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Laboratory simulation of coupled thermo-hydro-mechanical induced microseismicity as an analogue for volcanic seismic signals

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We report results from triaxial deformation experiments on samples of basalt from Mount Etna (Italy) performed at an effective confining pressure representative of conditions under a volcanic edifice (40 MPa), and a constant strain rate of 5 x 10-6 s-1. We have monitored the complete deformation cycle of samples of 125mm length and 50mm diameter through contemporaneous measurements of stress, strain, compressional wave velocities and full waveform acoustic emission (AE) output at a sampling rate of 10Mhz. A small axial conduit of approximately 3mm diameter was drilled centrally to allow access of the pore water directly to and from the shear/damage zone. Location of AE events through time shows the formation of a classical ˜30 degree fault plane and waveforms exhibit the typical high frequency characteristics of volcano-tectonic (VT) earthquakes. The fluid in the sample pore space was then rapidly decompressed via the conduit in order to stimulate rapid fluid outflow. Such decompression creates resonance and fluid-decompression related signals that are qualitatively very similar to low frequency (LF) and hybrid events observed at the field scale, and which commonly precede volcanic unrest. In addition, we observe the same switch between VT and LF events, with the LF events generated during decompression and outflow preferentially located within the damage zone created during the shear deformation process.

At elevated temperatures (up to 175žC), we additionally observe more complex, coupled hydro-mechanical behaviour and long-lasting seismic events analogous to volcanic tremor. As before, AE events during decompression are all preferentially located within the damage zone created during the shear process, and events related to rapid fluid outflow show a higher proportion of CLVD (compensated linear vector dipole) and isotropic source mechanisms, and waveform frequencies an order of magnitude lower, than events related to brittle shear failure. Using a simple size-frequency scaling relation (Burlini et al., 2006), our laboratory-measured frequencies and crack dimensions can be shown to scale well to observations of sources of the order of hundred of metres to kilometers, typical of those in volcanic edifices.