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Barium isotope evidence for high primary productivity during the Ordovician

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The Great Ordovician Biodiversification Event (GOBE) is one of the most significant and sustained increases in marine biodiversity. It has been proposed that this biodiversification or radiation was closely linked to nutrient inputs that fueled primary producers and the predators that fed on them. However, the background of primary productivity during the Ordovician was unknown, hampering our understanding of the causes of the GOBE and its relationship to associated environmental changes such as global cooling, increased oxygenation, and carbon isotope excursions. Sedimentary barium (Ba) isotopes have the potential to track oceanic productivity. The precipitation of pelagic barites from seawater is associated with substantial isotopic fractionation (–0.5‰ to –0.4‰), resulting in elevated $\delta^{138}Ba$ values in surface seawater that can be recorded in carbonates ($\delta^{138}Ba_{carb}$).

To elucidate the background and evolution of primary productivity during the Ordovician, we performed coupled analyses of $\delta^{138}Ba_{carb}$ and $\delta^{13}C_{carb}$ from an Ordovician marine carbonate borehole (YW2) in South China. Our results show that Ordovician $\delta^{138}Ba_{carb}$ values (0.23‰ to 0.96‰, median 0.73‰, n = 57) are significantly higher than those observed in modern seawater (median 0.45‰), indicating exceptionally high primary productivities during the Ordovician, at least in South China. This leads to a new mechanism to explain the correlation between biodiversity changes, climatic fluctuations and carbon isotope excursion during the GOBE. That is, primary productivity was significantly enhanced during the GOBE by the plankton explosion, which then increased organic carbon burial and gradually drove global cooling and the increase in $\delta^{13}C_{carb}$. Our results provide new insights into the co-evolution of marine life and the environment during this critical period.