Differentiating between euxinic and diagenetic pyrite in the Barney Creek Formation – implications for ore formation in the Teena sub-basin, Australia

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The Paleoproterozoic Barney Creek Formation (McArthur Basin, Australia) is host to a number of sediment-hosted massive sulphide (SHMS) deposits. The abundance of pyrite within the Barney Creek Formation (BCF) can be highly variable, and differentiating between syngenetic, diagenetic and hydrothermal pyrite is challenging. Furthermore, the relative timing of hydrothermal mineralisation with respect to pyrite formation is commonly debated. Here, we present *in situ* sulphur isotope data ($\delta^{34}S$) for pyrite from the BCF in the Teena sub-basin, located 9km from the world class HYC SHMS deposit. Samples have been selected from 3 drill-holes that intersect a hydrothermally mineralised interval that is overlain by a sequence of un-mineralised pyritic mudstones.

Within the un-mineralised sequence there is a discrete interval of pyrite enrichment. The pyrite within this interval preserves highly positive $\delta^{34}S$ values (+25 to +37‰), providing evidence of syngenetic pyrite formation from an euxinic water column. Above and below this euxinic interval, pyrite is characterised by negative $\delta^{34}S$ values (≥ –10‰) that likely developed via open system bacterial sulphate reduction within early diagenetic pore fluids. Euxinic conditions and syngenetic pyrite formation, therefore, were a temporally restricted feature of the Teena sub-basin. A hydrothermal assemblage, comprising sphalerite, galena and pyrite, is located lower down in the sequence, and clearly post-dates an early diagenetic assemblage of pyrite and nodular dolomite. The hydrothermal pyrite preserves complex zonation patterns, together with a broad distribution of $\delta^{34}S$ values (–3 to +27‰) that is intermediate between the syngenetic and diagenetic pyrite end-members. The high degree of isotopic variability that is preserved within domains of zoned hydrothermal pyrite crystals can be interpreted in two ways: (1) either sulphide was generated via different reduction pathways, or (2) there was a fluctuation between open and closed system sulphate reduction within diagenetic pore fluids during ore formation.