Experimental constraints on the effects of shear and displacement on vesicle coalescence

Robert Dennen[1], Benjamin Andrews[1], Michael Manga[2], Wim DeGruyter[3]

[1]Global Volcanism Program, Smithsonian Institution, USA, [2]Department of Earth and Planetary Science, University of California at Berkeley, USA, [3]School of Earth and Planetary Sciences, Georgia Institute of Technology, USA

E-mail: DennenR@si.edu

Vesiculation processes in magmas control whether eruptions result in explosive magma fragmentation or effusive eruption of lava. A better understanding of the effects of viscosity, shear, and time on the development of permeability (vesicle nucleation, growth, and coalescence) allows for better prediction of eruptive styles or changes in eruptive style. We present vesiculation experiments on natural, non-vesicular, high-silica rhyolite obsidian cores loaded into graphite cylinders that allow only uniaxial (upward) expansion. Experiments were performed at 800-1300℃, 1 atm, and for durations of 25 s to 4 hrs. Preliminary results show clear trends in vesiculation as a function of time and temperature (for example, reaching about 50% vesicles after 50 s at 1300℃, about 80% vesicles after 200 s, and collapsing back down to about 70% vesicles after 2000 s), reflecting vesicle growth, coalescence, and gas escape through ruptured vesicles. Portions of foamed samples that expanded past the end of their confining cylinders expanded in an unconfined manner, but later shrank back on themselves and retreated into the cylinder. Vesicle textures in the experiments are anisotropic; for example, samples run for about 900 s at 1300℃ contain large vesicles at the base, and smaller vesicles near the unconfined top, whereas samples run for about 2 hrs have a single vesicle running the length of the sample and very small, spherical vesicles in the dense, glassy exterior sample walls. Along axis gradients in expansion, displacement, and shear affect bubble coalescence rates and generate the observed textures. Darcian permeability measurements show that the bases of foamed samples increase in permeability from 1.2×10^{-13} to 1.1×10^{-12} m^2 between run times of 500 and 900 s, respectively, at 1300℃, while the permeability near the unconfined tops of samples is significantly lower. X-ray Computed Tomography (XRCT) imaging allows reconstruction of the internal structures of foamed samples, and reconstructions are used to estimate permeability independent of physical measurements. Our experiments demonstrate that shear and displacement affect vesicle coalescence rates, and suggest an inverse relationship between shear and coalescence rates.