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Acoustic emissions generated during uniaxial compressive strength tests on Lyttelton volcano rocks, Christchurch, New Zealand

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Earthquakes comprising the ongoing Canterbury sequence, South Island, New Zealand, have exhibited disproportionately large energy magnitude (Me) to moment magnitude (Mw) ratios (Fry and Gerstenberger, 2011). The 22 February 2011 Mw 6.3 event, for example, had an energy magnitude of 6.7 (USGS). The 22 February event may have ruptured immature faults with high apparent stress formed during the emplacement of Banks Peninsula volcanic rocks (12 Ma-6 Ma); these faults may have been further strengthened by cross-cutting intrusive rocks of the Lyttelton volcano (Fry and Gerstenberger, 2011). We measured P-wave velocity (Vp), S-wave velocity (Vs), density, elastic moduli, and unconfined compressive strength of Lyttelton volcano basalt, trachyte and rhyolite. Unconfined compressive strength (UCS) tests were conducted on specimens fitted with axial and radial strain gauges using a stress-controlled unconfined compression apparatus following ASTM standard method. UCS values range between 165 and 232 MPa for the trachyte and basalt samples; rhyolite UCS values range between 122 and 126 MPa. During UCS testing, acoustic emissions were recorded using 2 broadband AE sensors (PAC WSα 20kHz-1MHz) mounted in the end platens. AE event waveforms, magnitude-frequency relationships, and spectrograms were analyzed. Deformation of each rock type involved brittle-failure-generated AE events with broadband waveforms; numbers of AE events increased exponentially at failure. The magnitude-frequency plots of AE events display a sharp decrease in relative energy emitted at frequencies greater than 600 kHz. Quantifying absolute energy emitted at high frequencies remains challenging; we present preliminary results from experiments designed to characterize broadband frequency attenuation. Our experiments quantify the unconfined compressive strengths, elastic moduli, and characteristic AE waveforms emitted during failure of intraplate volcanic rocks comprising the Lyttelton volcano.

Reference:
Fry, B., and M. Gerstenberger (2011). Large apparent stresses from the Canterbury earthquakes of 2010 and 2011. Seismological Research Letters 82, 833-838.