

# Influence of the Frasnian-Famennian event on radiolarian faunas

Autor(en): **Wang, Yu-Jing / Luo, Hui / Aitchinson, Jonathan C.**

Objektyp: **Article**

Zeitschrift: **Eclogae Geologicae Helvetiae**

Band (Jahr): **99 (2006)**

Heft [1]: **Radiolaria : siliceous plankton through time : proceedings of the tenth meeting of the International Association of Radiolarian Palaeontologists INTERRAD X**

PDF erstellt am: **17.09.2024**

Persistenter Link: <https://doi.org/10.5169/seals-169258>

## **Nutzungsbedingungen**

Die ETH-Bibliothek ist Anbieterin der digitalisierten Zeitschriften. Sie besitzt keine Urheberrechte an den Inhalten der Zeitschriften. Die Rechte liegen in der Regel bei den Herausgebern.

Die auf der Plattform e-periodica veröffentlichten Dokumente stehen für nicht-kommerzielle Zwecke in Lehre und Forschung sowie für die private Nutzung frei zur Verfügung. Einzelne Dateien oder Ausdrucke aus diesem Angebot können zusammen mit diesen Nutzungsbedingungen und den korrekten Herkunftsbezeichnungen weitergegeben werden.

Das Veröffentlichen von Bildern in Print- und Online-Publikationen ist nur mit vorheriger Genehmigung der Rechteinhaber erlaubt. Die systematische Speicherung von Teilen des elektronischen Angebots auf anderen Servern bedarf ebenfalls des schriftlichen Einverständnisses der Rechteinhaber.

## **Haftungsausschluss**

Alle Angaben erfolgen ohne Gewähr für Vollständigkeit oder Richtigkeit. Es wird keine Haftung übernommen für Schäden durch die Verwendung von Informationen aus diesem Online-Angebot oder durch das Fehlen von Informationen. Dies gilt auch für Inhalte Dritter, die über dieses Angebot zugänglich sind.

# Influence of the Frasnian-Famennian event on radiolarian faunas

YU-JING WANG<sup>1</sup>, HUI LUO<sup>1</sup> & JONATHAN C. AITCHISON<sup>2</sup>

*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

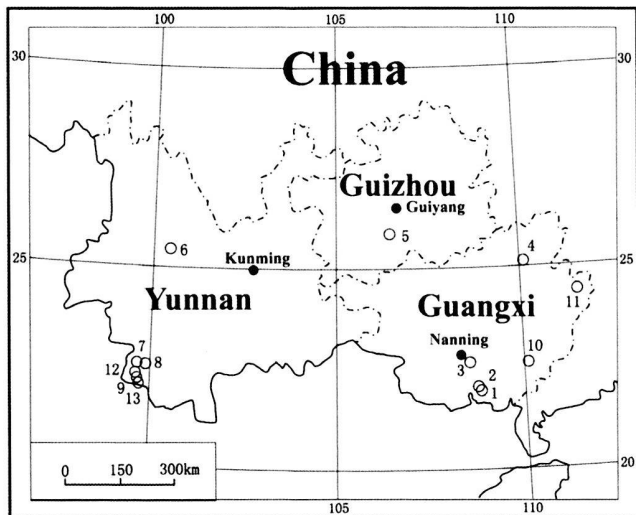
Our radiolarian samples were gathered from thirteen stratigraphic sections containing cherty rocks distributed in Yunnan (6 sections), Guizhou (1 section) and Guangxi (6 sections) respectively in South China (Fig. 1). The general characteristics of these sections include an age range from Frasnian to Famennian, rocks composed of thin-bedded cherts associated with mudstone and shale, and some rich radiolarian faunas. According to the developmental background of the deposi-

tional basin and the characteristics of the fossil assemblages, these 13 stratigraphic 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

<sup>1</sup> Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing 210008, China. Email: huiluo@nigpas.ac.cn

<sup>2</sup> Department of Earth Sciences, University of Hong Kong, Pokfulam Road, Hong Kong SAR, China



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 plating, 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 Forma-

