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Late Triassic palynofloras in the Sichuan Basin, South China: Synthesis and perspective

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Abstract

Mesozoic strata are well developed and exposed continuously across the Sichuan Basin, South China. In particular, the Upper Triassic strata yield diverse and abundant spore-pollen fossils, providing a significant reference for the study of palaeoenvironmental variations across the Triassic–Jurassic transition where mass extinctions were occurring. In this paper, we summarize the major progress on Late Triassic palynological studies in this basin. To date, 151 genera (454 species) of sporomorph fossils have been reported from the Late Triassic strata in the Sichuan Basin. Three palynological assemblages are distinguished for the Late Triassic in the Sichuan Basin. Late Triassic vegetation in the Sichuan Basin shows a remarkable predominance of ferns, followed by conifers and cycads/ginkgophytes, and conifers show a distinct increase in abundance in the latest Triassic. In general, the Late Triassic palaeoclimate in the Sichuan Basin was tropical-subtropical, humid and warm. A synthesis of the data shows that the Late Triassic did not have a constant palaeoclimate in the Sichuan Basin, several climatic events are recognized: two warm and humid climate events in Norian-Rhaetian time, coupled with a cooler and drier condition in the latest Late Triassic. Further investigations in higher resolution at more continuous sections in the Sichuan Basin are needed to better understand the Late Triassic vegetation response, climate changes, as well as palaeoecosystem variations across the Triassic–Jurassic boundary.

Keywords: Late Triassic; Palynomorph diversity; Palynological assemblage; Palaeovegetation; Palaeoclimate; Sichuan Basin

1. Introduction

The biotic turnover at the Triassic–Jurassic boundary (TJB) is recognized as one of the five largest mass extinction events in the Phanerozoic (Tanner et al., 2004; Schoene et al., 2010). This extinction is thought to be associated with the extensive Central Atlantic Magmatic Province (CAMP) volcanism (Marzoli et al., 1999, 2004; Olsen, 1999; Hesselbo et al., 2002; Pálfy, 2003; Knight et al., 2004), extremely elevated atmospheric pCO_2 concentration (Beerling and Berner, 2002; Steinthorsdottir et al., 2011), and global warming (McElwain et al., 1999). Terrestrial vegetation suffered a sudden and severe crisis at the TJB. For example, there is an 85% decline in species richness in plant communities at the TJB in Astartekløft, Greenland (McElwain et al., 2007, 2009), and a striking increase in trilete spores (fern spike) at the TJB has been found in Europe (Ruckwied et al., 2008; Götz et al., 2009; Larsson, 2009; Ruckwied and Götz, 2009). Palynological investigations are thus crucial for reconstructing terrestrial vegetational changes across the TJB.

The terrestrial deposits of the Triassic–Jurassic transition are well developed in China and represented in several inland basins, such as the Junggar, Ordos, and Sichuan basins. However, palynological studies of the Triassic–Jurassic transition are few in China, currently reported only in the Junggar Basin of Xinjiang, northwestern China (Lu and Deng, 2005, 2009; Huang, 2006; Ashraf et al., 2010; Sha et al., 2011). In southern China, terrestrial Upper Triassic and Lower Jurassic strata are well-developed in the Sichuan Basin, yielding diverse fossil remains, which are significant for regional and global correlations (Meng

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et al., 2005; Wang et al., 2010). In particular, the Upper Triassic Xujiahe Formation is widely distributed and well exposed in the basin, and contains a variety of fossil plants as well as fossil spores and pollen grains (Ye et al., 1986; Huang and Lu, 1992; Huang, 1995). Significantly, palynological analysis offers a broad window for unraveling past vegetation patterns and reconstructing climate changes, and thus is crucial for better understanding the terrestrial response of Triassic–Jurassic biotic and geological events in the Sichuan Basin.

Late Triassic palynological studies of the Sichuan Basin began in the early 1970s. Li (1974) first reported spore-pollen fossils from the Xujiahe Formation in Guangyuan, Pengzhou, Jiangyou, and Weiyuan areas. Early research focused mainly on the systematic description of fossil palynomorphs (e.g., Lu and Wang, 1980; Bai et al., 1983). Later, the Late Triassic deposits were extensively studied with regard to palynostratigraphy (e.g., Cao and Huang, 1980; Liu, 1982; Zhang, 1984; Yuan, 1989; Huang, 1991; Shang and Li, 1992). In the late 1980s, a comprehensive study of the Late Triassic spore-pollen records was reported for the basin, and spore-pollen assemblages were distinguished (Lu and Wang, 1987). More recently, palynological records were applied to palaeovegetation and palaeoclimate reconstruction of the basin (Wang et al., 2008; Xu et al., 2010). These results provide evidence for understanding palynological successions, geological age correlations, as well as initial understanding of palaeoclimate and palaeovegetation. It has become obvious that more data need to be collected on the Upper Triassic sequences to help interpret changes at the Triassic–Jurassic boundary. In this paper, we provide a synthesis of palynomorph diversity, palynological assemblages in the framework of updated stratigraphical correlations, with emphasis on palaeovegetation reconstructions, as well as palaeoclimate and palaeoenvironmental variations in the Sichuan Basin.

