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Sulfur Diffusivity in a Hydrous Alkali Fluid with Implications for PGE Reef Formation

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The Platinum Group Elements (PGE) are vital in today's economy for their catalytic properties and high melting points. While concentrations of platinum are ~10 ppb in basaltic melts, PGE reefs in layered mafic intrusions can reach 10 ppm. How these PGE-rich sulfide associated layers form remains debated. Existing models to explain reef formation involve sulfide settling, magma mixing, or concentration by secondary fluids.

Previous experimental work demonstrated that base metal sulfides placed within a fixed temperature gradient between 1100 °C and 870 °C migrated to the location of sulfide phase saturation and formed a discrete layer ~1050 °C [1]. Because sulfide/silicate melt partition coefficients for Pt are generally 10^5-10^6 [2], similar movement of sulfide through a crystal mush during top-down emplacement of a layered intrusion could concentrate PGE by a factor of 1000, forming economic reefs.

New temperature gradient experiments in an olivine and orthopyroxene aggregate dopped with 10 percent hydrous $Na_2Si_2O_5$, and 1 percent PtS have been conducted to test if PGE diffusion occurs within a temperature gradient. An experiment performed in a sealed 4 cm silica tube within a temperature gradient of 1052-1077 °C for 24 hours was analyzed by LA-ICP-MS. Results from this experiment show the formation of a prominent PGE layer occurring at 1068 °C. We performed additional experiments to measure sulfur and PGE diffusion coefficients within hydrous $Na_2Si_2O_5$, and measured diffusion rates exceeding $4x10^{-6}$ cm^2/s through the liquid. High diffusivity of sulfur in a hydrous alkaline medium can explain experimental results in a temperature gradient and argues that within a simple top-down emplacement process where sills accumulate at 1mm/yr, a reaction zone would be present that can diffuse sulfur, concentrate PGEs, and build an economic reef.

We will use geochemical and thermodynamic modeling using iridium, PetThermo tools, and Energy 2D to illustrate how a top-down continuous sill emplacement model can reproduce observed economic PGE distributions found within many layered mafic intrusions.

[1] C. C. Lundstrom & N. Gajos, (2014), *Economic Geology* 109,1257-1269.

[2] J. E. Mungall & J. M. Brenan, (2014), *Geochimica et Cosmochimica Acta* 125, 265-289.