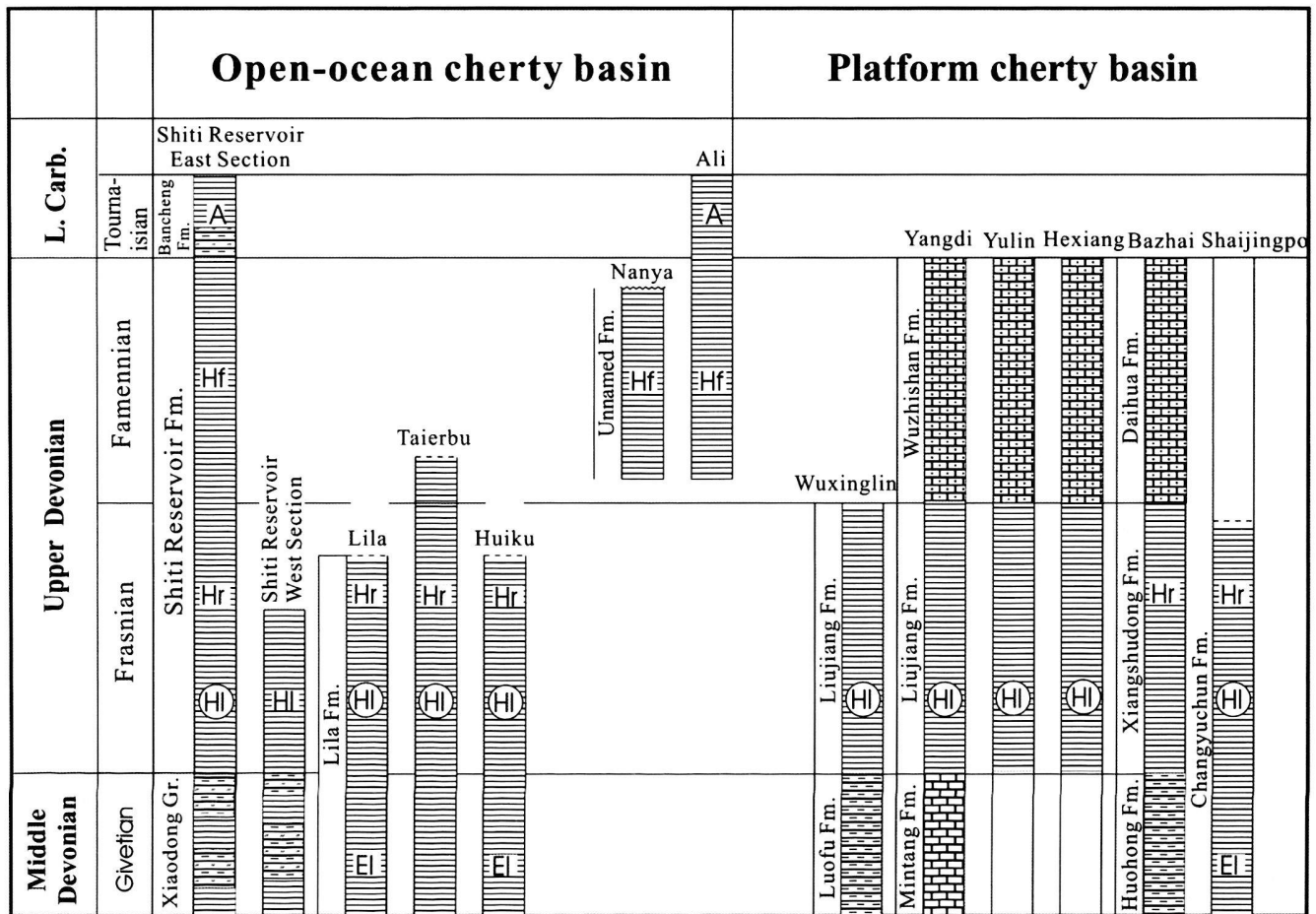
tion, west bank of the Shiti Reservoir, Bancheng countryside, Qinzhou, Guangxi (Wang et al. 2003). It is considered to be lower Frasnian. *Helenifore robustum* (Boundy-Sanders & Murchey 1999) is characterized by an elliptical shell with a narrower and thicker ring (Plate 1, Figs. 6–10). This is an upper 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 granularus* 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



