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Elastic and mechanical properties of Etna basalt

M. J. Heap (1), O. Lewis (1), P. G. Meredith (1), and S. Vinciguerra (2)

(1) Mineral, Ice and Rock Physics Laboratories, Department of Earth Sciences, University College London, London, UK. (2) HP-HT Laboratory, Department of Seismology and Tectonophysics, Istituto Nazionale di Geofisica e Vulconologia, Rome, Italy.

We report laboratory measurements of the elastic and mechanical properties basalts of an extruded lava flow basalt from Mt. Etna volcano (Italy). These properties are of fundamental importance in reliably interpreting large scale in-situ geophysical measurements, and in modelling volcanic processes such as ground deformation and edifice stability. In particular, reliable mechanical data are crucial in calibrating damage-mechanics models of the weakening of volcanic edifices, as they strongly influence the time-to-failure. At Mt. Etna volcano, measured deformation patterns have been modelled as due to pressurising sources, among which the most common are: (a) spherical sources and (b) opening of dykes through tensile dislocations in a half-space. For those models, the reliability of the modelling inversion depends strongly of the values used for the elastic moduli (especially the Young's modulus and the Poisson's ratio). Furthermore, geo-mechanical analysis of volcano stability requires an estimate of rock mass strength. Geomechanical analyses for volcano stability require also estimations of rock mass strength. Along with field-based determinations, the unconfined compressive strength (UCS) measured in laboratory experiments is the most commonly used parameter in determining the Rock Mass Rating (RMR).

We report results from a comprehensive series of elastic and mechanical property measurements made on core samples of Etna basalt. Uniaxial compression tests have been used to investigate the static elastic moduli and the UCS; while ultrasonic P and S wave velocity measurements have yielded dynamic elastic moduli. The static Young's modulus was found to be around 25 GPa and the UCS to average 155 MPa; uncharacteristically low values for basalt. These values compare, respectively, with 36 GPa and 350 MPa for a fresh, intrusive basalt from Iceland. We interpret the low values observed in Etna basalt as being due to its very high pre-existing micro-crack

density, thought to be of thermal origin [Vinciguerra *et al.*, 2005, IJRMMS, vol. 42, 900-910].

Since volcanic edifices are characterised by pressurization/de-pressurization cycles due to magma intrusion and high temperatures at shallow depths, we have simulated cyclic loading/unloading, by performing increasing-amplitude, stress-cycling experiments. Selected samples were thermally treated up to 900˚C in order to take in account thermal stress. The peak stress in each loading cycle was increased incrementally until the sample eventually failed. Both axial and radial strain were monitored throughout these cycling experiments so that we could follow the changes in elastic properties that occurred during progressive deformation and increasing crack damage. Results show a progressive degradation in sample stiffness during stress cycling, equating to a decrease in Young's modulus and an increase in Poisson's ratio. It is therefore important that such changes are taken into consideration when modelling the deformation of volcanic systems subject to pressure cycling over extended time periods.