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Lopingian (Upper Permian) trace fossils from the northern Penglaitan Section, Laibin, Guangxi, South China and their environmental implications

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Abstract

The end-Permian mass extinction has been widely documented to be accompanied with oceanic anoxia, which was considered as one of the most plausible killing mechanisms. However, it is still unclear when anoxia began to occur and how widely affected during the pre-extinction interval. In this study, Lopingian bottom-water oxygen level changes around the Wuchiapingian–Changhsingian boundary (WCB) at the northern Penglaitan section in Guangxi are analysed based on trace fossil assemblages and ichnofabric indices. Detailed bed-by-bed ichnological analyses confirm the presence of trace fossils *Chondrites intricatus*, *C.* isp., *Palaeophycus* isp., *Planolites* isp. A, *P.* isp. B, *Thalassinoides* isp. A, *T.* isp. B, *Trichichnus linearis*, *Zoophycos* isp., and other bioturbational structures. The ichnofabric indices around the WCB are mostly 1–2, but rapidly increase to 4–5 in some short intervals. The distinct fluctuations of ichnofabric indices suggest that the oxygen level of sediments was generally deficient, but the dysoxic or anoxic periods were punctuated by several short oxic intervals. Thus, it can be inferred that the benthic organisms were under secularly environmental stresses around the WCB at the northern Penglaitan section. The anoxic conditions unfavourable for aerobiosis in the deep basin may start in the late Wuchiapingian. However, more sections need to be studied to determine whether this is a local or regional phenomenon.

Keywords: Trace fossil; Lopingian; Northern Penglaitan section; Oxygen level

1. Introduction

The end-Permian mass extinction statistically extinguished over 90% of marine species (Jin et al., 2000; Erwin, 2006). The scenarios eliminating the biota in last decades are quite complex and involve rapid sea level changes (e.g., Ross and Ross, 1987; Hallam and Wignall, 1999; Cao and Zheng, 2009; Zheng et al., 2013a, 2013b; Yin et al., 2014), massively volcanic eruptions (e.g., Bowring et al., 1998; Kamo et al., 2003; Shen et al., 2011; Burgess and Bowring, 2015), and extra-terrestrial bolide impact (e.g., Becker et al., 2001). Environmental deterioration in marine ecosystem caused by oceanic anoxia or euxinia around the extinction interval has been also suggested as one of the most plausible scenarios (Wignall and Twitchett, 1996; Isozaki, 1997; Grice et al., 2005; Cao et al., 2009; Algeo et al., 2010; Feng and Algeo, 2014). However, it is still unclear whether this expansion of oceanic anoxia was quite rapid immediately before the end-Permian mass extinction (Brennecka et al., 2011) or it was a long-term event to induce the collapse of the marine ecosystem, which may have occurred much earlier in the early Changhsingian (Cao et al., 2009) or around the Wuchiapingian–Changhsingian transition (Shen et al., 2013).

As in situ preserved records of the behaviours and feeding activities of ancient fauna (Miller, 2007; Seilacher, 2007), trace fossils reliably reflect environmental conditions, in particular, the level of soluble oxygen in bottom and pore waters (Twitchett and Barras, 2004; Rodríguez-Tovar and Uchman,

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2006). In this study, we conducted investigations on trace fossils in an expanded marine Lopingian sequence along the northern side of the Penglaitan section in the Laibin area of Guangxi Autonomous Region. In this sequence, various trace fossils are extremely abundant, which enable us to analyse the changes of trace fossil composition and ichnofabric index to track the changes of oxygen level in the bottom waters during the Lopingian period.

2. Geological setting and biostratigraphy

The Penglaitan section (23°41′43″N; 109°19′16″E) on the southern bank of the Hongshui River, Laibin City of Guangxi Autonomous Region, is the GSSP section of the Guadalupian–Lopingian boundary (GLB) (Jin et al., 2006) (Fig. 1A). The succession from the Wuchiapingian to Middle Triassic, which is distributed mainly in the eastern margin of the Dian-Qian-Gui Basin (Fig. 1B), is more than 700 m thick and crops out well at the northern bank (23°41′37″N; 109°19′41″E). Most previous investigations on biostratigraphy and sedimentology were conducted on the GSSP section on the southern side of the Hongshui River (e.g., Wang and Sugiyama, 2001; Shen et al., 2007; Shen and Shi, 2009; Wignall et al., 2009), relatively less attention has been paid to the trace fossils in the succession on the northern side section (e.g., Li et al., 1986). The Lopingian strata consist of the Wuchiapingian Heshan Formation and the Changhsingian Talung Formation based on different lithological features. Rocks enriched in silica (cherty carbonate) dominate the Heshan Formation and are interpreted as a basinal/slope facies. The overlying Talung Formation, consisting of the Ergou and Penglaitan members in ascending order, is dominated by well-bedded siltstone, tuffaceous sandstone interbedded with siliciclastic rocks and composed of a regressive tract followed by a rapid transgressive tract in the topmost part of Talung Formation (Shao and Zhang, 1999; Shen et al., 2007).

