

## Extremely $^{34}\text{S}$ -rich organic sulfur in Cryogenian Mn ore deposit

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Organic sulfur compounds are considered to be generated mainly by the incorporation of  $\text{H}_2\text{S}$  originated from bacterial or thermochemical sulfate reduction (BSR or TSR) by organic matter during low ( $<80^\circ\text{C}$ ) and high ( $>120^\circ\text{C}$ ) temperatures, respectively, into sedimentary organic matter, and have been reported to have  $\delta^{34}\text{S}$  from  $-30\%$  to  $+41\%$  (Werne et al., 2003; Cai et al., 2016). Surprisingly, bulk organic matter or kerogen after pyrite removal is measured to have  $\delta^{34}\text{S}$  values up to  $56\%$  in the Member I manganese ore interval of Cryogenian Datangpo Formation, where the associated pyrites were reported to have  $\delta^{34}\text{S}$  up to  $70\%$ , being significantly heavier than the coeval seawater sulfate of about  $26\%$  (Feng et al., 2010; Cui et al., 2018). The superheavy pyrite is considered to result from Rayleigh-type fractionation during either BSR in low sulfate ( $<0.2\text{mM}$ ) seawater or shallow pore water or TSR in hydrothermal fluid, coupled with the oxidization of organic matter. The oxidation during diagenesis is supported by the associated carbonate species including kutnohorite ( $\text{CaMn}(\text{CO}_3)_2$ ) and rhodochrosite ( $\text{MnCO}_3$ ) with light  $\delta^{13}\text{C}$  values, and the positive relationship between  $\delta^{13}\text{C}$  and  $\delta^{18}\text{O}$ . The positive relationship between MnO and  $\delta^{18}\text{O}$  in our samples can be used to constrain the oxidation coupled with Mn(III/IV) reduction to low temperatures conditions with the presence of microbes unless significant meteoric water was influxed during late diagenesis. We consider that BSR and Mn reduction were competitive as indicated by the negative relationship between MnO and total sulfur content, and that the  $^{34}\text{S}$  enrichment in organic matter and pyrite occurred during early diagenesis after extensive Mn reduction in this Mn deposit as well as in the Ediacaran cap dolostones in Jiulongwan and Huajipo sections. However, it is not clear what controlled the link between Mn reduction and  $^{34}\text{S}$  enrichment. The further work is under way.

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