2. Geological setting and stratigraphy

2.1. Geological setting

The Sichuan Basin, one of the most studied large inland basins of China, has great significance for geoscience studies. Tectonically, the Sichuan Basin belongs to the Yangtze Stable Platform. Three stratigraphic units are recognized in this basin, including the Upper Yangtze, Lijiang, and Kangding units (Gu and Liu, 1997; Wang et al., 2010). The Upper Yangtze Unit is the major stratigraphic unit in the entire basin. Within this unit, Paleozoic-Early Mesozoic marine strata are developed, including Precambrian, Cambrian, Ordovician, Silurian, Carboniferous, Permian, and Lower to Middle Triassic. During the late Middle Triassic (Ladinian), the Yangtze region (including the Sichuan Basin) was subject to an extensive regression; most areas of the platform rose and a long history of marine sedimentation ended. In the early-middle Late Triassic, the basin

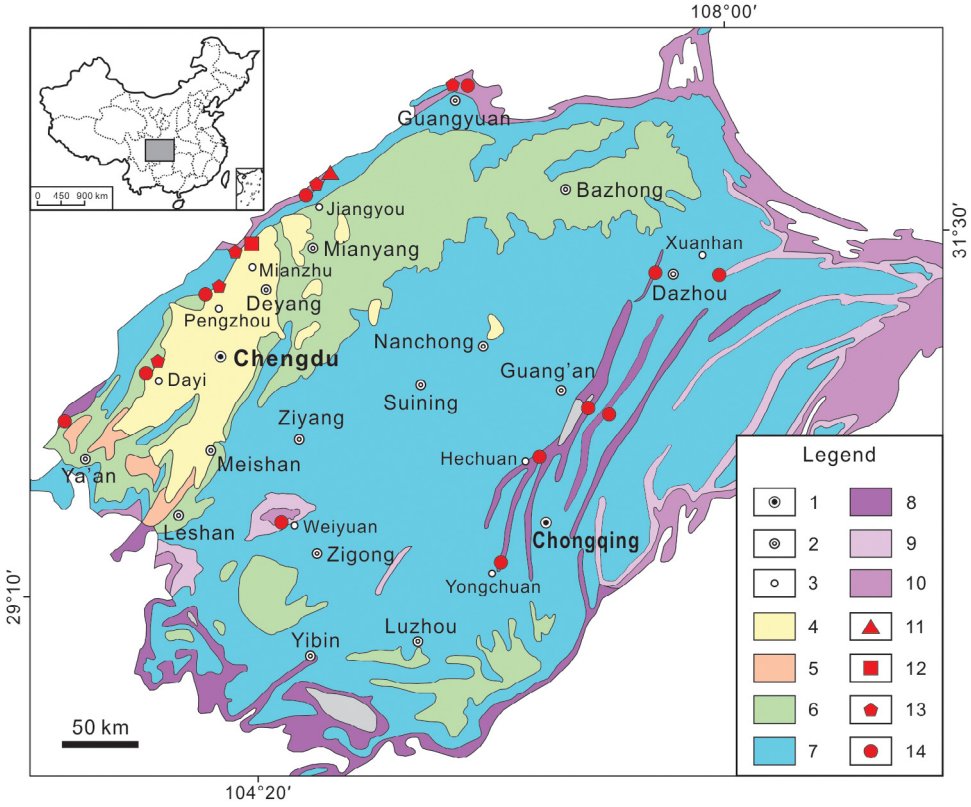

Fig. 1. Simplified geological map showing localities of previous Late Triassic palynological studies in the Sichuan Basin, China. 1. Provincial capital; 2. City; 3. County; 4. Quaternary; 5. Tertiary; 6. Cretaceous; 7. Jurassic; 8. Triassic; 9. Upper Triassic; 10. Lower-Middle Triassic; 11. Palynomorph fossil record of the Ma'antang Formation; 12. Palynomorph fossil record of the Kuahongdong Formation; 13. Palynomorph fossil record of the Xiaotangzi Formation; 14. Palynomorph fossil record of the Xujiahe Formation.