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Foam on the go – Shear enhanced vesiculation in magmatic conduits

Jenny Schauroth, Felix Von Aulock, Josh Weaver, Anthony Lamur, Jackie Kendrick, and Yan Lavallée
University of Liverpool, Earth, Ocean and Ecological Sciences, Liverpool, United Kingdom (jennyschauroth@gmail.com)

Volcanoes can undergo rapid transitions between effusive and explosive eruption styles. The eruptive behaviour is mainly linked to the melt's ability to devolatise and outgas volatiles through permeable networks. Therefore, understanding volatile exsolution, bubble formation and coalescence within the conduit is key to our comprehension of eruption dynamics. Current knowledge relies on isotropic vesiculation at ambient pressure, but how does this devolatilisation occur in differential stress fields, such as the dynamic environment of magmatic columns? During magma ascent strain localises, especially near the conduit margin, and differential stresses develop. Previous experiments showed how strain localisation leads to viscous and frictional heating, and thereby accelerates magma vesiculation. While the temperature effect on water solubility is well known, the influence of differential stress remains untested. This is potentially underestimated by current models of magma foaming by decompression.
Here, we used two different obsidians, with similar water contents, to study the onset of bubble nucleation and the rate of bubble growth under different strain rates: i) samples from Ceboruco volcano, Mexico, with minor crystals and ii) samples from Hrafntinnuhryggur, Iceland, which are pristine. A suite of experiments was combined to understand the onset of bubble nucleation and the rate of bubble growth under differential stress, at different strain rates: 1) anisotropic foaming experiments in a uniaxial press, where the two pistons were locked in position and in contact with the sample upon heating to foaming temperatures. This setup allowed the sample to foam radially along the compression platens, creating shear conditions. 2) anisotropic foaming in a dilatometer at different strain rates. This setup, although using much smaller samples, allowed precise temperature control and characterisation of the sample evolution with time.
Preliminary results show that both bubble nucleation and growth depend on the applied strain rate. Our hypothesis is that due to forced convection and potential changes in the melt structure, the kinetics of nucleation and growth are altered during shearing in a rate dependent process. Our first results highlight the importance of understanding the effect of differential stress on magma vesiculation and provide the basis to investigate this phenomenon further, in both pure silicate liquids and crystal-bearing magmas.