Unconventional Magmatic Sulfide Systems: Looking Outside of the Box for the Next New Ni-Cu-Co-PGE Discovery

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Magmatic Ni-Cu-Co-PGE sulfide deposits are the world's major source of battery-grade Ni and PGEs and important contributors to global Cu and Co resources. As such, the discovery and development of these deposits is critical to the energy transition. Magmatic sulfides are hosted by mantle-derived mafic-ultramafic intrusions and can occur at any level in the crust. Established models for their genesis, which thus provide direction for exploration models, are focussed on (1) a craton margin association for many Ni-rich deposits; (2) an intracratonic setting for PGE deposits; (3) the importance of plumes and extensional regimes for both; and (4) moderate to high (>15%) degrees of partial melting of dry, olivine-rich peridotitic source rocks. However, many deposits do not conform to these criteria, and there are a significant number of deposits in orogenic settings formed in more alkaline and hydrous magmas that were sourced from relatively lower degrees of partial melting. The role of metasomatized, hydrous mantle assemblages containing phlogopite is highlighted here, as an important source to magmatic sulfide systems in a wider range of geotectonic settings. A number of global examples of more unconventional deposits are explored to illustrate the variable characteristics of magmatic sulfide deposits formed from hydrous and carbonated pyroxenitic rather than peridotitic mantle sources, emplaced throughout the entire thickness of the continental crust. By identifying greater variability in the components of the Ni-Cu-Co-PGE mineral system, search spaces can be expanded, and the next new discovery could be outside of traditional, established Ni camps.