Mafic-Ultramafic Ore Systems: From Genetic Insights to Exploration Tools

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Our research group focuses on translating recent advancements in our understanding of genetic processes at play within mafic-ultramafic magmatic ore systems into practical exploration tools and workflows.

At the terrane-to-camp scale, we are developing methods to utilize indicator mineral chemistry for assessing the prospectivity of intrusive complexes. Spinel, olivine, and pyroxene chemistries can inform: 1) the nature of the host rock, 2) the potential assimilation of crustal material by the melt, 3) segregation and interaction with immiscible sulfide melt, and 4) overall dynamism of the magmatic system. To enhance prospectivity analysis and target ranking, we have begun implementing machine learning models using olivine and spinel composition as a starting point, testing those models at the terrane scale on data from Geoscience Australia's heavy mineral map, and at the camp scale on samples from industry partner's exploration projects.

At the prospect scale, our approach integrates experimental high-P&T petrology and analogue fluid dynamic modelling to deepen our understanding of these ore systems. Through high-pressure, high-temperature experiments, we are refining the role of volatiles in genetic processes for magmatic sulfide ores. This is leading to the identification of potentially prospective mineral chemistries such as halogens and other trace element contents in apatite, indicative of the presence of volatiles, favorable to the generation of high tenor sulfides and high-grade systems. Analogue experiments provide insights into sulfide transport, coalescence, and accumulation. We are now identifying specific characteristics, such as sulfide droplet size distributions and distinct sulfide textures, linked with mineralising processes such as sulfide percolation, and used to vector towards massive sulfide accumulations.

Finally, one objective is developing distance-to-ore machine learning models at the deposit scale. These models integrate whole-rock geochemistry, modal mineral proportions, and mineral chemistry - potentially incorporating sulfide size distributions - to enhance exploration efficiency and improve targeting accuracy.