Outgassing: influence on speed of magma fragmentation

Dominique Richard[1], Bettina Scheu[1], Sebastian P Mueller[2], Donald B Dingwell[1]

[1]Earth and Environmental Sciences, LMU Munich, Germany, [2]Institute of Geosciences, JGU Mainz, Germany

E-mail: b.scheu@lmu.de

Predicting explosive eruptions remains an outstanding challenge. Knowledge of the controlling parameters and their relative importance is crucial in order to deepen our understanding of conduit flow dynamics and accurately model the processes involved. This experimental study sheds light on one important parameter, outgassing, and evaluates its influence on magma fragmentation behavior. We perform fragmentation experiments based on the shock tube theory at room temperature on natural pyroclastic material with a connected porosity ranging from 15% to 78%. For each sample series, we determine the initial pressure (P) required to initiate magma fragmentation (fragmentation threshold, P_{th}). Furthermore, we measure the permeability of each sample for $P<P_{th}$ and the fragmentation speed for $P>P_{th}$. A significant loss of initial pressure, caused by outgassing in samples with permeability $\geq$ 1e-12 m^2, is observed within the fragmentation time scale (a few milliseconds). The samples are classified into: (a) dome/conduit wall rocks and (b) pumice/scoria. Substantial outgassing during fragmentation leads to higher fragmentation thresholds. Experimental fragmentation speeds are significantly higher than the modeled fragmentation speeds for high-permeability dome/conduit wall rocks, but lower, for high-permeability pumices. Experimental fragmentation speeds for low-permeability dome/conduit wall rocks and low-permeability pumice/scoria are as expected. We also find that low-porosity, low-permeability, altered dome/conduit wall rocks fragment at significantly higher speeds than expected. Because fragmentation threshold and fragmentation speed are among the determining parameters for the initiation, sustainment and cessation of an eruption, outgassing should be considered in the modeling of magma fragmentation dynamics.