

Isotopic evidence for oceanic barium cycling in the initial stage of the Mesoproterozoic

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Recent studies have revealed the possibility of fluctuations of oxygen in the atmosphere and ocean of Mesoproterozoic Era. Such fluctuations may have provided the necessary foundation for the emergence of eukaryotic organisms at this time. However, the current understanding of this apparent coevolution requires further constraints on the operation of the biosphere. Here we analyzed barium isotopic compositions ($\delta^{138}\text{Ba}$) together with other geochemical proxies within marine carbonates from the Gaoyuzhuang Formation (~1570 Ma) of the Yanliao Basin, North China Craton. Our results display $\delta^{138}\text{Ba}$ values similar to those of modern marine pelagic barite and both are lighter and have much less scatter compared to modern seawater values. We interpret these new $\delta^{138}\text{Ba}$ data to reflect the $\delta^{138}\text{Ba}$ composition of the initial stage of the Mesoproterozoic seawater, at least at the sediment-water interface. Moreover, we do not observe any clear fluctuations in $\delta^{138}\text{Ba}$ values coincident with carbonate $\delta^{13}\text{C}$ excursions. We interpret these observations as a response to the accumulation of dissolved barium in the low-sulfate Mesoproterozoic ocean and thus, a buffering of $\delta^{138}\text{Ba}$ against significant variation in response to factors such as primary productivity which influence modern marine $\delta^{138}\text{Ba}$ profiles. Moreover, our calculations estimate a ratio of $\approx 4:1$ of continental weathering to hydrothermal activity based on a steady-state box model. Furthermore, our simulations suggest that the residence time of barium was more than 100-fold longer in the initial stage of the Mesoproterozoic ocean than the modern, implying a much more conservative behavior of Ba and its isotopes.