Hl=*Helenifore laticlavium* fauna

⊕=*Radiolarian* fauna without *Helenifore laticlavium*

Hr=*Helenifore robustum* fauna

▨ Mudstone   ▤ Limestone   ▧ Phacoidal limestone   ▩ Cherts   ▪ Siliceous shale

El=*Eoalbaillella lilaensis* fauna

Hf=*Holoeciscus foremanae* fauna

A=*Albaillella* fauna

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 & Tägelehn 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 than half 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 | <i>proesulcata</i>  | <i>Holoeciscus foremanae</i>  |
|           | <i>expansa</i>      |                               |
|           | <i>postera</i>      |                               |
|           | <i>trachytera</i>   |                               |
|           | <i>marginifera</i>  |                               |
|           | <i>rhomboidea</i>   |                               |
|           | <i>crepida</i>      |                               |
| Frasnian  | <i>triangularis</i> | <i>Helenifore robustum</i>    |
|           | <i>linguiformis</i> |                               |
|           | <i>rhenana</i>      |                               |
|           | <i>janicie</i>      |                               |
|           | <i>hassi</i>        |                               |
|           | <i>punctata</i>     |                               |
|           | <i>transitans</i>   |                               |
|           | <i>falsiovalis</i>  | <i>Helenifore laticlavium</i> |

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

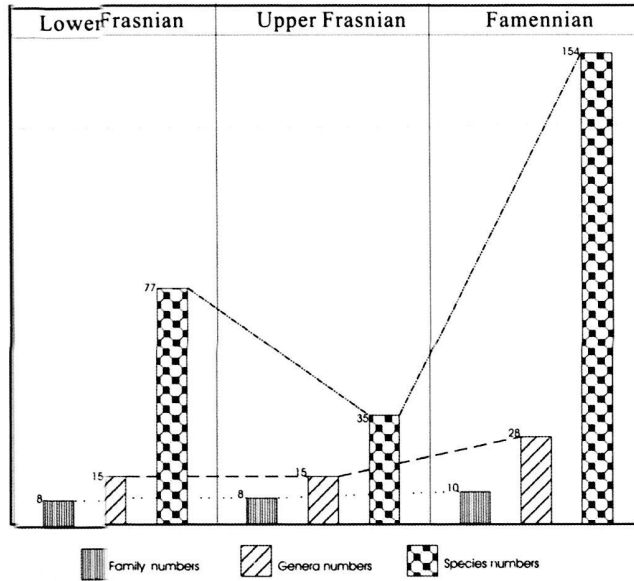


Fig. 4. Diversity changes of the radiolarian family, genera and species in Upper Devonian.

### 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 1 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 Fa-

|                            | Early Frasnian | Late Frasnian | Famennian |
|----------------------------|----------------|---------------|-----------|
| <i>Helenifore</i>          |                |               |           |
| <i>Ceratoikiscum</i>       |                |               |           |
| <i>Stigmospaerostylus</i>  |                |               |           |
| = <i>Entactinia</i>        |                |               |           |
| <i>Trilonche</i>           |                |               |           |
| = <i>Entactinosphaera</i>  |                |               |           |
| <i>Spongentactinia</i>     |                |               |           |
| <i>Polyentactinia</i>      |                |               |           |
| <i>Astroentactinia</i>     |                |               |           |
| <i>Helioentactinia</i>     |                |               |           |
| <i>Somphoentactinia</i>    |                |               |           |
| <i>Spongentactinella</i>   |                |               |           |
| <i>Secuicollata</i>        |                |               |           |
| <i>Palaeoscedidium</i>     |                |               |           |
| <i>Palaeotripus</i>        |                |               |           |
| <i>Haplentactinia</i>      |                |               |           |
| <i>Bissylentactinia</i>    |                |               |           |
| <i>Palacantholithus</i>    |                |               |           |
| <i>Protoalbaillella</i>    |                |               |           |
| <i>Archocyrtium</i>        |                |               |           |
| <i>Triaenosphaera</i>      |                |               |           |
| <i>Popofskyellum</i>       |                |               |           |
| <i>Holoeciscus</i>         |                |               |           |
| <i>Pylentonema</i>         |                |               |           |
| <i>Quadrupes</i>           |                |               |           |
| <i>Cerarchocyrtium</i>     |                |               |           |
| <i>Cyrtentactinia</i>      |                |               |           |
| <i>Huasha</i>              |                |               |           |
| <i>Cyrtisphaeractenium</i> |                |               |           |
| <i>Lapidopiscum</i>        |                |               |           |
| <i>Totollum</i>            |                |               |           |
| <i>Kantollum</i>           |                |               |           |
| <i>Staurentactinia</i>     |                |               |           |
| <i>Tetrentactinia</i>      |                |               |           |
| <i>Deflandrellium</i>      |                |               |           |
| <i>Robotium</i>            |                |               |           |

Fig. 5. Ranges of Upper Devonian radiolarian genera.

mennian 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.

