Global marine redox changes drove the rise and fall of the early animals

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The role of O_2 in the evolution of early animals—as represented by the Ediacara biota—has been heavily debated. Current geochemical evidence paints a conflicting picture regarding global marine O_2 levels during key intervals of the rise and fall of the Ediacara biota with evidence for both profound oxygenation and persistent anoxic conditions.

To help resolve this debate, we used U isotopes in carbonates to constrain the extent of global ocean oxygenation during the rise and fall of the Ediacara biota. We measured $\delta^{238}U$ in three well-studied Shuram Excursion (SE) sections in South China, Siberia, and USA, and two latest Ediacaran carbonate sections (551-541 Ma) in South China.

Our data reveal a large positive excursion in $\delta^{238}U$ (from ~ −0.74 ‰ to ~ −0.26 ‰) across the SE event. Subsequently, the latest Ediacaran carbonates (551-541 Ma) record the most negative carbonate $\delta^{238}U$ values yet reported (averaging −0.95 ‰). $\delta^{238}U$ of SE samples are slightly heavier than the modern seawater value of ~−0.4 ‰. Applying an offset of ~0.15 ‰ bettwen carbonate precipitates and seawater that is inferred from laboratory experiments, and assuming an average representative fractionation factor of 0.6 ‰ between seawater and anoxic sediments, a simple U isotope mass-balance modeling suggests that prior to the SE >50 % of the seafloor was overlain by anoxic waters, and that global ocean oxygenation rose to near-modern levels during the SE. This episode of oxygenation was followed by an episode of extensive ocean anoxia—covering nearly 100 % of the seafloor—during the latest Ediacaran Period.

This episode of pervasive ocean oxygenation across the SE immediately predates the initial diversification of the Ediacara biota. The subsequent shift to extensive anoxic conditions during the latest Ediacaran Period is coincident with the decline and extinction of the Ediacara biota. These findings suggest that global marine redox changes drove the rise and fall of the Ediacara biota.