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Mechanical architecture and dynamic evolution of caldera faults

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It is unknown how the formation and subsequent evolution of calderas are influenced by the physical properties of the faults that form calderas and their related basement faults. This is despite the fact that there are many hazardous caldera volcanoes around the world. Caldera fault zones have very different physical properties from that of their surrounding host rocks and so can significantly influence the unrest-related deformation and eruptive characteristics of caldera volcanoes. Yet, there is currently little knowledge about how the physical properties (i.e. strength, friction, cohesion and permeability) of caldera faults evolve over time. Stress distributions within and around calderas generate complex three-dimensional extension fracture patterns which ultimately control the path of fluids, but models that infer the conditions for slip on caldera faults are incomplete because the links between the anisotropy of the physical rock properties and stress are still not fully understood. This issue can be resolved via the use of experimental apparatus and numerical models that accurately recreate the complex crustal stress distribution in a volcano but such an approach has not yet been used. Here we introduce a multi-disciplinary research program that will combine the collection of geological field data from ancient and eroded caldera volcanoes, with novel true triaxial laboratory experiments and micromechanical and numerical models. The goal of the project is to harness recent technological advances in true triaxial experimental techniques together with detailed field mapping in order to understand the detailed architecture and mechanical behaviour of caldera faults. The key question is: How does the evolution of the rock physical properties in and around caldera and basement faults influence processes such as fault stability, stress distribution, surface deformation, and degassing pathways, all of which can contribute to the generation of explosive eruptions at caldera volcanoes. Many of these questions could not have been fully addressed previously because of the lack of suitable experimental equipment and modelling capability. This study aims to create an important bridge between volcanology, rock and fracture mechanics, and the geological structure of natural caldera fault zones, leading to an improved understanding of unrest signals at active caldera volcanoes.