Journal of Asian Earth Sciences 104 (2015) 127–144

Contents lists available at ScienceDirect

Journal of Asian Earth Sciences

journal homepage: www.elsevier.com/locate/jseaes

Permian fusulinid biostratigraphy of the Baoshan Block in western Yunnan, China with constraints on paleogeography and paleoclimate

Hao Huang [a,b,*], Yukun Shi [c], Xiaochi Jin [a]

[a] Institute of Geology, Chinese Academy of Geological Sciences, Beijing 100037, China
[b] Key Laboratory of Stratigraphy and Paleontology, Ministry of Land and Resources, Beijing 100037, China
[c] School of Earth Sciences and Engineering, Nanjing University, Nanjing 210093, China

ARTICLE INFO

Article history:
Received 20 March 2014
Received in revised form 24 September 2014
Accepted 11 October 2014
Available online 20 November 2014

Keywords:
Fusulinid
Baoshan Block
Permian
Paleobiogeography
Paleoclimate
Paleogeography

ABSTRACT

Newly obtained fossil materials together with published data enable a review on the Permian fusulinids of the Gondwana-derived Baoshan Block in western Yunnan, China. The Baoshan Block yields rather impoverish Sakmarian–Yakhtashian fusulinids with just *Eoparafusulina* and *Pseudofusulina* in its northern and southern parts. These fusulinids biogeographically demonstrate the feature of peri-Gondwana province and signify a temperate-water condition. Further comparison suggests the Baoshan Block was located distant from the tropical region and even with higher latitude than Central Iran and Central Pamir during the Sakmarian–Yakhtashian. In contrast, Murgabian–Midian fusulinids are more diversified. In the southern Baoshan Block, the *Schwagerina* assemblage, the *Eopolydiexodina* assemblage, the *Sumatrina* assemblage and the *Verbeekina* assemblage could be recognized in the Xiaoxinzhai area, and the *Yangchienia–Nankinella* assemblage and the *Chusenella–Rugosofusulina* assemblage in the Bawei area, in ascending order. Contemporaneously, the *Neofusulinella* assemblage occurs in the northern and the *Eopolydiexodina* assemblage in the southwestern Baoshan Block respectively. These Murgabian–Midian fusulinids show affinity of western Tethyan province and suggest a warm-water environment. Interestingly, the Midian *Verbeekina* assemblage is characterized by relatively low diversity and rather abundance of just one genus. Such compositional feature most likely signifies warm but still not optimal sea-surface water for the diversification of fusulinids. Also taking into account of the presence of Verbeekinids and Neoschwagerinids and the moderate total diversity, the Middle Permian fusulinids indicate that the Baoshan Block, during the Murgabian–Midian, was probably located between equatorial region with warm water to the north and the majority of Sibumasu areas lacking Verbeekinids and Neoschwagerinids with temperate water to the south.

1. Introduction

Spatio-temporal variation of fusulinid assemblages during the Permo-Carboniferous not only is valuable for stratigraphic correlation, but also record unique information for paleogeographic and paleoclimatic analysis. Such significant usefulness of fusulinids has been especially demonstrated in reconstructing the geological evolution of small terranes which have accreted to large crustal continents, e.g. Cimmerian continents derived from the northern Gondwana and exotic terranes in the Circum-Pacific, as these small terranes oftentimes have experienced a highly dynamic paleogeographic evolution and lack reliable paleomagnetic data (Newton, 1988; Smith and Xu, 1988; Kobayashi, 1997a,b, 1999; Belasky et al., 2002; Vachard et al., 2002; Ueno, 2003; Davydov and Arefifard, 2007; Huang et al., 2009; Leven, 2009; Davydov et al., 2013; Zhang et al., 2013).

