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Stress distribution evolution in multi-cyclic calderas appraised by using Distinct Element Method (DEM) models

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Active, multi-cyclic caldera systems represent major hazards. A significant problem for hazard assessment is the uncertainty of the structural evolution of these systems, and how stress distribution changes as caldera faults initiate and propagate. The inaccessibility of active caldera interiors' limits such analysis, and inactive, eroded calderas have undergone repeated cycles of deformation already, obscuring how these systems develop in early stages.

Previous analysis of stress distribution within volcanic systems using numerical models has been performed primarily with continuum-based approaches (e.g. Finite Element). However, stress distribution changes drastically with the creation of complex discontinuities, such as fault systems, growth of which is difficult to represent accurately in continuum-based models. Here we use the Distinct Element Method (DEM), which can more directly model the initiation, growth, rupture, and reactivation of complex discontinuities like faults.

Because the stress distribution controls failure modes, as well as fault initiation and propagation locations, we examine how stress distribution evolves before, during, and after initial inflation (tumescence) of a magma body. We then investigate how this influences the stress fields and location of fault initialization or reactivation during subsequent collapse. Our analysis helps to shed light on the mechanics at work underneath active calderas and to improve volcanic hazard assessment.