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Oxygen isotope ensemble reveals enhanced carbon recycling and modest temperatures on early-Earth

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While the evolution of atmospheric pCO_2 levels is believed to have supported habitable surface conditions since the Archean, the mechanisms responsible for its long-term trend remain debated. Using a novel oxygen isotope ensemble approach—comprising shale, iron oxide, carbonate, and chert records—we reconstruct a single self-consistent multi-billion-year history of seawater $\delta^{18}O$, temperature, and marine authigenic clay CO_2 release. We find that a temperate Proterozoic climate was terminated by a contemporaneous decline in clay authigenesis and temperatures through the Paleozoic coincident with the rise of siliceous life. This provides the first direct evidence that enhanced ocean-atmosphere carbon recycling tied to clay formation sustained clement early-Earth conditions, and that siliceous ecosystems play a prominent role in regulating Earth's climate system.