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A new genus of Entactiniidae (Radiolaria) from the Upper Permian of South China

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Key words: Taxonomy, Radiolarian, Late Permian, South China

ABSTRACT

Four new species and one indeterminate species of radiolarians from the Changxiangian (Upper Permian) of southern Guangxi, South China are introduced. They all belong to one new genus: *Megaporus* n. gen. This new genus is characterized by two concentric spherical shells with pentagonal and hexagonal pore frames composed of thick but narrow bars, which is very similar in morphology to some genera within the Mesozoic subfamily Pantanelliinae PESSAGNO (1977), but differs from the latter in possessing initial spicules within medullary shell.

Introduction

The studies on the mass extinction of Permian radiolarians indicated that the Changxingian was a main extinction interval for the Permian radiolarian fauna and the main extinction event was a gradual process (Kakuwa 1996; Vishnevskaya 1997; Kuwahara & Yao 1998). Our investigations in South China, however, prove that some taxa, such as Entactinaria (Kozur & Mostler 1982), had high diversity during the late Changxingian, and then experienced rapid extinction at the end of the Changxingian. In the high diversity stage, some new taxonomic units developed. One of these units, described herein as *Megaporus* n. gen., is characterized by having two concentric spherical shells with large pores, which is very similar to some genera of the Mesozoic subfamily Pantanelliinae PESSAGNO (1977) in morphology, but differs from the subfamily in possessing initial spicules within the medullary shell.

Stratigraphy

The fauna described herein was collected from an area located between Dongmen and Liuqiao Towns, Fusui County, Guangxi Zhuang Autonomous Region (Fig. 1) and the strata in this region mainly consist of Upper Permian and Lower Triassic successions (BGMRGZAR 2001). The Upper Permian is divided in ascending order into three formations: the Heshan, Changxing and Dalong formations (Fig. 1). All specimens described in the present paper were collected from the Dongpan Section near Dongpan Village (22°16.196'N, 107°41.505'E). In this section, the Dalong Formation overlies Changxingian limestone of the Changxing Formation and is overlain by mudstones of the Lower Triassic Luolou Formation containing *Ophiceras tingi* TIEN and *Claraia dieneri* NAKAZAWA. Therefore, the Dalong Formation is upper Changxingian. The lower part of the Dalong Formation is mainly composed of mudstones and siliceous rocks; the middle part, of bedded siliceous rocks with shales; and the upper part, of siliceous mudstones, bentonites and muddy siliceous rocks with Permian ammonites, bivalves and brachiopods, for example: *Huananoceras* cf. *perornatum* CHAO & LIANG, *Laibinoceras* cf. *compressum* YANG, *Qiangjiangoceras* sp., *Euchondria jiangxianensis* GU & LIU, *Euchondria dalongensis* YIN, *Leptochondria intermedia* YIN, *Paracrurithyris pigmae* (LIAO), *Martinia* sp., *Spinomarginifera* and so on (Fig. 2). Abundant well-preserved radiolarians were obtained from the bedded siliceous rocks, including *Neoalbaillella optima* ISHIGA, KITO & IMOTO, *Albaillella triangularis* ISHIGA, KITO & IMOTO, *Albaillella yaoi* KUWAHARA, and so on together with the radiolarians described in this paper, which belong to the upper Changxingian *Neoalbaillella optima* Zone (Kuwahara et al. 1998; Yao et al. 2001) (Fig. 2).

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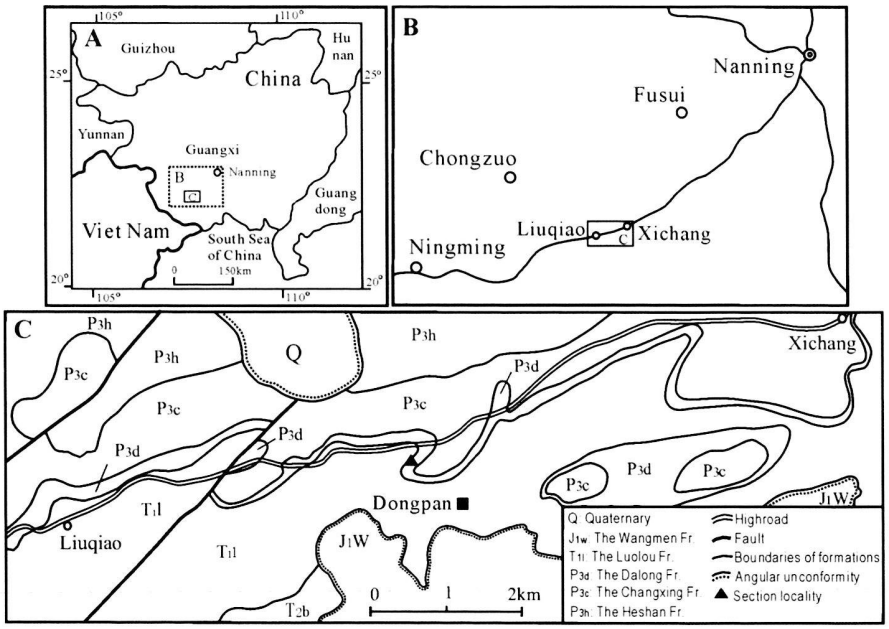

