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Upper Lower Triassic stromatolite from Anhui, South China: Geobiologic features and paleoenvironmental implications

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ABSTRACT

Widespread stromatolites and other microbialite deposits characterize Lower Triassic marine successions worldwide. This study documents a stromatolite deposit, 1.1 m thick, from the upper Spathian (Lower Triassic) of the Susong area, South China. The stromatolite comprises distinct laminated domes in the basal part and columns at the upper part. Dark laminae are loosely spaced and interlayered with thicker light colored laminae. Diffusive dark colored laminae are composed of peloidal micrite that grade locally into microclotted structures, and yield copies of bacteria clump-like and coccoid-like spheroid aggregates. The former are characterized by cloudy, micrite nuclei rimmed by coarse-grained, euhedral sparry calcite crystals, while the latter are comprised of solid calcite crystal nuclei coated with rather thin micrite envelopes. The cloudy, micrite nuclei resemble bacteria clump-like structures observed in present-day travertine. Both the coccoid-like spheroids and bacteria clump-like structures are surrounded by coarse-grained euhedral calcite crystals, suggesting a similar accretion mechanism. Both spherical structures therefore could be crucial in the accretion of the Susong stromatolite. The laminated/microclotted structures are interpreted as the result of variation in timing of lithification relative to the timing of the decay of microbes. Micro-analysis also unravels the common occurrence of authigenic micro-quartz crystals in association with Fe-bearing illite clay minerals in the stromatolite columns. Their coalescing nature with each other, together with the associated pyrite grains, strongly support the formation of micro-quartz crystals from microbial reduction of an Fe-bearing smectite precursor by sulfate reducing bacteria. A comparison of the Susong stromatolite with its counterparts from the upper Lower Triassic strata in Dajiang, South China reveals many similarities in stromatolite microstructures, suggesting that a harsh, euxinic–anoxic environment resulting in the bloom of sulfate reducing bacteria most likely extended into the latest Spathian in South China.

1. Introduction

The end-Permian mass extinction (EPME) is known to have adversely and severely affected both marine and terrestrial ecosystems with substantial loss of species diversity (Erwin, 2006). The high magnitude of this biotic crisis and associated environmental and climatic extremes caused persistently deleterious oceanographic conditions in the Early Triassic (Bottjer et al., 2008; Algeo et al., 2011), and different recovery patterns among various clades (Chen and Benton, 2012). Alternatively, a resurgence of microbially induced deposits/structures (i.e. stromatolites, thrombolites and wrinkle structures) occurred globally in the post-extinction sedimentary record (Pruss et al., 2004, 2006; Baud et al., 2007; Bottjer et al., 2008; Mata and Bottjer, 2009, 2011, 2012; Kershaw et al., 2012; Woods, 2014; Tu et al., 2016). Four peak temporal intervals of microbialite occurrence have been recognized from the Early Triassic, corresponding to the early Griesbachian, late Griesbachian to early Dienerian, early Smithian, and Spathian, respectively (Pruss et al., 2006; Baud et al., 2007). Later, Chen et al. (2014) and Luo et al. (2014) added a microbial proliferation interval in late Smithian and early Anisian, respectively. Accordingly, six occurrence peaks of microbialites are known from the EPME to middle–late Anisian (early Middle Triassic) when complete ecosystem structures were established, marking the final completeness of ecosystem recovery (Chen and Benton, 2012). Of these, the Permian–Triassic boundary microbialites (PTBM), immediately after the main phase of the EPME, are most abundant and widespread (Kershaw et al., 2012). These PTBMs have been interpreted as the outcome of combined reduction in metazoan diversity and elevated seawater saturation state (Riding and Liang, 2005; Kershaw et al., 2007, 2012; Woods et al., 2007). Such inference is open to question because both PTBMs and modern stromatolite deposits contain abundant metazoan fossils (Yang et al., 2011, 2015a,b; Forel et al., 2012; Forel, 2013; Tarhan et al., 2013).

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Many attempts have been undertaken on documenting environmental and paleoecologic aspects of Lower Triassic microbialites (Schubert and Bottjer, 1992; Sano and Nakashima, 1997; Lehrmann, 1999; Ezaki et al., 2003, 2008, 2012; Adachi et al., 2004; Richoz et al., 2005; Wang et al., 2005; Pruss et al., 2006; Hips and Haas, 2006; Baud et al., 2007; Farabegoli et al., 2007; Kershaw et al., 2007, 2011, 2012; Woods and Baud, 2008; Mary and Woods, 2008; Mata and Bottjer, 2011, 2012; Yang et al., 2011; Chen et al., 2014; Wu et al., 2014). However, studies concerning geobiologic features and accretion process of those microbial deposits are largely lagging, although some attempts have been undertaken in the past decade (Ezaki et al., 2003, 2008, 2012; Yang et al., 2011; Chen et al., 2014; Wu et al., 2014). Some focal questions still remain unanswered. For example, what are the geobiologic process involved in the accretion and formation of Lower Triassic microbialites? Are the same constructors responsible for the accretion of PTBMs and younger Early Triassic microbialites? Did the younger Early Triassic microbialites also form in harsh environments?

