Homogeneous bubble nucleation in rhyolite

SAHAND HAJIMIRZA[1]*, HELGE M. GONNERMANN[1], JAMES E. GARDNER[2] AND THOMAS GIACHETTI[3]

[1]Department of Earth, Environmental and Planetary Sciences, Rice University, Houston, TX, USA (*correspondence: sahand@rice.edu)
[2]Jackson School of Geosciences, University of Texas, Austin, TX, USA
[3]Department of Earth Sciences, University of Oregon, Eugene, OR, USA

Magma degassing during ascent is a consequence of pressure dependent solubility of volatiles, mostly water and carbon dioxide. The first step in magma degassing is bubble nucleation. To nucleate a bubble an interface between the melt and the nucleating bubble must form. The energy of formation for this interface depends on searface tension, which highly controls the rate of nucleation. Thus predictions about volcanic eruptions require estimation of surface tension during nucleation. However it is impossible to measure surface tension of a nucleus during nucleation directly, because it is very small, only a few nanometers, and ephemeral.

Here we provide a formulation for surface tension during bubble nucleation in rhyolite based on Toman correction, which accounts for the dependency of surface tension on the nucleus size. We performed a suite of homogeneous nucleation experiments, wherein water saturated rhyolite samples were decompressed under controlled rates and magnitudes and quenched. Bubble number density (BND) for each experiment was measured from thin section of the quenched samples. We then modeled bubble nucleation and growth during each experiment to predict BND. We calibrated the Tolman correction by minimizizng the difference between BND observed and predicted for the entire suit of experiments. We demonstrate that our new formulation for surface tension will significantly improve the prediction of bubble nucleation rate in our experiments.

Two distinct types of nucleation is predicted in our experiments, which can be distinguished based on a dimensionless parameter, θ, defined as the ratio of diffusion time scale over decompression time scale. In experiments with $\theta >> 1$, nucleation occurs over a short time interval, ~1 s, and is controlled by the competition between decompression rate and diffusion rate of water into bubbles. On the other hand, in experiments with $\theta < 1$, nucleation occurs over the experiments time scale, because it is unaffected by diffusion.

This abstract is too long to be accepted for publication. Please revise it so that it fits into the column on one page.