C. R. Palevol xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

Comptes Rendus Palevol

www.sciencedirect.com

General Palaeontology, Systematics and Evolution (Micropalaeontology)

Integrated radiolarian and conodont biostratigraphy of the Middle Permian Gufeng Formation (South China)

Biostratigraphie intégrée de radiolaires et de conodontes issus de la formation de Gufeng du Permien moyen (Chine méridionale)

Qiangfen Ma[a,b], Qinglai Feng[a,*], Martial Caridroit[b], Taniel Danelian[b], Ning Zhang[a]

[a] *State Key Laboratory of Geological Processes and Mineral Resources, China University of Geosciences, 430074 Wuhan, Hubei, PR China*
[b] *Université de Lille – Sciences et Technologies, CNRS, UMR 8198, Évo-Éco-Paléo, 59655 Villeneuve-d'Ascq cedex, France*

ARTICLE INFO

Article history:
Received 20 May 2015
Accepted after revision 3 February 2016
Available online xxx

Handled by Shuhai Xiao

Keywords:
Middle Permian
Gufeng Formation
Radiolaria
Conodonts
South China

ABSTRACT

Radiolarians are usually abundant in chert sequences and they have thus been widely used for the biostratigraphy of deep-water sediments. However, there are many difficulties in the correlation of radiolarian biostratigraphic schemes with the standard conodont zones. In this study, 21 radiolarian species were extracted from the Gufeng Formation that crops out in the Luojiaba (LJB) section (western Hubei, China), together with 5 co-occurring conodont species. In this way, it is the first time that the *Pseudoalbaillella globosa*, *Follicucullus monacanthus* and *F. scholasticus* radiolarian zones can be directly correlated with the *Jinogondolella nankingensis gracilis*, *J. aserrata* and *J. postserrata* conodont zones. Accordingly, the 3 radiolarians zones are now firmly correlated with the Roadian to middle Capitanian interval (Middle Permian).

Mots clés :
Permien moyen
Formation de Gufeng
Radiolaires
Conodontes
Chine méridionale

RÉSUMÉ

Les radiolaires sont souvent abondants dans les séries biosiliceuses, et ils sont largement utilisés pour la biostratigraphie des séries pélagiques profondes. Néanmoins, nombreuses sont les difficultés de corrélation des biozonations à radiolaires avec les zones standard à conodontes. Dans cette étude, 21 espèces de radiolares ont été extraites de la formation de Gufeng, qui affleure dans la coupe de Luojiaba (LJB) de la province de Hubei (Chine), ainsi que cinq espèces de conodontes. De cette façon, c'est la première fois que les zones à *Pseudoalbaillella globosa*, *Follicucullus monacanthus* et *F. scholasticus* des radiolaires peuvent être directement corrélées aux zones à *Jinogondolella nankingensis gracilis*, *J. aserrata* et *J. postserrata* des conodontes. Par conséquent, trois zones à radiolaires sont maintenant corrélées avec certitude avec l'intervalle Roadien à Capitanien moyen (Permien moyen).

* Corresponding author.
E-mail address: qinglaifeng@cug.edu.cn (Q. Feng).

http://dx.doi.org/10.1016/j.crpv.2016.02.001
1631-0683/

1. Introduction

Radiolarians are usually abundant in chert sequences and consequently they have been used extensively for biostratigraphic investigations of deep-water sediments. However, correlations are in general difficult between radiolarian zones and the standard conodont zones used for Permian strata (Gradstein et al., 2012). Although 16 radiolarian zones exist for the Permian, their correlation with the 36 Permian conodont zones has only been roughly established given the extremely scarce co-occurrence of the two microfossil groups in the same sedimentary sequences. Moreover, nearly all existing studies have focused either on the Early Permian (Ishiga, 1986, 1990) or on the Guadalupian-Lopingian boundary (Xia et al., 2005; Sun and Xia, 2006) or finally the Cisuralian-Guadalupian boundary (Zhang et al., 2010). Accurate age assignments of Middle Permian radiolarian zones are still missing.

Holdsworth and Jones (1980) first introduced Permian radiolarian assemblages mainly based on the presence of albaillellids, but its chronostratigraphic calibration was very coarse due to the lack of other index fossils (e.g. bivalves, foraminifers and ammonoids). A few years later, Ishiga (1986, 1990) established 13 radiolarian assemblages or assemblage zones for the Late Carboniferous to Late Permian interval based on material from Southwest Japan, where some of the radiolarian zones could be correlated with conodont and fusulinacean zones. Later, Permian radiolarian zones established in North America (Blome and Reed, 1992) and South China (Wang et al., 1994) were recognized. The Permian biostratigraphic framework has improved and a high-resolution Permian conodont biostratigraphic sequence was drawn up (Mei and Henderson, 2001). Therefore, in order to ascertain the accurate age calibration of Middle Permian radiolarian zones, comparative studies of radiolarians and other age diagnostic fossils, especially conodonts, have become an important task.

