

An Oxygen and Carbon Isotope Study of Fluid Flow in the High-Grade Iron Ore Deposits (>63 wt % Fe) of the Southern Hamersley Province

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The carbon and oxygen systematics in the southern Hamersley province were studied to provide new constraints on the chemistry of hypogene fluids responsible for the transformation of unmineralized banded iron formation (BIF) to high-grade iron ore (>63 wt % Fe). The iron ore deposits of Mt. Tom Price and Paraburdoo have clearly defined hypogene alteration halos that form a consistent transition between unmineralized BIF and high-grade iron ore. These alteration halos extend to up to 600 m from high-grade iron ore deposits, making them a clear vector to mineralization and an exploration tool. Determining the hypogene carbonate alteration minerals from the primary carbonate minerals within the BIF is often difficult, particularly in areas distal to the orebody. A study of the carbon and isotopic values was conducted to determine if the interactions between hypogene fluids and the BIF allow differentiation of the hypogene alteration minerals and if isotopic alteration footprint surrounds the high-grade iron.

Carbon and oxygen isotope data are from regional BIF layers (n = 12) and the Wittenoom Formation (n = 15), as well as from hypogene alteration zones surrounding and underlying the Paraburdoo (n = 9) and Mt. Tom Price (n = 56) deposits. Siderite ($\delta^{13}\text{C}$; $-8.8 \pm 2.0\text{‰}$; 1σ , n = 25) and calcite ($\delta^{13}\text{C}$; $-7.2 \pm 0.6\text{‰}$; 1σ , n = 3) from distal hypogene alteration assemblages at Tom Price and Paraburdoo, respectively, show depleted $\delta^{13}\text{C}$ values compared to unmineralized BIF ($\delta^{13}\text{C}$; $-10.3 \pm 1.3\text{‰}$; 1σ , n = 12). The carbon isotope values of ankerite ($\delta^{13}\text{C}$; $-6.4 \pm 2.6\text{‰}$; 1σ , n = 31) and dolomite ($\delta^{13}\text{C}$; $-2.3 \pm 0.5\text{‰}$; 1σ , n = 6) from intermediate and proximal alterations zones at Mt. Tom Price and Paraburdoo exhibit even greater depletion compared to unmineralized BIF.

Siderite ($\delta^{18}\text{O}$; $-17.2 \pm 2.0\text{‰}$; 1σ , n = 25) and calcite ($\delta^{18}\text{O}$; $-18.1 \pm 0.7\text{‰}$; 1σ , n = 3) from distal hypogene alteration assemblages and ankerite ($\delta^{18}\text{O}$; $-16.8 \pm 2.3\text{‰}$; 1σ , n = 31) and dolomite ($\delta^{18}\text{O}$; $18.1 \pm 0.7\text{‰}$; 1σ , n = 6) from intermediate and proximal alterations zones at Mt. Tom Price and Paraburdoo show depletions similar to $\delta^{13}\text{C}$ values when compared to unmineralized BIF ($\delta^{18}\text{O}$; $-20.2 \pm 0.7\text{‰}$; 1σ , n = 12).

The progressive depletion of $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ values from unmineralized BIF to high-grade iron ore indicates progressive exchange (mixing) with an external fluid with a heavy carbon and oxygen isotope signature. More importantly, there is definable spatial distribution of the carbon and oxygen surrounding the high-grade iron ore deposits that can be used as a vector toward mineralization.