Fingerprint of Fluid Flow in Alteration Halos Around High-Grade Hematite Orebodies

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Exploration drilling has detected occurrences of high-grade hematite ore below unmineralized banded iron formations (BIFs). Such intersections beg the question: have neighboring holes been terminated too early? Drilling additional holes to test blind ore deposits can be a costly exercise if a direct intersection is required to find an orebody at depth. Chemical alteration halos around orebodies are thus important tools to define orebody extents in mineral exploration.

Trace element chemistry is commonly used to indicate alteration by fluid-flow through a rock mass. The oxidation of magnetite to hematite and desilification of BIFs by fluid-flow give rise to high-grade hematite orebodies. Zones around hematite orebodies where BIFs and shale bands have been altered but silica was not removed show changes in the trace element chemistry that are not observed in major elements detectable by routine XRF analysis of drilling samples.

Magnetite-chert BIFs distal to hematite orebodies have overall low transition metal and rare earth element (REE) contents characterized by low Gd/Yb ratios. Oxidized hematite-(goethite)-chert BIFs show altered trace element signatures, with a general increase in ΣREE. In proximity to the contact to high-grade hematite ore, a distinct increase in light REE (LREE) and middle REE (MREE) in BIFs is observed, giving rise to an increase in Gd/Yb ratios. This is a small-scale feature that is not visible in BIF farther away from the contact with hematite orebodies. It is inferred that fluid-flow depleted adjacent shale bands of LREE and MREE and enriched these elements in the BIF. In subsequent desilification of BIF and simultaneous residual hematite enrichment, LREE and MREE are leached and give rise to high-grade hematite ore with low Gd/Yb. Further, Ce anomalies can indicate a goethite precursor to hematite due to immobile behavior of Ce once in an oxidized (Ce^{4+}) state.

The observed trace element relationships show that LREE and MREE enrichment in hematite-(goethite)-chert BIF indicates zones of fluid alteration in proximity to high-grade hematite orebodies. Thus, REE relationships, especially Gd/Yb ratios, could be used as an exploration tool to detect hidden mineralization at depth. Further analysis is currently being undertaken to test whether these observations on the small scale can be applied at the deposit and regional scale. Using trace element signatures in exploration programs has the potential for reducing the risk of misinterpreting extents of orebodies and reducing cost in drill planning.