Thesis funding:

Fracturing in a volcanic edifice and triggering of a debris avalanche

Financing: ClerVolc Laboratory of Excellence (https://clervolc.uca.fr/)

Duration: 3 years from 1 September 2022

Host laboratory: Magmas and Volcanoes Laboratory (http://lmv.uca.fr/fr/), University of Clermont Auvergne

Supervision: Karim Kelfoun[1], Luc Scholtès[1], Bastien Chevalier[2] and Pierre Breul[2]

1. Magmas and Volcanoes Laboratory, 2. Polytech

Qualification required: Master 2 (or engineering school) in geology, physics or mechanics.

Skills required: motivation for volcanology, programming (Python, Matlab) and numerical simulation (YADE-DEM, VolcFlow).

Application deadline: 30 April 2022.

Application file: (1) CV, indicating your grades from L1 to M2 (or equivalent) and your ranking in the class, (2) letter of motivation, (3) reference from your Master's research project supervisor and their contact details, and (4) contact details of your course supervisor.

Contact: karim.kelfoun@uca.fr (https://lmv.uca.fr/kelfoun-karim/)

Background:

The Merapi volcano (Java, Indonesia) crisis of 2020-2021 alerted us to the fact that a relatively unexceptional dome eruption could evolve into a flank slide without any apparent change in magma supply conditions. The consequences of such a transition are catastrophic in terms of risk to the populations surrounding these volcanoes. This thesis project aims to improve our understanding of the conditions under which such a transition can occur and to identify the precursors of volcanic flank destabilization.

Description of the thesis project:

The objective is to model the fracturing processes that develop in a volcanic edifice using a discrete element model (DEM) specifically adapted to the problem. This model will be based on the DEM method implemented in the open source calculation code YADE-DEM (https://yade-dem.org/doc/), a tool which is increasingly used in civil engineering, as well as mining and petroleum engineering.

The proposed plan for the thesis is as follows:

1) **Fracturing of a magmatic conduit:** we will study the pressures necessary to initiate fracturing based on the topography, the heterogeneities (lithology, geological structures) and the local tectonic context (the constraints in place).

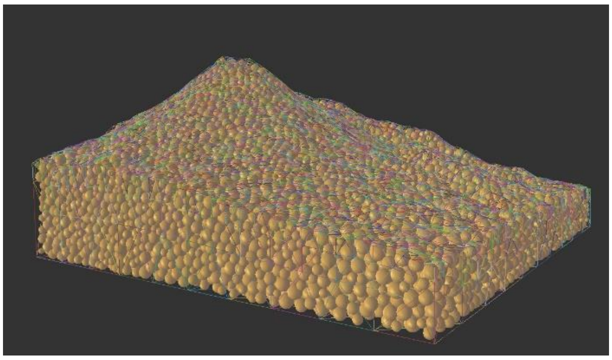
2) **Fracture propagation in the volcanic edifice:** once fracturing is initiated, we will study its propagation within the volcano. We also want to determine the different volumes that could be destabilised, and their relative probability of occurrence.

3) **Under what conditions does slip not take place?** Not all fracturing leads to flank collapse. Slip could be prevented by a mechanical blockage (caused by heterogeneities in the mechanical properties) or by cooling of the lava in a dyke that has become too long and narrow. To study this second possibility, we will simulate the thermal cooling of the dyke and the heating of the host rock.

4) **Simulation of seismic signals:** the DEM approach allows us to calculate the rupture energy and, consequently, to estimate the seismic energy released. This feature will allow us to compare our results with seismic signals recorded during real crises. We also want to determine whether there is a critical seismic energy threshold above which a collapse is inevitable.

5) **Propagation of destabilised material:** the aim will be to consider the volumes of the destabilised material and the rupture surfaces, obtained with discrete element modelling using the VolcFlow code (https://lmv.uca.fr/volcflow/), in order to estimate the distances travelled by the debris avalanches generated, their thicknesses, and the duration of emplacement. A further objective will be to link hazard maps created using VolcFlow with the seismic energy released, calculated with YADE-DEM, in order to predict the risks of future volcanic destabilizations.

Merapi volcano, Indonesia



Example of DEM geometry applied to Merapi