp. A described by Sashida and Tonishi (1986) from Itsukaichi, Tokyo Prefecture, Japan. *Ishigaum klaengensis* may be distinguished from *Ishigaum* sp. A by having finer and larger ellipsoidal spongy meshwork.

Etymology: The specific name, *klaengensis* comes from the geographical name Klaeng, eastern Thailand, where the type species was obtained.

Measurements (in µm): Length of rays, 220 to 260 (average 245); maximum width of ellipsoidal spongy meshwork, 180 to 205 (average 195); averages based on 10 specimens.

Types: Holotype, Plate 2, figure 1, sample KWC-1-9, IGUT-KS-ET5523; paratype, Plate 2, figure 2, sample KWC-1-9, IGUT-KS-ET5528.

Occurrence: Upper Permian (Changxingian). Eastern Thailand.

Ishigaum ? sp.

Plate 2, figures 22, 24, 25

Ishigaum ? sp. SASHIDA et al. 1995, p. 55, figs. 11.7-11.11.
 Incertae sedis I, KUWAHARA and YAO 1998, pl. 5, fig. 143.

Remarks: Our material is incompletely preserved specimens of this species. The shell may consist of three rays composed of a bundle of three thin rods. In some specimens, one rod is wider, covers a neighboring rod, and shows a tube-like ray with weak torsion (e.g., pl. 1, fig. 25). A needle-like terminal spine protrudes from the spongy club-like tips. The central part of three rays may be composed of spongy meshwork (pl. 1, fig. 24), but its exact shape and structure are unknown. The generic position of this species is tentative.

Occurrence: Upper Permian (Changxingian). Peninsular Malaysia, eastern Thailand.

Family TRIPLANOSPONGIDAE Kozur 1999

Remarks: This family differs from Latentifistulidae Nazarov and Ormiston 1983 by having a central structure with two thick bars on each arm or lobe. So far, only the genus *Triplanospongus* Sashida and Tonishi 1988 is included in this family.

Genus *Triplanospongus* Sashida and Tonishi 1988

Type species: *Triplanospongus musashiensis* Sashida and Tonishi 1988

Occurrence: Upper Permian (Wuchiapingian to Changxingian). Japan, south and southwestern China, North America, Philippines, peninsular Malaysia, northern and eastern Thailand.

Triplanospongus musashiensis Sashida and Tonishi 1988

Plate 2 figures 6, 7

?*Paronaella* sp. A, WAKITA 1983, pl. 7, fig. 7.

Angulobracchia ? sp., TAKAEMURA and NAKASEKO 1981, pl. 34, fig. 12.

Angrobracchia ? sp., YOSHIDA and MURATA 1985, pl. 2, fig. 18.

Triplanospongus musashiensis SASHIDA and TONISHI 1988, p. 536-539, figs. 9.7-9.12. - TUMANDA et al. 1990, pl. 2, fig. 14. - WANG 1991, pl. 3, fig. 9. -

FENG and LIU 1993, pl. 6, figs. 4-8. - WANG and LI 1994, p. 208, pl. 3, figs. 1-4. - WANG et al. 1994, p. 193, pl. 4, figs. 16, 17. - SASHIDA et al. 1995, p. 55, figs. 11.12, 11.13. - KUWAHARA et al. 1997, pl. 3, figs. 7-9. - KUWAHARA and YAO 1998, pl. 4, fig. 131. - FENG et al. 1998, p. 244, figs. 5a, 5b.

Triplanospongus cf. *T. musashiensis* SASHIDA and TONISHI, CHENG 1989, p. 142, pl. 3, figs. 13-16.

Latentifistula sp. cf. *L. similiculis* CARIDROIT and DE WEVER, CHENG 1989, p. 140, pl. 1, figs. 13-14, 16.

Trifidospongia dekkasensis NOBLE and RENNE, BLOME and REED 1992, p. 376-379, figs. 13.13, 13.14.

Remarks: Development of spongy meshwork is variable within specimens. Although the fragile spongy part of the shell is mostly broken, the illustrated specimens are very similar to those of *Triplanospongus musashiensis* in having two thick bars on the arms.

Occurrence: Upper Permian (Wuchiapingian to Changxingian). Japan, North America, Philippines, peninsular Malaysia, northern and eastern Thailand, south and southwestern China.

Family TORMENTIDAE Nazarov and Ormiston 1983

Genus *Foremanhelena* De Wever and Caridroit 1984

Type species: *Foremanhelena triangularis* De Wever and Caridroit 1984

Occurrence: Upper Permian (Wuchiapingian to Changxingian). Japan, south China, Philippines, eastern Thailand.

Foremanhelena triangula De Wever and Caridroit 1984

Plate 2, figures 3-5

Foremanhelena triangula DE WEVER and CARIDROIT 1984, p. 106, pl. 2, figs. 10-18. - CARIDROIT and DE WEVER 1986, p. 86, pl. 5, figs. 12-19. - TUMANDA et al. 1990, pl. 2, fig. 5. - WANG et al. 1994, p. 192, figs. 15, 16. - WU et al. 1994, pl. 3, fig. 13. - WANG and LUO 1998, pl. 3, figs. 18, 19.

Foremanhelena sp. A, KUWAHARA and YAO 1998, pl. 3, fig. 92.

Remarks: *Foremanhelena triangula* is characterized by having three arms similar to those of *Ishigaum* Caridroit and De Wever and an outer triangular spongy structure. According to the original description of this species, the triangular crown consists of "three pairs of beams, one on each side between two arms"

(Caridroit and De Wever 1986, p. 87). In our specimens, the beam connecting two arms is not observed. As shown in the holotype and paratypes of De Wever and Caridroit (1984), this species has rather strong depression at the middle of a side of triangular crown. Compared with them, our specimens have a rather expanded triangular shape. I believe that these characteristics are within specific variations.

Occurrence: Upper Permian (Wuchiapingian to Changxingian). Japan, south and southwestern China, eastern Thailand.

Superfamily ACTINOMMACEA Haeckel 1862

Family SPONGURIDAE Haeckel 1862

Genus *Pseudospongoprimum* Wakamatsu, Sugiyama, and Furutani 1990

Type species: *Pseudospongoprimum tazukawaensis* Wakamatsu, Sugiyama and Furutani 1990.

Remarks: Wakamatsu et al. (1990) placed this genus in Spumellaria Incertae Sedis because it has differently arranged pore frames compared with other genera in Family Sponguridae Haeckel 1887. I tentatively include this genus in Family Sponguridae because it possesses outer shell features similar to those of *Spongoprimum* Haeckel 1887 and *Archaeospongoprimum* Pessagno 1973. Outwardly, this genus is also similar to *Copicyntra* Nazarov and Ormiston 1985. The former, however, differs from the latter by having concentric layers.

Occurrence: Upper Silurian to Upper Permian. Japan, northern and eastern Thailand.

Pseudospongoprimum ? fontainei Sashida n. sp.

