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The solubility of anhydrite in magmatic fluids and its implications for porphyry ore genesis

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Porphyry-type Cu-Au-Mo deposits are typically even larger positive anomalies for sulfur in the crust than they are for Cu. Both sulfur and ore metals are thought to be dominantly derived from associated magmas by degassing at depth. Therefore, it is important to understand how various physical-chemical parameters affect the efficiency of S extraction from magmas. Anhydrite has recently been recognized as a stable primary magmatic mineral in several porphyry Cu-Au ore related magmas and has also been proposed to be a possible source of excess sulfur in volcanic eruptions. Yet, the solubility of anhydrite in magmatic fluids is poorly understood.

We performed three series of experiments to determine the effect of T (600 – 900 °C), P (120 and 240 MPa) and fluid salinity (0, 1, 2, 4, 8, 32m NaCl) on the solubility of anhydrite at oxygen fugacity (fO_2) corresponding to the Re-ReO_2 buffer. The experiments at higher T were conducted in Molybdenum-Hafnium Carbide externally-heated pressure vessel assemblies, whereas for lower T runs, a Rene 41 cold-seal pressure vessel was used. The fluid phase was sampled at run conditions in the form of synthetic fluid inclusions in a quartz cylinder, which was fractured *in-situ* after equilibrium has been achieved. The concentrations of S and Ca in the fluid inclusions have subsequently been analyzed by Laser Ablation ICP-MS. The results show that the effect of fluid salinity is the most prominent on the solubility of anhydrite, which exponentially increases by more than 2 orders of magnitude as fluid salinity increases from 0 to 32 m at 800 ^{o}C and 240 MPa. Increasing T from 600 to 900 ^{o}C yields an 8-fold increase in anhydrite solubility in vapour like fluids, whereas in brine-like fluids, a 4-fold increase is apparent between 600 and 800 ^{o}C. However, the opposite trend is observed with increasing P from 120 to 240 MPa, i.e. the solubilities decrease by a factor of 7.7 and 1.2 in vapor- and brine-like fluids, respectively.

The data suggest that the exsolution of aqueous fluids from felsic magmas may efficiently lead to the consumption of earlier crystallized magmatic anhydrite and significant amounts of S may be transferred into the overlying hydrothermal systems as dissolved sulfate species even at moderately oxidizing conditions.