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Rheology of Three-Phase Magmas

M. Pistone (1), L. Caricchi (2), P. Ulmer (1), E. Reusser (1), F. Marone (3), and L. Burlini (1)

(1) ETH, Switzerland (mattia.pistone@erdw.ethz.ch), (2) University of Bristol, United Kingdom, (3) Swiss Light Source, Paul Scherrer Institute, Switzerland

Luigi Burlini was a conscious supervisor, a brilliant teacher and a dear friend. He instilled in me optimism and passion for research. His scientific eclecticism to combine several disciplines and methodologies to challenge and solve science issues has enhanced my approach of analysis and observation. His "simple" curiosity to test new scientific pathways and truly know the validity of own proposals represents my primary inspiration to continue the academic career. He was the far-seeing and carpe diem man at the same time; from this I learnt to live intensively day by day without forgetting what will be next. The work I will present is dedicated to him.

We present experimental results from a study mainly aiming to constrain the dependence of rheology of three-phase magmas (ranging from dilute suspensions to crystal mushes) on the viscosity of the suspending silicate melt, on the relative contents of crystals and bubbles and on the interactions occurring between the three phases during deformation. Hydrous haplogranitic magmas containing variable amounts of quartz crystals (between 24 and 65 vol%), and fixed bubble volume (9-12 vol% CO_2-rich bubbles) were deformed in simple shear with a Paterson-type rock deformation apparatus at high temperature (823-1023 K) and high pressure (200 MPa), in strain-rate stepping (5•10-5 s-1 - 4•10-3 s-1) from low to high deformation rate.
The rheological results suggest that three-phase suspensions are characterized by strain rate-dependent rheology (non-Newtonian behavior). Two kinds of non-Newtonian behaviors were observed: shear thinning (decrease of viscosity with increasing strain rate) and shear thickening (increase of viscosity with increasing strain rate). Microstructural observations suggest that: shear thinning dominantly occurs in crystal-rich magmas (55-65 vol% crystals) because of crystal size reduction and shear localization; shear thickening prevails in dilute suspensions (24-44 vol% crystals) due to outgassing promoted by bubble coalescence.