Plate 2, figures 15-18

Diagnosis: Spongy, fusiform shell with two conical polar spines.

Description: The spongy shell is fusiform to elliptical in outline and has two polar spines. Polar spines are rod-like, their length and shape are variable. The length of longer spines is two-thirds the maximum diameter of the fusiform shell.

Remarks: Although the internal shell structure cannot be detected, the outer shell is very similar to that of genus *Pseudospongoprimum*. This species slightly resembles *Pseudospongoprimum sagittatum* described from the Lower Devonian of the Kurosegawa Tectonic Zone by Wakamatsu et al. (1990). *Pseudospongoprimum sagittatum*, however, differs from *Pseudospongoprimum ? fontainei* by having a longer fusiform shell with coarser spongy meshworked pattern and more sturdy polar spines. This species is tentatively included in *Pseudospongoprimum* even though the internal shell features cannot be observed.

Etymology: The species is named for Dr. Henri Fontaine in honor of his contribution to the paleontology in Thailand.

Measurements (in μ m): Diameter of shell, 100 to 145 (average 120); width of shell, 65 to 105 (average 80); length of longest spines, 65 to 100 (average 85); length of shorter spines, 25 to 55 (average 35); averages based on 10 specimens.

Type: Holotype, Plate 2, figure 16, sample KWC-1-9, IGUT-KSET5510; paratype, Plate 2, figure 15, sample

KWC-1-9, IGUT-KSET5557; Plate 2, figure 17, sample KWC-1-9, IGUT-KSET5508.

Occurrence: Upper Permian (Changxingian). Eastern Thailand.

Family ORBICULIFORMIDAE Pessagno 1973

Genus *Klaengspongos*, Sashida, n. gen.

Type species: *Klaengspongos spinosus* Sashida, n. sp.

Diagnosis: Large, discoidal, spongy shell with short conical spines in the equatorial plane. Central cavity shallow, flanked by deep depression.

Remarks: Although the precise internal shell feature has not been determined, the external characters of this genus is quite similar to that of Mesozoic Spumellaria with a discoidal shell, such as *Orbiculiformella* Kozur and Mostler 1978, *Praeorbiculiforma* Kozur and Mostler 1978, *Orbiculiforma* Pessagno 1973 and *Pseudoaulophacus* Pessagno 1963. This new genus is easily distinguished from *Eostylodictya* Ormiston and Lane 1976 and *Copiellintra* Nazarov and Ormiston 1985 by having a shell lacking a concentric inner shell. This form may be an ancestor of the post-Mesozoic radiolarians having a spongy discoidal shell. This new genus is placed in Orbiculiformidae Pessagno 1973, herein.

Etymology: *Klaeng* is a place name in eastern Thailand; *spongos* means spongy; gender masculine.

Occurrence: Upper Permian (Changxingian). Eastern Thailand.

Klaengspongos spinosus Sashida n. sp.

Plate 3, figures 7, 8

Copicyntroides ? sp. C, KUWAHARA and YAO 1998, pl. 2, fig. 54.

Diagnosis: Spongy discoidal shell with conical spines in the equatorial plane.

Description: The spongy shell is disc-shaped and circular in outline with eighteen short, three-bladed spines in the equatorial plane. The length of the spines is less than one-third that of the diameter of central cavity. The central cavity is shallow and flat and flanked by a deep depression. Meshwork of the central area is fine, composed of tetragonal, pentagonal, and hexagonal pore flames. The outer meshwork is coarser toward the periphery.

Remarks: This species is rather similar to species of *Eostylodictya* in its external shell features, but the former is distinguished from the latter by lacking concentric shells.

Etymology: Specific name *spinosus* means spiny.

Measurements (in μm): Diameter of shell, 295 to 455 (average 350); thickness of shell, 90 to 150 (average 120); maximum length of spines, 55 to 100 (average 80); averages based on eight specimens.

Type: Holotype, Plate 3, figure 8, sample KWC-1-9, IGUT-KS-ET5511; paratype, Plate 3, figure 7, sample KWC-1-9, IGUT-KS-ET5525.

Occurrence: Upper Permian (Changxingian). Eastern Thailand, Japan.

Spumellaria gen. et sp. indet. A

Plate 3, figure 12

Remarks: Several poorly preserved specimens of this general form were examined. This species has an inflated discoidal or spherical spongy shell with four long conical spines in the equatorial plane. Most equatorial spines are three bladed, but some have three grooves only proximally. Internal shell structure cannot be observed. This species is slightly similar to *Tetrentactinia* sp. Sheng and Wang 1985, described by Wang and Qi (1995) from the Kuhfeng Formation. But the latter differs from *Spumellaria* gen. et sp. indet. A by having long, conical spines. Giving a generic and suprageneric name for this species is not

PLATE 1

All specimens are from sample KWC-1-9

1-4 *Neobaillella optima* Ishiga, Kito and Imoto. 1, IGUT-KSET5504, $\times 100$; 2, IGUT-KSET5501, $\times 100$; 3, IGUT-KSET5503, $\times 100$, 4, IGUT-KSET5502

