Repose periods in cyclic Vulcanian activity: Textures and timescales of shallow magma densification

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Degassing and densification are often linked in conceptual models of shallow magma conduits. Cyclic Vulcanian eruptions are associated with inflation and deflation and commonly interpreted as periods of gas pressurisation and depressurisation in partially degassed plugs. Inflation and deflation could be explained by changes in pore-volume in cracks or bubbles in or beneath this plug. However, the specific mechanism by which this occurs and the timescales over which pore-networks can collapse remain poorly constrained. To investigate a densification scenario we present results from experiments using pumice from the February 2010 partial collapse of Soufrière Hills volcano (SHV). We measured the change in volume and the pore network by helium pycnometry, P and S wave velocities and permeability. We used X-ray computed tomography and optical microscopy to compare the 3D and 2D textural evolution of experimentally deformed samples with naturally deformed and dense samples from the same eruption. Sample core volume, porosity and texture were measured and assessed before and after experiments. We heated samples under atmospheric pressure conditions at 2 °C.min^{-1} and 20 °C.min^{-1} to isotherms of 860 °C, 900 °C and 940 °C for intervals up to 8 hours before cooling. Over an 8 hour timescale relevant to SHV cyclicity, samples show a $\leq$ 54% volume loss. For a given peak temperature, samples with initial total porosities of 80-84% reduce in volume an order of magnitude more quickly than samples with an initial total porosity 70-74%. Using thermo-gravimetric analysis (TGA) we confirm that the total volatile content is $\leq$ 0.16 wt.% and thus the de-volatilisation effect on melt viscosity does not contribute significantly to the collapse rate. Samples of similar porosity but different aspect ratios collapse proportionally, leading to the exclusion of gravity as the significant mechanism driving densification in our experiments. Consequently, we propose that surface tension acts to increase pore connectivity and reduce internal surface area. We show that the initial rate of volume loss can be correlated with the initial connected pore volume and the experimental temperature. Therefore we propose that for a given melt composition the collapse under static atmospheric conditions can be estimated from the initial connected porosity. In a volcanic context, the pore and confining pressures modify the effective pressure, thus the dynamics. Our experiments provide a constraint of the timescale and resultant textures during the collapse of bubble-bearing magma at temperature conditions relevant to SHV following explosive eruptions.