

Alteration and isotopic vectoring at the syenite-hosted Young-Davidson gold deposit, Matachewan, Ontario

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The Young Davidson mine is a syenite-hosted orogenic gold deposit at the western end of the Cadillac-Larder-Lake deformation zone in the southern Abitibi greenstone belt, Canada. The earliest stage of veining (V_1) consists of folded and boudinaged quartz-ankerite veins. V_2 is comprised of folded quartz-pyrite veinlets and disseminated sulphides and V_3 consists of an echelon or planar quartz-carbonate veins with sulphide minerals. The major phase of Au mineralization is associated with V_2 veins. Gold occurs as inclusions in V_2 pyrite, along quartz-carbonate grain boundaries in V_3 veins and as inclusions in disseminated pyrite in zones of intense potassic-hematite alteration.

Contouring of whole rock drillcore data indicate that Au is correlated with K_2O , S and Ba, consistent with the result of core logging, which established an association of Au with intense potassic-hematite alteration, quartz veining, pyritization and decreased magnetic susceptibility. Increases of K_2O (2 to 9 wt%) and Ba (600 to 3800 ppm) and a decrease of whole rock $\delta^{18}O$ values (11.4 to 9.2 ‰) is observed for some of the mineralized zones. Thus potassic alteration and whole rock $\delta^{18}O$ contours show promise as vectors to Au mineralization likely associated with high temperature magmatic fluids.

Bulk rock XRD analysis supports the idea of different alteration zones extending from shallower to deeper parts of the deposit. In shallower parts, ankerite abundance increases and that of calcite decreases towards the zone of mineralization. In deeper parts, this distribution pattern is reversed. In terms of oxide minerals, shallow mineralization is dominated by hematite (the concentrations of rutile and barite are also high enough to be identified in XRD patterns). In the deeper zones of mineralization hematite abundance decreases and magnetite abundance increases towards the mineralized zones.

Temperatures calculated from mineral pair oxygen isotope thermometry indicate the fluids ranged from approximately 330° to 460°C. Calculated V_3 vein fluid compositions range from 6.4 to 11.9 ‰ and V_1 from 6.6 to 7.4 ‰. In the deeper zones Au mineralization is correlated to high K_2O alteration, high sulphur concentrations and low $\delta^{18}O$ values, which indicate magmatic fluid involvement. However, in shallower zones gold mineralization is consistent with high $\delta^{18}O$ values, which is interpreted that the fluids were at lower temperatures and/or dominated by metamorphic fluids reflecting a separate and possibly later mineralizing event. We conclude that there are multiple stages of Au mineralization at Young-Davidson and that $\delta^{18}O$ whole rock values, potassic alteration and sulphur concentrations can be used as vectors for mineralization within different alteration zones.

Magnetite - An indicator mineral for hydrothermal ore deposits

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Magnetite and other Fe-Ti oxides have been recognized as potential indicator minerals for exploration purposes since the 1980s. However, only recent studies have presented data that illustrate characteristic variations among magnetites of hydrothermal origin and describe distinct compositional signatures that can discriminate specific geologic settings such as hydrothermal ore deposits. The major controls for the geochemistry of hydrothermal magnetite are lithology/fluid composition, $T, fO_2/S_2$ and re-equilibration processes. Exploratory data analysis has established the following upper threshold concentrations for hydrothermal magnetite from Ag-Pb-Zn veins, porphyry Cu-Mo, and skarn deposits (Table 1). The most important overall discriminators for the minor and trace element geochemistry of hydrothermal magnetite are Mg, Al, Ti, V, Co, Mn, Zn, and Ga. Nickel and Cr, which can have significant concentrations in igneous magnetite, are not commonly present at levels above their respective detection limits. Hydrothermal magnetite is typically depleted in Ti compared to igneous magnetite. Aluminum and V display a similar trend although the overlap between hydrothermal and igneous magnetite is more pronounced for these elements. Depleted Ti and V concentrations in combination with enriched Mg contents up to wt% values are in particular characteristic for hydrothermal magnetite from magnesian skarn. Manganese concentrations vary significantly among hydrothermal and igneous magnetites but concentrations are commonly lesser in hydrothermal magnetite with values up to several 1000 ppm. Cobalt, Zn, and Ga are enriched in hydrothermal magnetite from skarn compared to other hydrothermal magnetite. In addition to minor and trace element concentrations, the occurrence, abundance and composition of inclusions in magnetite is a potential tool to discriminate magnetite sample populations and fingerprint mineral deposits. Minor and trace elements that are commonly associated with micro- or nano-inclusions in magnetite include Ca + REEs (apatite and carbonates), Si (silicates), Cu (Cu-sulfides), Nb (rutile). Copper can be particularly indicative for mineralized zones where magnetite is closely associated with Cu-sulfides such as chalcopyrite or chalcocite.

Table 1: Upper threshold concentrations in ppm for n-number of hydrothermal magnetites from a range of geological settings.

	Ag-Pb-Zn	Porphyry	Mg-skarn	Skarn
n	30	126	17	57
Mg	740	490	25810	8780
Al	900	3180	2730	11330
Ti	4160	10500	20	8820
V	170	1460	20	14190
Co	10	40	5	320
Mn	1220	1880	1600	2900
Zn	110	280	260	5470
Ga	10	60	30	600