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The perspective use of halogen ratios in porphyry ore-fluids to trace the evolution of underlying magma reservoirs

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The genesis of giant porphyry-type Cu-(Mo-Au) ore deposits require the extraction of metals from hundreds to thousands of cubic kilometers of magma. Driven by our ever- increasing understanding of the architecture of crustal magma reservoir systems, the classic model of magmatic-hydrothermal ore genesis assuming fluid extraction from a crystallizing single upper crustal magma chamber needs to be updated. The emplacement depth of magmas serving as a fluid source, the timing of fluid exsolution, and the role of magma rejuvenation and/or fluid fluxing are intensely debated questions with significant impact on ore genetic models.

Here we propose the use of Br/Cl and iodine/Cl ratios as measured by LA-ICP-MS in primary magmatic fluid inclusions in high-temperature quartz veins deposited by feeder fluids to porphyry ore systems to trace the progress of fluid exsolution and fluid fluxing events in the underlying magma reservoirs. To facilitate this, we conducted experiments to determine the fluid/melt partition coefficients of Cl, Br and iodine over a broad range of pressure (*P*) – temperature (*T*) conditions and fluid and silicate melt compositions (X) to allow the construction of fluid/melt partitioning models applicable to the *P*-*T*-X range relevant to arc magmatism. The experiments were conducted by using rapid-quench externally heated pressure vessel and piston cylinder apparatuses, and the composition of the equilibrium fluid was determined by mass balance. The results show significantly increasing halogen partitioning into the fluid phase with increasing fluid salinity, pressure and melt polymerization, decreasing temperature, and importantly, with increasing halide ion radius. Models predicting the fluid/melt partition coefficients of the 3 studied halogens with typically less than 20% mean absolute percentage error over the studied range of *P*-*T*-X conditions (760 – 1000 ºC, 120 – 830 MPa, from basalt to rhyolite and low-salinity to hypersaline fluids) have been constructed. Using these to simulate magma degassing scenarios at crustal depths shows that Br/Cl and I/Cl ratios in the magmatic fluids are sensitive indicators of the progression of crystallization-driven degassing and the potential fluxing of the upper crustal reservoirs with deep fluids.