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Load stress controls on directional lava dome growth at Volcán de Colima, Mexico

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During eruptive activity of andesitic stratovolcanoes, the extrusion of lava domes and intermittent explosions are common volcanic hazards. Many lava domes grow into a preferred direction, producing lava and pyroclastic flows due to oversteepening of the dome margins. Access at steep lava dome building volcanoes is difficult and hazardous, so detailed data characterising lava dome growth are typically limited, keeping the processes controlling the directivity of extrusions unclear. Here we combine TerraSAR-X satellite radar observations with high resolution airborne photogrammetry, and perform finite element modelling to investigate the impact of loading stress on magma ascent pathways associated with directed lava dome extrusion and crater formation at Volcán de Colima, México.

The TerraSAR-X data, acquired in 2-m resolution spotlight mode, enables us to derive an accurate chronology of the eruptive processes and allowing intensity-based time-lapse observations of the general crater and dome evolution. The satellite images are complemented by close-range airborne photos, processed by the Structure-from-Motion workflow. This allows the derivation of high resolution digital elevation models, providing insight into detailed morphological and structural features.

During the observation period from Jan-2013 to Feb-2016, we identify a dominantly W-directed dome growth and lava flow production until Jan-2015. In Feb-2015, following the removal of the active summit dome, the surface crater widens and elongates along a NE-SW axis. Later in May-2015, a new dome grows towards the SW of the crater while a separate vent develops in the NE of the crater, reflecting a change in the direction of magma ascent and possible conduit bifurcation. Finite element models show a significant stress change in agreement with the observed magma ascent direction changes in response to the changing surface loads, both for loading (dome growth) and unloading (crater forming excavation) cases. These results allow insight into shallow dome growth dynamics and the migration of magma pathways in response to changing volcano summit morphology. They further highlight the importance of detailed volcano summit surveillance, as changes in direction or location of dome extrusion may have major implications regarding the directions of potential volcanic hazards, such as pyroclastic density currents generated by dome collapse.