Geophysical Research Abstracts
Vol. 19, EGU2017-17258-1, 2017
EGU General Assembly 2017

The influence of strain localisation on spine extrusion dynamics during the 1991-1995 eruption at Unzen volcano (Japan)

Paul A. Wallace (1), Jackie E. Kendrick (1), James D. Ashworth (1), Rebecca Coats (1), Oliver Lamb (1), Takahiro Miwa (2), Elisabetta Mariani (1), and Yan Lavallée (1)

(1) University of Liverpool, Department of Earth, Ocean and Ecological Sciences, Liverpool, United Kingdom (paul.wallace@liverpool.ac.uk), (2) National Research Institute for Earth Science and Disaster Prevention, Ibaraki, Japan

The eruption of highly viscous magma at lava domes is commonly followed by the extrusion of a spine, a typical manifestation of waning activity marking the cessation of a prolonged eruptive episode. Exogenous dome growth can lead to catastrophic consequences on overall dome stability and thus its understanding is central to the mitigation of associated risks. Spine extrusion during the final stages of the 1991-95 lava dome eruption at Unzen volcano (Japan) has provided a unique opportunity to investigate the contribution of the different deformation textures and varying petrological phenomena associated with magma ascent. The protraction of this dense magmatic plug formed a 6 m wide shear zone consisting of four structurally discrete units including gouge (1), a highly sheared zone (2) to a moderately sheared zone (3) and an undeformed magmatic core (4). We present the first systematic study of the microstructures, mineralogy, crystal stability, geochemistry and crystal size distribution across this shear zone. The data is complimented by laboratory permeability measurements and seismic observations over the extrusion period. The crystal-rich ($\sim$70 vol.%) dacitic spine preserves an abundant record of both brittle and ductile deformation. Gouge material is dominated by cataclastic microstructures with comminution of crystals and formation of conjugate microfractures, a result of loss of cohesion due to friction along the fault. A decrease in crystal size and circularity with increasing shear indicates brittle processes dominate near the spine margins. The porous network varies significantly with pore size decreasing with increasing shear, a result of shear-enhanced compaction, consistent with a decrease in permeability of one order of magnitude. The interaction of crystals (via strain-partitioning) further facilitates in localising stress and strain along the conduit margin leading to crystal-plastic deformation. Electron backscatter diffraction (EBSD) enables the quantification of the degree of plasticity across this shear zone. Results show significant strain localisation in the gouge and high shear zones as evidenced by an increased degree of lattice misorientation, with the majority of strain being accommodated in the groundmass plagioclase microlites and weak phenocryst phases (i.e. biotite). Crystal-plastic behaviour may thus be used to unravel a history of deformation in the magma, acting as a strain marker for the viscous-brittle transition during ascent. Mineral destabilisation is evident across the entire shear zone, with amphibole breakdown rims suggesting disequilibrium conditions. Textural variations in reaction rims exist with granular rims being present only in the gouge, whereas symplectitic rims situate in the sheared and bulk magma. These observations suggest different breakdown triggering processes, with granular rims being specific to gouge processes perhaps due to the increased effects of gas and fluid flow. These deformation microstructures and associated processes that occur in the shallow conduit have important rheological implications that can lead to permeability anisotropy, significantly altering the degassing efficiency and therefore the style of activity we see at the surface.