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.

## Acknowledgements

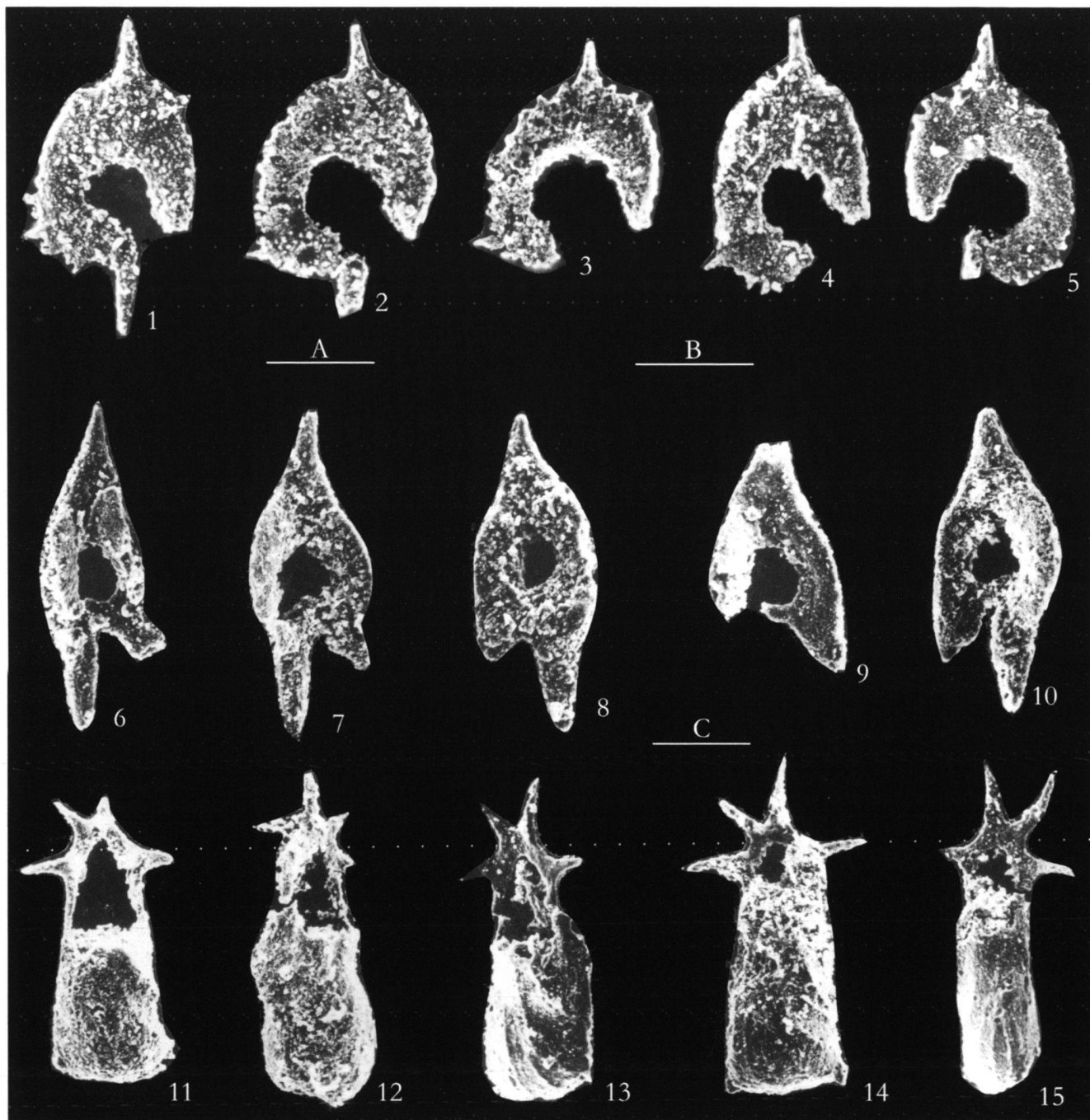
We thank Dr. Martial Caridroit for his helpful review and comments on the manuscript. This study was supported by Chinese Academy of Sciences (Grant# KZCX2-SW-129), National Natural Science Foundation of China (Grant # 40172004), and the MOST-Pre 973 Project (2001CCA01800).

