Chlorine partitioning between granitic melt and C-O-H-Cl aqueous fluids in the Earth's upper crust, and implications for magmatic-hydrothermal ore genesis

YING-JUI HSU[1], ZOLTAN ZAJACZ[2], PETER ULMER[1], AND CHRISTOPH A. HEINRICHA[1]

[1] Institute of Geochemistry and Petrology, ETH Zurich, Clausiusstrasse 25, Zurich, Switzerland; ying-jui.hsu@umu.se

[2] Dept. of Earth Sciences, University of Toronto, 22 Russell St., Toronto, ON, Canada

Carbon dioxide (CO_2) is one of the most abundant volatile components in magmas after H_2O along with S and Cl, which are of great importance to the extraction of the trace metals into magmatic-hydrothermal fluids and their precipitation as ore minerals. Yet the effect of CO_2 on the partition coefficients of chlorine between water-rich fluid and melt, [$D_{Cl}^{(f/m)}$], is still poorly constrained. We conducted a set of experiments to constrain the effect of CO_2 on $D_{Cl}^{(f/m)}$ by equilibrating felsic silicate melts with aqueous NaCl-bearing fluids while varying the concentration of CO_2 at pressures between 120 and 300 MPa and at temperatures of 850 and 1000 °C. The results demonstrate that the addition of CO_2 into aqueous metal chloride-bearing fluids induces a pronounced drop in $D_{Cl}^{(f/m)}$, the extent of which is only weakly affected by pressure, temperature and fluid salinity, at least at relatively low Cl concentrations (<12 wt% NaCl equivalent).

The presence of CO_2 suppresses fluid salinity at a given chloride content of a granitoid melt, which will also hinder the extraction of chloride-complexed ore metals (e.g. Cu, Pb, Zn, Mo, and Ag) into magmatic fluids, reducing the likelihood of base-metal ore formation (e.g. porphyry copper deposits) from such fluids in the uppermost crust. On the other hand, the highly volatile components CO_2, H_2S and SO_2 are enriched in magmatic fluids exsolving early during the ascent of hydrous magmas. Chloride suppression by CO_2 and enrichment of fluids in sulfur species near the SO_2/H_2S predominance boundary favors extraction of sulfide-complexed metals, notably Au as $Au(HS)^0$, $Au(HS)_2^-$, $NaAu(HS)_2^0$ or $Au(HS)S_3^-$ into low-salinity magmatic fluids. Such fluids resemble those forming mid-crustal lode gold deposits that are typically poor in base metals. Our experimental results may therefore be taken as indirect support for a magmatic component in fluids forming orogenic lode gold deposits.