Geophysical Research Abstracts
Vol. 18, EGU2016-326-2, 2016
EGU General Assembly 2016

Strain-dependent permeability of volcanic rocks.

Jamie Farquharson, Michael Heap, and Patrick Baud

Université de Strasbourg, Ecole et Observatoire des Sciences de la Terre, Géophysique Expérimentale, Strasbourg, France (jifarq89@googlemail.com)

We explore permeability evolution during deformation of volcanic materials using a suite of rocks with varying compositions and physical properties (such as porosity φ). 40 mm × 20 mm cylindrical samples were made from a range of extrusive rocks, including andesites from Colima, Mexico (φ~0.08; 0.18; 0.21), Kumamoto, Japan (φ~0.13), and Ruapehu, New Zealand (φ~0.15), and basalt from Mt Etna, Italy (φ~0.04).

Gas permeability of each sample was measured before and after triaxial deformation using a steady-state benchtop permeameter. To study the strain-dependence of permeability in volcanic rocks, we deformed samples to 2, 3, 4, 6, and 12 % axial strain at a constant strain rate of 10^{-5} s^{-1}. Further, the influence of failure mode—dilatant or compactant—on permeability was assessed by repeating experiments at different confining pressures. During triaxial deformation, porosity change of the samples was monitored by a servo-controlled pore fluid pump.

Below an initial porosity of ~0.18, and at low confining pressures ($\leq$ 20 MPa), we observe a dilatant failure mode (shear fracture formation). With increasing axial strain, stress is accommodated by fault sliding and the generation of ash-sized gouge between the fracture planes. In higher-porosity samples, or at relatively higher confining pressures ($\geq$ 60 MPa), we observe compactant deformation characterised by a monotonous decrease in porosity with increasing axial strain. The relative permeability k' is given by the change in permeability divided by the initial reference state. When behaviour is dilatant, k' tends to be positive: permeability increases with progressive deformation. However, results suggest that after a threshold amount of strain, k' can decrease. k' always is negative (permeability decreases during deformation) when compaction is the dominant behaviour.

Our results show that—in the absence of a sealing or healing process—the efficiency of a fault to transmit fluids is correlated to the degree of strain to which is subjected. Volcanic processes such as dome extrusion, which involve progressive strain on complex fault systems, have been seen to cause fault sliding and the prolific generation of fault gouge. Our results indicate that the permeability of these faults will tend to remain constant or increase during continued extrusion, allowing magmatic gases to readily outgas through permeable fault architectures despite the generation and accumulation of gouge. On the other hand, deeper regions of the edifice that will typically be compacting due to the relatively higher confining pressures, will exhibit a continuous decrease in permeability. The interplay between permeability-increasing and permeability-decreasing processes within the edifice is likely to influence outgassing and eruptive cycles at active volcanoes.