Fig. 1. A and B: Locality map of the studied area; C: Geologic map of the studied area and locality of the studied section.

Systematic Paleontology

All specimens described in this paper are deposited in Museum of China University of Geosciences, Wuhan, People's Republic China.

Class ACTINOPODA
Subclass RADIOLARIA
Superorder POLYCYSTIDA EHRENBERG 1838, *emend.* RIEDEL 1967
Order ENTACTINARIA KOZUR & MOSTLER 1982
Family Entactiniidae RIEDEL 1967

Type genus. – *Entactinia* RIEDEL 1967

Diagnosis. – Spherical to subspherical Entactinaria with commonly six to eght-spined initial spicule. Shell latticed, with one or more shells (De Wever et al. 2001).
Occurrence. – Ordovician to Lower Jurassic.

Genus ***Megaporus*** FENG new genus
Type species. – *Megaporus jini* FENG n. sp.

Description. – Test small, with two concentric shells: cortical and medullary shells. Cortical shell spherical, and composed of pentagonal and hexagonal pore frames with two to six three-bladed primary spines; pore frames thick and narrow; pores very large. Medullary shell small, consisting of pentagonal, hexagonal and irregular pore frames, and connected with cortical shell by some three-bladed and cylindrical beams. There is an initial spicule inside the medullary shell, and the spicule is relatively strong compared to the small medullary shell.

Discussion. – The structure of this new genus resembles that of *Entactinosphaera* FOREMAN (1963) from which it differs by the presence of very large pores on the cortical shell, and by irregular arrangement of the primary pines on the cortical shell. It is also similar to some genera of Pantanelliinae PESSAGNO (1977), such as *Cana* MEKIK (2000), *Gorgansium* PESSAGNO & BLOME (1980), and *Pantanellium* PESSAGNO (1977), but differs from the latter by having initial spicule in the medullary shell. The new genus is assigned to the Entactiniidae RIEDEL (1967) because it has two latticed shells and an initial spicule.

Etymology. – mega (Latin, adj.) = large; porus (Latin, adj.) = pore.

Occurrence. – Upper Permian, Dalong Formation in southern Guangxi, China.

Megaporus jini FENG new species
Plate 1, Figures 1–19; Plate 2, Figures 1–3, 8, 9, 12
?*Cryptostephanidium* sp., SHANG, CARIDROIT & WANG 2001, pl. 4, fig. 20.

Diagnosis. – A species of *Megaporus* with five to six three-bladed primary spines irregularly arranged on the cortical shell.

Description. – Test small, spherical, and with five to six approximately equal three-bladed primary spines. Spines gradually decrease in width distally. They are irregularly distributed on the cortical shell, the angle between two close spines being variable and not always at right-angle. Cortical shell is composed of pentagonal and hexagonal pore frames with massive but short secondary spines at the pore frame vertices besides the primary spines; pore frame thick and narrow; pores very large, about seven to ten pores present on outer surface of hemisphere. Medullary shell small, consisting of pentagonal, hexagonal and

