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The emergence of subaerial crust and onset of weathering 3.7 billion years ago

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Reconstructing the emergence and weathering of continental crust in the Archean is crucial for our understanding of early ocean chemistry, biosphere evolution and the onset of plate tectonics. However, considerable disagreement exists between the various elemental and isotopic proxies that have been used to trace crustal input into marine sediments, and data are scarce prior to 3 billion years ago. Here we show that chemical weathering modified the Sr isotopic composition of Archean seawater as recorded in 3.52 to 3.20 Ga stratiform marine-hydrothermal barite deposits from three different cratons. We use a combination of barite crystal morphology, oxygen, multiple sulfur and strontium isotope data to select barite samples with the most seawater-like isotopic compositions, and subsequently use these in a hydrothermal mixing model to calculate a plausible seawater Sr isotope evolution trend from measured $^{87}Sr/^{86}Sr$ data. From modeled mixing ratios between seawater and hydrothermal fluids required for barite precipitation and comparison of $^{87}Sr/^{86}Sr$ in theoretical seawater-hydrothermal fluid mixtures with those recorded in the barite, we obtain a novel seawater Sr isotope evolution trend for Paleoarchean seawater that is much more radiogenic than the curve previously determined from carbonate rocks. Our findings require the presence and weathering of subaerial and evolved (high Rb/Sr) crust from 3.7 ± 0.1 Ga onwards, and demonstrate that crustal weathering affected the chemistry of the oceans 500 million years earlier than previously thought.