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Influence of the Frasnian-Famennian event on radiolarian faunas

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Key words: Radiolaria, Frasnian, Famennian, extinction event, South China

ABSTRACT

The impact of the Frasnian-Famennian biotic mass extinction event (F-F event) on radiolarian faunas is examined in 13 sections, which belong to two types of cherty basin in South China. No appreciable decrease in radiolarian biodiversity is observed across the F-F boundary. Indeed, radiolarian faunas flourished during the Famennian. The F-F event may not have had any dramatic effect on the radiolarian faunas in deep water and the disappearance of Famennian radiolarians in shallow water platform sections may simply be a result of sea level change rather than any biotic crisis.

Introduction

The F-F event is one of the great biotic mass extinction events that occurred during the Phanerozoic. It took place between late Frasnian and Famennian time in the Late Devonian and its scale was of only marginally lesser magnitude than the largest mass extinction, which occurred at the P/T boundary. The F-F event caused a great extinction or rapid diminution in the abundance of marine invertebrate animals, such as stromatoporoids, brachiopods, rugose corals, tabulate corals, trilobites, ammonoids, tentaculitids, ostracods, conodonts and so on. Over 60% of total taxa of these animals disappeared at the end of the Frasnian (Xian et al. 1995). Based on Frasnian-Famennian radiolarian materials collected from South China and those reported from elsewhere, we discuss the effects of the F-F biotic mass extinction event on radiolarian faunas.

Stratigraphy and lithologic characteristics

Our radiolarian samples were gathered from thirteen stratigraphic sections containing cherty rocks distributed in Yunnan (6 sections), Guizhou (1 section) and Guangxi (6 sections) respectively in South China (Fig. 1). The general characteristics of these sections include an age range from Frasnian to Famennian, rocks composed of thin-bedded cherts associated with mudstone and shale, and some rich radiolarian faunas. According to the developmental background of the depositional basin and the characteristics of the fossil assemblages, these 13 stratigraghic sections may be divided into two basin types, namely the open-ocean cherty basin type and the cherty platform basin type (Fig. 2). These two cherty basins experienced different developmental histories during the F-F biotic mass extinction event.

The open-ocean cherty basin indicates deep-water basin deposition except for minor platform and the slope sediments. This is a basin of compensative lack that experienced the same deep-water anoxic conditions for a long time (possibly from Silurian to Permian or Triassic). The Devonian sections at the Shiti Reservoir, Bancheng, Qinzhou, Guangxi and in the Changning-Menglian terrane, west Yunnan are considered to be the typical representatives of this kind of basin. They contain continuous radiolarian zones composed of the Frasnian *Helenifore laticlavium* and *Helenifore robustum* zones and the Famennian *Holoeciscus foremanae* zone. The cherty platform basin developed as a result of siliceous pelagic sedimentation within a platform basin. This basin experienced slow sedimentation in an anoxic environment during periods of the platforms development (e.g. during the early or late Frasnian), owing to sea level rise caused by transgression in the basin. With the exception of the sections in the Qinzhou area, Guangxi and in Changning-Menglian terrane, Yunnan, the other stratigraphic sections cited-above belong to this basin type. In these sections, there are no continuous radiolarian zones. Generally, only one fossil zone, such as, the lower or

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1. East section of Shiti Reservoir, Qinzhou, Guangxi
2. West section of Shiti Reservoir, Qinzhou, Guangxi
3. Wuxiangling section, Nanning, Guangxi
4. Yangdi section, Guilin, Guangxi
5. Bazhai section, Ziyun, Guangxi
6. Shaijingpo section, Xiangyun, Yunnan
7. Lila section, Lancang, Yunnan
8. Taierbu section, Lancang, Yunnan
9. Huiku section, Menglian, Yunnan
10. Niuyunling section, Yulin, Guangxi
11. Etang section, Hexian, Guangxi
12. Nanya section, Menglian, Yunnan
13. Ali section, Lancang, Yunnan

Fig. 1. Map showing the locations of sections studied through Upper Devonian cherty strata in South China.

upper Frasnian *Helenifore laticlavium* or *Helenifore robustum* zone can be distinguished. Moreover, Famennian radiolarians and radiolarian zones have never been discovered. From middle Frasnian to Famennian, the radiolarian-bearing cherts in the cherty platform basin were gradually replaced by phacoidal limestone due to regression. The timing of this facies change differed between areas. It occurred in the middle Frasnian in SE Guangxi and in the Famennian in SW Guizhou.

