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Early Animal Mobility and Terminal Ediacaran Oxygen Oases

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Abstract: The Ediacaran Period opens in the wake of Cryogenian snowball Earth glaciations and closes on the eve of the Cambrian explosion of animals. Thus, it represents a key chapter in the history of the Earth-life system and provides critical insights in the early evolution of animals. The terminal Ediacaran Period (ca. 551–539 Ma) in particular is crucial in analyzing the dynamics of coupled animal-environment evolution. Available geochemical data indicate that the terminal Ediacaran Period is characterized by a major expansion of marine anoxia and dynamic redox conditions in shallow shelf environments where animals lived (Wood et al., 2015; Tostevin et al., 2018; Wei et al., 2018; Zhang et al., 2018). It is thus likely that the terminal Ediacaran animals may have been impacted by and may have had an impact on the redox history on surface Earth. However, exactly how early animals and the Earth's surface redox environment interacted is not clearly defined and tested.

The terminal Ediacaran Shibantan Member of the Dengying Formation in South China offers an unprecedented opportunity to analyze the relationship between animals and redox conditions, because it preserves abundant trace fossils (Chen et al., 2013; Meyer et al., 2014; Meyer et al., 2017; Chen et al., 2018), Ediacara-type fossils (Chen et al., 2014), and other enigmatic fossils (Xiao et al., 2005; Shen et al., 2017) in limestones that are amenable to geochemical analysis (Wei et al., 2018; Zhang et al., 2018). Macrofossils in the Shibantan Member are characteristic of the Nama assemblage and include abundant vendotaenids, arboreomorphs, erniettomorphs, rangeomorphs, tubular fossils, various discoidal fossils, as well as a number of unnamed forms. Bilateralomorphs, triradialomorphs, tetraradialomorphs, pentaradialomorphs, and kimberellomorphs are absent from the Shibantan Member. Trace fossils are abundant on certain surfaces and bedding plane bioturbation intensity can reach 22–41%. Millimeter-sized shallow horizontal burrows dominate the Shibantan ichnofossil assemblage, but surface tracks and trails, short vertical traces, lateral probes, and uniserially arranged burrow segments are common.

A detailed analysis of Shibantan trace fossils shows that they are closely associated with microlaminae interpreted as microbial mats. This association is interpreted as an early animal behavior to explore localized oxygen oases within cyanobacterial mats in an ocean characterized by relatively low levels of dissolved O_2. Because the dissolved O_2 concentration within cyanobacterial mats is dynamic as a consequence of diurnal changes in photosynthetic production of O_2, animals exploring these oxygen oases must also be able to respond to such dynamic changes by maneuvering in and out the cyanobacterial mats. We hypothesize that such localized and dynamic O_2 oases were an environmental stimulus that drove the evolution of mobility among early benthic bilaterian animals.

Keywords: Ediacaran Period, Shibantan Member, South China, Animal, Trace fossil

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