The Baoshan Block in western Yunnan, Southwest China represents such a continental block. It is generally believed to have been located at the northern margin of Gondwana at high latitude in Early Permian, then drifted northwards toward low latitude after rifted from Gondwana, and finally docked to the Eurasian continent (Jin, 1994; Shi and Archbold, 1998; Metcalfe, 2002). Meanwhile, global climate has been suggested to change from icehouse to greenhouse during the Permian period (Rees et al., 1999; Scotese et al., 1999; Shi and Waterhouse, 2010). The coupled effects of such paleogeographic and paleoclimatic scenarios would be expected to prompt compositional transition of the environment-sensitive fusulinids in the Baoshan Block. Thus, inspecting

* Corresponding author at: Institute of Geology, Chinese Academy of Geological Sciences, Beijing 100037, China. Tel.: +86 10 68999885.
E-mail addresses: geohaohuang@gmail.com (H. Huang), ykshi@nju.edu.cn (Y. Shi).

http://dx.doi.org/10.1016/j.jseaes.2014.10.010
1367-9120/

these fusulinids could offer insights for better understanding the paleogeographic evolution of this block, which is in turn indispensable for the Gondwana dispersion and Asian accretion.

Since the 1980s, many efforts have been devoted to report or systematically describe the Permian fusulinids of the Baoshan Block and further address their paleogeographic and paleoclimatic significance (e.g. Duan et al., 1983; Yang, 1983; Chen, 1984; Sugiyama and Ueno, 1998; Fang et al., 2000; Ueno, 2003; Huang et al., 2009; Shi et al., 2011). However, the paleoclimatic meaning of these fusulinids has not been fully disclosed and the exact paleogeographic position of the Baoshan Block in relation to other Gondwana-derived blocks has been still controversial (Metcalfe, 2002; Ueno, 2003; Huang et al., 2009; Wopfner and Jin, 2009; Ali et al., 2013; Zhang et al., 2013). Solving these issues is partially hindered by the inadequacy of solid fossil materials, especially Middle Permian fusulinids. We have recently measured a new section with abundant Middle Permian fusulinids, discovered a *Verbeekina* assemblage with usual taxonomic features and a *Neoschwagerina* assemblage in the Baoshan Block. These newly obtained fossils together with published data in literate enable a review in this paper on taxonomic composition and biostratigraphic succession of the Permian fusulinids in the Baoshan Block. Furthermore, we compare these fusulinids of the Baoshan Block with those from equatorial region and other Gondwana-derived blocks. By doing that, we are able to refine the paleobiogeographic affinity and paleoclimatic implications of these fusulinids, and calibrate the paleogeographic position of the Baoshan Block.

2. Geological background

According to the development of Permo-Carboniferous stratigraphy, the Baoshan Block has been divided into three subdivisions (Fig. 1) (Jin, 1994). The Permian lithological sequences are generally consistent in its northern, southern and southwestern subdivisions, although varying names of lithological formations have been applied (Fig. 2) (Wang et al., 2002; Jin et al., 2008). The Lower Permian is mainly composed of siliciclastic deposits followed by basalts, while the Middle and Upper Permian is majorly carbonate sediments. The lowest siliciclastic deposits in the northern and southern Baoshan Block are named Dingjiazhai Formation. This formation represents a transgressive sequence and consists of sandstone, siltstone, mudstone, with limestone in its top part. Probable glaciogenic diamictites with poorly sorted and angular pebbles in fine siliciclastic matrix are characteristic in the lower part of this formation in the northern Baoshan Block, but rather poorly developed in the southern subdivision (Jin, 1994, 2002). Fossils in this formation, such as brachiopods, corals and spores and pollens, show features of cool water and Gondwana affinity (Fang, 1994; Fang and Fan, 1994; Shi et al., 1996; Gao, 1998; Fang et al., 2000; Wang et al., 2001). These diamictites and cool-water fossils are the main evidence to relocate the Baoshan Block in the northern margin of Gondwana in the Early Permian (Wang, 1983; Jin, 1994; Wopfner, 1996; Metcalfe, 2002). Taxonomically poor fusulinids occur in the limestones of the top Dingjiazhai Formation. The basalts of the Woniusi Foramtion overlie the Dingjiazhai Formation and may signify the rift of this block from the Gondwana (Wopfner, 1996; Shi and Archbold, 1998). Either the Dingjiazhai Formation or the Woniusi Formation is absent in the southwestern Baoshan Block.

