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Sulfur's Double Life: Multi-species Diffusion and Solubility in Dacitic Melts

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The solubility of sulfur in magmas is a key factor influencing volcanic degassing, ore deposit formation, and internal sulfur cycles. Hydrated oxidized basaltic magmas, for example, in volcanic arcs, can carry up to 1.5 wt% of S as sulfate until low pressures (Jugo et al., 2005). In this study we investigated the influence of pressure, temperature, and volatiles (H, C, F, Cl) on sulfate solubility in a synthetic glass composition based on the 1991 Pinatubo dacite, a well-characterized natural silicic magma. Experiments were performed at high oxygen fugacity (fO_2) to investigate pure sulfate solubility. Since sulfate ions diffuse very slowly (log D –12.8 @1325 °C), equilibration times are lengthy (>3 weeks for a typical experimental capsule). Thus, diffusion experiments were performed with solid anhydrite as the sulfate source. Contrary to recent studies by [1][2], our experiments suggest a non-negligible effect of pressure on the Sulfur Concentration at Anhydrite Saturation (SCAS)

The last studies on the diffusion of sulfur [3][4] only acknowledge the presence of sulfide and sulfate ions, but do not study the diffusion rate of each species in their experiments. To address these gaps, we performed diffusion experiments of sulfate and sulfide, and mixed sulfate/sulfide ions under controlled fO_2 conditions to better constrain the diffusion rates. Speciation was determined using Fe & S-XANES at the K-edge at the European Synchrotron Research Facility (ESRF). Diffusion coefficients were then calculated for both species, as well as a model for mixed-volatiles diffusion.

The global aim of our study is to provide a precise integrated view of the diffusion coefficients of the sulfide and sulfate species, as well as their relative solubility. These findings will contribute to resolving existing discrepancies in the literature (“S-excess”) and refining models of sulfur behaviour in volcanic systems. This work will aid in the interpretation of sulfur emissions from explosive eruptions, understanding volatile transport in subduction zones, and improving thermodynamic models of sulfur.

[1]Thomas R.W. & Wood B.J. (2026) *GCA* **417**.

[2]Zajacz Z. & Tsay A. (2019) *GCA* **261**.

[3]Baker L.L. & Rutherford M.J. (1996) *CMP* **123**.

[4]Freda C., Baker D.R. & Scarlato P. (2005) *GCA* **69**.