Geophysical Research Abstracts
Vol. 18, EGU2016-815, 2016
EGU General Assembly 2016

The effect of shear on permeability in a volcanic conduit: a case study at Unzen volcano, Japan

James Ashworth (1), Yan Lavallée (1), Paul Wallace (1), Anthony Lamur (1), Jackie Kendrick (1), and Takahiro Miwa (2)

(1) Department of Earth, Ocean & Ecological Sciences, University of Liverpool, United Kingdom, (2) National Research Institute for Earth Science and Disaster Prevention, Ibaraki, Japan

The efficiency of outgassing at volcanoes is a function of permeability, and exerts a major influence on the type of eruptive behaviour exhibited. Understanding how shear affects the permeability profile across volcanic conduits is therefore a key part of understanding volcanic processes and the associated hazards.

During the final months of the 1990-1995 eruption of Unzen volcano in southern Japan, extrusion of a dacite spine followed a period of endogenous dome growth. Many of the resulting formations are relatively accessible, allowing for the study of a variety of associated deformation phenomena. One of these formations, a ~6 m wide block, is a section of the extruded spine, that forms the basis for this study on shallow conduit processes. It displays a textural gradation from highly sheared rock to rock with negligible deformation, and is bounded at the high shear end by an agglutinated block of gouge that is thought to represent the conduit margin.

A multi-faceted approach was taken to investigate the variation of permeability across the spine and its implications for processes occurring within the conduit. The permeability was measured at several points along the exposed surface of the spine transect using a field permeameter. Sample blocks from four of these locations were collected and tested in the lab using a hydrostatic pressure vessel water-flow permeameter and categorized as: gouge; highest shear; moderate shear; negligible shear. Each block was tested in three orthogonal axes: one perpendicular to observed shear; and two in the plane of shear. For each of these rocks, permeability and porosity measurements were made at a wide range of effective pressures (5 to 100 MPa), using a controlled upstream/downstream pore pressure gradient of 0.5 MPa (at an average pore pressure of 1.25 MPa). Thin sections of each sample were also taken prepared and analysed to describe the primary microstructures controlling the permeability of the rock.

Textural analysis showed significant crystal deformation and breakage in the most highly sheared samples; we note a progressive increase in fracture density towards the outer margin of the shear zone. Permeability data obtained both in the field and lab show a strong control of shear on permeability in a conduit, through the development of anisotropy; permeability is generally lower perpendicular to the shear plane. With increasing effective pressure, we measure a nonlinear reduction in porosity of up to 4% due to crack closure, which results in a permeability decrease of up to one order of magnitude. Upon release of effective pressure, the porosity and permeability were observed to increase but not exactly to the initial value, owing to a certain degree of hysteresis during the compression/decompression cycle. The effects of both shear and effective pressure changes on permeability have important implications on the outgassing efficiency of magma and the subsequent eruptive behaviour.