5 *Neobaillella* ? sp., IGUT-KSET5527, $\times 150$

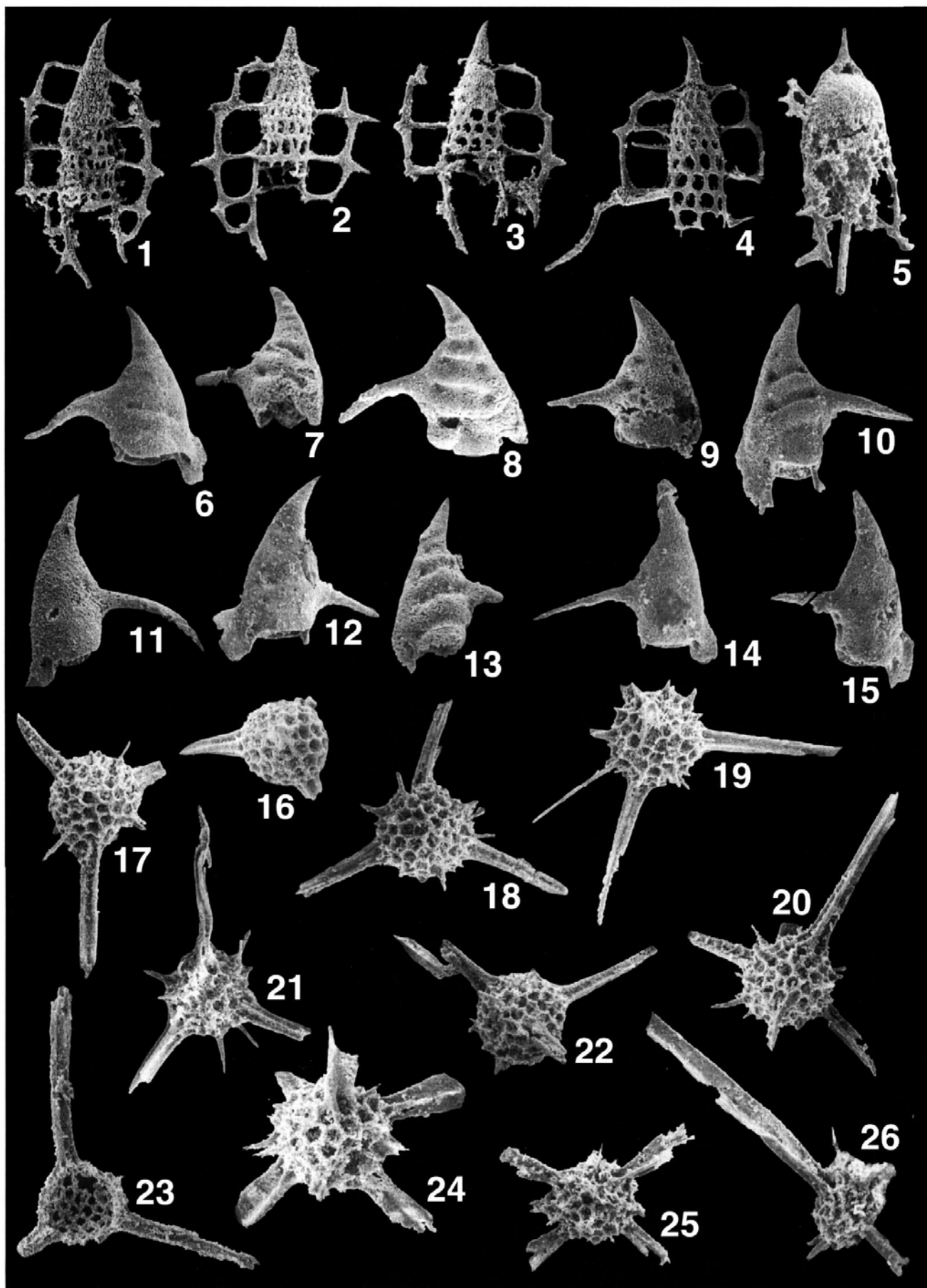
6-10, 13 *Albaillella triangularis* Ishiga, Kito and Imoto. 6, IGUT-KSET5569, $\times 150$; 7, IGUT-KSET5550, $\times 150$; 8, IGUT-KSET5540, $\times 150$; 9, IGUT-KSET5534, $\times 150$; 10, IGUT-KSET5544, $\times 150$; 13, IGUT-KSET5560, $\times 150$

11, 12, 14, *Albaillella levis* Ishiga, Kito and Imoto. 11, IGUT-KSET5536, $\times 150$; 12, IGUT-KSET5541, $\times 150$; 14, IGUT-KSET5577, $\times 150$; 15, IGUT-KSET5542, $\times 150$

16 *Triaenosphaera minutus* Sashida and Tonishi, IGUT-KSET5600, $\times 150$

17-23 *Triaenosphaera longispina* Sashida, n. sp. 17, Paratype, IGUT-KSET5520, $\times 150$; 18, Paratype, IGUT-KSET5498, $\times 150$; 19, Holotype, IGUT-KSET5496, $\times 150$; 20, Paratype, IGUT-KSET5516, $\times 150$; 21, Paratype, IGUT-KSET5497, $\times 150$; 22, IGUT-KSET5499, $\times 150$; 23, IGUT-KSET5529, $\times 150$

24-26 *Entactinia itsukaichiensis* Sashida and Tonishi. 24, IGUT-KSET5513, $\times 200$; 25, IGUT-KSET5506, $\times 150$; 26, IGUT-KSET5500, $\times 150$



possible until many more well-preserved specimens have been examined.

Occurrence: Upper Permian (Changxingian). Eastern Thailand.

ACKNOWLEDGMENTS

We are grateful to Elizabeth Carter, Kitty Reed, and Annika Sanfilippo for reading the manuscript and offering many useful comments and suggestions. Our field survey was funded by a grant under the Monbusho (Government of Japan) International Scientific Research Program. We acknowledge the Department of Mineral Resources of Thailand for offering facilities to carry out our research.