The stratigraphical interval from Bed 5 to 32 (bed numbers after Shen et al., 2007) across the WCB has been investigated for trace fossils. The base of Bed 5 is a black carbonaceous shale with abundant ammonites. Rocks from Bed 6 to 14 sharply change into chert with intermittent limestone lumps (Fig. 2A). The Ergou Member (from Bed 15 to 22) in the lower Changhsingian consists typically of thin-bedded tuffaceous siltstone, mudstone, and bioclastic wackestone, containing a pelagic fauna of sponge spicules and radiolarians (Fig. 2B). At the base of the overlying Penglaitan Member (Bed 23), thick-bedded coarsely-grained pyroclastic sandstones dominate (Fig. 2C); up-section, these pass into thin-bedded fine-grained tuffaceous sandstone and siltstone from Bed 24 to 29. Horizontal laminations

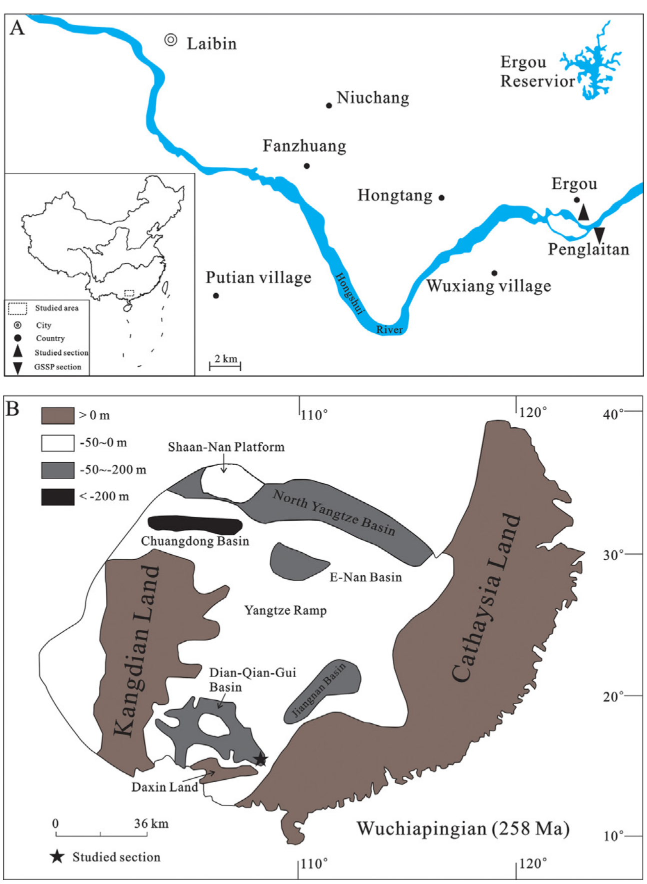

Fig. 1. Geographical maps showing localities of the northern Penglaitan section (A) and the palaeogeographic reconstruction during the Wuchiapingian (B) (after Shen et al., 2007).

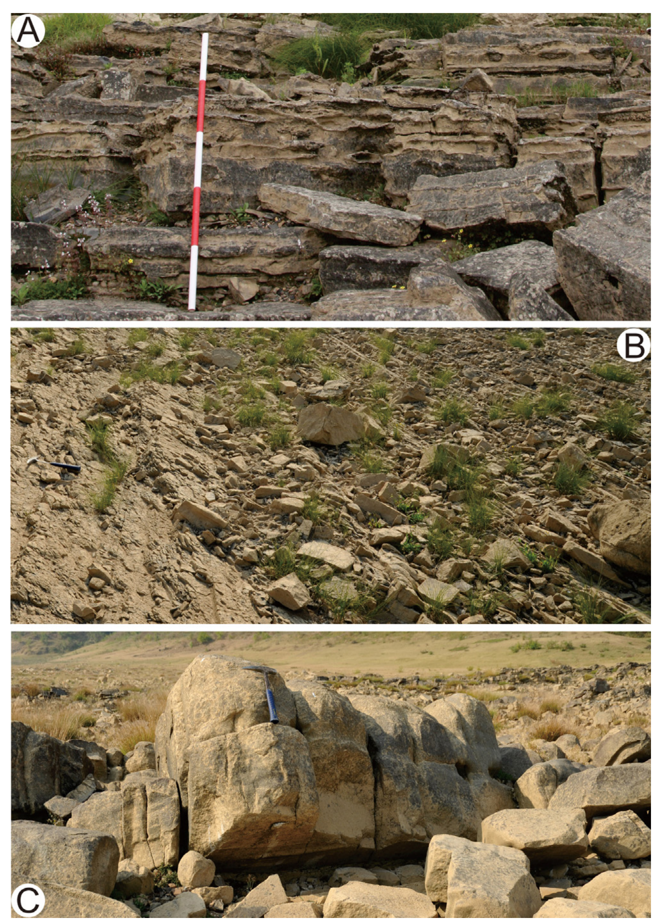

Fig. 2. Field views of the northern Penglaitan section. (A) Banded siliceous limestone in the upper part of the Heshan Formation; (B) bioclastic packstone in the Ergou Member; (C) pyroclastic sandstone in the basal Penglaitan Member.