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Forecasting magma pathways and eruptive vent location by inversion of the volcano stress history

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Volcanoes may erupt dominantly at their summit or on their flanks, depending on edifice shape, magma composition, tectonic setting. At calderas, which lack a summit to focus ascending magma, past eruptive vents are often scattered within or around the caldera rim, distributed in patterns that may show shifts during the history of the volcanic complex. Volcanic hazards may thus affect vast areas of such systems, making forecasting of future vents difficult to asses.
Here we show that magma pathways, and thus future vent locations, may be forecasted by combining the physics of magma transport by dyking, whose propagation direction is controlled by stresses, with a Monte Carlo inversion scheme for the stress history of the volcano, constrained by the location of past vents. We apply our new approach on Campi Flegrei (Italy). We find that shifts in vent patterns are controlled by a delicate balance between regional/local stresses and the stresses induced by surface loads (including topography and volcanic deposits), which at most volcanoes varies in time due to eruptive activity. The resulting stress balance governs the curvature of the trajectories of ascending dykes and thus the location of future vents. Our method offers a mechanical explanation for the vent clustering and migration observed over the successive eruptive epochs at Campi Flegrei. We also show how vent opening probability maps may be calculated based on a parametric stress model for the volcano.