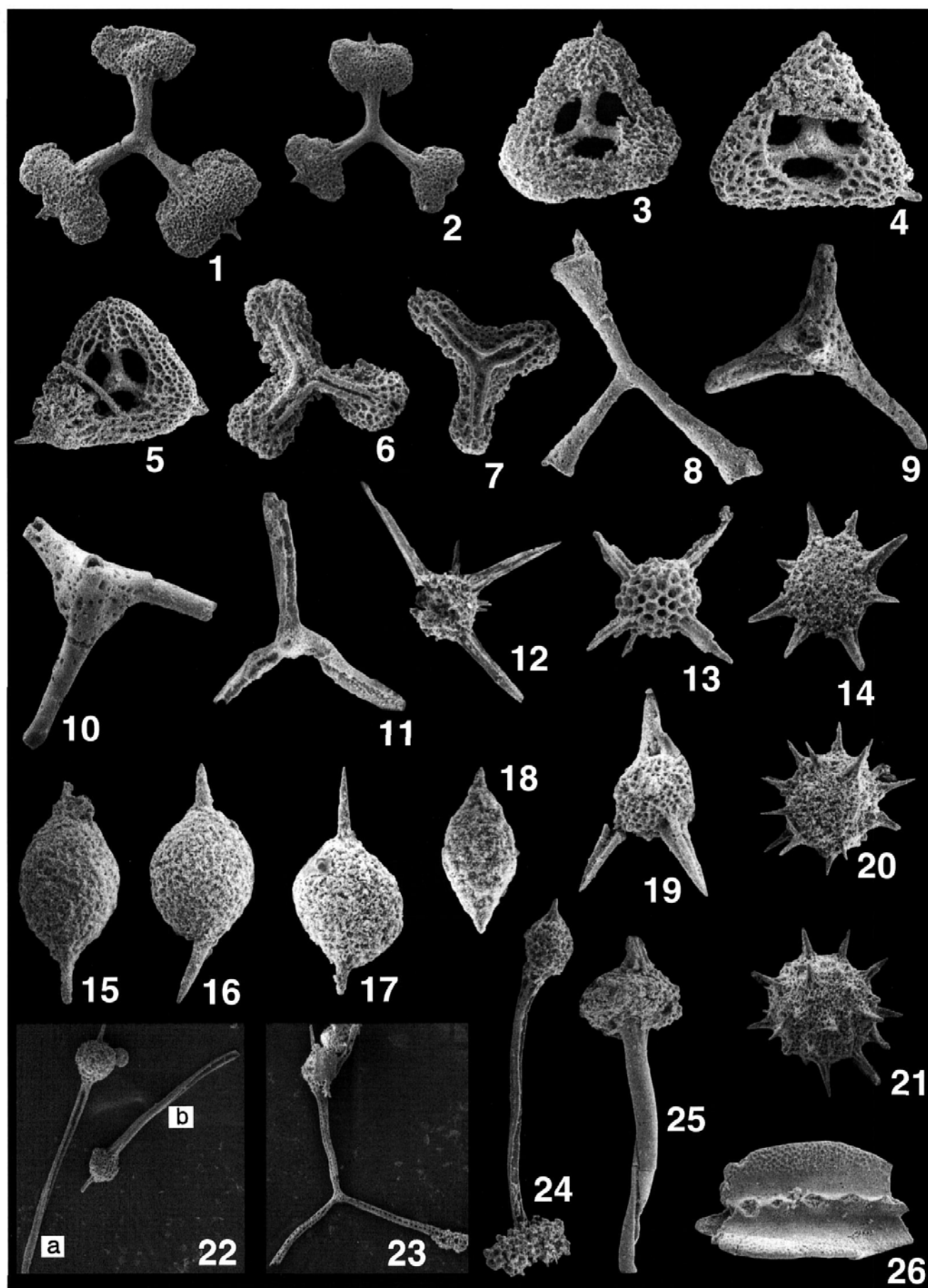
REFERENCES

- ANDO, H., TSUKAMOTO, H. and SAITO, M., 1991. Permian radiolarians in the Mt. Kinkazan Area, Gifu City, Central Japan. *Bulletin of the Mizunami Fossil Museum*, 18:101-106. [In Japanese with English abstract.]
- BLOME, C. D. and REED, K. M., 1992. Permian and Early (?) Triassic radiolarian faunas from the Grindstone terrane, central Oregon. *Journal of Paleontology*, 66:351-385.
- , 1995. Radiolarian biostratigraphy of the Quinn River Formation, Black Rock terrane, north-central Nevada: Correlations with eastern Klamath terrane geology. *Micropaleontology*, 41:49-68.
- BUNOPAS, S., 1981. Paleogeographic history of western Thailand and adjacent parts of South-east Asia: A plate tectonics interpretation. *Geological Survey Paper*, 5 (Special Issue). Department of Mineral Resources of Thailand, Bangkok, 810 p.
- , 1992. Regional stratigraphic correlation in Thailand. In *Proceedings of the National Conference on Geological Resources of Thailand: Potential for Future Development*, Bangkok, 1992, 189-208, Department of Mineral Resources of Thailand, Bangkok.
- CARIDROIT, M. and DE WEVER, P., 1986. Some Late Permian radiolarians from pelitic rocks of the Tatsuno Formation (Hyogo Prefecture), southwest Japan. *Marine Micropaleontology*, 11:55-90.
- CARIDROIT, M., ICHIKAWA, K., and CHARVET, J., 1985. The Ultra-Tamba Zone, a new unit in the inner zone of southwest Japan—its importance in the nappe structure after the example of the Maizuru area. *Earth Science (Chikyu Kagaku: Journal of the Association for the Geological Collaboration in Japan)*, 39: 210-219.
- CHENG, Y.-N., 1986. Taxonomic studies on Upper Paleozoic Radiolaria. *National Museum of Science, Special Publication*, 1, 311 p.
- , 1989. Upper Paleozoic and Lower Mesozoic radiolarian assemblages from the Busuanga Islands, North Palawan Block, Philippines. *National Museum of Natural Science, Bulletin*, 1:129-175.
- DEFLANDRE, G., 1952. *Albaillella* nov. gen., Radiolaire fossile du Carbonifère inférieur, type d'une lignée aberrante éteinte. *Comptes Rendus des Séances de l'Académie des Sciences (Paris)*, 234: 872-874.
- , 1953. Radiolaires fossiles. In: Grassé, P. D., Ed., *Traité de Zoologie*, Masson, Volume 1, Pt. 2, 398-436.
- , 1973. Observations et remarques sur les Radiolaires Sphaerellaires du Paléozoïque, à propos d'une nouvelle espèce viséenne, du genre *Foremaniella* Defl., parfait intermédiaire entre les

PLATE 2

All specimens are from sample KWC-1-9

- | | |
|---|--|
| 1,2 <i>Ishigaum klaengensis</i> Sashida, n. sp. 1, Holotype, IGUT-KSET5523, ×100; 2, Paratype, IGUT-KSET5528, ×75 | 12,13 <i>Entactinia</i> ? sp. A. 12, IGUT-KSET5531, ×100; 13, IGUT-KSET5568, ×150 |
| 3-5 <i>Foremanhelena triangula</i> De Wever and Caridroit. 3, IGUT-KSET5494, ×150; 4, IGUT-KSET5492, ×150; 5, IGUT-KSET5509, ×100 | 14 <i>Copicyntroides</i> ? sp. A, IGUT-KSET5521, ×150 |
| 6,7 <i>Triplanospongos musashiensis</i> Sashida and Tonishi, 6, IGUT-KSET5532, ×100; 7, IGUT-KSET5586, ×100 | 15-18 <i>Pseudospongoprimum</i> ? <i>fontainei</i> Sashida n. sp. 15, Paratype, IGUT-KSET5557, ×150; 16, Holotype, IGUT-KSET5510, ×150; 17, Paratype, IGUT-KSET5508, ×150; 18, IGUT-KSET5545, ×150 |
| 8 <i>Praedeflandrella</i> sp., IGUT-KSET5533, ×100 | 19 <i>Entactinosphaera</i> ? sp., IGUT-KSET5565, ×150 |
| 9,10 <i>Nazarovella inflata</i> Sashida and Tonishi. 9, IGUT-KSET5552, ×100; 10, IGUT-KSET5575, ×100 | 20, 21 <i>Copicyntira akikawaensis</i> Sashida and Tonishi. 20, IGUT-KSET5518, ×100; 21, IGUT-KSET5524, ×100 |
| 11 <i>Nazarovella gracilis</i> De Wever and Caridroit, IGUT-KSET5571, ×100 | 22,24,25 <i>Ishigaum</i> ? sp. 22a, IGUT-KSET5574-a, ×45; 22b, IGUT-KSET5574-b, ×45; 24, IGUT-KSET5522, ×75; 25, IGUT-KSET5570, ×75 |
| | 23 <i>Latentifistula</i> sp., IGUT-KSE5519, ×75 |
| | 26 Fragment of neogondolellid conodont, ×100 |