Age assignment

Upper Devonian radiolarian faunas

Our recent study suggests that the species *Helenifore laticlavium* identified by various scholars may be separated into two stratigraphically and morphologically distinct species (Wang et al. 2003). *Helenifore laticlavium* NAZAROV & ORMISTON (1983) is characterized by a shell with a thinner, nearly circular plate-ring, two spines (top and base spines) and an opening on one extremity of the ring (Plate 1, Figs. 1–5). This species occurs in the Gogo Formation, Canning Basin, western Australia (Nazarov & Ormiston 1983) and the Shiti Reservoir Formation, west bank of the Shiti Reservoir, Bancheng countryside, Qinzhou, Guangxi (Wang et al. 2003). It is considered to be lower Frasnian. *Helenifore robustum* (Boundy-Sanders & Murchey 1999) is characterized by an elliptical shell with a narrower and thicker ring (Plate 1, Figs. 6–10). This is an upper Frasnian species, which is distributed worldwide. It has been reported from eastern Australia (Ishiga 1988; Ishiga et al. 1988; Stratford & Aitchison 1997), Thailand (Sashida et al. 1998), Nevada (Boundy-Sanders & Murchey 1999) and Guangxi, Guizhou, Yunnan in China (Wang et al. 1998; Wang et al. 2003). Therefore, we subdivide the Upper Devonian radiolarian fauna into 3 zones: Two zones (*Helenifore laticlavium* zone and *H. robustum* zone) are Frasnian and one zone (*Holoeciscus foremanae* zone) is Famennian.

Correlation between Upper Devonian radiolarian and conodont zones

At present 15 typical Upper Devonian conodont zones are erected (7 zones belonging to Frasnian and 8 zones to Famennian, respectively) (Fig. 3) (Wang Cheng-yuang 2000). The *Helenifore laticlavium* zone from the Gogo Formation of western Australia is associated with conodonts that include *Polygnathus asymmetrica* and *Ancyrodella rotundilobata rotundilobata*. It is comparable to the lower-middle part of the *Polygnathus asymmetrica* zone (Nazarov & Ormiston 1983). The *Helenifore robustum* zone occurs in the Slaven Chert of the Shoshone Range, Nevada, USA (Boundy-Sanders and Murchey 1999) and in the Tarbu area, Lachang county, western Yunnan, China (Wang et al. 2000). It is associated with conodonts that include *Palmatolepis eureka, P. rhenana masuta, P. aubrecta, Polygnathus brevilaminus*, P. aff. *timanicus* (Boundy-Sanders and Murchey 1999) or *Palmatolepis rhenana rhenana, P. rhenana nasuta, P. hasii* and *P.* sp. (Wang et al. 2000). Consequently, the radiolarian *Helenifore robustum* zone may be correlated with the conodont *Palmatolepis hasii* zone to *Palmatolepis rhenana* zone. The *Holoeciscus foremanae* radiolarian zone from the Frankenwald area, northern Bavaria, Germany is associated with the conodonts *Palmatolepis rugosa, P. glabra lepta, P. gracilis gracilis, P. perlobata schindewolfii, Branmmehla bohlenana, Pseudopolygnathus granulasus* and occurs in the *Palmatolepis trachytera* zone to lower *P. postera* zone in the middle Famennian (Kiessling & Tragelehn, 1994). The same radiolarian zone from the Shiti Reservoir Formation in Bancheng, Qinzhou, Guangxi is also associated with the conodonts *Palmatolepis glabra acuta, P. perlobata schindewolfii.* It is correlated with the Famennian *Palmatolepis crepida* zone to *P. marginifera* zone (Wang et al. 1998). Therefore, the *Holoeciscus foremanae* zone can be correlated with the *Palmatolepis crepida* zone to *P. postera* zone (Fig. 3).

