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Multiple stages of platinum-group element deposition in alkalic Cu-Au porphyry systems in the Canadian Cordillera, and links to mafic magmatism

A lecture by GAC Howard Street Robinson Lecturer 2013/2014

Jacob Hanley

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Event Details:

Where:	UBC Robson Square, C300 theater, 800 Robson Street
When:	February 4th, 2014, 4 pm
Cost:	Free (GAC-CS; SEG student chapter, UBC; and MDRU invite)

Additional talk on February 3rd, 2014, at 3 pm in ESB building Room 5104, University of British Columbia Campus

The origin and role of volatiles in the formation of magmatic Ni-Cu-platinum-group element deposits:
What have we learned from fluid and melt inclusions?

Multiple stages of platinum-group element deposition in alkalic Cu-Au porphyry systems in the Canadian Cordillera, and links to mafic magmatism

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Whereas a genetic model for Cu-Au enrichment in porphyry and epithermal deposits is well established, the factors controlling PGE enrichment in porphyry-epithermal deposits in alkalic settings are not well characterized. Once the PGE introduced into a fluid phase, the thermochemical conditions (e.g.,pH, fO_2) in these environments are often ideally suited for efficient PGE transport by chloride complexation. However, the processes that govern PGE precipitation, and the mechanisms responsible for enrichment of PGE in porphyry magmas and their parental melts from which PGE-enriched magmatic volatiles must ultimately separate, are not well characterized. Direct evidence from rocks for the transfer of PGE from source region to the crust via the interaction of silicate melt, sulfide melt and volatile phases is lacking.

Studies in alkali porphyry systems in the Canadian Cordillera show that bulk rock correlations between the PGE, Cu and Au in porphyry ores are only the result of a spatial coincidence of the sites of deposition of PGE phases and Cu-Au phases (i.e., ore-forming hydrothermal fluids of differing origin or timing accessing common structures). Deposition of PGE occurred in (i) early-stage Co-Ni-rich pyrite with near-mantle S isotope compositions and (ii) as discrete Te-Bi-As-Hg mineral inclusions in later (epithermal) stage pyrite-quartz-carbonate veins. Pyrite as the dominant host phase has particular significance to exploration and mineral processing, because it is discarded during processing and is not routinely assayed, suggesting that the global PGE resources reported for porphyry and epithermal deposits are misrepresentative. Fluid boiling and the partitioning of Pd (along with B, Au, As, Sb) into low density vapour were primary controls on the mass transfer of Pd to epithermal veins from cooling porphyry magmas. PGE precipitation in epithermal veins occurred due to aqueous bisulfide depletion associated with pyrite deposition, or bisulfide dilution associated with mixing of condensed vapours with heated groundwater.

Silicate melt inclusions in leucite- and pyroxene-rich mafic sills and dykes coeval with porphyry stocks have Pd/Pt ratios identical to bulk porphyry stage ores, and Pd contents (up to 400 ppb dissolved in silicate melt) much higher than previously expected for typical alkalic arc magmas. The results provide direct evidence that highly-oxidized, foid-normative ankaramitic magmas contributed the PGE to porphyry-stage magmas, either through direct fractionation and/or mixing with felsic liquids resulting in hybrid porphyry magmas, or through secondary alteration of these mafic intrusions (and remobilization of PGE from volcanic products) adjacent to coeval porphyry stocks. In some cases, high Pd/Pt ratios observed in the ores are suggested to reflect a primary source magma composition, and not secondary metal fractionation related to selective fluid/melt partitioning, contrasting solubilities of Pd vs. Pt in ore fluids, or contrasting efficiency of metal precipitation. Evidence for the resorption of Cu-Au-PGE-rich sulfide melt into porphyry source magmas is also seen; sulfide melt inclusions are abundant within amphibole xenocrysts in alkalic porphyry rocks that are mineralized, have Au/Pd, Au/Ag, and Cu/Au ratios identical to bulk ores, and were sourced from either cumulate residues in the mid-lower crust or hydrous, mafic alkalic magma reservoirs containing amphibole cumulates.