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Lower Triassic anachronistic facies capping the Qinghai-Tibet Plateau seamount: Implications for the extension of extraordinary oceanic conditions deep into the interior Tethys Ocean

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ABSTRACT

The Bayan Har area, situated in the northeast of the Qinghai-Tibetan Plateau, has long been regarded as a deep-water turbidite basin during Early Triassic. However, a sequence of Lower Triassic shallow-water carbonate rocks has been documented from the region, indicating the existence of isolated seamount carbonate platforms in the basin. The seamount carbonate platform sediments differ from synchronous deep basin flysch sediments, and consist of shallow-water oncoids, ooids and cortoids. Microfacies studies reveal that the oncoids have a thick cortex comprised of irregular, non-concentric and partially overlapping micritic laminae and contain abundant well-preserved foraminifera, indicating a relatively low-energy environment in subtidal settings. Ooids exhibit thinner and more regular concentric laminations, which are interpreted to have formed by frequent overgrowth while rolling in a relatively high-energy setting. Cortoids are predominantly composed of tiny fossil fragments and intraclasts with a micritic envelope, indicating a shallow-marine warm water environment located in the intertidal or supertidal zone. Ooids in the Bayan Har area differ from those found on stable platforms, in that they sometimes nucleated onto volcanic quartz grains, reflecting an unstable tectonic setting that was frequently affected by volcanic activity. Widespread ooids and other microbial carbonates formed in the Early Triassic have been regarded anachronistic facies that are indicative of harsh marine conditions. Most Lower Triassic anachronistic facies are distributed along the shallow margin of the Tethys Ocean and the western margin of Pangea; however, Bayan Har was located in the center of the Palaeo-Tethys. The discovery of oncoids and oolites capping a seamount in this area provides strong evidence that extraordinary marine conditions spread far into the interior of the Palaeo-Tethys Ocean.

1. Introduction

A global marine mass extinction at the end of the Permian not only led to the devastation of Earth's biota, but also dramatically changed oceanic ecosystems, and is associated with typical hydrochemical conditions before, during and after the extinction (Isozaki, 1997; Payne et al., 2004; Knoll et al., 2007; Bottjer, 2012; Payne and Clapham, 2012; Sun et al., 2012; Joachimski et al., 2012; Song et al., 2014). One result of unusual oceanic chemistry in the aftermath of end-Permian mass extinction is the widespread distribution of a set of peculiar carbonate sediments, known as "anachronistic facies" that were widely deposited around the Tethys Ocean. Anachronistic facies are carbonate sediments that were very common in marine settings from the Precambrian to the early Palaeozoic, but decreased in abundance during much of the Phanerozoic (Sepkoski et al., 1991). However, these special carbonate deposits are frequently widespread in the aftermath of several major Phanerozoic mass extinctions (Sepkoski et al., 1991; Whalen et al., 2002; Sheehan and Harris, 2004), and are particularly well-known in the wake of the Permian–Triassic mass extinction (e.g., Pruss et al., 2005; Woods, 2009, 2013). Examples of anachronistic facies include thrombolites, stromatolites, unusually large ooids, flat pebble conglomerates, and vermicular limestones (e.g., Pruss et al., 2004; Wang et al., 2005; Baud et al., 2007; Kershaw et al., 2007; Mata and Bottjer, 2009; Li et al., 2013; Woods et al., 1999; Woods, 2013; Wu et al., 2014).

Documented Lower Triassic anachronistic facies are mainly distributed in carbonate platforms from South China, the Middle East and western North America (Ezaki et al., 2003; Wang et al., 2005; Pruss et al., 2006; Baud et al., 2007; Woods and Baud, 2008; Woods, 2009). During the Early Triassic, the Middle East was located in the southern Palaeo-Tethys, the South China block lay between the Panthalassa Ocean and the Palaeo-Tethys Ocean, and western North America was situated along the eastern border of Panthalassa (Fig. 1). Therefore, anachronistic facies occur widely in low-latitude shallow waters on both sides of Panthalassa and along the periphery of the Tethys Ocean.

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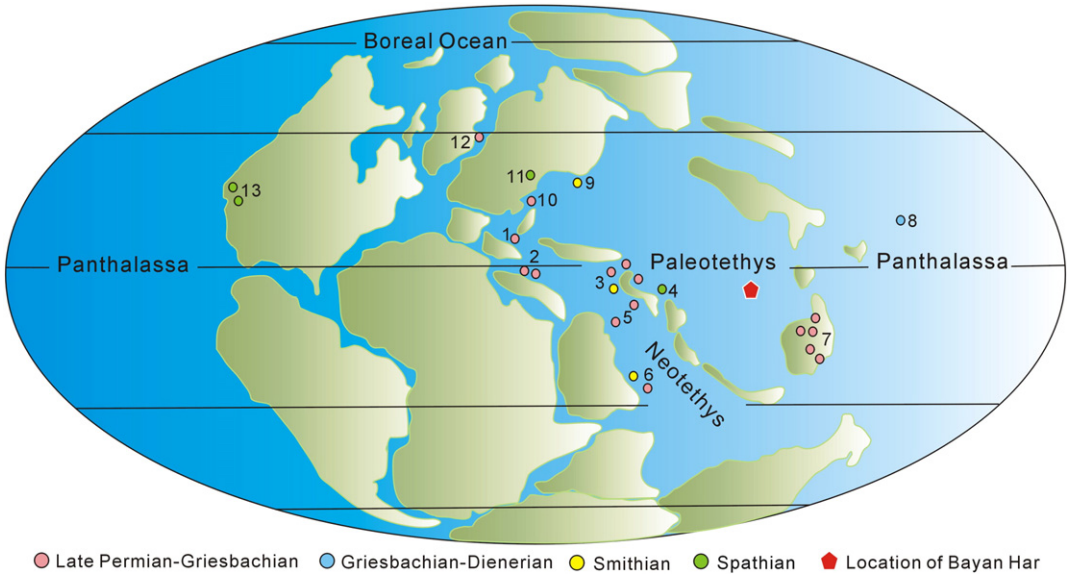