## REFERENCES

- AITCHISON, J.C. 1993: Devonian (Frasnian) radiolarians from the Gogo Formation, Canning Basin, Western Australia. *Palaeontographica Abt. A* 228(4-6), 105-128.
- AITCHISON, J.C. & STRATFORD, J.M.C. 1997: Middle Devonian (Givetian) Radiolaria from Eastern New South Wales, Australia: a reassessment of the Hinde (1899) fauna. *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen* 203, 369-390.
- AITCHISON, J.C., DAVIS, A.M., STRATFORD, J.M. & SPILLER, F.C. P. 1999: Lower and Middle Devonian radiolarian biozonation of the Gamilaroi terrane New England Orogen, eastern Australia. *Micropaleontology* 45, 138-162.
- BOUNDY-SANDERS, S.Q., SANDBERG, C.A., MURCHEY, B.L. & HARRIS, A.G. 1999: A late Frasnian (Late Devonian) radiolarian, sponge spicule and conodont fauna from the Slaven Chert, northern Shoshone Range, Roberts Mountains allochthon, Nevada. *Micropaleontology* 45(1), 62-68.
- CHENG, Y.N. 1986: Taxonomic Studies on Upper Paleozoic Radiolaria. *Nat. Mus. Nat. Sci. Spec. Publ.* 1, 1-311.
- FOREMAN, H.P. 1963: Upper Devonian Radiolaria from the Huron member of the Ohio shale. *Micropaleontology* 9(3), 267-304.
- HOLDSWORTH, B.K., JONES, D.L. & ALLISON, C. 1978: Upper Devonian Radiolarians Separated from Chert of the Ford Lake Shale, Alaska. *Jour. Research U. S. Geol. Survey* 6(6), 775-788.
- ISHIGA H., 1988: Paleontological study of radiolarians from the southern New England Fold Belt, Eastern Australia. In: IWASAKI, M., IIZUMI, S., WATANABE, T. & ISHIGA, H. (Eds.): Preliminary Report on the Geology of the New England Fold Belt, Australia. Co-operative Research Group of Japan and Australia, Matsue, Japan, 77-93.
- ISHIGA H., LEITCH, E.C., NAKA, T., WATANABE, T. & IWASAKI, M. 1987: Late Devonian Paleosconidiidae from the Hastings Block, New England Fold Belt, N.S.W., Australia. *Earth Science (Chikyū Kagaku)* 41(6), 297-302.
- ISHIGA H., LEITCH, E.C., WATANABE, T., NAKA, T. & IWASAKI, M. 1988: Radiolarian and conodont biostratigraphy of siliceous rocks from the New England fold belt. *Aust. J. Earth Sci.* 35, 73-80.
- KIESSLING, W.K. & TAGELEHN, H. 1994: Devonian Radiolarian Faunas of Conodont-Dated Localities in the Frankenwald (Northern Bavaria, Germany). *Abhandlungen der geologisches Bundesanstalt in Wien*, 50, 219-255.
- LI, H. 1986: The Upper Paleozoic Radiolaria in Menlian County, Yunnan Province, Qinghai-Tibet Plateau. *Research Symposium for the exploration in Hengduan Mountain* 2, 8-15.
- LI, Y.X., & WANG, Y.J. 1991: Upper Devonian (Frasnian) Radiolarian fauna from the Liukiang Formation, eastern and southeastern Guangxi. *Acta Micropalaeontologica Sinica* 8(4), 395-404.
- NAZAROV, B.B. 1973: Pervye nakhodki radiolyarii Entactiniidae i Ceratoidiscidae v verkhnem devone yuzhnogo Urala (First occurrences of Radiolaria of the Entactiniidae and Ceratoidiscidae families in the upper Devonian of the Southern Urals). *Doklady Akademii Nauk SSSR (Transactions of the Academy of Sciences, USSR)* 210(3), 696-699.
- NAZAROV, B.B. 1975: Radiolyarii nizhnego-srednego paleozoya Kazakhstana (metody issledovaniy, sistematika, stratigraficheskoe znachenie (Lower and middle Paleozoic radiolarians of Kazakhstan (methods of investigation, systematics and stratigraphic significance)). In: RAABEN, M.E. (Ed.), *Trudy Akademii Nauk SSSR, Geologicheskii Institut (Transactions of the Academy of Sciences of the USSR, Geological Institute)*. Izdatel'stvo Nauka, Moscow, USSR, 1-203.
