Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.36171

Decompression experiments on S, CO_2 and H_2O degassing in basaltic melts

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Volcanic degassing of H_2O, CO_2, and S is crucial in controlling the nature and timing of volcanic eruptions. Currently, all available degassing models[1] and most experiments assume that degassing occurs at equilibrium. While several experiments have demonstrated disequilibrium degassing of CO_2 [2-4], the kinetic control of S degassing in basaltic systems has not been experimentally investigated. This study explores the scenarios where disequilibrium degassing of one or multiple volatiles potentially occur in the ascending basaltic andesite by conducting decompression experiments using an Internally Heated Pressure Vessel from 300 MPa to different final pressures and with decompression rates of 0.05, 0.1, and 0.25 MPa/s.

Our results and comparisons with different equilibrium degassing models and experiments show that H_2O mostly follows equilibrium degassing regardless of final pressure and only slightly deviates from equilibrium at the fastest decompression rate. CO_2 shows disequilibrium degassing to varying extents depending on final pressures and decompression rates, with average CO_2 degassing increasing as vesicularity increases[2]. On the contrary, S degasses little (<30%) in all decompression experiments. At final pressure of 25 MPa, experiments with all three decompression rates show decreasing S concentration towards the bubble-melt interface in the surrounding areas of vapor bubbles. Notably, all profiles show S concentrations at the bubble-melt interface that are significantly higher than the predicted value at 25 MPa. Fitting twelve S-profiles using a 1-D diffusion model constrains S diffusivities of $10^{-11.2}$ m/s^2 to $10^{-12.2}$ m/s^2, consistent with the calculated S diffusivities in hydrous basalts with 1- 2 wt.% H_2O at an experimental temperature of 1200 ±20 °C[5]. The modeled total diffusion times reveal that the onset of diffusive S loss occurs at 50-100 MPa regardless of decompression rates. Finally, the decoupling behavior of H_2O and S in the magma could be used to identify S-degassing disequilibrium, which could also lead to an overestimate of degassing depths based on CO_2/S ratios in volcanic gases.

1 Iacovino et al. (2021) *Earth Sp. Sci.;* 2 Pichavant et al. (2013) *CMP*; 3 Yoshimura (2015) *Chem. Geol.*; 4 Mollo et al. (2017) *Period. di Mineral*; 5 Zhang et al. (2010) *Rev. Min. Geo.*