Accordingly, this paper aims to document geobiologic features of an uppermost Lower Triassic stromatolite from Susong County, Anhui Province, South China (Fig. 1) and test its biogenecity. The geobiologic processes that led to key spheroidal structures and authigenic quartz grains embedded in stromatolite columns are also investigated through detailed micro-analysis. The possible constructors of stromatolite and the environments in which they grew are also discussed in a broad context by a means of a comparison of the Susong example with PTBMs and younger Early Triassic microbialites in South China.

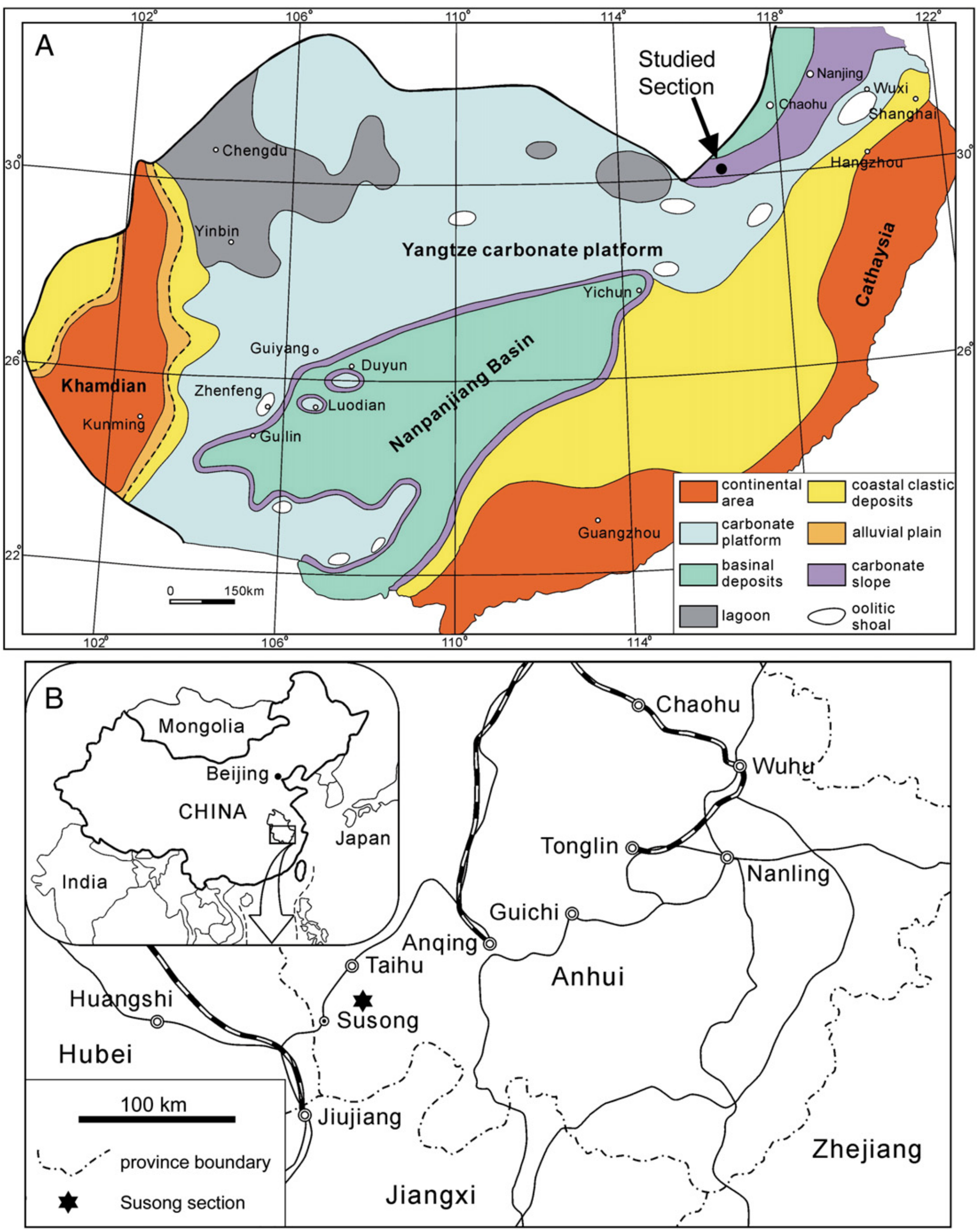

Fig. 1. A, Early Triassic paleogeographic configuration of South China showing that the Susong area was located within a platform ramp setting during Spathian time (base map modified from Feng et al., 1997). B, Geographic map showing location of the study section at Susong, Anhui Province, South China.