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Decoding micro-structural damage related to caldera collapse at Santorini Volcano

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Deformation in damage zones, as micro fracture density, can be estimated at a given distance from a fault as a function of fault displacement, based on empirical relationships derived from detailed quantitative field studies of natural faults that cut through low porosity, crystalline rocks in strike-slip tectonic environments. For the first time, we attempt to apply the same method to study the characteristics of a damage zone generated by caldera collapse along a bounding circumferential ring-fault.

We have undertaken a field campaign at Santorini Volcano, Greece, and mapped sections of a dyke swarm in the northern caldera wall. The dykes, associated lavas, and eruptive units are partially cut by a series of historic caldera collapses. The dykes represent elastic inclusions in an otherwise heterogeneous and complex edifice which makes up the Santorini Volcano. To study caldera-related damage we sampled dykes at varying distance from the inferred caldera fault. The collected samples were cut into several different orientations to map micro-fracture density and orientation with relation to the strike of the historic caldera faults. In addition, benchtop ultrasonic wave velocity measurements were made on all samples.

Preliminary fracture analysis of plagioclase crystals and velocity data suggests relationship between proximity to the fault and micro-fracture density. We also find a mechanical anisotropy control which may relate to the orientation of fractures generated by historic caldera collapses on Santorini. An analysis of the anisotropy and micro-fractures may help to identify the mechanism of caldera faulting at Santorini (e.g. near-surface tension fractures and normal faulting or reverse faulting).

In addition to our micro-structural study, we will investigate the presence of hydrothermal/chemical alteration within the inferred caldera damage zone. Our aim is to set up numerical models to investigate stress distribution within the dykes and host rock during caldera collapse and create models on the generation of damage during caldera collapse at Santorini.