- périaxoplastidiés et les Pylentonémidés. Comptes Rendus des Séances de l'Académie des Science (Paris), 276:147-1151.
- DEPARTMENT OF MINERAL RESOURCES OF THAILAND, 1984. Geological Map of Thailand 1:250,000, Changwat Rayong.
- DE WEVER, P. and CARIDROIT, M., 1984. Description de quelques nouveaux Latentifistulidae (Radiolaries Polycystines) Paleozoiques du Japon. Revue de Micropaléontologie, 27:98-106.
- , 1986 Some Late Permian radiolarians from the pelitic rocks of the Tatsuno Formation (Hyogo Prefecture), southwest Japan. Marine Micropaleontology, 11:55-90
- EHRENBERG, C. G., 1838. Über die Bildung der Kreidefelsen und des Kreidemergels durch unsichtbare Organismen. Abhandlungen der Königliche Akademie des Wissenschaften zu Berlin, Jahrgang, 1838:59-147.
- , 1875. Fortsetzung der mikogeologischen Studien als Gesamt-Übersicht der mikroskopischen Paläontologie gleichartig analysirter Gebirgsarten der Erde, mit specieller Rücksicht auf den Polycystinen-Mergel von Barbados. Abhandlungen der Königliche Akademie der Wissenschaften zu Berlin, Jahrgang 1875, 226 p.
- ERWIN, D. H., 1993. The great Paleozoic crisis-life and death in the Permian. New York: Columbia University Press, 327 p.
- FENG, Q. and LIU, B., 1993. Permian radiolarians on southwest Yunnan. Earth Science. Journal of China University of Geosciences, 18:553-564.
- FENG, Q., FANG, N., ZHANG, Z. and HUANG, J., 1998. Uppermost Permian Radiolaria from southwestern China. Journal of China University of Geosciences, 9:238-245.
- FOREMAN, H. P., 1963. Upper Devonian Radiolaria from the Huron Member of the Ohio Shale. Micropaleontology, 9:267-304.
- FONTAINE, H. and VACHARD, D., 1981. Découverte de microfaunes scytho-anisienne au Sud-Est de Bangkok (Trias de Thaïlande); Consequences Paleogeographiques. Compte Rendu Sommaire des Séances. Societe Géologique de France, Paris, 1981, 23:63-66.
- GOURMELON, F., 1987. Les radiolaires Tournaisiens des nodules phosphatés de la Montagne Noire et des Pyrenées Centrales Systematique-biostratigraphie, paleobiogeographie. Biostratigraphie du Paléozoïque, 6:1-172.
- HADA, S., BUNOPAS, S., ISHII, K., and YOSHIKURA, S., 1999. Rift-drift history and the amalgamation of Shan-Thai and Indochina/East Malaya Blocks. In Metcalfe, I. ed., Gondwana Dispersion and Asian Accretion, 67-87, A. A. Balkema, Rotterdam.
- HAECKEL, E., 1862. Die Radiolarien (Rhizopoda Radiolaria): Eine Monographie. Reimer, Berlin. xiv+572 pp.
- , 1887. Report on the Radiolaria collected by H.S. Challenger during the years 1873-76. Report on the Scientific Results of the Voyage of H.M.S. Challenger, Zoology, 18, clxxxvii+803 pp.
- HOLDSWORTH, B. K., 1966. The relationship between the genus *Albaillella* Deflandre and the ceratohiscid Radiolaria. Micropaleontology, 15:230-236.
- , 1969. Namurian radiolaria of the genus *Ceratohiscum* from Staffordshire and Derbyshire, England. Micropaleontology, 15:221-229.
- , 1977. Paleozoic Radiolaria; stratigraphic distribution in Atlantic borderlands, 167-184. In: Swain, F. M., Ed., Stratigraphic Micropaleontology of Atlantic Basin and Borderlands. Elsevier, Amsterdam.
- HUTCHISON, C. S., 1975. Ophiolite in Southeast Asia. Geological Society of America Bulletin, 86:797-806.
- ISHIDA, K., YAMASHITA, M. and ISHIGA, H., 1992. P/T boundary in pelagic sediments in the Tanba Belt, southwest Japan. Geological Reports of Shimane University, 11:39-57. [In Japanese with English abstract.]
- ISHIGA, H., 1985. Discovery of Permian radiolarians from Katsumi and Oi Formations along south of Maizuru Belts, southwest Japan and its significance. Earth Science (Chikyu Kagaku: Journal of the Association for the Geological Collaboration in Japan), 39:175-185. [In Japanese with English abstract.]
- , 1990. Paleozoic radiolarians. In: Ichikawa, K. et al., Eds., Pre-Cretaceous terranes of Japan, 285-295. Publication of IGCP Project No. 224: Pre-Jurassic Evolution of Eastern Asia. Nippon Insatsu Shuppan, Co. Ltd. Osaka.
- , 1991. "Dimorphic pairs" of *Albaillellaria* (Late Paleozoic Radiolaria), Japan. Memoires of the Faculty of Science, Shimane University, 25:119-129.
- , 1992. Late Permian anoxic event and P/T boundary in pelagic sediments of southwest Japan. Memoires of the Faculty of Science, Shimane University, 26:117-129.
- ISHIGA, H., and IMOTO, N., 1980. Some Permian radiolarians in the Tamba district, southwest Japan. Earth Science (Chikyu Kagaku: Journal of the Association for the Geological Collaboration in Japan), 34:335-345.
- ISHIGA, H., and MIYAMOTO, T., 1986. *Follicucullus* (Radiolaria) from the Upper Permian Kuma Formation, Kyushu, southwest Japan. Transactions and Proceedings of the Palaeontological Society of Japan, New Series, 141:322-335.
- ISHIGA, H., and SUZUKI, S., 1984. Discovery of Permian radiolarians and conodonts from the Shimomidani Formation in the "Maizuru Belt", southwest Japan and its significance. Earth Science (Chikyu Kagaku: Journal of the Association for the Geological Collaboration in Japan), 38:197-206.
- ISHIGA, H., KITO, N. and IMOTO, N., 1982. Late Permian radiolarian assemblages in the Tamba district and an adjacent area, southwest Japan. Earth Science (Chikyu Kagaku: Journal of the Association for the Geological Collaboration in Japan), 36:10-22.
- ISOZAKI, Y., 1997. Permo-Triassic boundary superanoxia and stratified superocean: Records from lost deep sea. Science, 276:235-238.
- JASIN, B., SAID, U. and RAHMAN, R. A., 1995. Late Middle Permian Radiolarian from the Jenka area, central Pahang, Malaysia. Journal of Southeast Asia Earth Science, 12:79-83.
- KOJIMA, S., 1982. Some Jurassic, Triassic and Permian radiolarians from the eastern part of Takayama City, central Japan. News of Osaka Micropaleontologists, Special Volume, 5 (Proceedings of the First Japanese Radiolarian Symposium):81-92. [In Japanese with English abstract.]
- KOZUR, H. W., 1999. Permian development in the western Tethys. In: Ratanasthien B. and Rieb, S. L., Eds., Proceedings of the International Symposium on Shallow Tethys (ST) 5, 101-135, Department of Geological Science, Faculty of Science, Chiang Mai University, Chiang Mai.
- KOZUR, H. W., and KRAHL, 1987. Erster Nachweis von Radiolarien im tethyaien Perm Europas. Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen, 175:357-372.

