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Pre-existing fault-controlled eruptions from the lateral tips of a laccolith in SE Iceland

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Volcano eruption forecasting relies on models of sub-volcanic magmatic plumbing systems that link ground deformation to sub-surface magma movement. However, many of these models typically assume that eruption sites occur directly above laccolithic reservoirs. Furthermore, many of these models assume deformation of the host rock is exclusively elastic with few studies highlighting the role inelastic deformation (e.g., faulting/fracturing). Whilst the dynamics of magma flow have previously been well constrained in ancient in sub-volcanic systems, its geometrical and kinematic relationship with the corresponding host rock deformation remains poorly understood which, is critical to volcanic hazard assessment.

Here, we examine the structure of the shallow-level (i.e. intruded <1 km below the palaeosurface), silicic Reyðarártindur laccolith in SE Iceland, and demonstrate how the underlying mechanisms of lateral magma flow coupled with pre-existing host rock structures influenced the localisation of volcanic activity. In particular, we use anisotropy of magnetic susceptibility (AMS) fabric analysis and show that the intrusion contains several laterally emplaced magma lobes, with magma flowing along a SW-NE axis, parallel to the strike of pre-existing, steeply dipping fault arrays in the host basalt lavas. Lateral magma flow and inflation of the lobes promoted upward intrusion along these pre-existing faults, which we posit acted as preferential pathways for magma to reach eruption sites that were laterally offset by tens to hundreds of metres from the underlying main intrusion.

Our interpretation provides field evidence for the reactivation of pre-existing structures as inclined magma conduits to eruptive vent sites on the outer margins of subjacent lateral magma bodies. This supports seismic observations where (i) Volcanoes overlie the lateral tips of subjacent intrusions in subvolcanic systems; (ii) ground, and host rock deformation preceding eruptions can be most prominent in areas adjacent to the volcano site; and (iii) volcanoes overlie and are aligned along fault traces suggesting that pre-existing normal faults influence the localisation of volcanic activity.