# Organic matter $\delta^{34}S$ lighter than the pyrite in Cryogenian Datangpo Fm

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Up to now, marine sediments have generally been reported to have bulk organic matter $\delta^{34}S$ values 5 to 15‰ heavier than the associated pyrite. The possible reasons include preferential or faster reaction of $^{32}S$-rich $H_2S$ with reactive iron to precipitate pyrite, formation of organic sulfur from organic matter with polysulfides or element sulfur with more $^{34}S$-rich than $H_2S$. Surprisingly, in the Cryogenian Datangpo Formation Mn-rich sediments, all bulk organic matter has $\delta^{34}S$ values lighter than the associated pyrite, and most of organic matter and pyrite have $\delta^{34}S$ heavier than the coeval seawter, up to 56‰ and 70‰, respectively, but all lighter than the carbonate-associated sulfates (CAS). The organic matter shows the relationship between $\Delta^{33}S$ and $\Delta^{36}S$ and small $\Delta^{33}S$ values indicating a BSR origin, and the relationship between $\delta^{34}S$ and $\Delta^{33}S$ characterized by its source sulfate and BSR in a low-$SO_4$ environment as the result of a closed system Rayleigh fractionation. Based on these lines of evidence, two hypotheses are proposed as follow: 1) Earlier $^{32}S$-rich $FeS/FeS_2$ but no significant amount of organic sulfur were oxidized by $MnO_2$ from the enhanced weathering immediately after the Sturtian Snowball to sulfate. No sulfur isotope fractionation is expected during this process as supported by the slightly S-isotopically heavier CAS than the pyrite, consequently, pyrite was precipitated from low sulfate conditions with sulfate from both sulfide reoxidation and $^{34}S$-rich $SO_4$ residue after the early bacterial sulfate reduction. 2) During early BSR, pyrite precipitation was inhibited and all $^{32}S$-rich $H_2S$ was incorporated into organic matter, forming the first generation of relatively $^{32}S$-rich organic sulfur compounds. With progressive BSR in a closed diagentic environment, most of the pore water sulfate was depleted, all pyrite and second generation of organic sulfur formed from such environment are expected to have extremely heavy $\delta^{34}S$ values as found from some saline lacustrine sediments. Further work is ongoing.

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