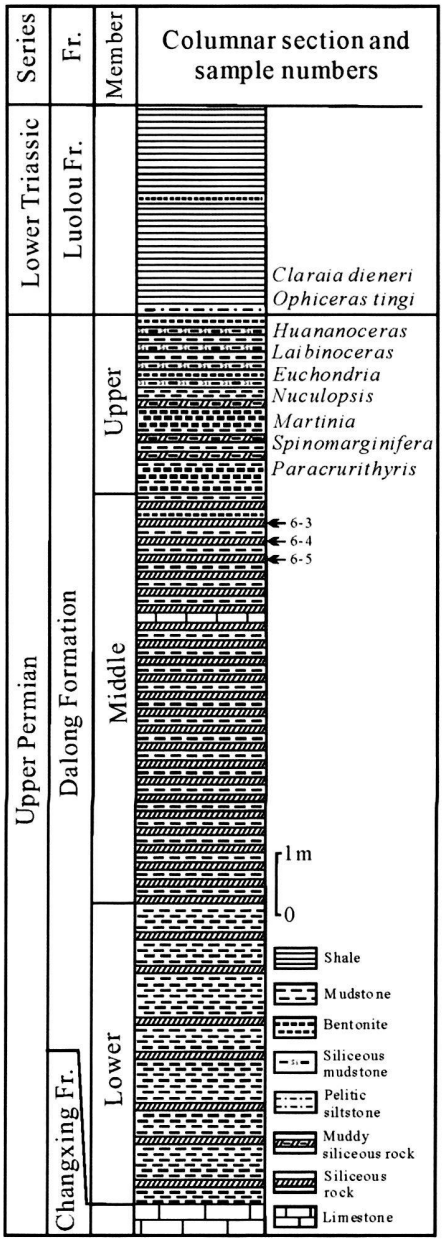

Fig. 2. Columnar section showing the stratigraphic position of the radiolarian fauna described in this paper.

irregular pore frames, and connected with cortical shell by some three-bladed and cylindrical beams. There are initial spicules inside the medullary shell, but the number of spicules is unclear.

Etymology. – This species is named for Prof. Yugan Jin of the Nanjing Institute of Geology and Palaeontology in honor of his many contributions to the study of the Permian stratigraphy.

Type. – Holotype, Plate 1 Figure 14, sample C6-3, catalog number X0301-14.

Measurements (μm). – Based on 24 specimens, of which only a few possess a medullary shell. Diameter of cortical shell 48-87 (average 72, holotype 70), diameter of pore of cortical shell 19-32 (average 26, holotype 29); diameter of medullary shell 25-27 (average 26, holotype 28), width of pores on medullary shell 5-9; width of primary spines near base 12-25 (average 20, holotype 21); length of primary spines 48-106 (average 80, holotype 56).

Occurrence. – This species is only known from the middle part of the Dalong Formation (upper Changxingian) in the Dongpan Section, southern Guangxi, China.

Discussion. – This species is similar to *Cana elegans* MEKIK (2000) from the Lower Cretaceous of Northwest Turkey in the characteristics of the cortical shell, but differs from the latter in having approximately equal primary spines irregularly distributed on the cortical shell and an initial spicule.

Megaporus yini FENG new species

Plate 2, Figures 4–7, 10, 11; Plate 3, Figures 16–20; Plate 4, Figures 1–9

Diagnosis. – A species of *Megaporus* with three unequal, coplanar primary spines and well-developed nodes.

Description. – Test is small, with two spherical concentric shells: cortical and medullary shells. Cortical shell composed of pentagonal and hexagonal pore frames with well-developed nodes at the pore frame vertices. Thickness of bars on the pore frames about 3 times their width. Pore very large, about six to nine pores present on out surface of hemisphere. Medullary shell with polygonal pore frames, and connected with the nodes on the cortical shell by several beams. Three coplanar primary spines are similar in configuration: three-bladed and gradually decreasing in width toward distal end, but unequal in length and asymmetrical in arrangement: two spines (basal spines) nearly equal in length and closer together, often shorter than third spine (polar spine). There are initial spicules inside the medullary shell.

Etymology. – This species is named for Prof. Hongfu Yin of China University of Geosciences (Wuhan) in honor of his many contributions to the study of the Permian-Triassic boundary.

Type. – Holotype, Plate 4, Figure 1, sample C6-5, catalog number X0301-15.

Measurements(μm). – Based on 16 specimens. Length of polar spine 37-63 (average 52, holotype 38), width of polar spine near base 11-24 (average 17, holotype 11); length of basal spine 35-53 (average 42, holotype 35), width of basal spine near base 11-23 (average 16, holotype 11); diameter of cortical shell 57-88 (average 71, holotype 57); diameter of pore of cortical shell 19-35 (average 29, holotype 19).

Occurrence. – This species is only collected from the middle part of the Dalong Formation (upper Changxingian) in the Dongpan Section, southern Guangxi, China.

Discussion. – This species resembles some species of the Mesozoic *Gorgansium* PESSAGNO & BLOME (1980) in outline, but differs from the latter in having a smaller test, larger pores on cortical shell and an initial spicule.

***Megaporus yangi* FENG new species**
Plate 3, Figures 1–6, 12–14

Diagnosis. – *Megaporus* with two unequal polar spines and well-developed nodes on cortical shell.