Fig. 1. Global palaeogeography during the Permo-Triassic transition and approximate position of Lower Triassic anachronistic facies (revised from Baud et al., 2007). 1. South Alps, 2. Turkey, 3. Armenia and north-west Iran, 4. Azerbaidjan, 5. Iran, 6. Oman, 7. South China, 8. Japan, 9. East Iran, 10. Hungary, 11. Romania, 12. Greenland, 13. North America.

The Bayan Har area is in the north of the Tibetan Plateau and was palaeogeographically located in the interior of Tethys Ocean during the Early Triassic. Previous studies have shown that this region is dominated by the deposition of deep-water flysch deposits during the Early Triassic (Bureau of Geology and Mineral Resources of Qinghai Province, 1997; Zhu et al., 2009). Our recent work, however, shows that there were isolated seamount carbonate platforms within this deep-water flysch basin (Fig. 2). Similar to previously reported anachronistic limestones from other areas, the seamount carbonate platform consists of a mix of oolitic limestone, oncolitic limestone and cortoid limestone. The discovery of Lower Triassic anachronistic limestone in the Bayan Har area provides new evidence for understanding marine environments in the central Palaeo-Tethys Ocean in the aftermath of the end-Permian mass extinction.

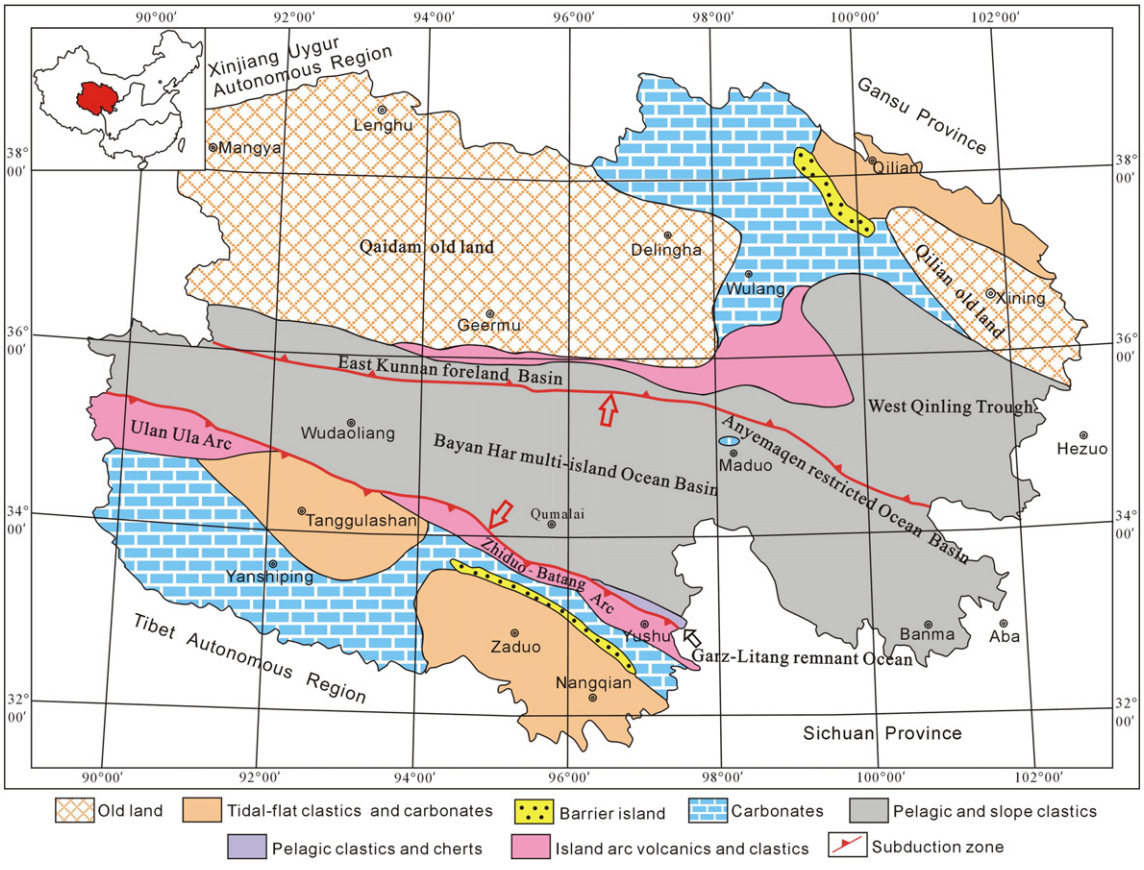

Fig. 2. Triassic palaeogeography of Qinghai Province (revised after Zhu et al., 2009).