Geophysical Research Abstracts
Vol. 18, EGU2016-9602, 2016
EGU General Assembly 2016

Experiments on the rheology of vesicle-bearing magmas

Alessandro Vona (1), Amy G. Ryan (2), James K. Russell (2), and Claudia Romano (1)

(1) Università di Roma Tre, Dip. di Scienze, Rome, Italy (alessandro.vona@uniroma3.it), (2) University of British Columbia, Dept of Earth, Ocean and Atmospheric Sciences, Vancouver, BC Canada

We present a series of high temperature uniaxial deformation experiments designed to investigate the effect of bubbles on the magma bulk viscosity. Starting materials having variable vesicularity (ϕ = 0 - 66%) were synthesized by high-temperature foaming (T = 900 - 1050 ˚C and P = 1 bar) of cores of natural rhyolitic obsidian from Hrafntinnuhryggur, Krafla, Iceland. These cores were subsequently deformed using a high-temperature uniaxial press at dry atmospheric conditions. Each experiment involved deforming vesicle-bearing cores isothermally (T = 750 ˚C), at constant displacement rates (strain rates between 0.5-1 x 10^{-4} s^{-1}), and to total strains (ε) of 10–40%. The viscosity of the bubble-free melt (η_0) was measured by micropenetration and parallel plate methods and establishes a baseline for comparing data derived from experiments on vesicle rich cores. At the experimental conditions, the presence of vesicles has a major impact on the rheological response, producing a marked decrease of bulk viscosity (maximum decrease of 2 log units Pa s) that is best described by a two-parameter empirical equation: log η_{Bulk} = log η_0 – 1.47 * $[\phi/(1-\phi)]^{0.48}$. Our model provides a means to compare the diverse behaviour of vesicle-bearing melts reported in the literature and reflecting material properties (e.g., analogue vs. natural), geometry and distribution of pores (e.g. foamed/natural vs. unconsolidated/sintered materials), and flow regime. Lastly, we apply principles of Maxwell relaxation theory, combined with our parameterization of bubble-melt rheology, to map the potential onset of non-Newtonian behaviour (strain localization) in vesiculated magmas and lavas as a function of melt viscosity, vesicularity, strain rate, and geological condition. Increasing vesicularity in magmas can initiate non-Newtonian behaviour at constant strain rates. Lower melt viscosity sustains homogeneous Newtonian flow in vesiculated magmas even at relatively high strain rates.