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The multiple sulfur isotope composition of diagenetic and hydrothermal sulfides from the Barney Creek Formation (McArthur Basin, Australia): implications for Zn metallogenesis

The mid-Proterozoic stratigraphy of the McArthur Basin (Australia) contains some of the most well-preserved sedimentary rocks of Precambrian age, which also host giant, clastic dominant (CD-type) massive sulfide Zn deposits. Previous studies on CD-type deposits have investigated δ34S values in order to reconstruct sulfide precipitation pathways; however, δ34S values can be influenced by multiple environmental factors and it is often challenging to differentiate between organoclastic sulfate reduction (OSR), anaerobic oxidation of methane coupled with sulfate reduction (AOM-SR), and thermochemical sulfate reduction (TSR). In this study, we present multiple sulfur isotope data on mineralized and unmineralized samples from the Barney Creek Formation, which hosts the Teena Zn deposit, to try and resolve different pathways of diagenetic and hydrothermal sulfate reduction.

The sulfide mineralogy and paragenesis is characterized by fine-grained early diagenetic pyrite, which is then overgrown and partly replaced by coarser grained pyrite and sphalerite. Bulk rock sulfur in powdered drill core samples was extracted from pyrite as chromous reducible sulfur (CRS; n=40) and from sphalerite and galena as acid volatile sulfur (AVS; n=13). The sulfur isotope composition of CRS and AVS broadly overlap, with a wide range of δ34S, Δ33S and Δ36S values, between -2.8 and 35.7 ‰, -0.08 and 0.05 ‰ and -0.40 and 0.67 ‰. A series of Rayleigh distillation trends have been modelled to evaluate possible mixing scenarios. The data plot as convex arrays in $\delta^{34}S$–$\Delta^{33}S$ space, consistent with OSR. There is no evidence of mixing between OSR and AOM-SR, which should result in a concave trajectory; nor is there evidence of TSR, which should produce lower Δ33S values compared to microbial processes. Importantly, the results suggest that hydrothermal sulfides most likely precipitated from sulfur that was derived from the replacement of pre-existing diagenetic pyrite.

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