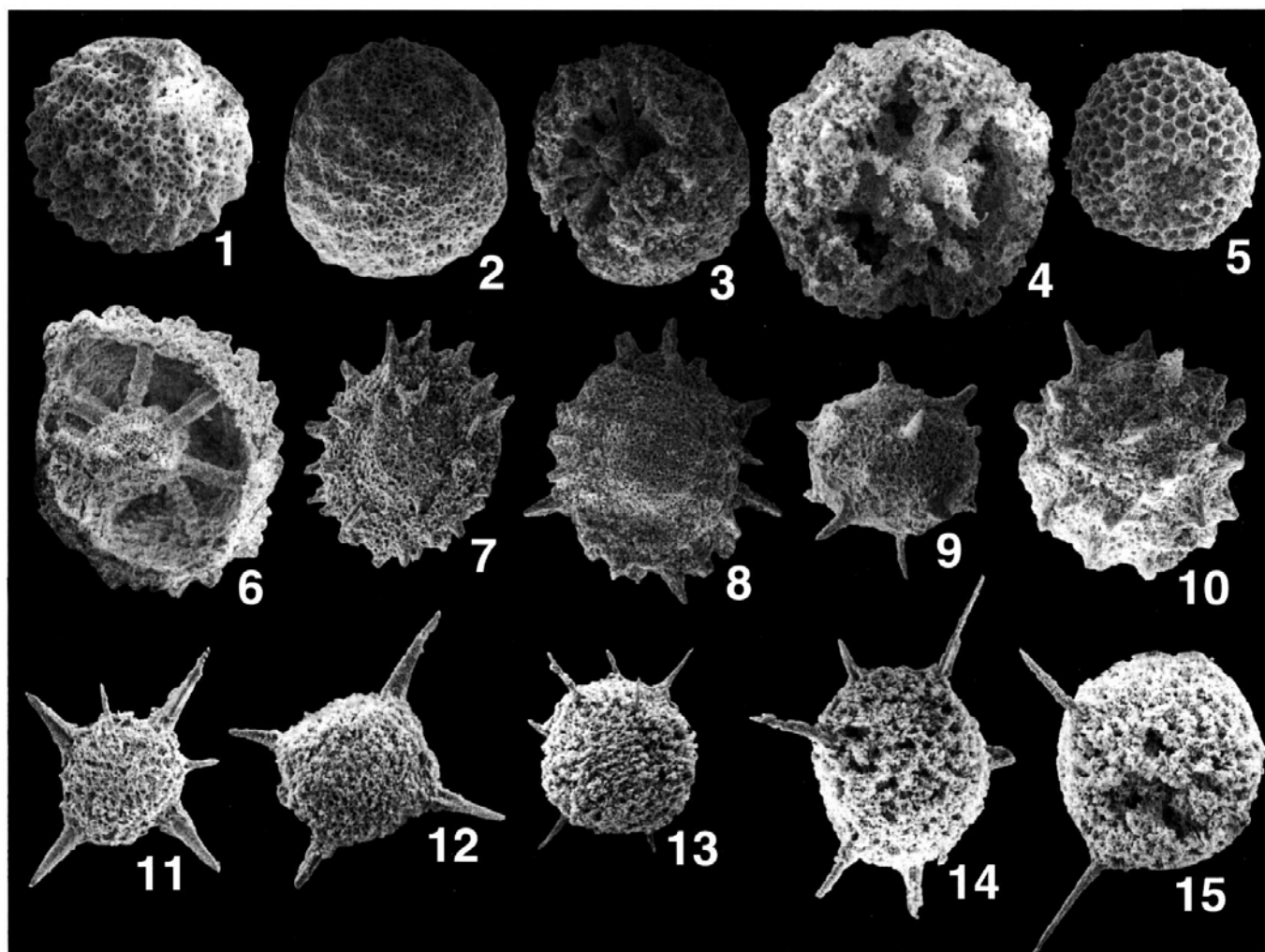


PLATE 3

All specimens are from sample KWC-1-9

- | | | | |
|-------|--|-------|--|
| 1-4,6 | <i>Hegleria mammilla</i> (Sheng and Wang). 1, IGUT-KSET5573, $\times 75$; 2, IGUT-KSET5561, $\times 75$; 3, IGUT-KSET5563, $\times 75$; 4, IGUT-KSET5572, $\times 125$; 6, IGUT-KSET5562, $\times 100$ | 10 | <i>Copicyntra akikawaensis</i> Sashida and Tonishi, IGUT-KSET5551, $\times 150$ |
| 5 | <i>Entactinia</i> ? sp. B, IGUT-KSET5558, $\times 100$ | 11 | <i>Copicyntroides</i> ? sp. B, IGUT-KSET5512, $\times 150$ |
| 7,8 | <i>Klaengspongius spinosus</i> Sashida n. sp. 7, Paratype, IGUT-KSET5525, $\times 100$; 8, Holotype, IGUT-KSET5511, $\times 100$ | 12 | <i>Spumellaria</i> gen. et sp. indet. A, IGUT-KSET5517, $\times 150$ |
| 9 | <i>Copicyntra</i> sp. A, IGUT-KSET5554, $\times 100$ | 13,15 | <i>Copicyntra</i> sp. B, 13, IGUT-KSET5514, $\times 150$; 15, IGUT-KSET5507, $\times 150$ |
| | | 14 | <i>Copicyntra</i> sp. C, IGUT-KSET5505, $\times 150$ |

