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Insights into magma depth under resurgent domes from analogue modelling

Elodie Brothelande and Olivier Merle

Laboratoire Magmas et Volcans, Clermont Université, Université Blaise Pascal BP 10448, 63000 Clermont-Ferrand, France (elodie_brothelande@yahoo.fr)

Post-collapse resurgence is a common process observed in many calderas, yet the mechanisms of this phenomenon are still poorly known. Whereas most models account for circular doming, deviations from circular shape is common in nature, reflecting either the shape of the underlying reservoir or the influence of regional structures. We conducted a series of scaled experiments to investigate the structural evolution of a resurgent dome in response to an elongated source.

A sand-plaster mixture was chosen as the analogue for the brittle pile of volcanic rocks and silicone putty simulates the ductile behavior of the intruding magma. The uplift of the intrusion roof drives the resurgence. A set of 21 experiments have been conducted varying the thickness of the brittle overburden and the width of the silicone intrusion. Three types of extensional patterns associated with doming are observed: two lateral grabens, a single axial graben, and no graben. In the third type, the shape of the dome is significantly less elongated and extension is accommodated by two sets of normal faults, which are roughly concentric and radial from the center of the dome. These three extension modes are strongly related to the thickness of the brittle overburden. The "single axial graben" type, frequently observed in nature, corresponds to intermediate thicknesses.

Results of experiments with a single graben show that the dome width is dependent on both tested parameters. In contrast, the graben width is strongly dependent on the overburden thickness whereas the intrusion width is of limited importance. As a significant result, the graben width shows an almost perfectly linear dependency upon the brittle overburden thickness. A simple geometrical model of the analogue system can be proposed, in which opposite master faults of the graben intersect at depth at the junction with the rising viscous intrusion. Geometric constants, or nearly so, such as the slope of the dome flanks and the dip of the graben master faults, may be used to calculate the thickness of the overburden. This result should provide a first-order estimation of the magma depth related to many resurgent domes, and a useful tool for assessing associated potential hazards.