Description. – Test small, with two concentric shells: cortical and medullary shells. Cortical shell spherical, composed of pentagonal and hexagonal pore frames (predominantly hexagonal) with well-developed nodes at the pore frame vertices; nodes long, massive, and triradiate. Thickness of bars on the pore frames approximately four times their width. Pore very large, about seven to ten pores present on outer surface of hemisphere. Two polar spines are similar in configuration, but unequal in length and obliquely opposed to each other. Both spines are made up of three narrow, rounded longitudinal ridges alternating with three wide longitudinal grooves, and gradually decrease in width at distal direction. Medullary shell with polygonal pore frames, and connected with the nodes on the cortical shell by several triradiate and cylindrical beams. There is an initial spicule inside medullary shell.

Etymology. – This species is named for Prof. Qun Yang of Nanjing Institute of Geology and Palaeontology in honor of his many contributions to the study of the Jurassic Radiolaria.

Type. – Holotype, Plate 3, Figure 1, sample C6-3, catalog number X0301-16.

Measurements (μm). – Based on 9 specimens. Length of long polar spine 53-83 (average 75, holotype 77), width of long polar spine near base 19-37 (average 28, holotype 30); length of short polar spine 46-57 (average 51, holotype 50), width of short polar spine near base 28-40 (average 32, holotype 30); diameter of cortical shell 64-79 (average 71, holotype 71).

Occurrence. – This species is only collected from the middle part of the Dalong Formation (upper Changxingian) in the Dongpan Section, southern Guangxi, China.

Discussion. – The morphology of this species is similar to some species of the genus *Pantanellium* PESSAGNO (1977) from Upper Triassic-Lower Cretaceous in morphology, but differs from the latter in having an initial spicule inside medullary shell and longer nodes on the cortical shell.

***Megaporus unicum* FENG new species**
Plate 3, Figures 7–9

Diagnosis. – *Megaporus* with two unequal polar spines between which the minimum angle is 103°–140°.

Description. – Test small with two concentric shells: cortical and medullary shells. Cortical shell spherical, composed of pentagonal and hexagonal pore frames (predominantly pentagonal) with well-developed nodes at the pore frame vertices; nodes long, massive, and triradiate. Thickness of bars on the pore frames about three times their width. Pore very large, about eight pores present on outer surface of hemisphere. Medullary shell small, with polygonal pore frames, and connected with the nodes on the cortical shell by several triradiate and cylindrical beams. Two polar spines are similar in configuration: consisting of three rounded longitudinal ridges alternating with three wide longitudinal grooves, and gradually decreasing in width at distal direction, but they are unequal in length and asymmetrical in arrangement: long primary spine is nearly two times the length of the short spine, and minimum angle between them about 125°.

Etymology. – *Unicus-a-um* (Latin, adj.) = unique.

Type. – Holotype, Plate 3, Figure 7, sample C6-5, catalog number X0301-17.

Measurements (μm). – Based on three specimens. Length of long polar spine 57-83 (average 70, holotype 83), width of long polar spine near base 23-30 (average 28, holotype 30); length of short polar spine 43-52 (average 48, holotype 43), width of short polar spine near base 18-27 (average 22, holotype 20); diameter of cortical shell 80-90 (average 85, holotype 83); minimum angle between both polar spines 105°-140° (average 125°, holotype 103°).

Occurrence. – This species is only collected from the middle part of the Dalong Formation (upper Changxingian) in the Dongpan Section, southern Guangxi, China.

Discussion. – This species is similar to *Denize magnifica* MEKIK (2000) from the Lower Cretaceous of northwestern Turkey in morphology, but different from the latter in having an obtuse angle between both polar spines and well-developed nodes. It is distinguished with *Megaporus yangi* n. sp. by strongly asymmetrical arrangement of both polar spines.

***Megaporus* sp.**
Plate 2, Figure 13; Plate 3, Figures 10, 11

Description. – Test small, with two concentric shells: cortical and medullary shells. Cortical shell spherical, composed of pentagonal and hexagonal pore frames (predominantly pentagonal) with poorly developed nodes at the pore frame vertices. Thickness of bars on the pore frames approximately three times their width. Pore very large and about seven to nine pores present on outer surface of hemisphere. Two polar spines are similar in configuration, but unequal in length and obliquely opposed to each other. They are with three narrow, rounded longitudinal ridges alternating with three wide longitudinal grooves, and gradually decreasing in width at distal direction.

Occurrence. – Changxingian, the Dalong Formation in southern Guangxi, China.

Discussion. – It differs from *Megaporus yangi* n. sp. and *Megaporus unicum* n. sp. in having poorly developed nodes at the pore frame vertices.

