Insights on a new pattern of dyke propagation in volcanic edifices

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Dyke intrusions in volcanoes contribute to edifice internal growth and feed flank and summit eruptions. Understanding the control factors on dyke paths is thus critical to assess areas prone to vent formation, and for the general understanding of how volcanoes work.

As a contribute to this wide topic, we present our field and laboratory results dealing with an understudied magma path system, characterized by a central summit rectilinear volcanic rift zone that turns into an outward-widening, fan-arranged pattern of eruptive fissures and dykes at two opposite volcano flanks, giving an overall “hourglass” configuration.

We identified nine elongated volcanoes in different tectonic settings showing evidence of this pattern, and we analysed their geological, structural and morphometric characteristics, highlighting those volcanic-structural features that depict this configuration.

Then, in order to constrain the relation between the state of stress in the edifice and dyke propagation, we developed a series of scaled analogue models. Volcanic edifices were reproduced in gelatine with defined geometries based on field data, while sheet intrusions were simulated by injecting coloured water at different locations below the volcano respect to its flanks and elongation axis.

Our results suggest that this “hourglass” configuration of magma paths in volcanoes can result from the dominance of stress tensors with different geometries in diverse parts of the edifice. These stresses should also have diverse origins; while regional tectonics might exert a control on the orientation of the central part of the rift system, the geometry of the edifice (with defined ranges of elongation and volume) can reorient the local stress field and dictate the pattern of dyke propagation at the volcano edges. These findings complete and integrate previous works on the development of volcanic rift zones, contributing to the assessment of volcanic hazards associated to the opening of dyke-fed eruptive fissures on the volcano flanks.