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Large contribution of oxygen to organic matter degradation during the Ediacaran Shuram excursion

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The Shuram excursion, the largest global negative $\delta^{13}C_{carb}$ excursion in Earth history, has been related to ocean oxidation during the Ediacaran Period. The Shuram excursion is considered to have originated from microbial sulfate reduction (MSR) activity due to an increase in the difference of sulfur isotopic compositions of carbonate associated sulfate (CAS) and bulk pyrite, chromium reducible sulfur (CRS). However, recent studies revealed that the isotopic composition of CRS is a mixture of isotopic compositions of pyrite formed in the water column or sediments at varying depths. Thus, quantifying the isotopic composition of primary pyrite, which likely retained the sulfur isotope fractionation of MSR, is crucial for reconstructing the paleo-oceanic sulfur cycle. In this study, we carried out multiple sulfur isotope analyses of large pyrite grains (> 100 μm) by a fluorination method combining with *in-situ* $\delta^{34}S$ analyses by SIMS in the Member 3 of Ediacaran Doushantuo Formation using a drilling core collected from the Three Gorges area, South China. The method allowed us to quantify the sulfur isotope fractionation of MSR. The microbial isotope fractionation calculated in the middle to later part of the Shuram excursion was $^{34}\varepsilon$ = 55.7‰ and $^{33}\lambda$ = 0.5129, which is a typical sign of MSR. Furthermore, our results revealed that microbial sulfur isotope fractionation increased during the Shuram excursion. However, the decrease in pyrite concentration, which cannot be explained by a deficient iron supply, suggests that an alternate factor contributed to the Shuram excursion. Previous studies showed that, during the Shuram excursion, the TOC and Ba concentrations decreased and increased, respectively, with the decrease in pyrite concentration; this indicated a buildup of dissolved oceanic O_2 at that time. Thus, we propose that buildup of oceanic O_2 enhanced the decomposition of dissolved organic matter, which subsequently decreased the supply of organic matter to the MSR zone and increased the sulfur isotope fractionation thereof. Our findings shed light on the significance of oxygen, which is critical for considering coevolution of earth and life, during the Shuram excursion.