Geophysical Research Abstracts
Vol. 18, EGU2016-529, 2016
EGU General Assembly 2016

Fracture and healing in magmas: a dual role on permeability evolution

Anthony Lamur (1), Yan Lavallée (1), Richard Wall (1), James Ashworth (1), Jackie Kendrick (1), and Fabian Wadsworth (2)

(1) University of Liverpool, Liverpool, United Kingdom (anlamur@liv.ac.uk), (2) Department of Earth and Environmental sciences, Ludwig Maximilian University, Munich, Germany

The development of a permeable network in silicic volcanic conduits controls outgassing and plays a major role on the subsequent eruptive behaviour. Efficient outgassing, at higher permeabilities, is achieved through the coalescence of pores and fractures. Whilst the relationship between permeability and increasing connected porosity is now relatively well constrained, the effects of fractures have, on the other hand, rarely been investigated. Here, we present the results of an experimental study focusing on the impacts of tensile fracturing and healing on permeability.

Permeability measurements have been performed on over 60 disk-shaped samples (26 mm diameter, 13 mm thickness) with connected porosities ranging from 2 to 45%. Our results for unfractured samples display the same porosity-permeability trend as previous studies and permeabilities span from 10^{-15} at low porosities to over $5x10^{-12}$ m^2 at higher porosities. These samples were then broken via Brazilian tests and the resultant permeability of the rocks were then measured across the fracture zone. Whilst high porosity samples reached permeabilities of about $5x10^{-10}$ m^2 (2 orders of magnitude higher than intact samples), low porosity samples, on the other hand, reached permeabilities around $5x10^{-12}$ m^2 (more than 3 orders of magnitude above intact samples). Our results show that fracturing favours the development of a permeable network that adheres to a different permeability-porosity relationship than previously presented, and that this effect is emphasized in magmas with low connected porosities.

The effect of fracture healing by diffusion on permeability has been investigated through a series of experiments on borosilicate standard glass (NIST 717a). These experiments were conducted at 560^{o}C (viscosity of $10^{10.33}$ Pa.s) on pairs of columns pressed and held in contact at constant load for times varying between 0.5s and 15000 s before being pulled apart at a strain rate of $10^{-3}s^{-1}$. Using Maxwell's theory of viscoelasticity, we estimate the relaxation timescale for this viscosity at ~2s. Results show that healing starts after a minimum contact time of 60 s, more than 1 order of magnitude slower than the time predicted by the theory of viscoelasticity. Furthermore, healing and strength recovery increase logarithmically from then. Strength recovery is estimated with respect to the tensile strength of this glass; 25 MPa when measured under the same conditions (560^{o}C and strain rate of $10^{-3}s^{-1}$). The time for full-healing can thus be estimated at ~52000 s, or $2.5x10^4$ times the relaxation timescale. We hereby propose that healing efficiency depends on the destruction of the contact area through atomic diffusive exchanges and bond creation during viscous sintering between the two parts of the sample.

The combination of our two sets of experiments allows us to propose a model in which fractures can promote the development of a permeable network which may lead a volcano toward more effusive behaviour, or whereby healing can destroy permeability and allow pressure build-up that could lead to explosive eruption.