Cu and Fe diffusion in rhyolitic melts during chalcocite “dissolution”

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Porphyry-type ore deposits account for about 60% of world’s copper [1]. In order to understand the formation of porphyry ore deposit systems, much work has been done on melt inclusions and partitioning, but almost no Cu diffusion data are available (except one study in dry sodium silicate melt [2]) to understand the transport of Cu during sulfide segregation and vapor phase exsolution. In this study, we investigate chalcocite “dissolution” in rhyolitic melts to obtain Cu diffusivities as a function of temperature and water content.

Piston cylinders experiments were carried out by placing a chalcocite (Cu_2S) wafer in contact with a rhyolitic glass cylinder. This experimental design was aimed at obtaining both Cu and S diffusivities by dissolving chalcocite into the silicate melt. The experiments however show that S was retained inside the sulfide phase while Cu diffused into the silicate melt and Fe diffused into the sulfide. Hence, the process is better described as “metal exchange” instead of “crystal dissolution”. Experiments were carried out at 750 to 1400 ºC and 0.5 to 1 GPa. Six different rhyolites with H_2O concentrations from 0.1 to ~6 wt% were used to study the effect of water content on diffusivities. Cu concentration profiles were measured by both EMPA and LA-ICP-MS.

Cu diffusivities are very high, between those of Na and K, and about 2 orders of magnitude higher than those of Fe in the same experiments. Water content of the rhyolitic glass has a significant effect on Fe diffusivity and smaller effect on Cu diffusivity. Activation energy for Cu diffusion varies from 99 kJ/mol for dry rhyolites to 59 kJ/mol at 6 wt% H_2O. Our Cu diffusion data in hydrous rhyolitic melts are about 2 orders of magnitude higher than Cu diffusivity used in a previous model on metal extraction and transport [3]. The high Cu diffusivity implies that Cu partitioning may be roughly considered to be in equilibrium during sulfide melt segregation and volatile phase exsolution.

[1] Singer (1995) *Econ. Geol.*, **90**, 88-104. [2] von der Gönna & Rüssel (2000). *J. Non-Cryst. Solids*, **261**, 204-210. [3] Huber et al. (2012) *G^3*, **13**.