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Gas transport and vesicularity in low-viscosity liquids

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Vesicle textures of basaltic scoria preserve information on magma bubble content at fragmentation and are commonly used to constrain degassing, vesiculation and magma permeability. These studies are based on the assumption that microscale textures are representative of the conduit-scale structures and processes. However, the conditions for which this assumption is valid have not been investigated in detail.

We have investigated conduit-scale structures by performing a series of experiments of separate two-phase flows in a 6.5-m high cylindrical bubble column using a combination of air with pure glucose syrup, water-syrup mixtures and pure water to reproduce open-system degassing and strombolian activity conditions in the upper volcanic conduit (i.e. at very low or zero liquid fluxes). We have varied gas fluxes, initial liquid height, gas inlet configuration and liquid viscosity and analyzed flow regimes and properties. Temperature and pressure were measured at several heights along the pipe and vesicularity was calculated using pressure data, liquid level measurements and an Electrical Capacitance tomography (ECT) system, which measures instantaneous vesicularity and phase distribution from capacitance measurements between pairs of electrodes placed uniformly around the pipe circumference. The aim of the experiments was to identify the effect of gas-flow rates on the flow regimes (i.e. bubbly, slug, churn and annular), the main degassing structures and the total gas content of the column. The effect of increasing and decreasing gas flow rates was also studied to check hysteresis effects.

Results indicate that the vesicularity of the liquid column depends primarily on gas flux, whereas flow regimes exert a minor control. In fact, vesicularity increases with gas flux following a power-law trend whose exponent depends on the viscosity of the liquid.

In addition, distributions of instantaneous gas fraction in the column cross section during syrup experiments have shown that gas is mainly transported by large, conduit-size bubbles rising in a microvesicular liquid. Coalescence processes occur throughout the whole column, and are strongly affected by bubble size, shearing and flow dynamics. Increasing gas fluxes increases frequency and length of the large bubbles but does not affect the concentration of small bubbles in the liquid matrix. Scaling of these experiments suggest that these conditions could be met in low viscosity, crystal-poor magmas and we therefore suggest that this dynamics could also characterize two-phase flow in open conduit mafic systems.