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Effect of alkalinity on sulfur concentration at sulfide saturation in hydrous basaltic andesite to shoshonite melts at 1270 °C and 1 GPa

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Abstract

We have measured the effect of alkalis on S concentration at sulfide saturation (SCSS) in an under-explored compositional space of natural hydrous arc melts (basaltic andesite to shoshonite) at 1270 °C and 1 GPa. At an oxygen fugacity approximately 2.5 log units below the fayalite-magnetite-quartz (FMQ) buffer, SCSS increases with Na_2O (562 ppm S/wt% Na_2O), K_2O (98 ppm S/wt% K_2O), and total alkalis (88 ppm S/wt% Na_2O+K_2O) over the compositional range we have studied (1.6–3.1 wt% Na_2O; 0–6.5 wt% K_2O; 1.9–6.3 wt% FeO^{tot}). Experiments with ~1.3 wt% H_2O show approximately half the increase in SCSS with alkalinity compared to those with ~3.0 wt% H_2O. Our results show a possible limit to the increase in SCSS solely by increasing alkali concentration at ~7.5 wt% total alkali concentration. Using our results and published data, we retrained earlier SCSS models to provide a better fit to test data. We also developed a new empirical model using theoretical optical basicity as a compositional parameter that predicts SCSS in the overall data set with slightly better accuracy compared to previous models:

$$\ln(SCSS_{ppm}) = 16.34 - \frac{5784}{T} - 339.4\frac{P}{T} + 10.85\ln(\Lambda) + 3.750X_{FeO} + 6.703X_{H_2O}$$

with temperature (T) in Kelvin, pressure (P) in GPa, the optical basicity (Λ) and mole fractions (X) of FeO (calculated from Kress and Carmichael 1991), and H_2O in the melt. The discrepancies between observed and predicted SCSS for our experiments of varying alkalinity reflects the heavy bias toward anhydrous, alkali-poor basalt compositions in the underlying data sets on which most models are developed.

Keywords: Sulfur, alkalinity, melts, experiment; Planetary Processes as Revealed by Sulfides and Chalcophile Elements