

The coupling of marine sulfur and iron cycle in the wake of Marinoan Snowball Earth

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The terminal Cryogenian Marinoan Snowball Earth glaciation (~650 – 635 Ma) was immediately followed by the diversification of eukaryotes and oxygenation in the deep ocean. Previous studies proposed rapid recovery of marine primary productivity and the development of oceanic euxinia after the Marinoan glaciation. In this scenario, the dissimilatory sulfate reduction (DSR) occurred in the water column, and diffusion of H₂S from euxinic seawater into sediment porewater resulted in the syndepositional pyrite precipitation near the top of glacial deposits. This argument explained the platform-wide distributions of pyrite aggregates in the top of Nantuo Formation in South China. Pyrite formation involves with both DSR and dissimilatory iron reduction (DIR). Abundant pyrite aggregate formation also requires active DIR in sediment porewater. In this study, we analyzed sulfur ($\delta^{34}\text{S}_{\text{py}}$) and iron isotope composition ($\delta^{56}\text{Fe}_{\text{py}}$) of single pyrite crystals in the topmost Nantuo Formation. Samples were collected from three sections, spanning from shelf, slope, to basin environments. Pyrites from different sections have distinct $\delta^{34}\text{S}_{\text{py}}$ and $\delta^{56}\text{Fe}_{\text{py}}$ values. Pyrite from the slope section has the highest $\delta^{34}\text{S}_{\text{py}}$ and $\delta^{56}\text{Fe}_{\text{py}}$ of crustal composition, while the shelf samples have the lowest $\delta^{34}\text{S}_{\text{py}}$ but the highest $\delta^{56}\text{Fe}_{\text{py}}$ values. We applied the two-Rayleigh distillation model to simulate the DIR and pyrite formation in sediments. The modeling results indicate the quantitative consumption of Fe²⁺ by pyrite formation, probably due to high seawater H₂S concentration and limited supply of organic matter for DIR, and excessive Fe²⁺ supply with respect to low seawater H₂S content in the shelf. Our study indicates the redox zonation in the postglacial ocean was reversed, and the marine sulfur and iron cycles were coupled by the surface ocean productivity in the aftermath of Marinoan Snowball Earth.