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Plate 1

Scanning electron photomicrographs of the Changxingian radiolarians from the Dalong Formation in southern Guangxi, Southw China (1–14, 16, 17: bar=50μm 15, 18: bar=20μm; 19: bar=10μm). 1–19 *Megaporus jini* n. sp.; 1, C6-4/1698; 2, C6-4/1693; 3, C6-5/1723,; 4, C6-4/1696; 5, C6-4/1699; 6, C6-5/1722; 7, C6-5/1718; 8 C6-4/1710; 9, C6-4/1712; 10, C6-4/1700; 11, C6-5/1725; 12, C6-5/2055; 13, C6-5/1727; 14, C6-3/1140, holotype; 15, C6-3/1255, magnification of holotype, showing medullary shell; 16, C6-4/1716; 17, C6-4/1695; 18, C6-5/1717, magnification of figure 16, showing medullary shell and initial spicules in the medullary shell; 19 C6-5/1739, magnification of figure 16, showing initial spicules in the medullary shell.

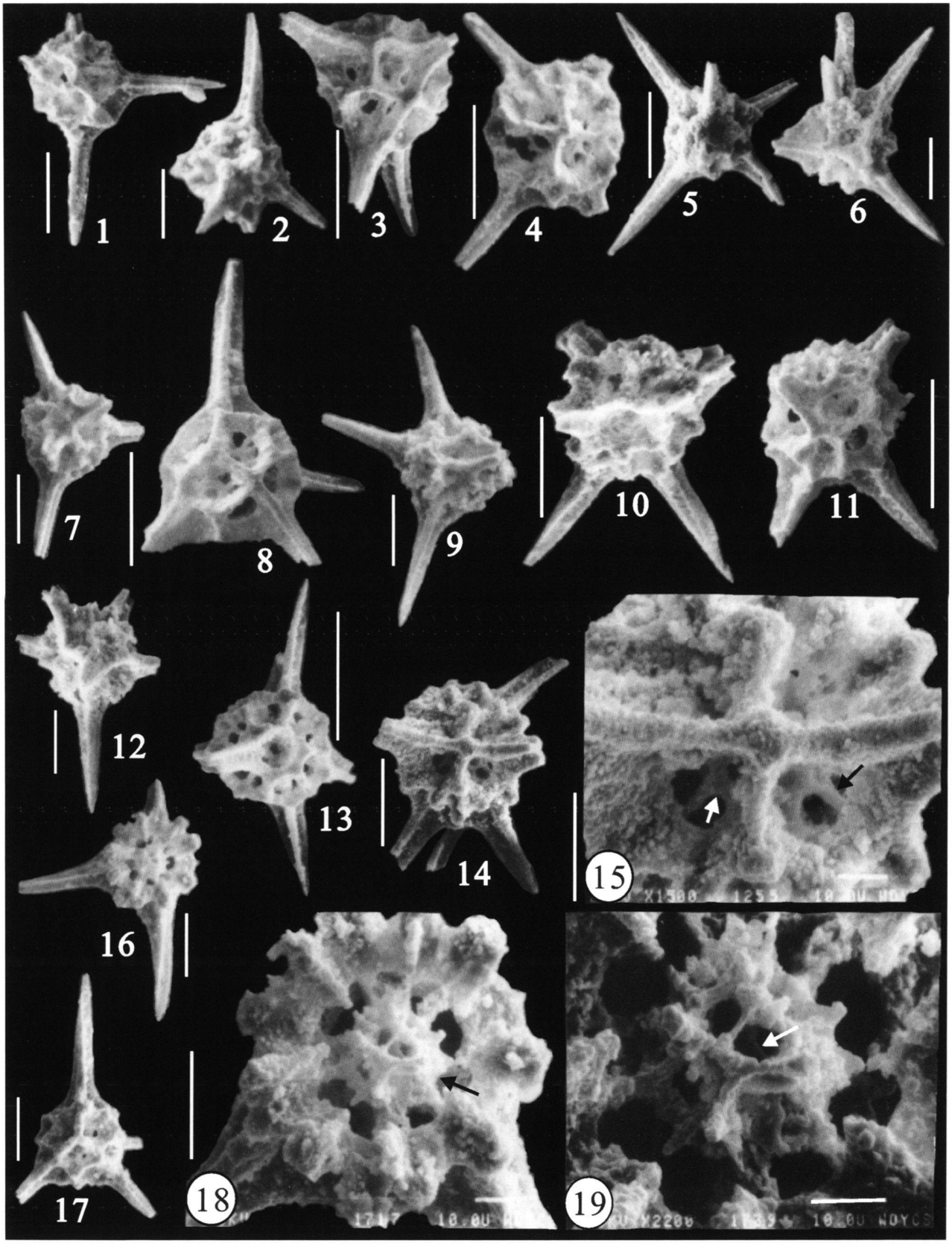
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Plate 2

