The solubility of copper in hydrous rhyolitic melts: The effects of oxygen, chlorine and sulfur.

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Porphyry-Cu deposits are unquestionably linked to subduction zone (arc) magmas. Yet the source magmas for these deposits remain unclear, despite recognition that arc-magmas are water-bearing and relatively oxidised. This study focuses on understanding some of the chemical parameters that may affect the solubility of Cu in hydrous melts using experimental petrology. In particular, the effect of oxygen fugacity and Cl and S content of the melt was investigated.

The experiments were conducted in an internally-heated pressure vessel where the oxygen fugacity is controlled by the addition of H_2 to the Ar pressure medium. The sample charges consisted of powdered synthetic glass of rhyolitic composition containing water (7wt%) and various amounts of NaCl or a S-bearing phase (FeS or $CaSO_4$ depending on fO_2). The samples were sealed in welded AuCu capsules and run at 4 kbars and 800ºC and 900ºC for up to 10 days. 12 samples can be run simultanously in the same vessel enabling the P,T and fO_2 conditions to be identical for each sample. The fO_2 was checked using solid Ni-Pd and Co-Pd sensors. The fO_2 ranged from NNO-1 to approx. NNO+3; the Cl contents varied from O to 9000ppm at 900ºC, and O to 6500ppm at 800ºC; the S content in the melt was very low for all runs, typically <80ppm.

Results show that although there is a very slight positive correlation between Cl and Cu, Cl does not appear to play a dominant role in the solubility of Cu. The main control on Cu solubility is oxygen fugacity, which correlate linearly, Cu increasing with fO_2. The oxidation state of Cu in these experiments can be determined using the reaction $\log aCuO_n^{glass} = n/2 * \log fO_2 + C$, where 2n is the valence of dissolved Cu. A slope of 0.25-0.30 suggests dissolution as a Cu_2O-like compound where Cu is present as Cu^+. This explains the strong correlation between oxidised magmas and porphyry-Cu deposits.

The solubility of S was too low to be varied significantly within detection limits and excess sulfur was found to form a discrete sulfide phase. At lower oxygen fugacities (approx. NNO-1) it consists of a Cu-Fe-S phase, whereas at higher oxygen fugacities (up to NNO+3) a Cu-S phase precipitates. This is contrary to the expectation that at high oxygen fugactities sulfide is no longer stable and suggests that Cu greatly expands the stablity field of sulphide liquids.