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In-situ high-temperature rheology of pore-bearing magmas

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Porous rocks represent the products of all explosive volcanic eruptions. As magma ascends to the Earth's surface, bubbles form as a consequence of the evolving saturation state of volatiles dissolved in the melt. The presence of pores (either filled with pressurized volatiles or not) strongly controls the rheological behaviour of magma and thus influences all volcanic processes (pre- syn- and post-eruptive). Nevertheless, the effects of porosity on the rheology of magma are not well characterised, and a general parameterization is not available yet.
Here we present a new set of experiments designed to investigate the rheology of porous melts at high temperature (750-800 °C), low strain rates (10ˆ6-10ˆ7 sˆ-1) and variable porosity. Experiments were performed at 1 atm using a Setaram Setsys vertical dilatometer. The starting materials are 5 x 5 mm cores of natural rhyolitic obsidian from Hrafntinnuhryggur, Krafla, Iceland (vesicle and crystal-free) initially containing 0.11(4) wt% dissolved H_2O.
The experimental procedure is composed by two steps: 1) synthesis of bubble-bearing materials by heating and expansion due to foaming; 2) deformation of the foamed samples.
During the first step, the obsidian cores are heated above the glass transition temperature to 900- 1050° C and held for set amounts of time (2–24 h); the volume of the foamed samples increases because H_2O vapour-filled bubbles nucleate and expand. The change in volume (measured by He-pycnometry) is linked to the change in porosity (10-50 vol%).
For the second step, two different experimental strategies are employed, hereafter "single-stage" and "double-stage" measurements. Single-stage measurements involve deformation of the samples directly after foaming (without quenching). The sample is cooled down from the foaming T to different target T (750-800 °C), a constant load (150 g) is applied by silica or alumina probes to the core, and the cores deform isothermally for 5-20 hours. Conversely, double-stage measurements involve deformation of previously synthesised and quenched pore-bearing cores. In this case the sample is heated up to the target T and deformed under an applied load for similar amount of time (5-20 hours). In both cases, the variation in length (displacement) and volume (porosity) is continuously recorded and used to calculate the viscosity of the foamed cores using Gent's equations.
Preliminary results suggest for single-stage measurements a lower effect of bubbles on the bulk viscosity, compared to double-stage measurements. We suggest that the different behaviour may be related to the different microstructure of the experimental materials. For single-stage measurements, closed and H_2O vapour-filled bubbles contribute to the observed higher viscosity, whereas in double-stage measurements, possible gas leaking and melt micro-cracking during quenching are able to weaken the porous material and markedly lower suspension viscosity.