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SPECIAL COLLECTION: GLASSES, MELTS, AND FLUIDS, AS TOOLS FOR UNDERSTANDING VOLCANIC PROCESSES AND HAZARD

Anhydrite stability and the effect of Ca on the behavior of sulfur in felsic magmas†

Ruifang Huang[1,2] and Hans Keppler[1,*]

[1]Bayerisches Geoinstitut, Universitaet Bayreuth, 95440 Bayreuth, Germany
[2]State Key Laboratory of Isotope Geochemistry, Guangzhou Institute of Geochemistry, Chinese Academy of Sciences, 510640 Guangzhou, PR China

Abstract

The distribution of sulfur in the system Na_2O-K_2O-CaO-Al_2O_3-SiO_2-H_2O-S was investigated at 2 kbar, 750–950 °C, and oxygen fugacities ranging from the Co-CoO to the Re-ReO_2 buffer. Anhydrite ($CaSO_4$) crystallized in all the experiments conducted at oxidizing conditions (Ni-NiO + 0.5 to 1 and above). Under otherwise equal conditions, an inverse relationship between sulfur and CaO concentration was observed in melts coexisting with anhydrite, with the solubility product $K = [CaO][SO_3]$ being constant, where [CaO] and [SO_3] are the molar fraction of CaO and SO_3 in the quenched glasses. This suggests that anhydrite dissociates upon dissolution in the melt according to $CaSO_{4\ anhydrite} = Ca^{2+}_{melt} + SO^{2-}_{4\ melt}$. The solubility product strongly depends on temperature, with $\ln K = -(28\,573 \pm 917)/T + (11.26 \pm 0.80)$. This corresponds to an enthalpy of dissolution of $\Delta H_R = 237.5 \pm 7.6$ kJ/mol. Under reducing conditions (Co-CoO and Ni-NiO buffer), CaO has no effect on the fluid/melt partition coefficient of sulfur $D_S^{fluid/melt}$. At 850 °C, 2 kbar partition coefficients were 519 ± 30 at the Ni-NiO buffer and 516 ± 11 at the Co-CoO buffer, for CaO contents in the melt up to 1 wt%. These data are virtually identical to those measured in the CaO-free haplogranite system under reducing conditions. However, under more oxidizing conditions, the fluid/melt partition coefficient of sulfur appeared to have increased somewhat in the presence of CaO. This increase may, however, also be related to the fact that the final melt compositions in these runs were distinctly peraluminous. Our data show that calcium has no effect on the degassing of sulfur at reducing conditions, but it greatly reduces the amount of sulfur available for rapid degassing under oxidizing conditions by stabilizing anhydrite.

Keywords: Anhydrite, sulfur, haplogranite, solubility, partitioning, oxygen fugacity