

Enhanced Seawater Mixing during the late Ediacaran Shuram Excursion

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The Ediacaran Shuram excursion event (SE; ca. 574-567 Ma)—the most pronounced negative inorganic carbon isotope ($\delta^{13}\text{C}_{\text{carb}}$) anomaly in Earth's history, most likely represents a substantial oxidation of marine organic matter (OM) in the ocean. However, the physical process related to this OM oxidation remains elusive. To address this issue, we conducted integrated analyses of strontium ($^{87}\text{Sr}/^{86}\text{Sr}$) and neodymium (ϵ_{Nd}) isotopes of marine carbonates across three SE-bearing sections from South China (Sishang and Lianghong sections) and the Tarim basin (Mochia-Khutuk section). Our results reveal an increase in $^{87}\text{Sr}/^{86}\text{Sr}$ (from 0.708 to 0.710 at Sishang section, from 0.710 to 0.713 at Lianghong section, and from 0.712 to 0.713 at Mochia-Khutuk section), and a decrease in ϵ_{Nd} (from 7.72 to -4.27 at the Sishang section and from -0.83 to -5.57 at the Lianghong section) at the onset of SE. Notably, ϵ_{Nd} values show large spatial variations prior to the SE (7.72 at the Sishang section, -0.83 at the Lianghong, and -4.27 at the Mochia-Khutuk section), but converge to consistently low values of about -5 during the SE. Considering the orders-of-magnitude difference in seawater residence time between Sr (>1 Myr) and Nd (<1 kyr), these coupled variations between $^{87}\text{Sr}/^{86}\text{Sr}$ and ϵ_{Nd} are less likely to be resulted from any single process alone. In the modern ocean, seawater ϵ_{Nd} compositions vary considerably across different regions, making ϵ_{Nd} a potential proxy for global seawater mixing. We propose a dual-control mechanism, where intensified continental weathering of felsic rocks contributed to the rising $^{87}\text{Sr}/^{86}\text{Sr}$ ratios, and enhanced ocean mixing of different water masses during the SE event led to more homogeneous ϵ_{Nd} composition of the seawater. The converged ϵ_{Nd} values from different continents provides robust evidence for strong seawater mixing during the SE, which may have facilitated the oxidation of marine organic matter, which ultimately lead to the largest negative $\delta^{13}\text{C}_{\text{carb}}$ excursion in Earth's history.