
**Trace-element systematics of massive sulphide deposits
in the Bathurst Mining Camp, New Brunswick:
implications for exploration**

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Massive sulphides and iron formation in the Bathurst Mining Camp are hosted within a Middle Ordovician bimodal volcanic and sedimentary sequence. Complex polyphase deformation and associated lower- to upper-greenschist grade, regional metamorphism are partly responsible for the present geometry and textural modification of these syngenetic-exhalative deposits. Despite heterogeneous ductile deformation, the hydrothermal architecture has been preserved in many deposits, with base-metal and trace-element zonation evident in massive sulphide lenses.

Major and trace elements, including rare-earth elements (REE), were determined for 212 samples of massive sulphide from 41 deposits. Overall, Σ REE concentrations average 34.0 ppm, exhibit a strong Spearman Rank correlation with Y ($r' = 0.86$), and a strong positive Eu correlation with P ($r' = 0.71$), indicating the presence of accessory minerals such as xenotime and apatite. Chondrite-normalized REE profiles for massive sulphides exhibit a consistent positive Eu anomaly (Eu/Eu^*) averaging 6.0 with values as high as 30.4, and correlating with In ($r' = 0.50$) and Sn ($r' = 0.60$).

Variations in the REE signature of exhalative sediments with respect to hydrothermal centers have been shown to be a valuable vectoring tool in the exploration for massive sulphide deposits. Strong inter-element correlations between Al_2O_3 , TiO_2 , Zr, Sc, Th, Hf, and Nb in massive sulphide samples from the Bathurst Mining Camp indicate variable detrital and pelagic input (mass change effect), which may mask low abundance hydrothermal components like the REE. Using these immobile elements as monitors, and testing Yb (HREE) immobility, the mass contribution from intercalated terrigenous sediments can be calculated, accounted for, and stripped revealing the net hydrothermal contribution to exhalative sediment. Ytterbium-based mass balanced REE data from the Heath Steele B zone reveals a strong increase in Eu/Eu^* in the proximal bedded sulphide facies with anomalies as high as $\text{Eu}/\text{Eu}^* = 1767$, due to lower HREE and LREE contents. The underlying chalcopyrite-pyrrhotite-rich zone contains higher REE contents and a smaller Eu/Eu^* (average = 18.0), likely a result of REE saturation during high temperature-low pH fluid reaction (cooling, neutralization, and exchange) during zone refining of the massive sulphide system. From an exploration standpoint, resolving the stratigraphic distribution of REE in massive sulphide deposits is beneficial for targeting hydrothermal centers.