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Vesiculation processes in rhyolitic magma as a response to heating and slow decompression

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The degassing dynamics of a magma exert a first order control on the potential for explosivity at erupting volcanos as they control the overpressure of the magma in the shallow crust. Bubbles can grow both by gas expansion and by mass addition via volatile diffusion from the melt. Both of these mechanisms are dependent on pressure gradients during ascent, together with composition-dependent melt properties including volatile solubility, diffusivities and viscosity. Quite importantly, at (pre-)eruptive conditions volatile solubility is an increasingly strong function of pressure and temperature, such that both temperature increases or pressure decreases can cause magma vesiculation. Here we investigate the role of 1) heating and 2) slow decompression on rhyolite magma vesiculation. The experiments were conducted using cores of natural obsidians from Hrafntinnuhryggur, Krafla volcano with different low initial water contents (0.11-0.15 wt%).

In a first series of experiments, we exposed the obsidian to slow and fast heating to temperatures of 800-1000°C and at 1 bar ambient pressure using an optical dilatometer. These heating experiments were conducted with initially cylindrical samples, which remained axisymmetrical in shape during vesiculation permitting the application of the solid-of-rotation to obtain continuous data of volume from ambient to final temperature. During heating, the volume of the sample increased nonlinearly as bubbles nucleated and grew. Selected samples were analysed by X-ray computed microtomography to determine vesicularity, bubble number density and bubble connectivity. In these experiments, the bubbles grew due to the temperature-induced supersaturation of water which drove nucleation and diffusion of water into bubbles. X-ray tomography revealed low bubble number densities (1-7 mm^{-3}) consistent across a large range of vesicularities (6-60%). Even samples at the high end of the vesicularity range exhibit a low to very low vesicle connectivity, indicating isolated bubble growth in this unconstrained, slow vesiculation scenario. These continuous porosity-time data will be compared with numerical models for bubble growth in rhyolites.

In a second series of experiments, we are exposing the same composition of obsidian samples as well as synthetic hydrated samples (0.3-1.8 wt%) of Krafla obsidian to magmatic temperatures (750-900°C) and varyingly slow decompression scenarios, both linear and non-linear. In these experimental series we are exploring the effect of pressure changes on bubble nucleation and growth, to mimic the regimes and changes relevant for the shallow rhyolitic magma reservoir found at Krafla in Iceland. The decompression and heating textures will then be compared quantitatively. The results may shed light on the relative roles of decompression and heating in nucleation scenarios in nature.