Highly siderophile element enrichment in native-Fe basaltic ores

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Native-Fe is an uncommon phase in terrestrial rocks due to prevailing oxidizing conditions; however, native-Fe-bearing basaltic intrusions are known to occur in three localities: 1) Siberian trap intrusions, 2) Disko Island (Greenland), and 3) Bühl basalt (Germany). The presence of native-Fe within these basaltic rocks indicates formation conditions at abnormally low fO_2 for basalitc magmas, below the IW buffer.

We present new LA-ICP-MS, platinum group element (PGE), and trace-element data for native-Fe basalitc ores of the Dzhaltul intrusion, Siberia, in order to constrain the formation of these unusual PGE-rich ores. The Dzhaltul intrusion formed contemporaneously with the Noril'sk Ni-Cu-PGE sulfide ore deposit. The Dzhaltul native-Fe ores are composed of ~50 vol.% metal, in decreasing order of abundance: kamacite (FeNi), cohenite (Fe_3C), native copper (Cu), and minor troilite (FeS). Kamacite is the dominant carrier of PGEs with concetrations (ppm) of approximately: Pt-6.0; Pd-20.0; Os-1.5; Ir-1.0. Kamacite also contains high Sb, Sn, and Ge contents. In contrast, chalcophile elements (e.g., Au, Ag, Sn) are dominantly contained in native copper.

In typical Noril'sk-style sulfide-rich deposits, PGE enrichment of the parent magma is interpreted to occur in lower crustal staging chambers, due to the assimilation of crustal material and resultant formation of immiscible sulfide liquids. We present a model for PGE ore formation, whereby PGE-rich magmas in the upper crust assimilate carbonaceous material, effectively reducing the magmatic fO_2 to below the IW buffer. Siderophile elements partition into the metal phase, producing highly siderophile- and chalcophile-enriched, but sulfide-poor basaltic ores. The necessity for carbonaceous material in ore-forming processes provides important temporal and stratigraphic constraints, which will benefit future PGE exploration efforts.