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A Monte Carlo Markov Chain Approach to Stress Inversion and Forecasting of Eruptive Vent Locations

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Current approaches to vent opening forecast produce probabilistic maps on the base of the spatial density of past eruptive vents, as well as the surface distribution of structural features such as faults and fractures. One of the main challenges in forecasting future vent locations in the case of distributed volcanism is that we usually deal with scarce, spatially scattered data to support these approaches. As sophisticated as our statistical analysis can be, such data are difficult to interpolate between and extrapolate from, resulting in spatially coarse forecasts and large uncertainties. More recently, Rivalta et al. (2019) proposed a forecasting strategy to predict future vent locations, combining the physics of magma transport at depth (where magma trajectories are assumed to be driven entirely by stress) with a Monte Carlo inversion technique for key stress parameters. This method has been first tested on the Campi Flegrei caldera; however, further validations and development are needed. Here we validate the strategy of Rivalta et al. with data from analog models (air injection in gelatine). We stress a gelatine block in controlled conditions (extension/compression, surface loading/unloading, layering) and observe air-filled crack trajectories. With these data, we test a flavour of the strategy that combines boundary element magma trajectory calculations with a Monte Carlo Markov chain approach. We find the scheme is able to retrieve the parameters of the stress imposed on the gelatine and forecast subsequent vents in the same experimental setups. We also discuss how it may be applicable to natural cases, and what data are necessary for the approach to be feasible.

Primary author: Mr MANTILONI, Lorenzo (GeoForschungsZentrum (GFZ) Potsdam)

Co-authors: Mr DAVIS, Timothy (GeoForschungsZentrum (GFZ) Potsdam); Ms ROJAS, Ayleen Barbara Gaete (GeoForschungsZentrum (GFZ) Potsdam); Dr RIVALTA, Eleonora (GeoForschungsZentrum (GFZ) Potsdam)

Presenter: Mr MANTILONI, Lorenzo (GeoForschungsZentrum (GFZ) Potsdam)

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