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Modelling unstable lava domes: testing collapse triggers using a discrete element method

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Lava dome collapse can result in a range of activity including rockfalls, debris avalanches, pyroclastic flows and explosive eruptions, all of which can present hazards to communities living on the volcano flanks. Many mechanisms have been observed to trigger collapse including: gravitational collapse due to oversteepening; internal gas overpressures; interaction of the dome with rainfall; a switch in extrusion direction and topography-controlled collapses (e.g. a dome exceeding the size of the crater in which it sits).

Despite the hazards associated with dome collapse, there remains limited understanding of the interaction between a dynamically evolving dome and factors influencing its stability. In order to interrogate such interactions, we establish and interrogate a global, historical database (Global Archive of Dome Instabilities, GLADIS). This allows the most common mechanisms attributed to dome collapse to be identified, and we use these as scenario models for a numerical analysis.

We create a 2D numerical model in Itasca's Particle Flow Code. We calibrate our dome emplacement model to realistic dome rock properties from Soufrière Hills Volcano, Montserrat and use this model as a starting condition for a suite of models that test the collapse trigger mechanisms outlined above. Here we present initial results of the numerical analysis simulating a switch in extrusion direction and the application of a gas overpressure, thus showing the subsequent development of two different failure mechanisms: (1) shallow, small-scale rockfalls, and (2) deep, rotational shear failure.