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 HSU1, ZOLTAN ZAJACZ2, PETER ULMER1, AND CHRISTOPH A. HEINRICH1

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 (CO2) is one of the most abundant volatile components in magmas after H2O 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 CO2 on the partition coefficients of chlorine between water-rich fluid and melt, [DCl(f/m)], is still poorly constrained. We conducted a set of experiments to constrain the effect of CO2 on DCl(f/m) by equilibrating felsic silicate melts with aqueous NaCl-bearing fluids while varying the concentration of CO2 at pressures between 120 and 300 MPa and at temperatures of 850 and 1000 °C. The results demonstrate that the addition of CO2 into aqueous metal chloride-bearing fluids induces a pronounced drop in DCl(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 CO2 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 CO2, H2S and SO2 are enriched in magmatic fluids exsolving early during the ascent of hydrous magmas. Chloride suppression by CO2 and enrichment of fluids in sulfur species near the SO2/H2S predominance boundary favors extraction of sulfide-complexed metals, notably Au as Au(HS)0, Au(HS)2-, NaAu(HS)20 or Au(HS)S- 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.