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Analogue modelling of flank dynamics at Mount Etna, Italy

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Mount Etna, Italy, is characterized by the instability of its East and South flanks. Factors governing this flank instability are still matter of debate. We investigate the role of different possible factors on flank instability, using analogue models.

The apparatus consists of a cone and base made of granular material, simulating the volcanic edifice and its basement, respectively. The granular material we use is a mixture of low cohesion silica sand and high cohesion crushed silica powder. Alternated layers with different cohesion are used to account for differences in the crustal structure of the basement, in terms of cohesion and permeability. The geometry of the experiments is designated to simulate the topographic and bathymetric gradients at the base of the volcano. Injections of high viscosity silicone putty and low viscosity vegetable oil are used to model the inflation of reservoirs below the volcano and the emplacement of dikes, respectively. Some experiments are conducted on a sheared basal layer, to simulate regional extensional tectonics. Finally, injection of compressed air at the base of the model allows to simulate the effect of pore pressure and the behavior of low friction – low shear strength materials.

Several sets of experiments are run to account for the role of each factor or combination of factors on the flank dynamics of the volcano. We use a high resolution laser scanner and control points on the surface of the models to trace surface deformation as a function of the imposed physical conditions.

The experiments show that the asymmetric topography systematically enhances the deformation on the side with the highest topographic gradient (i.e. seaside), under inflating reservoirs and dike emplacements (up to 3-4 times), regional tectonics (up to 15%), crustal layering (up to 25%) and the effect of pore pressures. These results, compared with the known rates in nature, allow us to define the relative importance of the different factors on flank instability at Etna. While magmatic activity (inflation and dike emplacement) plays the major role, a progressively lower importance is associated with extensional tectonics. crustal layering and pore pressures.