

Understanding the interplay between S source and metal availability in the Archean: an example from the Jeerinah Formation

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In this contribution we present detailed petrography, in-situ LA-ICPMS trace element data for pyrite, and $\delta^{34}\text{S}$ and $\Delta^{33}\text{S}$ values for microdrilled drilled pyrite from the Jeerinah Formation (2.68 Ma), Western Australia. Four distinct pyrite textures occur within the Jeerinah Formation: fine grained disseminated pyrite; equigranular nodules; bladed nodules; and late, equigranular replacements of shale clasts. Each of these features contains unique trace element and sulfur-isotope signatures that can yield insight into the sources of S and trace element abundances of the pore water. Trace element content of pyrite tends to be higher in earlier pyrite and lower in later pyrite. Presumably, as diagenesis progresses, the decreasing trace element contents of pyrite are tracking parallel decreases in the trace element content of the pore fluids. This finding is significant because several trace elements are important cofactors for biological enzymes associated microbial metabolisms in the subsurface. Nickel in particular is an essential cofactor for methanogenic bacteria; a potential Ni deficiency could limit the rate of methanogenesis in the sediments. If Ni is depleted before sulfate, then it stands to reason that methanogenesis would be limited in those settings because sulfate reduction is more energetically favourable than methanogenesis. In Archean-aged sediments S isotopes can provide additional insight. During the Archean there were two main sources of S to marine systems: element S and sulfate. S isotopes, as expressed as $\delta^{34}\text{S}$ and $\Delta^{33}\text{S}$ values, are convenient ways to identify the source of S in a given pyrite. Our analyses reveal how the source of S and trace element pore water content varied during diagenesis, with important implications for the degree of methane production during the deposition of the Jeerinah Formation.