Geodynamics Control the Variability of Magmatic Ni-Cu-PGE Sulfide Mineral Systems Through Time

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Conventional models for the magmatic Ni-Cu-PGE sulfide mineral system emphasise the requirement for a large heat driver to sufficiently melt enough mantle peridotitic olivine to liberate Ni into the resultant melts. Recent work, however, has shown that hydrous, metasomatized mantle can also produce Ni-rich melts but at lower temperatures. Based on this understanding, we have identified evidence of diverse mantle source compositions and melting dynamics in the variable chalcophile metal signatures of magmatic Ni-Cu-PGE deposits through time. Through Earth history, the metal signature of magmatic sulfide systems evolves, with mostly high temperature melting events producing Ni- and PGE-dominant deposits >1.8 Ga, associated with large igneous provinces (LIPs). Conversely, from 1.8 Ga onwards, low temperature melting of hydrous mantle becomes more common, forming dominantly Ni- and Cu-dominant rich deposits that are characteristically poor in PGE, and have no spatial or temporal link with LIPs. We interpret these secular changes to be a function of: (1) a cooling mantle from the Archaean to the present; (2) varying compositions of mantle as a product of a spectrum of mantle metasomatism processes; (3) the mineralogical deportment of chalcophile metals in mantle rocks; and (4) the variety of thermal triggers to melt such assemblages. We provide a predictive capacity to assess the relative metal fertility of mafic-ultramafic systems through time.