Trace Element and Gold Content and Speciation in Pyrites: Insights into Metal Mobility and Gold Mineralization at the Dome Mine

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Gold in orogenic systems is commonly associated with pyrite mineralization and pyrite trace element content provides insights into hydrothermal fluid chemistry, metal content and mobility, and gold mineralization. Synchrotron X-ray spectroscopy provides non-destructive, micron scale trace element analysis and mapping of ore and alteration minerals with ppm detection limits by uXRF (micro-X-ray fluorescence), and speciation information using XANES (X-ray absorption near-edge structure) spectroscopy. These techniques have been applied to samples from the Dome mine in Timmins, Ontario, Canada to reconstruct the mineralization history of the deposit and provide insights into mineralizing mechanisms. There are multiple generations of veining at the Dome mine and gold is intimately related to pyrite mineralization, however, the geochemical fingerprint of gold and fluid events, and the nature of refractory gold, was not well understood.

uXRF mapping of pyrites identified 3 distinct fluid events with consistent variability in trace element and gold content. The earliest stages of mineralization are enriched in metals and metalloids such as Cu, As and Ni, with respect to main stage mineralization. These enrichments are observed both as inclusions in early pyrite cores, and in growth haloes. Additionally, the gold in each event has variable trace element content, and by using the fundamental parameters based spectral deconvolution (fitting) and dynamic analysis capabilities of GeoPIXE™, quantitative composition analysis for individual mineral grains can be ascertained. Invisible/refractory gold was identified by uXRF and was correlated with As content using SIMS which identified nano-inclusions of gold, and potential lattice bound gold. However, using XANES analysis, Au was identified as metallic. Together, this supports a predominantly inclusion style of metallic nano-Au incorporated into arsenian pyrites rather than lattice bound Au.

Unlike with conventional geochemical analysis, we applied uXRF and XANES to whole rock samples at the beginning of the workflow. This is a paradigm shift in the application of high-resolution techniques and provides a new framework for investigating mineralizing fluids and depositional mechanisms.