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Dilatancy and Failure in Basalt From Mt Etna Under Triaxial Compression

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The recent history of Mt Etna volcano was marked by several flank eruptions from fractures that opened and feeded lava flow towards the eastern flank of the volcano. In Mt Etna as in most volcanic systems pervasive fracturing of rocks whether it is the lava dome or the surrounding rocks is a dominant feature. Understanding how the strength of volcanic rock varies with stress state, pore fluid content and pressure, damage (content and anisotropy) is fundamental to understanding the dynamics of volcanic systems and in particular modeling the progressive transport of magma towards Earth's surface that leads to eruptions.

In this study, we investigated the micromechanics of failure in Mt Etna's basalt. Basalt samples had a bulk density of 2,7g/cm^3, a connected porosity (measured with a helium pycnometer) of 4,4% and a total porosity of 4,8%. Etna's basalt is composed mainly of pyroxene, olivine and feldspar. Microstructural observations of the intact material revealed the presence of thin cracks (probably formed during the rapid cooling of the lava) and quasi-spherical voids formed during degassing. Under hydrostatic conditions however, significant compaction was observed even after closure of the cracks up to 450 MPa of effective pressure. We performed 23 conventional triaxial experiments on water saturated samples in drained conditions at confining pressures between 10 and 150 MPa and with 10 MPa of pore pressure. Dilatancy and brittle faulting were observed in all samples. Below 150 MPa of effective pressure, a single shear band oriented at 30° cut through the samples. At 150 MPa of effective pressure, a somewhat different failure mode involving conjugate shear bands was observed. Up

to 50 MPa of effective pressure, Young's modulus increased linearly with pressure. Beyond 50 MPa of effective pressure, the failure envelope became nonlinear. Several experiments were stopped at different stages of the deformation after dilatancy at 10 and 50 MPa of effective pressures. Petrophysical thin sections of the deformed samples were prepared. Optical and scanning electron microscopy observations revealed that the stress-induced microcracks and their coalescences predominately occurred in the grand mass, which were probably responsible of the development of dilatancy and shear localization.