Scanning electron photomicrographs of the Changxingian radiolarians from the Dalong Formation in southern Guangxi, South China (1–3: bar=1μm; 4–8 bar=10μm; 9–13: bar=50μm). 1–3, 8, 9, 12 *Megaporus jini* n. sp.; 1–3, magnification of plate 1 figure 16, showing initial spicules in the medullary shell; 8, magnification of the figure 12, showing initial spicules in the medullary shell; 9, C6-5/3116; 12, C6-5/2500. 4–7, 10, 11, *Megaporus yini* n. sp.; 4 and 5, magnification of the figure 10, showing initial spicules in the medullary shell; 6 and 7, magnification of the figure 11, showing initial spicules in the medullary shell; 10, C6-5/3112; 11 C6-5/2498. 13, *Megaporus* sp., C6-5/3105.

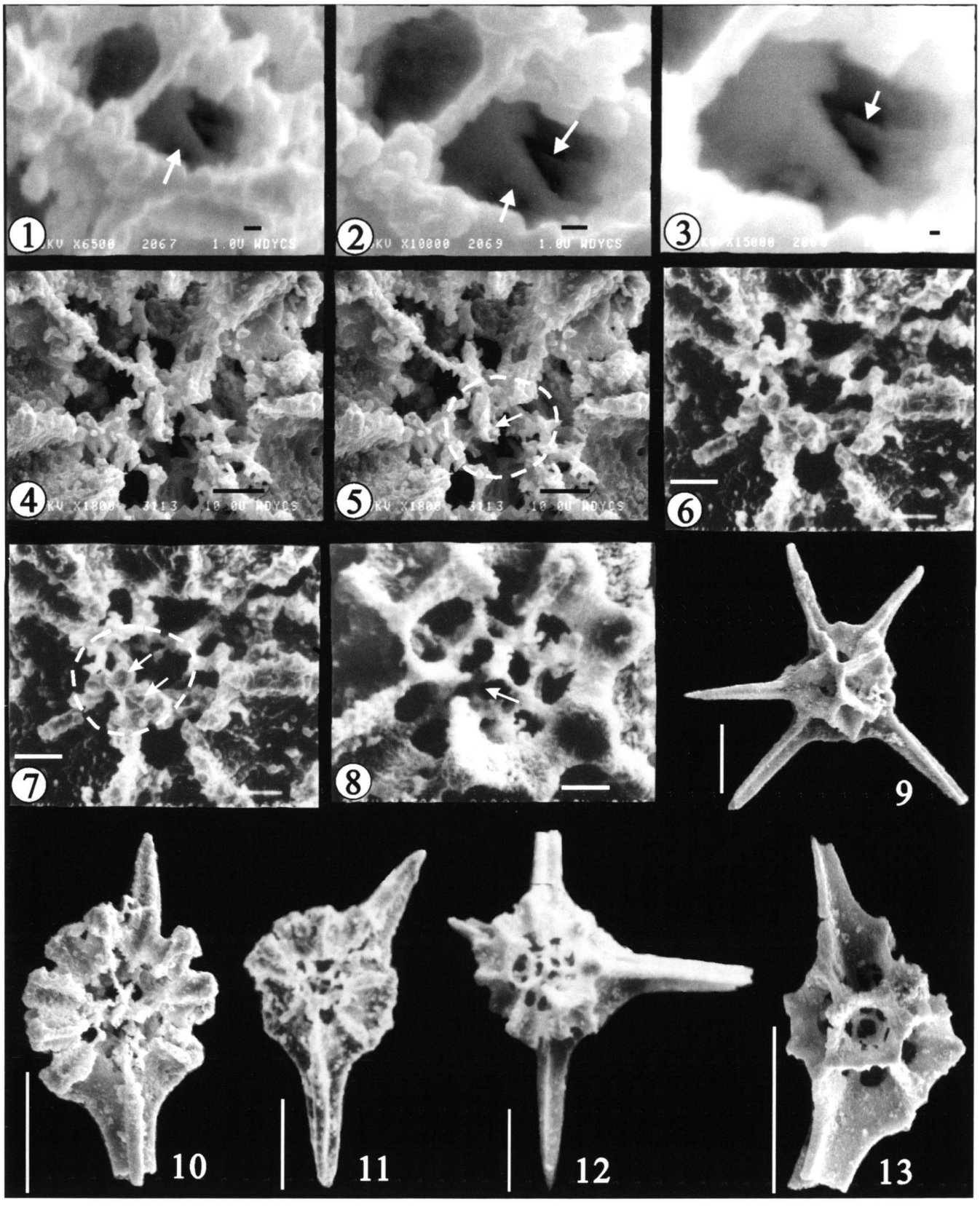
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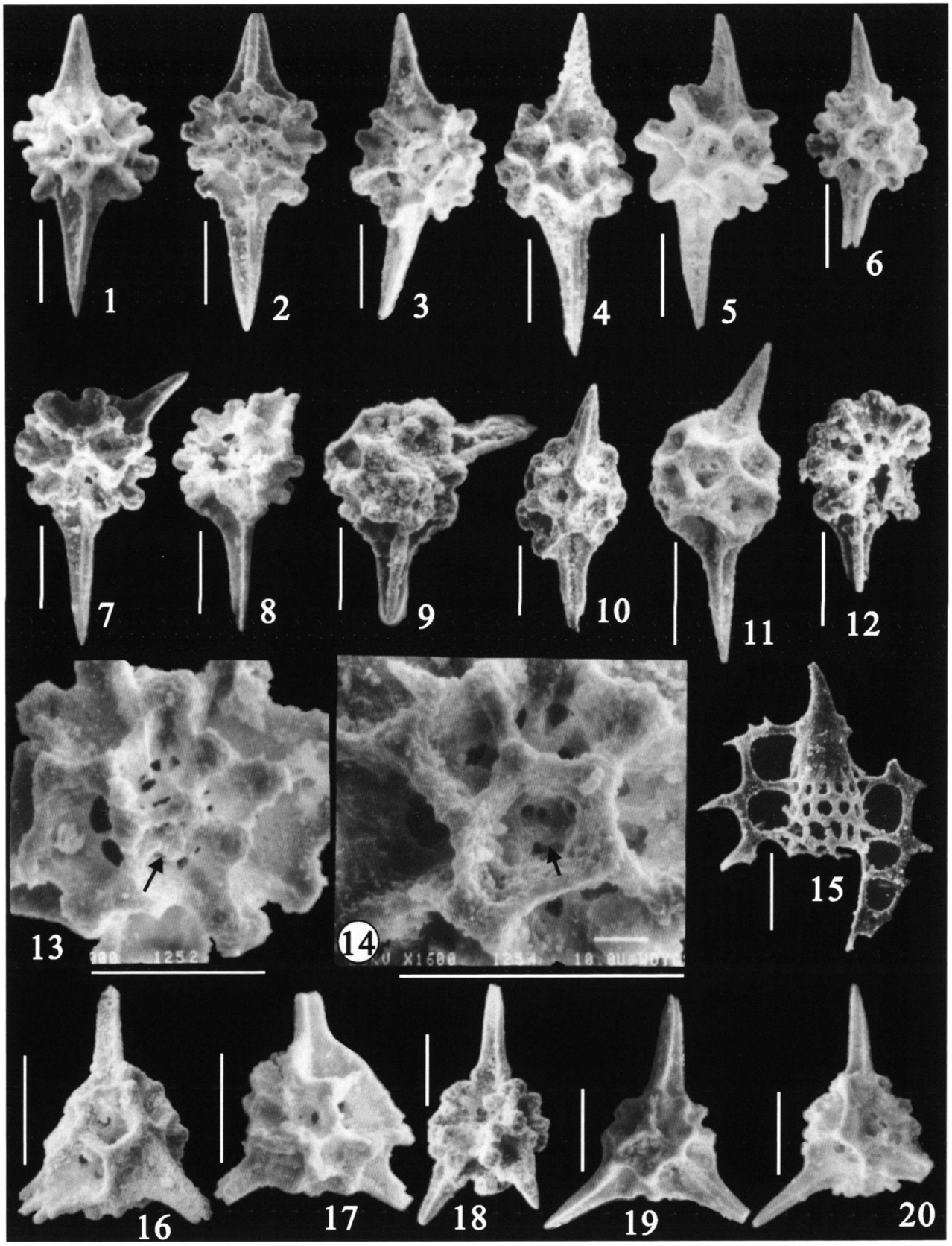
Plate 3