- KOZUR, H. W., and MOSTLER, H., 1978. Beitrage zur Erforschung der mesozoischen Radiolarien Teil II: Oberfamilie Trematodiscacea haeckel 1862 emend. und Beschreibung ihrer triassischen Vertreter. Geologisch-Palaontologische Mitteilungen Innsbruck, bd.8:123-182.
- , 1989. Radiolarien und Schwammskelern aus dem Unterperm des Vorurals. Geologisch-Palaontologische Mitteilungen Innsbruck, sonderband, 2:147-275.
- KUWAHARA, K., 1997. Upper Permian radiolarian biostratigraphy: Abundance zones of *Albaillella*. News of Osaka Micropaleontologists, Special Volume, 10 (Proceedings of the Fifth Radiolarian Symposium):55-75. [In Japanese with English abstract.]
- KUWAHARA, K., and SAKAMOTO, M., 1992. Late Permian *Albaillella* (Radiolaria) from a bedded chert section in the Gujo-hachiman area of the Mino belt, central Japan. Journal of Geosciences, Osaka City University, 35:33-51.
- KUWAHARA, K., and YAO, A., 1998. Diversity of late Permian radiolarian assemblages. News of Osaka Micropaleontologists, Special Volume 11 (Proceedings of the Sixth Radiolarian Symposium):33-46. [In Japanese with English abstract.]
- KUWAHARA, K., and YAO, A., and AN, T., 1997. Paleozoic and Mesozoic complexes in the Yunnan area, China (Part 1): Preliminary report of Middle-Late Permian radiolarian assemblages. Journal of Geosciences, Osaka City University, 40:37-49.
- KUWAHARA, K., and YAO, A., and YAMAKITA, S., 1998. Reexamination of Upper Permian radiolarian biostratigraphy. Earth Science (Chikyu Kagaku: Journal of the Association for the Geological Collaboration in Japan), 52:391-404.
- KUWAHARA, K., NAKAE, S. and YAO, A., 1991. Late Permian "Toishi-type" siliceous mudstone in the Mino-Tamba Belt. Journal of Geological Society of Japan, 97:1005-1008. [In Japanese.]
- LIU, B., FENG, Q. and FANG, N., 1991. Tectonic evolution of the Palaeo-Tethys in Changning-Menglian Belt and adjacent regions, western Yunnan. Journal of China University of Geosciences, 2:18-28.
- MIYAMOTO, T. and TANIMOTO, Y., 1986. Discovery of Late Permian radiolarians from the so-called Yuzuruha Formation, Kumamoto Prefecture, southwest Japan. News of Osaka Micropaleontologists, Special Volume, 7 (Recent Progress of Research on Radiolarians and Radiolarian Terranes of Japan):211-217. [In Japanese with English abstract.]
- NAKA, T. and ISHIGA, H., 1985. Discovery of Permian radiolarians from the Nishiki Group in western part of Sangun-Chugoku Belt, southwest Japan. Earth Science (Chikyu Kagaku: Journal of the Association for the Geological Collaboration in Japan), 39:229-233.
- NAZAROV, B. B., 1975. Radiolaria of the Lower-Middle Paleozoic of Kazakhstan Academia Nauk SSSR, Geologicheskii Institut (1956-), Trudy, 275:1-202.
- NAZAROV, B. B., and ORMISTON, A. R., 1983. A new superfamily of stauraxon polycystine Radiolaria from the Late Paleozoic of the Soviet Union and North America. Senckenbergiana Lethaea, 64:363-379.
- , 1985. Radiolaria from the Late Paleozoic of the southern Urals and west Texas, USA. Micropaleontology, 31:1-54.
- NISHIZONO, Y., 1996. Mesozoic convergent process of the Southern Chichibu Terrane in West Kyushu, Japan, on the basis of Triassic to Early Cretaceous radiolarian biostratigraphy. Kumamoto Journal of Science (Earth Science), 14:45-226. [In Japanese with English abstract.]
- NISHIZONO, Y., OHISHI, T., SATO, T., and MURATA, M., 1982. Radiolarian fauna from the Paleozoic and Mesozoic formations distributed along the mid-stream of Kuma River, Kyushu Japan. News of Osaka Micropaleontologists, Special Volume, 5 (Proceedings of the First Japanese Radiolarian Symposium): 311-326. [In Japanese with English abstract.]
- NOBLE, P. and RENNE, P., 1990. Paleoenvironmental and biostratigraphic significance of siliceous microfossils of the Permo-Triassic Redding section, eastern Klamath Mountains, California. Marine Micropaleontology, 15:379-391.
- ORMISTON, A. R. and LANE, H. R., 1976. A unique radiolarian fauna from the Sycamore Limestone (Mississippian) and its biostratigraphic significance. Palaeontographica, Abt. A, 154:158-180.
- PESSAGNO, E. A. Jr., 1963. Upper Cretaceous Radiolaria from Puerto Rico. Micropaleontology, 9:197-214.
- , 1973. Upper Cretaceous Spumellariina from the Great Valley sequence, California Coast Ranges. Bulletin of American Paleontology, 63:49-102.
- RIEDEL, W. R., 1967. Subclass Actinopoda, 291-298. In: Harland, W. B. et al., Eds., Protozoa, the Fossil Record. Geological Society of London Publication.
- RUDENKO, V. and PANASENKO, E. S., 1990. A new findings of the Upper Permian radiolarians in Primorye region. New data in Paleozoic and Mesozoic biostratigraphy of the south Far East, Vladivostok. Far Eastern Branch of the USSR Academy of Sciences, 117-124.
- SALYAPONGSE, S., FONTAINE, H., PUTTHAPIBAN, P. and LAMJUAN, A., 1997. Guidebook for excursion: Geology of the eastern Thailand (Route No. 1). Geological Survey Division, Department of Mineral Resources of Thailand, Bangkok, 69 p.
- SASHIDA, K., 1988. Lower Jurassic multisegmented Nassellaria from the Itsukaichi area, western part of Tokyo Prefecture, central Japan. Science Reports of the Institute of Geoscience, University of Tsukuba, section B, 9: 1-27.
- SASHIDA, K., and TONISHI, K., 1985. Permian radiolarians from the Kanto Mountains, central Japan - Some Upper Permian Spumellaria from Itsukaichi, western part of Tokyo Prefecture. Science Reports of the institute of Geoscience, University of Tsukuba, section B, 6:1-19.
- , 1986. Upper Permian stauraxon polycystine Radiolaria from Itsukaichi, western part of Tokyo Prefecture. Science Reports of the Institute of Geoscience, University of Tsukuba, section B, 7:1-13.
- , 1988. Additional notes on Upper Permian radiolarian faunas from Itsukaichi, western part of Tokyo Prefecture, central Japan. Transactions and Proceedings of the Palaeontological Society of Japan, New Series, 151:523-542.
- SASHIDA, K., ADACHI, S., IGO, H., KOIKE, T., and IBRAHIM, A. B., 1995. Middle and Late Permian radiolarians from the Semanggol Formation, northwest peninsular Malaysia. Transactions and Proceedings of the Palaeontological Society of Japan, New Series, 177:43-58.
- SASHIDA, K., and IGO, H., 1999. Occurrence and tectonic significance of Paleozoic and Mesozoic Radiolaria in Thailand and Malaysia. In: Metcalfe, I., Ed., Gondwana Dispersion and Asian Accretion, 175-196, Balkema Rotterdam.

