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Mapping the ductile-brittle transition of dome lavas

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The failure of magma and onset of an explosive eruption is commonly preceded by accelerations in discharge rate and seismic activity. As magma is mechanically forced through the ductile-brittle transition, cracks propagate and coalesce, thereby generating an increasing amount of seismic energy, which can be used to forecast the onset of explosive eruptions. In this study dome lavas from Volcán de Colima (Mexico) are deformed at 930 °C under various stresses (1 to 76 MPa) in a uniaxial press. Crack propagation in the magma is monitored by two acoustic emission sensors and used as a proxy to forecast the time of failure (e.g., Kilburn, J. Volcanol. Geotherm. Res. 2003). We assess the degree of fracture damage and anisotropy of the fracture network in 3-D via high-resolution (30 micron) Neutron Computer Tomography imaging. Tomography images of magmas experimentally deformed in the ductile-brittle transition reveals that at high strain rate, failure occurs rapidly along macroscopic cracks and requires less strain than failure at lower strain rate. The time window to accurately forecast the failure of magma thus diminishes with strain rate.