Dramatic changes in the biogeochemical cycle of barium isotopes in the Ediacaran Yangtze Platform

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Barium (Ba) isotopes may have the potential as a novel proxy for paleo-productivity. This application relies on the strong control of biological productivity on the behavior of Ba isotopes in the modern oxic oceans. However, the ocean was dominantly anoxic throughout the majority of Earth history, and the biogeochemical cycle of barium in ancient oceans may have been different. The Ediacaran Period was marked by a dramatic evolution in the climate, atmospheric and oceanic oxygen level, marine carbon cycle, and biosphere, which have been documented in the Ediacaran successions, providing an opportunity to investigate variations in biogeochemical Ba isotope cycle during this period. In this study, we find large Ba isotope ($\delta^{138}Ba$) variations in carbonates from the Ediacaran Doushantuo and Dengying formations in the Yangtze Gorges area, South China. Detrital contaminations and potential post-depositional alterations cannot explain the $\delta^{138}Ba$ variations. The post-Marinoan carbonates record generally negative authigenic $\delta^{138}Ba$ ($\delta^{138}Ba_{auth}$) around -0.3 ‰, reflecting the existence of a replete, homogeneous, and isotopically light Ba reservoir in the deglacial ocean, which accumulated during the Marinoan glaciation or even before. Although the Shuram/Wonoka correlative carbonates documented a prominent negative $\delta^{13}C_{carb}$ excursion, the $\delta^{138}Ba_{auth}$ values merely show minor fluctuations between 0.00 and 0.35 ‰, possibly due to the local anoxia inhibiting the biogeochemical cycle of Ba isotopes. The late-Ediacaran carbonates are characterized by the co-elevation of $\delta^{138}Ba_{auth}$ and cerium anomalies, suggesting the establishment of the modern-ocean-like cycle of Ba isotopes in shallow waters of the Yangtze Platform, which likely resulted from the replacement of cyanobacteria by eukaryotic phytoplankton as the dominant primary producer. In summary, we suggest that Ba isotope cycle in ancient marine system is strongly controlled by local redox conditions, and thus Ba isotopes could be utilized to trace variations in paleo-productivities, especially in oxic environments.