

Using In Situ Mineral Chemistry to Extend the Detectable Lithogeochemical Footprint of Magmatic Sulfide Orebodies

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In magmatic sulfide systems, mineral chemistry helps infer ore-forming processes, such as sulfide melt segregation in silicate magma. However, no chemical traits have been established that empirically link mineral chemistries with proximity to sulfide orebodies. Consequently, mineral chemistries are yet to offer compelling guidance towards sulfide accumulations at the prospect scale. Using the Nova-Bollinger Ni-Co-Cu deposit, this research interrogates ferromagnesian silicate chemistry to identify inter- and intra-mineral traits that plausibly reflect interaction with sulfide melt. Mineral chemistries are contextualized with automated mineralogy, synchrotron-based element mapping, and bulk-rock geochemistry.

In the studied ferromagnesian silicates, ratios of first row and post-transition metals differ in sulfide-bearing rocks and weakly correlate with orebody proximity (as computed using three-dimensional geological models). For example, the Co/Mn values of olivine and poikilitic orthopyroxene are consistently lower in sulfide-bearing samples and their Ni/Co values broadly increase with orebody proximity. The Co/Pb values of poikilitic clinopyroxene and symplectic hornblende are also distinctly lower in sulfide-bearing samples. These ratios in minerals comprising sulfide-free samples display strong positive inter-mineral correlations; however, they deviate from linearity in sulfide-bearing samples. For example, Ni/Co values of peritectic orthopyroxene are lower for given Ni/Co values of reactant olivine in sulfide-bearing samples.

Thermodynamic modelling is being utilized to distinguish traits that cannot be explained by magmatic differentiation or contamination, highlighting patterns that plausibly reflect direct interaction with sulfide melt and which may be translated into predictive exploration tools. Comparable datasets from regional magmatic sulfide occurrences—together with published data and an in-house global database—are being interrogated to assess whether these signatures can robustly indicate interaction with sulfide melt. By first identifying prospective traits in situ and then validating their relevance at other sites, the approach aims to enable both confident recognition of indicative signatures in ex situ minerals and apply them in situ as prospect-scale orebody vectors.