Noble metal enrichment in the crust through hydrous boninitic melts

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Kamchatka and West Bismarck peridotites from the sub-arc lithospheric mantle preserve percolation of low-Ca boninite melts as orthopyroxene and sulfide-rich veins. Noble metals (platinum group elements [PGE], Au and Ag), Re and base metals in bulk peridotites and veins, combined with *in-situ* analyses of sulfides, show these low-Ca boninites have exceptionally high PGE abundances (e.g., 0.5-1.5 ppb Ir), which are close to those in komatiites. These features originate from hydrous melting of PGE-rich harzburgites at high temperature (≥1400°C) and high oxygen fugacity. Detailed documentation (SEM and EPMA mapping, LA-ICPMS analyses) of the vein sulfides reveal the early precipitation of refractory Os-Ir alloys.

The mantle veins are 10 to 1000 times enriched in I-PGE at similar P-PGE abundances relative to erupted boninites and boninitic crustal cumulates from Kamchatka. This outlines the role of primary nuggets and possibly Fe^{3+}-rich spinels in scavenging I-PGEs at the earliest crystallization stages of the boninitic liquid. Indeed, Cr contents measured in primitive (≥15 wt.% MgO) melt inclusions are very high (≥0.3 wt.% Cr_2O_3), and oxidized Cr-spinels are abundant in the veins. Low-Ca boninite veins have U-shaped REE patterns formed from melt-rock interaction in the mantle, together with high abundances of most incompatible lithophile elements (Cs, Rb, Ba, Th, U). Both anhydrous and hydrous minerals have much higher F and Cl contents in the veins than in the host peridotites, likely related to amphibole breakdown during re-melting of refractory harzburgites.

The high Cr, U-shaped REE patterns and F-Cl-rich hydrous minerals, along with elevated noble metal abundances, are distinctive features of economic reef horizons in massive layered intrusions, such as Bushveld or Stillwater. We suggest formation of these reef horizons involved low-Ca boninite liquids derived from re-melting of Si-rich, shallow sub-continental mantle lithosphere, typified by refractory, orthopyroxene-rich spinel harzburgite.