Upper Devonian radiolarian diversity

According to our Upper Devonian radiolarian materials collected from South China (Wang 1997; Wang et al. 2003) and

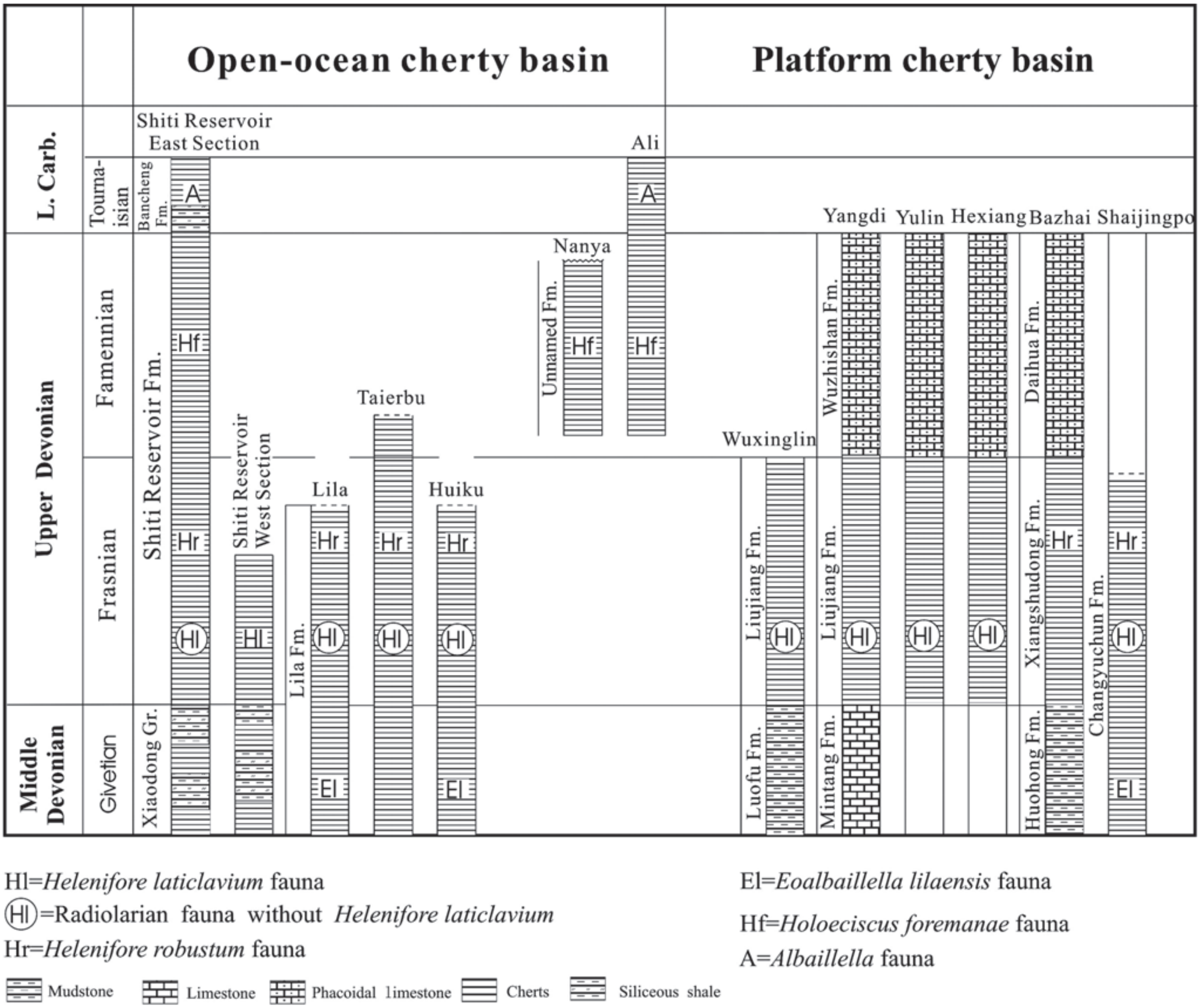

Fig. 2. Two different basin types containing cherty facies.

other published materials on Upper Devonian radiolarian faunas (Aitchison 1993; Boundy-Sanders et al. 1999; Cheng 1986; Foreman 1963; Holdsworth et al. 1978; Ishiga et al. 1988; Kiessling & Tagelehn 1994; Li & Wang 1991; Nazarov 1973, 1975; Nazarov & Ormiston 1983; Nazarov et al. 1982; Sashida et al. 1993; Schwartzapfel & Holdsworth 1996; Stratford & Aitchison 1997), we find that there are 77 and 35 species within the Frasnian *Helenifore laticlavium* zone and *H. robustum* zone respectively. They all belong to 15 genera and 8 families. Although these two faunas have the same number of families and genera, the number of species recognized in the *Helenifore robustum* zone is less half than that in the *H. laticlavium* zone. 10 genera and 12 species are same in both zones indicating a close affinity. However, in the Famennian *Holoeciscus foremanae* zone, 154 species, belonging to 28 genera and 10 families, are described. 18 species and 13 genera, as well as 8 families continued through from two Frasnian zones. 2 new families (Holoeciscidae and Pylentonemidae) and 14 new genera appear. The number of newborn genera is almost double the total number of radiolarian genera in the Frasnian. Although the species number decreased in Upper Frasnian compared to that of Lower Frasnian, the diversity of Famennian radiolarian families, genera and species are obviously higher than that of whole Frasnian (Fig. 4, Fig. 5).

