Mineralogy and Geochemistry of the Temagami Algoma-type BIF: Metal Sources and Transport Pathways

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We present a complete geochemical and mineralogical study of the different facies of the 2.74 Ga banded iron formation in Temagami, Ontario, a type locality of Archean oxide facies Algoma-type BIF. The results reveal unexpectedly large variations in detrital, hydrothermal, and seawater components in the element budget, reflecting both primary and secondary processes. The Temagami BIF is characterized by finely banded magnetite-rich, chert-rich, and chlorite-rich layers that are distinct in outcrop. However, even visually distinct red, black and white layers contain mixtures of paragenetically distinct hematite, magnetite and quartz. The chert-rich layers can be divided into (1) relatively pure quartz layers (white chert); (2) chert with very finely disseminated magnetite (black chert); (3) chert with very finely disseminated hematite and magnetite (jasper). Other lithologies related to the BIF units include black shales and volcaniclastic sandstones.

Geochemically distinct detrital igneous components (e.g., Ti, Al, Zr, and other HFSE), hydrothermal components (e.g., Eu enriched over other REE, Ca, Zn, Pb, and Sn), and mixed hydrothermal/hydrogenetic inputs (e.g., P, Ni, Mn, ±Fe, ±Si) can be identified by distinct trajectories in multi-element plots of the different facies. The purer white chert, jasper layers, and magnetite-hematite layers are interpreted to be relatively unaltered precipitates from a hydrothermally influenced water column. In these lithologies, electron microprobe analyses reveal euhedral late-stage (metamorphic) generations of magnetite are free of any detectable levels of impurities, reflecting the absence of widespread, postdiagenetic mineralization processes. Most chlorite layers contain a dominant detrital component, but some are more likely originated from direct precipitation of a hydrothermal or hydrogenetic aluminosilicate phase (e.g., nontronite) that was enriched in Co, Pb, and U by adsorption and scavenging processes. Co and Pb are also enriched in black shale units associated with the BIF, but these sulfidic lithologies interestingly lack enrichments in some redox-sensitive metals such as Mo, Re, and U. B (along with Fe, Mn, and Si) behaves remarkably, as it is significantly depleted in black shales in comparison to chlorite, chert, and magnetite layers.

The Temagami BIF is interpreted to have formed in a setting with a relatively steady precipitation of an iron-silica-rich precursor material that periodically received input from both detrital (volcaniclastic) and primary aluminosilicate (clay-rich) sources. Metal enrichment in all layers was by scavenging of metals from the hydrothermally influenced water column (or pore water) by iron(oxy-)hydroxides and clays, and in black shales by sulfides. The complex interplay of different hydrothermal, detrital, and hydrogenetic inputs argues for a dynamic but relatively contained depositional environment (e.g., a caldera), where a hydrothermally influenced water body or brine pool established an interface with the overlying marine water mass).