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Spatiotemporal fluctuations of pyrite sulfur isotope with pyrite morphology during the Ediacaran-Cambrian transition

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The rapid fluctuations in the bulk-sample sulfur isotope of sedimentary pyrite ($\delta^{34}S_{py}$) serves as a crucial indicator of marine redox changes during the Ediacaran-Cambrian transition (E-C). However, these bulk-sample $\delta^{34}S_{py}$ values are susceptible to diagenetic alterations, which can alter the ratio of euhedral to framboidal crystals, thereby inducing fluctuations in $\delta^{34}S_{py}$ values. To assess the impact of diagenesis on $\delta^{34}S_{py}$ variability across the E-C transition, we conducted a comprehensive analysis of spatiotemporal variations in $\delta^{34}S_{py}$ across five E-C sections in South China, encompassing diverse environmental settings. Additionally, we characterized pyrite morphologies, distinguishing between framboidal and non-framboidal forms. The results demonstrate a consistent decrease in $\delta^{34}S_{py}$ values with increasing water depth, accompanied by an increase in the proportion of framboids. Specifically, in shallow water platform settings, the mean $\delta^{34}S_{py}$ value is +34.0‰, with a mean framboid proportion of 6%. Conversely, in the deep water basin environment, the mean $\delta^{34}S_{py}$ values drops to +5.6‰, with a mean framboid proportion of 45%. Notably, $\delta^{34}S_{py}$ values exhibit irregular fluctuations approaching the Cambrian period. A positive $\delta^{34}S_{py}$ excursion, ranging from +5.1‰ to +51.0‰, is observed in the platform at the base of the E-C transition, while a negative excursion, spanning from +13.0‰ to -28.2‰ (and from +14.9‰ to -19.5‰ in another section), is evident in the basin. Crucially, a consistent negative correlation is observed between framboid proportion and bulk-sample $\delta^{34}S_{py}$ values. This relationship underscores the significance of both the timing of pyrite formation and the local redox conditions. Our findings reveal that marine oxidation occurred in uneven pulses during the E-C transition. Furthermore, we emphasize the necessity of considering pyrite morphologies when interpreting $\delta^{34}S_{py}$ records, as framboids may offer a more reliable signal of seawater conditions. Overall, this study provides new insights into the complex interplay between diagenetic alterations, pyrite morphology, and marine redox variations during the E-C transition, underscoring the dynamic nature of marine oxidation during this critical period in Earth's history.