	conodont zones	radiolarian zones
Famennian	*praesulcata*	
	expansa	
	postera	*Holoeciscus foremanae*
	trachytera	
	marginfera	
	rhomboidea	
	crepida	
	triangularis	
Frasnian	*linguiformis*	
	rhenana	*Helenifore robustum*
	jamieae	
	hassi	
	punctata	*Helenifore laticlavium*
	transitans	
	falsiovalis	

Fig. 3. Correlation of Upper Devonian radiolarian and conodont zonations.

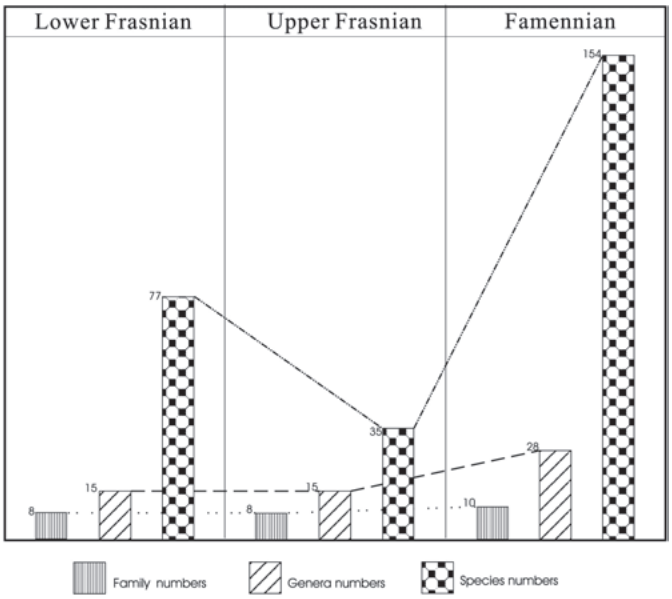

Fig. 4. Diversity changes of the radiolarian family, genera and species in Upper Devonian.

Influence of the F-F event on radiolarians

The materials mentioned above show that the F-F biotic mass extinction event did not have any marked negative effect upon the open ocean radiolarian fauna. In the open ocean cherty basin 8 upper Frasnian radiolarian families continue to flourish and only 2 out of 15 genera become extinct in the Famennian. No families and only 13% of genera become extinct. These figures are well below the minimum level of extinction (11% at family level and 20–25% of genera) regarded as indicative of a biotic mass extinction (Raup 1982). Elsewhere, in the cherty platform basin, the radiolarians belonging to *Helenifore laticlavium* and *H. robustum* zones thrived during the early and late Frasnian. However, as the radiolarian-bearing cherts were replaced by phacoidal limestone because of regression, no Famennian radiolarians are present. The disappearance of radiolarians from the platformal sections is obviously related to facies change rather than extinction. We note that in the Early Carboniferous, when deposition in the platform basin changed from limestone facies into a cherty facies again an albaillellid radiolarian fauna re-appeared in this platform basin.

Fig. 5. Ranges of Upper Devonian radiolarian genera.

Consequently, we conclude:

1. The F-F event may have only resulted in a major biotic mass extinction for biotas associated with shallow water reef facies and parts of the pelagic biota. It did not have a great influence on the radiolarian fauna in deep water and indeed radiolarians flourished during the Famennian.
2. The disappearance of radiolarians from shallow water platform sections may simply be a result of sea level change rather than any biotic crisis. In deeper water successions, radiolarians were less affected by sea level change. There was no appreciable decrease in radiolarian biodiversity across the F-F boundary.

In order to test this hypothesis we need to find and examine more Famennian platformal cherty successions.