- SASHIDA, K., IGO, H., ADACHI, S., UENO, K., NAKORNSRI, N. and AMPORNMAHA, A., 1994. The Permian/Triassic boundary in the bedded chert sequence in northern Thailand. In: Angsuwathana, P. et al., Eds., Proceedings of the International Symposium on Stratigraphic Correlation of Southeast Asia, IGCP Project 306, 130. Department of Mineral Resources of Thailand, Bangkok.
- SASHIDA, K., IGO, H., ADACHI, S., UENO, K., NAKORNSRI, N. and AMPORNMAHA, A., and SARSDUD, A. 1998. Late Paleozoic radiolarian fauna from northern and northeastern Thailand. Science Reports of the Institute of Geosciences, University of Tsukuba, section B, 19:1-27.
- SASHIDA, K., UENO, K., NAKORNSRI, N. and SARSDUD, A., 1999. Lithofacies and biofacies of the Khlong Kon Limestone, southern Peninsular Thailand. In: Rathanasthien, B. and Rieb, S. L., Eds., Proceedings of the International Symposium on Shallow Tethys (ST) 5, 228-241, Department of Geological Science, Faculty of Science, Chiang Mai University, Chiang Mai.
- SHENG, J. and WANG, Y., 1985. Fossil Radiolaria from Kufeng Formation at Longtan, Nanjing. Acta Palaeontologica Sinica, 24:171-180.
- SHENG, J., CHENG, C., WANG, Y., RUI, L., LIAO, Z., BANDO, Y., ISHII, K., NAKAZAWA, K. and NAKAMURA, K., 1984. Permian-Triassic boundary in Middle and Eastern Tethys. Journal of the Faculty of Science, Hokkaido University, series 4, 21:133-181.
- SUGIYAMA, K., 1992. Lower and Middle Triassic radiolarians from Mt. Kinkazan, Gifu Prefecture, central Japan. Transactions and Proceedings of the Palaeontological Society of Japan, New Series, 167:1180-1223.
- SWEET, W., YANG, Z., DICKINS, J. M. and YIN, H., 1992. Permo-Triassic events in the eastern Tethys. Stratigraphy, classification and relations with the western Tethys. Cambridge University Press, New York, 179 p.
- TAKEMURA, A. and NAKASEKO, K., 1981. A new Permian radiolarian genus from the Tamba belt, southwest Japan. Transactions and Proceedings of the Palaeontological Society of Japan, New Series, 124:208-214.
- TUMANDA, F., SATO, T. and SASHIDA, K., 1990. Preliminary Late Permian radiolarian biostratigraphy of Busuanga Island, Palawan, Philippines. Annual Reports of the Institute of Geosciences, University of Tsukuba, 16: 39-45.
- VACHARD, D. and FONTAINE, H., 1988. Biostratigraphic importance of Triassic foraminifera and algae from Southeast Asia. Revue de Paleobiologie, 7:87-98.
- WAKAMATSU, H., SUGIYAMA, K., and FURUTANI, H., 1990. Silurian and Devonian radiolarians from the Kurosegawa Tectonic Zone, southwest Japan. Journal of Earth Science, Nagoya University, 37:157-192.
- WAKITA, K., 1983. Allochthonous blocks and submarine slide deposits in the Jurassic formation southwest of Gujo-Hachiman, Gifu Prefecture, central Japan. Bulletin of the Geological Survey of Japan, 34: 329-342. [In Japanese with English abstract.]
- WANG, R., 1993a. Fossil Radiolaria from the Kufeng Formation of Chaoku, Anhui. Acta Palaeontologica Sinica, 32:442-457.
- , 1993b. Fossil radiolarians from the Kufeng Formation, Hushan area, Nanjing. Acta Micropalaeontologica Sinica, 10:459-468.
- WANG, Y., 1991. On progress in the study of Paleozoic radiolarians in China. Acta Micropalaeontologica Sinica, 8:237-251.
- WANG, Y., CHENG, Y., and YANG, Q., 1994. Biostratigraphy and systematics of Permian radiolarians in China. Palaeoworld, 4:172-202.
- WANG, Y., and LI, J., 1994. Discovery of the *Follicucullus bipartitus* - *F. charveti* radiolarian assemblage zone and its geological significance. Acta Micropalaeontologica Sinica, 11:201-212.
- WANG, Y., and Qi, D., 1995. Radiolarian fauna of the Kufeng Formation in southern part of Jiangsu and Anhui Provinces. Acta Micropalaeontologica Sinica, 12:374-387.
- WANG, Y., and LUO, H., 1998. Late Devonian-Late Permian strata of cherty facies at Xiaodong and Bancheng counties of the Qinzhou area, SE Guangxi. Acta Micropalaeontologica Sinica, 15:351-366.
- WU, H. and LI, H., 1989. Carboniferous and Permian Radiolaria in the Menglian area, western Yunnan. Acta Micropalaeontologica Sinica, 6: 337-343.
- WU, H., XIAN, X., and KUANG G., 1994. Late Paleozoic radiolarian assemblages of southern Guangxi and its geological significance. Scientia Geologica Sinica, 29:339-345.
- XIAN, W. and ZHANG, N., 1998. Early to Middle Permian radiolarians from the Kufeng Formation in southeastern Guangxi, South China. Earth Science (Chikyū Kagaku: Journal of the Association for Geological Collaboration in Japan), 52:188-202.
- YAMAKITA, S., 1987. Stratigraphic relationship between Permian and Triassic strata of chert facies in the Chichibu Terrane in eastern Shikoku. Journal of the Geological Society of Japan, 93:145-148. [In Japanese.]
- YAMASHITA, M., ISHIDA, K., YAMAOKA, Y., GOTO, H. and ISHIGA, H., 1991. P/T boundary occurs in the "Toishi type" shale of southwest Japan. Appendix: Early Triassic radiolarians. Geological Reports of the Shimane University, 10:47-52. [In Japanese.]
- YAO, A. and KUWHARA, K., 1997. Radiolarian faunal change from Late Permian to Middle Triassic times. News of Osaka Micropaleontologists, Special Volume, 10 (Proceedings of the Fifth Radiolarian Symposium):87-96. [In Japanese with English abstract.]
- YAO, A., YU, J. and AN, T., 1993. Late Paleozoic radiolarians from the Guizhou and Guangxi areas, China. Journal of Geosciences, Osaka City University, 36: 1-13.
- YOSHIDA, H. and MURATA, M., 1985. Permian radiolarian biostratigraphy from the northeastern part of Saiki City, Oita Prefecture, Japan. Journal of the Geological Society of Japan, 91:525-533. [In Japanese with English abstract.]
- YU, J., 1996. Permian radiolarian biostratigraphy in the Guizhou area, China. Journal of Geosciences, Osaka City University, 39:123-135.

Manuscript received July 25, 1999

Manuscript accepted February 29, 2000

ELLIS AND MESSINA

CATALOGUE OF DIATOMS

The Catalogue of Diatoms will resume publication this year, with vol. 15 for 2000. This follows suppl. vol. 14, for 1997, after a two-year hiatus. The 2000 supplement will be full size, adding more than 400 scrupulously extracted, individualized and re-set units of genus and species-level type descriptions to the 5,600 already catalogued. Classic diagnoses by Ehrenberg, Cleve, Frenguelli, Brun, Donkin, and Peragallo, as well as modern studies on material from Russia, California, Peru and deep sea cores, are scheduled for these pages.

As before, the Catalogue is available in printed form or CD-ROM; new for 2000 is internet access at no added cost. We are pleased to invite past and potential subscribers to visit the complete Catalogue of Diatoms on the internet at <http://www.micropress.org>, at no cost until June 30, 2000, after which access will be for paid subscribers only. Sign-up requests and IP registration are available on the website.

No password, no limits. As in the other Ellis and Messina Catalogues, ONLINE Diatom comes without password or other restriction for all computers that share the subscriber's Class C IP address block; other address blocks in the same institution may also be added without added cost. Free passwords will be issued to subscribers without a fixed IP address, who use a third party ISP such as AOL or Earthlink.

University and museum subscription is \$495. Payment terms, and prices for other categories (including "INTERNET-ONLY" membership with no initial or reactivation fees) are posted on our website (above). Pro-forma quotations are available on request from Micropaleontology Press, AMNH, New York, NY 10024, USA; email micro@amnh.org or fax USA-212-769-5653.