Magmatic Cu-Mo Partitioning: Influence of $\sum$Cl, fO$_2$, and fS$_2$

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A critical step in the formation of porphyry Cu-Mo-Au deposits is the efficient extraction of the ore metals from the magma by exsolving magmatic volatile phases (MVPs). For more than 30 years experiments have been improving our understanding of the physical-chemical controls on this partitioning. This work has highlighted the critical importance of the salinity of the fluids (represented by the $\sum$Cl)[1][2][3] and the presence and speciation of sulfur (controlled by both the fS$_2$ and fO$_2$)[2]. We have combined these factors by conducting new experiments and incorporating data from existing studies to examine Cu-Mo partitioning into MVPs at salinities covering the range from 1wt% to greater than 70wt%, including vapors, brines and supercritical fluids.

Using this combined data set we have established a quantitative correlation between D$_{Cu}$ and $\sum$Cl in MVPs across a wide range of exsolution conditions, which highlights the dominance of (Na,K,H)$^+$[CuCl$_2$]$^-$ with secondary effects of CuCl^0 and changes in aH$_2$O. We will present a refined equilibria equation that defines D$_{Cu}$ as a function of $\sum$Cl in terms of all three of these factors. In addition, our combined dataset suggests that Mo partitioning is also influence by $\sum$Cl with a prevalence of (Na,K,H)$^+$[MoO$_3$Cl]$^-$ or similar mono-chloride complex controlling D$_{Mo}$.

Our new study also examines the role of H$_2$S as well as SO$_2$ through controlled fO$_2$. Similar to previous experiments, our new data suggests that H$_2$S will increase D$_{Cu}$ for vapor by a factor of ~3 and brine by a factor of ~2, resulting in a small shift of Cu partitioning towards vapor. However, under no conditions does Cu prefer vapor over a coexisting brine. Furthermore, increased partitioning is limited by consideration that these enrichments only occur at sulifde satuation in the MVPs. Our data confirms that when fS$_2$ is low, or when SO$_2$ dominates the sulfur speciation, there is no discernable effect of S on D$_{Cu}$. Thus, for oxidized sulfurous volatile exsolution D$_{Cu}$ will remain controlled by $\sum$Cl. Magmatic Mo partitioning shows no increase with H$_2$S, though D$_{Mo}$ does increase with fO$_2$, as a result of the oxy-hydroxy nature of the Mo complexes. This new combined dataset, provides a means to model Cu and Mo exchange between silicic melts and a range of MVP compositions based upon their bulk chemistry and/or exsolution conditions.

[1] Candela and Holland (1984) GCA 373-380 [2] Simon et al. (2006) GCA, 5583-5600 [3] Tattitch et al. (2015) GCA, 81-99 [4] Ulrich and Mavrogenes (2008), GCA, 2316-2330