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Sulfate triple oxygen isotopes witnessed oceanic oxygenation 570 million years ago

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The largest negative inorganic carbon isotope excursion in Earth's history, namely the Shuram Excursion (SE) at ~574-567 million years ago, closely followed by radiation of the earliest animals, has been widely interpreted as the consequence of oceanic oxidation. However, the primary nature of the signature, source of oxidants, and tempo of the event remain contested. Here, we show that marine carbonate-associated sulfate from three different paleocontinents (South China, South Australia, and Tarim) all have conspicuous negative ^{17}O anomalies (i.e., $\Delta'^{17}O$ values down to −0.53‰) during the SE. Furthermore, the $\Delta'^{17}O$ varies in correlation with its corresponding sulfur and oxygen isotopes ($\delta^{34}S$ and $\delta^{18}O$) as well as the carbonate carbon isotope composition ($\delta^{13}C_{carb}$), decreasing initially followed by a recovery over the ~7 million-year SE duration. Incorporating this unique line of evidence in a dynamic flux model, we determined that seawater sulfate concentration had increased and the added contribution came mainly from fresh sulfur oxidation by $[O_2]$ due to water-column ventilation. Therefore, we argue for a period of sustained water-column ventilation and consequently enhanced sulfur oxidation in the ocean during the SE. Our finding is consistent with the SE being a global oceanic oxygenation event, in which a mass-anomalously ^{17}O-depleted atmospheric O_2 was ultimately responsible for the oxidation of the reduced sulfur and organics in the oceans.