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Solubility determination of Pb, Mo and PGE sulfides in hydrous alkali silicate liquids: application to ore deposits at the magmatic-hydrothermal interface

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The processes that transport and deposit chalcophile elements like Pb, Cu, Mo and even Platinum Group Elements (PGE) are poorly understood. Sulfide minerals often form economic deposits of these elements. Whether these deposits reflect magmatic or hydrothermal processes is debated—indeed the magmatic hydrothermal transition is poorly understood. Pb is an important petrogenetic tracer of igneous, metamorphic and hydrothermal processes while Cu & Mo are found in critical porphyry systems. PGEs form reefs and country rock deposits in layered intrusions. All these sulfides have exceedingly low solubility in simple hydrous fluids. Recent work shows a continuous change in quartz-feldspar saturated liquids from rhyolite at the quartz-albite eutectic to Na-silicate liquid with 40 wt% H2O at 330°C [1]. Notably, [2] found >5 wt% solubility of base metal sulfides in similar hydrous Na-silicate liquids.

We performed preliminary tabletop solubility studies with Molybdenite (MoS) and Galena (PbS) at 50°C, 100°C and 140°C by immersing these minerals in Na silicate solution for one week. Results found ~911 ppm to ~7500 ppm of these metals in solution, greatly exceeding known solubilities. To ensure oxidation to sulfate did not control this result, a N_2 atmosphere experiment produced Pb concentrations of 416ppm. Experiments measuring solubilities of these sulfides in hydrous Na silicate liquid at 1 kb pressure and 300 to 800°C are in progress. Au and Ti capsules are being loaded with MoS, PbS, PtS, or PdS plus hydrous $Na_2Si_2O_5$ powder and run over day to week timescales. These experiments will be measured using LA-IC-PMS for metal contents in glass to determine solubilities.

It was suggested that hydrous Na-silicate liquids circulate in the ocean crust controlling heat flow [1]. To test their role we examine Pb isotope ratios across an epidosite transect in the basaltic sheeted dike complex of the Troodos ophiolite (Cyprus). We've performed MC-ICP-MS analysis of samples from the epidosite contact to its center. Results show homogeneous ratios across the transect, consistent with a pervasive fluid with high Pb content imprinting on rocks; ratios show excellent agreement with previous published work[3].

1. Lundstrom, JGR, 2020; 2. Mustart, Stanford thesis, 1972. 3. Spooner et al. 1982