

Sedimentologic, Petrographic, and Sulfur Isotope Constraints on Fine-Grained Pyrite Formation at Mount Isa Mine and Environs, Northwest Queensland, Australia

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Abstract

Fine-grained pyrite is the earliest generation of pyrite and the most abundant sulfide within the Urquhart Shale at Mount Isa, northwest Queensland. The pyrite is intimately interbanded with ore-grade Pb-Zn mineralization at the Mount Isa mine but is also abundant north and south of the mine at several stratigraphic horizons within the Urquhart Shale. Detailed sedimentologic, petrographic, and sulfur isotope studies of the Urquhart Shale, mostly north of the mine, reveal that the fine-grained pyrite ($\delta^{34}\text{S} = -3.3$ to $+26.3\%$) formed by thermochemical sulfate reduction during diagenesis. The sulfate source was local sulfate evaporites, pseudomorphs of which are present throughout the Urquhart Shale (i.e., gypsum, anhydrite, and barite). Deep-burial diagenetic replacement of these evaporites resulted in sulfate-bearing ground waters which migrated parallel to bedding. Fine-grained pyrite formed where these fluids infiltrated and then interacted with carbon-rich laminated siltstones.

Comparison of the sulfur isotope systematics of fine-grained pyrite and spatially associated base metal sulfides from the Mount Isa Pb-Zn and Cu orebodies indicates a common sulfur source of ultimately marine origin for all sulfide types. Different sulfur isotope ratio distributions for the various sulfides are the result of contrasting formation mechanisms and/or depositional conditions rather than differing sulfur sources. The sulfur isotope systematics of the base metal and associated iron sulfide generations are consistent with mineralization by reduced hydrothermal fluids, perhaps generated by bulk reduction of evaporite-sourced sulfate-bearing waters generated deeper in the Mount Isa Group, the sedimentary sequence which contains the Urquhart Shale. The available sulfur isotope data from the Mount Isa orebodies are consistent with either a chemically and thermally zoned, evolving Cu-Pb-Zn system, or discrete Cu and Pb-Zn mineralizing events linked by a common sulfur source.