- NAZAROV, B.B. & ORMISTON, A.R. 1983: Upper Devonian (Frasnian) radiolarian fauna from the Gogo Formation, Canning Basin, Western Australia. *Micropaleontology* 29, 454-466.
- NAZAROV, B.B., COCKBAIN, A.E. & PLAYFORD, P.E. 1982: Late Devonian Radiolaria from the Gogo Formation, Canning Basin, Western Australia. *Alcheringa* 6(3), 161-173.
- RAUP, D.M. 1982: Biogeographic extinction: A feasibility test. In: SILVER, L. I. & SCHULTZ, P. H. (Eds.): *Geological Implications of Impacts of Large Asteroids and Comets on the Earth*. *Geol. Soc. Amer. Spec. Pap.* 190, 277-281.
- SASHIDA, K. et al. 1993: Occurrences of Paleozoic and Mesozoic radiolarians from Thailand and Malaysia and its geologic significance (preliminary report). *News of Osaka Micropaleontologists, Special Volume*, 9, 1-17.
- SCHWARTZAPFEL, J.A. & HOLDSWORTH, B.K. 1996: Upper Devonian and Mississippian radiolarian zonation and biostratigraphy of the Woodford, Sycamore, Caney and Goddard Formations, Oklahoma. *Cushman Foundation Forum. Res. Spec. Publ.* 33, 1-276.
- SPILLER, F.C.P. & METCALFE, I. 1995: Late Paleozoic radiolarians from the Bentong-Raub, *Jour. Southeast Asia Earth Sci.* 11(3), 217-224.
- STRATFORD, J. M. C. & AITCHISON, J. C. 1997: Lower to Middle Devonian radiolarian assemblages from the Gamilaroi terrane, Glenrock Station, NSW, Australia. *Marine Micropaleontology* 30, 225-250.
- WANG, CHENG-YUANG 2000: Devonian. In: *ACADEMIA SINICA (Ed.): Stratigraphical studies in China (1979-1999)*. Hefei. Press of University of Science and Technology of China, 73-94.
- WANG, Y.J. 1991: On progress in the study of Paleozoic radiolarians in China. *Acta Micropalaeontologica Sinica (Wei Ti Ku Sheng Wu Hsueh Pao)* 8(3), 237-251.
- WANG, Y.J. 1994: Cherts and radiolarian assemblage zones of Qinzhou area, Guangxi. *Chinese Science Bulletin* 39(15), 1300-1304.
- WANG, Y.J. 1997: An Upper Devonian (Famennian) radiolarian fauna from carbonate rocks, northern Xinjiang. *Acta Micropalaeontologica Sinica* 14(2), 149-160.
- WANG, Y.J. & LUO, H., 2004: Impact of the Frasnian-Famennian Extinction Event on Radiolarian Faunas in South China. In: RONG J. Y. et al. (Eds.): *Mass Extinction and Recovery - Evidences from the Paleozoic and Triassic of South China*. Hefei. Press of University of Science and Technology of China, 381-408.
- WANG, Y.J., LUO, H., KUANG, G.-D. & LI, J.-X. 1998: Late Devonian - Late Permian strata of cherty facies at Xiaodong and Bancheng counties of the Qinzhou area, SE Guangxi. *Acta Micropalaeontologica Sinica*, 351-366.
- WANG, Y.J., FANG, Z.-J., YANG, Q., ZHOU, Z.-C., CHENG, Y.-N., DUAN, Y.-X. & XIAO, Y.-W. 2000: Middle-Late Devonian Strata of Cherty Facies and Radiolarian Faunas from west Yunnan. *Acta Micropalaeontologica Sinica* 17(2), 235-254.
- WANG, Y.J., AITCHISON, J.C. & LUO, H. 2003: Devonian radiolarian faunas from South China. *Micropaleontology* 49(2), 127-145.
- WU, H., XIAN, X. & KUANG, G. 1994: Late Paleozoic Radiolarian assemblages of southern Guangxi and its geological significance. *Scientia Geologica Sinica* 29(4), 339-344.
- XIAN, S.Y., CHEN, J.R. & WANG, Z.Q. 1995: Devonian Ecostatigraphy, Sequence Stratigraphy and Sea-level Changes in Guanxi, Longmen Mountain Area, Sichuan. *Sedimentary Facies and Palaeogeography* 15(6), 1-47.

Manuscript received January 2004

Revision accepted February 2005



**Plate 1**

Index species of Late Devonian radiolarian zonations from South China. All scales = 100  $\mu$ m: 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.