Scanning electron photomicrographs of the Changxingian radiolarians from the Dalong Formation in southern Guangxi, South China (1–14, 16–20: bar=50μm; 15: bar=100μm). 1–6, 12–14 *Megaporus yangi* n. sp.; 1, C6-3/1142, holotype; 2, C6-3/1145; 3, C6-5/1730; 4, C6-5/2057; 5, C6-5/1726; 6, C6-5/1737; 12, C6-3/1059, showing thickness of cortical shell, and beams between cortical and medullary shells; 13, C6-3/1252, magnification of figure 2, showing medullary shell; 14, C6-3/1254, magnification of the holotype, showing medullary shell. 7–9 *Megaporus unicum* n. sp.; 7, C6-5/2060, holotype; 8, C6-4/1686; 9, C6-3/1238. 10, 11 *Megaporus* sp.; 10, C6-3/1127; 11, C6-5/2058. 15, *Neoalbaillella optima* Ishiga, Kito and Imoto, C6-3/1093. 16–20 *Megaporus yini* n. sp.; 16, C6-5/1728; 17, C6-4/1706; 18, C6-5/1720; 19, C6-4/1713; 20, C6-4/1714.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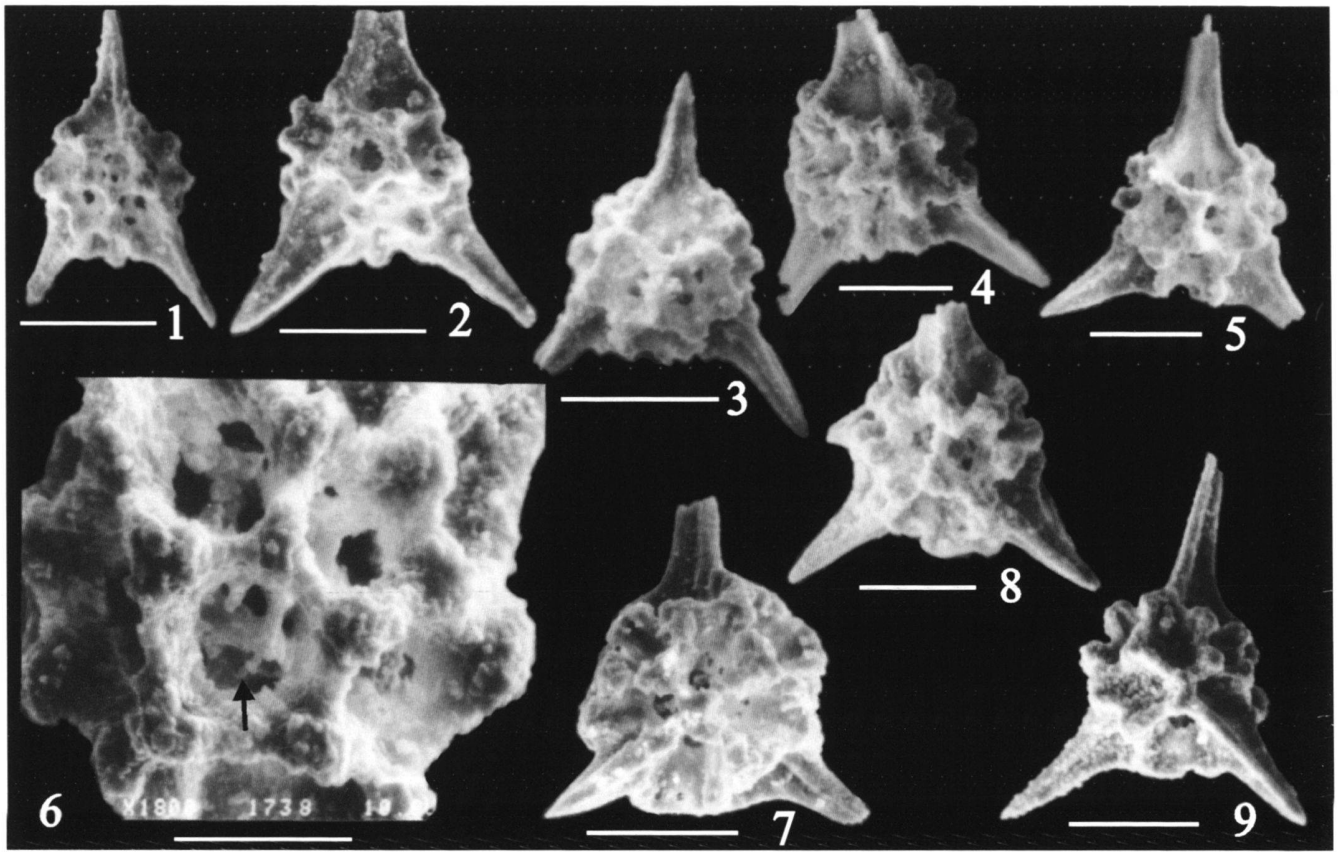

Plate 4

Scanning electron photomicrographs of the Changxingian radiolarians from the Dalong Formation in southern Guangxi, South China (1–5, 7–9: bar=50μm; 6: bar=20μm). 1–9 *Megaporus yini* n. sp.; 1, C6-5/1732, holotype; 2, C6-5/1735; 3, C6-4/1711; 4, C6-5/1731; 5, C6-5/1729; 6, C6-5/1738, magnification of the holotype, showing medullary shell; 7, C6-3/1143; 8, C6-5/1736; 9, C6-5/1734.