Abundant radiolarians were recovered and radiolarian bioevents and zones were recognized from the Luojiaba section, Jianshi county, western Hubei province; a preliminary report was presented Ma and Feng (2012). Further detailed investigations allowed us to find in some beds abundant conodonts together with radiolarians, allowing thus direct correlations between the radiolarian and conodont record. Moreover, several additional radiolarian species were recently identified, which improved understanding the diversity of the recovered radiolarian assemblages in the studied section.

2. Paleogeographic setting and lithostratigraphy of the studied section

It is likely that following the influence of oceanic upwelling during the Permian (Shang et al., 2008), radiolarian cherts of the Gufeng and Dalong formations (Middle and Upper Permian, respectively) accumulated in basins situated around the Yangtze Block (Feng et al., 1993). During the Permian, the study area was situated at the northern margin of the Yangtze platform (Fig. 1A).

The studied Luojiaba section is 19 m-thick and crops out in a quarry close to the village of Luojiaba, 80 km northeast of the Enshi City, in western Hubei, China (Fig. 1B). It is divided into 8 members and 3 formations (Fig. 2). The Maokou Formation is composed of light gray limestones. The 16 m-thick Gufeng Formation is characterized by intercalations of black cherts and siliceous/carbonaceous mudstone, yielding numerous radiolarians and conodonts. The overlying Wuxue Formation is composed mainly of massive limestones.

3. Materials and methods

Sixty-one samples were collected from the studied section, 5 of them came from the Maokou Formation, 54 from the Gufeng Formation and 2 samples from the Wuxue Formation. Samples were processed for radiolarians and conodonts and etched with 3–4% hydrofluoric acid solution

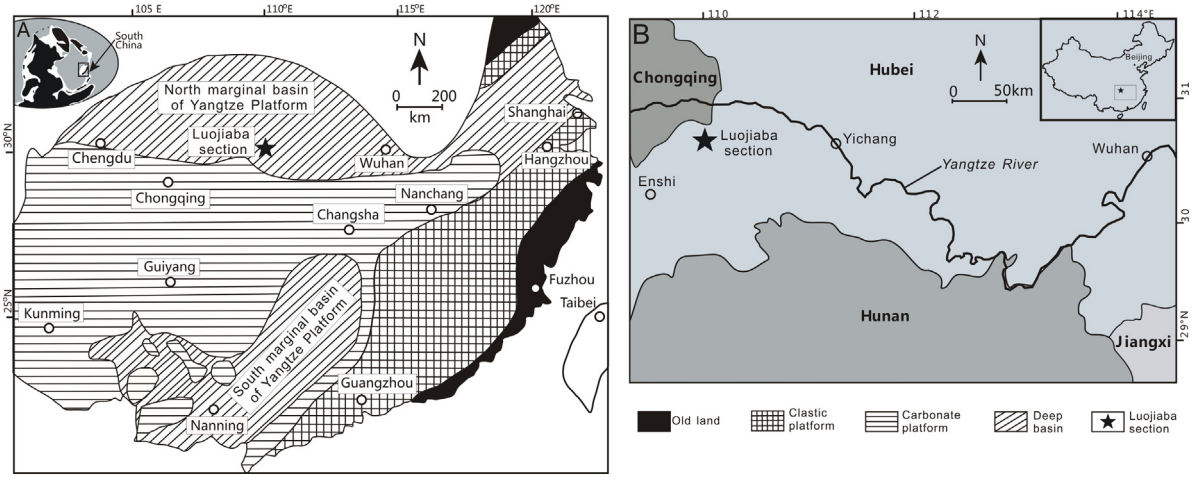

Fig. 1. Middle Permian paleogeographic map of South China and location of the Luojiaba section in Hubei Province (modified from Feng et al., 1993).
Fig. 1. Carte paléogéographique de la Chine du Sud au Permien moyen et localisation de la coupe de Luojiaba dans la province de Hubei (modifiée d'après Feng et al., 1993).

Please cite this article in press as:Ma, Q., et al., Integrated radiolarian and conodont biostratigraphy of the Middle Permian Gufeng Formation (South China). C. R. Palevol (2016), http://dx.doi.org/10.1016/j.crpv.2016.02.001