A short hiatus may exist after the eruption of the basalts, because hard ground is observed at the top of the Woniusi Formation at some outcrops. Above these basalts, variegated siliciclastic sediments steadily occur throughout the Baoshan Block and represent the beginning of a new transgression, although they have been named the Manli Formation in the southwestern subdivision, the Bingma Formation in the northern subdivision and the lower part of the Yongde Formation in the southern subdivision (Geological Survey Team of Yunnan, hereafter as GSTY, 1966, 1980, 1984). Upwards, the carbonate sequences are initially composed of argillaceous limestone and limestone which are subsequently overlain by dolomitic limestone to dolomite. The argillaceous limestone is considered upper part of the Yongde Formation in the southern subdivision, and together with limestone is grouped into the Daaozi Formation in the northern subdivision. The limestone and dolomitic limestone to dolomite are grouped into the Shazipo Formation in the southern and southwestern subdivisions, while the dolomitic limestone to dolomite is named a separate Hewanjie Formation in the northern subdivision. A marked difference is that the limestone portion is considerable thicker and more fossilliferous in the southern than in the northern and southwestern Baoshan Block. Fusulinids occur in both the argillaceous limestones and limestones in the lower part of carbonate sequence throughout the Baoshan Block. In the northern and southwestern subdivisions, the dolomitic limestones to dolomites are oftentimes severely brecciated in fields and thus referred to as "Cracked limestone", whereas they are less broken in the southern subdivision. A particular foraminiferal *Shanita* fauna occurs in these dololimitic limestones across the Baoshan Block (Sheng and He, 1983; Yang et al., 2004; Huang et al., 2007). This fauna is thought to be Midian to early Dzhulfian and geographically confined in blocks of Gondwana-origin (Huang et al., 2007; Ueno, 2003; Jin and Yang, 2004).

3. Fusulinid biostratigraphy

For the Permian chronostratigraphy, the traditional Tethyan scale (Leven, 2004), instead of the international standard of Jin et al. (1997), is used in this paper. The main reason is that the Permian Tethyan scale is defined by the evolutionary events of fusulinids, thus readily applied across the Tethyan realm. However, the international Permian stages, especially the Guadalupian ones, are based on conodonts from North America, and their recognition and precise correlation in the Tethyan region have not been solved so far with satisfaction (Leven, 2001; Leven and Bogoslovskaya, 2006). For convenience, the Asselian–Bolorian interval in the Tethyan scale is treated as Early Permian and Kubergandian–Midian interval is treated as Middle Permian hereinafter.

3.1. Early Permian

Early Permian fusulinids with similar composition firstly appear in the limestones in the top part of the Dingjiazhai Formation in both northern and southern Baoshan Block (Figs. 1 and 3). The southwestern Baoshan Block is devoid of Early Permian sedimentary records (Fig. 2). The fusulinids in the Dingjiazhai Formation were previously regarded to be dominated by *Triticites* with *Eoparafusulina*, *Hemifusulina*, and *Schwagerina* in association, and thus correlated to the Late Carboniferous *Triticites* zone (Duan et al., 1983; Yang, 1983; Chen, 1984; GSTY, 1980, 1984, 1985; Bureau, 1990). Unfortunately, these early studies did not provide illustration or description, which render the verification of the identification impossible. The dating of these fusulinids has been rectified to Early Permian by recent studies (Sugiyama and Ueno, 1998; Fang et al., 2000; Ueno, 2003; Shi et al., 2011). Sugiyama and Ueno (1998) and Ueno (2003) identified and illustrated these fusulinids as *Eoparafusulina* and *Pseudofusulina* from Dongshanpo Section and Woniusi Section in the northern Baoshan Block. Fang et al. (2000) systematically restudied the fusulinids from the top part of the Dingjiazhai Formation and considered them to be dominated by *Eoparafusulina* and *Schwagerina* with only a few *Triticites*. Shi et al. (2011) suggested that fusulinids in the top part of the Ding-