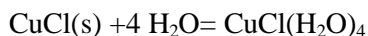


AN EXPERIMENTAL STUDY OF COPPER(I) CHLORIDE SOLUBILITY IN WATER VAPOR AT TEMPERATURES FROM 360°C TO 400°C AND WATER VAPOR SATURATED PRESSURE. Z. Xiao¹, A. E. Williams-Jones¹, and C. H. Gammons², ¹Department of Earth and Planetary Sciences, McGill University, Montreal, Quebec, H3A 2A7, Canada (zhifeng@eps.mcgill.ca), ²Department of Geological Engineering, Montana Tech of the University of Montana, Butte MT 59701, USA.

The solubility of $\text{CuCl}_{(s)}$ in vapor was measured in a vapor-saturated $\text{H}_2\text{O-NaCl-HCl}$ (NaCl/HCl ; 9:1) system at temperatures ranging from 360 to 400°C and total chloride concentration from 0.01 to 5 m. For experiments at 360°C, $\text{CuCl}_{(s)}$ was dissolved directly into the liquid. At higher temperatures (380°C and 400°C), $\text{CuCl}_{(s)}$ was separated from the liquid by a quartz glass tube, but reacted with vapor. Foils of metallic copper were added as a redox agent.

At 360°C, the experiments measure partitioning between liquid and vapor, and the copper concentration in vapor is controlled by its concentration in liquid. Data collected from these experiments show that the copper solubility in vapor is independent of the total chloride concentration in the liquid or the vapor density. This indicates that copper is dissolved as $\text{CuCl}_{(v)}$ in the vapor phase and thus the partitioning can be described by the reaction: $\text{CuCl}_{(aq)} = \text{CuCl}_{(v)}$. The equilibrium relationship for this reaction can be represented as $K_C \approx m_{\text{CuCl}_{(v)}} / m_{\text{CuCl}_{(aq)}}$, where $m_{\text{CuCl}_{(v)}}$ and $m_{\text{CuCl}_{(aq)}}$ are the concentrations of CuCl in vapor and CuCl^0 in liquid, respectively, and the log K_C at 360°C is about -2.65.

At 380°C and 400°C, the experiments measure solubility in saturated vapor. The copper concentration correlates negatively with total chloride concentration. As data from Bischoff [1] on the $\text{NaCl-H}_2\text{O}$ system show that increasing the NaCl concentration will decrease vapor density, it is believed that copper solubility in the vapor is controlled mainly by vapor density through the following reaction:



Following Armellini and Tester[2], the equilibrium relationship for above reaction can be written scribed as $K_C \approx m_{\text{CuCl}_{(v)}} / d_{\text{H}_2\text{O}(v)}^4$, where $m_{\text{CuCl}_{(v)}}$ is

the molality of copper in the vapor phase and $d_{\text{H}_2\text{O}(v)}$ is the density of water vapor. The log K_C values for these experiments at 380 and 400°C are 0.22 and 1.17, respectively.

The partition coefficients for copper between vapor and liquid were calculated for the $\text{CuCl-NaCl-HCl-H}_2\text{O}$ system at 400°C and water vapor saturated pressure at NaCl concentrations from 0.5 to 2.3 m and a HCl concentration of 0.001 m. The results indicate that the partition coefficients for copper are nearly identical to those of sodium under the same conditions(c.f. [1]). This suggests that NaCl partitioning data can be used to estimate Copper (I) Chloride partition coefficients at conditions for which no data for copper are available.

The partition coefficients referred to above have been used to predict copper concentration in a simple system where $T=400^\circ\text{C}$, $p=500$ bars, pH was fixed by muscovite-K-feldspar-quartz, f_{S_2} and f_{O_2} were fixed by the assemblage pyrite-magnetite-hematite, $\text{NaCl/KCl}=4$, and the total chloride concentration was up to 2.5 m. With the help of a modified Eq3/6 computer program, we have estimated that about 0.002 m copper will be transported by the vapor. Partition coefficients decrease with increasing salinity, due to the increase in the solubility of copper in the liquid phase. However, copper solubility in the vapor changes little as the total chloride concentration increases from 0.5 to 2.5 m. This suggests that even in a system with very high salinity, such as a porphyry copper, the concentration of copper in vapor could be high enough for vapor to transport appreciable copper.

References: [1] Bischoff J. L. (1991) *Am. J. Sci.*, 291, 309-338. [2] Armellini F. J. and Tester J. W. (1993) *Fluid Phase Equilibria*, 84, 123-142.