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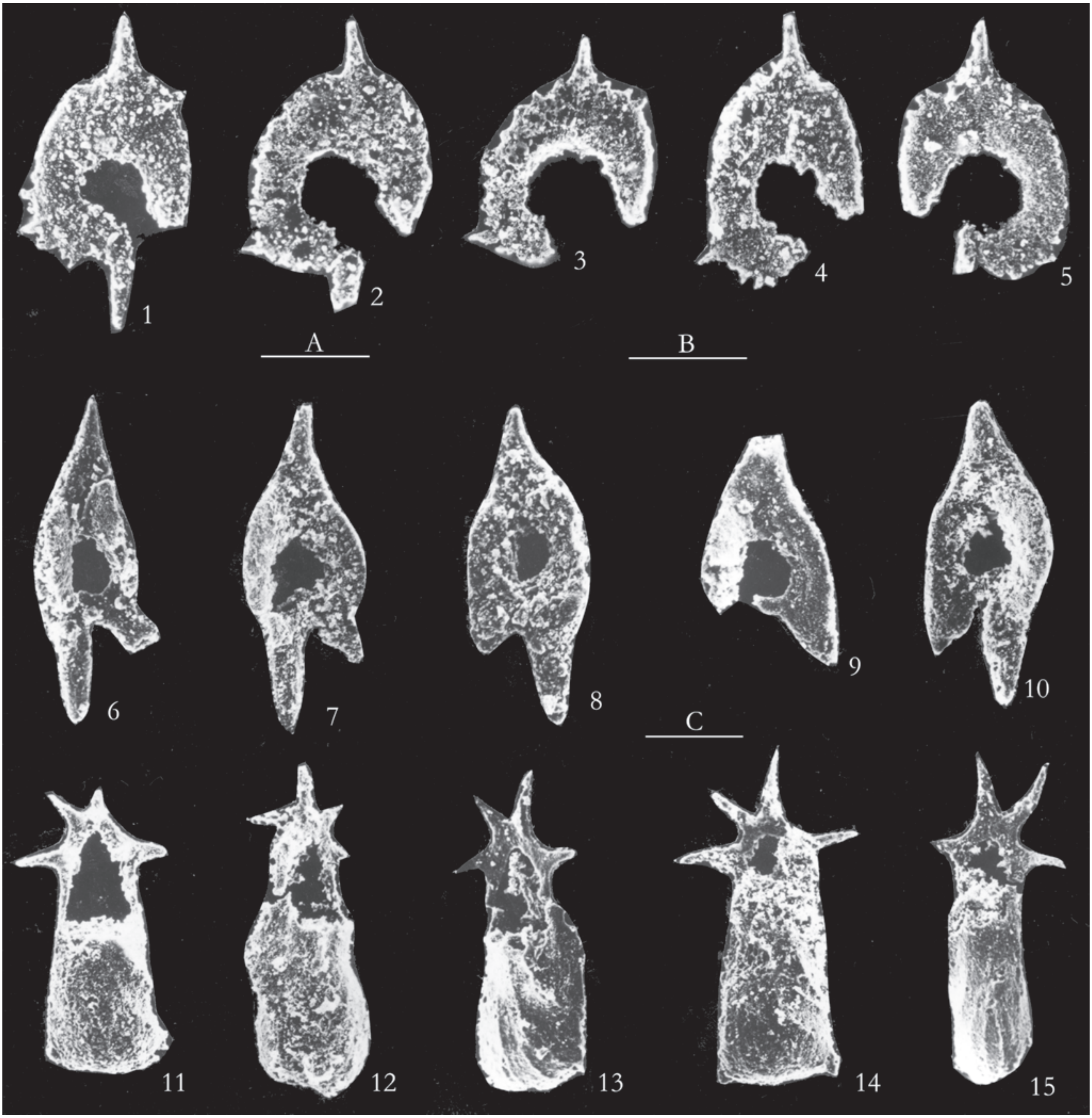

Plate 1

Index species of Late Devonian radiolarian zonations from South China. All scales = 100 µm: A for figure 1; B for figures 2–10; C for figures 11–15.

Figs. 1–5, *Helenifore laticlavium* Nazarov & Ormiston. 1–5 from sample 96shiti159, Shiti Reservoir Formation, Shiti, Bancheng, Guangxi.
Figs. 6–10, *Helenifore robustum* (Boundy-Sanders & Murchey). 6–10 from sample 92J9, Shiti Reservoir Formation, Shija, Bancheng, Guangxi.
Figs. 11–13, *Holoeciscus foremanae* Cheng. 11–13 from sample 96shiti185, Bancheng Formation, Shiti, Bancheng, Guangxi.
Figs. 14–15, *Holoeciscus elongates* Kiessling & Tragelehn. 14–15 from sample 96shiti185, Bancheng Formation, Shiti, Bancheng, Guangxi.