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Evaluation of Magnetite in Stream Sediments at the Casino Porphyry Copper-Gold-Molybdenum Deposit, Central Yukon as an Indicator Mineral and Vectoring Tool

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The Casino porphyry Cu-Au-Mo deposit is hosted in Late Cretaceous quartz monzonite of the Casino suite intruding Mesozoic granitoids of the Whitehorse suite in the unglaciated Dawson Range, west-central Yukon, Canada. It is one of Canada's largest and highest-grade porphyry deposits. Research is being carried out on relationships between the composition of magnetite in stream sediments and magmatic and magmatic-hydrothermal magnetite in this well-preserved deposit. Magnetite recovered from bedrock samples of mineralized, hydrothermally altered rocks from the Casino deposit and unmineralized granodioritic and monzonitic host rocks was compared to magnetite in sediment from two streams directly draining the deposit. For comparison, magnetite from sediments in four streams not draining the Casino deposit was also compared.

Optical and scanning electron microscopy, electron probe microanalysis (EPMA), and laser ablation-inductively coupled plasma mass spectrometry (LA-ICP-MS; "LA") were used to determine physical and chemical properties of igneous and magmatic-hydrothermal magnetite in polished thin sections, thick sections, and epoxy grain mounts. Data were acquired from 90 EPMA spot analyses from thick sections, 608 LA analyses of thick sections and grains from disaggregated bedrock samples, and 915 LA analyses of magnetite grains (0.25-2.0 mm) in grain mounts from six stream sites (1,523 total LA analyses). Spot analyses of magnetite from two bedrock samples containing igneous magnetite and one sample containing magmatic-hydrothermal magnetite, supported by petrographic observations, were compared with magnetite grains recovered from stream sediments using a variety of statistical and graphical methods.

Significant geochemical variability in magmatic-hydrothermal magnetite exists within the potassic alteration zone of the Casino deposit. Relatively low Ti, Al, and Mg concentrations in magmatic magnetite from the Casino deposit, compared with recent studies of similar deposits, are attributed to sub-solidus re-equilibration during cooling. A plot of Ti versus Ni/Cr (Fig. 1) is used to discriminate magmatic-hydrothermal magnetite from the potassic alteration zone and igneous magnetite from granodiorite and quartz monzonite hosting the Casino deposit.

A small number of studies have considered the chemistry of magnetite recovered from glacial sediments as a vector for porphyry copper deposits, but few, if any, have examined the chemistry of magnetite in stream sediments to detect porphyry copper deposits in Canada. The elements Mg, Al, Ti, V, Mn, Co, Cr, Ni, Cu, Ga, and Ge are used to discriminate between magmatic-hydrothermal and igneous magnetite using linear discrimination analysis and binary discriminant diagrams. Magmatic-hydrothermal magnetite from the potassic alteration zone at Casino is identifiable in streams draining the deposit. A detectable level of Cu in the magmatic-hydrothermal magnetite, present as inclusions or substituting in the cubic lattice, is a strong indicator of Cu mineralization. This approach may be of practical use in the exploration for porphyry systems in Canada.

Fig. 1. Ti versus Ni/Cr plot effectively separates igneous magnetite in granodiorite (red) and quartz monzonite (green), and magmatic-hydrothermal magnetite in contact breccia (blue) (modified from Dare et al., 2014). Point attributes (colour and shape) are based on linear discriminant analysis classifications. Re-equilibration of granodiorite during cooling reduces Ti concentrations in magnetite.