The Influence of Crystal Content and Type on Permeable Vesicular Pathways in High-Silica Melts

R.L. DEGRAFFENRIED[1]*, J. F. LARSEN[2], N.A. GRAHAM[2]

[1]University of Hawai'i at Manoa, Honolulu, HI 96822, USA (*correspondence: rdegraff@hawaii.edu)
[2]University of Alaska Fairbanks, Fairbanks, AK 99775, USA

The process of volatile exsolution and escape along permeable pathways as magma ascends helps control volcanic eruption style. Recent studies found that crystals lower percolation threshold (Φ_c), the porosity at which permeability develops, by apparently modifying bubble shape, resulting in a change in Φ_c and permeable network structure [1]. However, the influence of crystal content, size, or shape (i.e., phenocrysts vs. microlites, elongate vs. equant) has not yet been systematically studied to understand its effect on permeability.

We studied a suite of permeable experimental and natural samples that contain variable crystallinities, spanning crystal-poor (<10 vol.%), phenocryst-rich (≥20 vol.% phenocrysts, <5 vol.% microlites), and variably microlite- and phenocryst-rich (≥20 vol.% phenocrysts, >20 vol.% microlites). All samples have rhyolitic matrix glass compositions. Permeability was measured with a permeameter modeled after [2]. Transport porosity (Φ_{tra}), the porosity contributing to permeability, and characteristic pore throat radius (r_{ch}), the largest aperture between coalesced bubbles in the permeable pathway, were measured by water expulsion techniques [3].

All samples show increasing permeability with increasing Φ_{tra} and r_{ch}. A trend is not apparent between crystallinity and Φ_{tra}, across values from 7.0 to 65.1 vol.%. Microlite- and phenocryst-rich samples have r_{ch} ranging from 6.45±0.50 to 54.13±3.35 μm, phenocryst-rich samples have r_{ch} ranging from 2.69±0.08 to 121.08±10.70 μm, and crystal-poor samples have the largest r_{ch}, ranging from 9.3±0.19 to 154.2±11.04 μm. This implies microlites force bubbles into ellipsoidal shapes, resulting in smaller r_{ch}, though bubbles in phenocryst-rich melts also have some ellipsoidality. These results indicate that although crystals generally promote the development of permeability deeper in the conduit through modifications to vesicle shape, microlites may inhibit effective outgassing by restricting r_{ch} and thus restricting permeability.

[1] Lindoo *et al.* (2017) *Geology* **45**, 831-834 [2] Takeuchi *et al.* (2008) *J. Volcanol. Geotherm. Res.* **177**, 329-339 [3] Yokoyama & Takeuchi (2009) *J. Geophys. Res: Solid Earth* **114**