Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.37917

Investigating the Explosive to Effusive Transition in Rhyolitic Eruptions Using Diffusion of Hydrogen in Quartz Phenocrysts

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Studying the deposits of past rhyolitic eruptions is fundamental to understanding the controls on eruption style and how these controls are recorded in erupted products. A major control on eruptive style is the behavior of volatiles. Slower ascent and decompression allows for increased magma permeability and greater outgassing [1,2], leading to effusive behavior. Many methods have been used to infer ascent and decompression rates, including bubble and microlite number densities, hornblende breakdown rims, and diffusion of H_2O and CO_2 in melt-filled embayments. Here we utilize H^+ diffusion through quartz [3] via interstitial substitution of Al^{3+} associated with H^+ for Si^{4+} in the crystal lattice. We apply this method to the multi-episode 1314 CE Kaharoa eruption products of Tarawera volcano (New Zealand). Most of the magma erupted explosively (sub-Plinian to Plinian style), represented by fall and minor pyroclastic density current deposits. This explosive activity was followed by several years of lava dome extrusion, with associated block-and-ash flow (BAF) deposits [4].

We used FTIR spectroscopy to measure hydrogen concentration profiles along the c-axis of Kaharoa quartz phenocrysts. The hydrogen concentration decreases in the outermost 400-500 microns of crystals. Concentration profiles can be used with a diffusion model based on Jollands et al. [3] to estimate decompression timescales. Initial results for several quartz phenocrysts suggest decompression timescales for early fall material and late-stage BAF quartz are similar (~70 min), consistent with published results for embayments from the earliest fall deposit [5]. Hydrogen concentrations calculated for quartz core spectra from the early fall deposit (18±2ppm) and the BAF sample (16±3ppm) suggest similar melt H_2O concentrations at the onset of decompression. Further details of the spectroscopic methods and implications of preliminary results will be presented.

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