# From feeder dykes to volcanic vents: The influence of rock mechanics on magma intrusion in the crust

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## Introduction:

How does magma feed volcanic eruptions? This key question in volcanology remains unanswered, and yet the processes involved have a strong influence on the frequency and explosivity of volcanic eruptions and their associated hazards. All volcanic eruptions are fed by dykes, which are magma-filled fractures that transit the crust and cut across stratigraphic layers. Yet the majority of dykes are non-feeders that never breach the surface, instead stalling within the crust either as an arrested dyke or turning horizontally to form a sill. What are the controlling factors that influence the rise to the surface? The elastic and fracture properties of the country rock will play a large role (e.g. Smith et al. 2009); as will the pressure within the dyke, which will be controlled by the geometry of the intrusion (Kavanagh et al. 2015). This project aims to understand the effect of the rock properties and also the magmatic overpressure on fracture propagation and dyke ascent using a field and laboratory approach.

Direct access to the volcanic plumbing system beneath active volcanic fields is not possible, and so studies of ancient eroded systems are crucial to address key questions of the magma ascent dynamics and the mechanical processes that lead to the transition of a feeder dyke to volcanic vent (Figure 1; Townsend et al. 2015). The Cherro Chivo volcanic field in the Chubut Province of Northern Patagonia, Argentina, is a remarkably well exposed shallow crustal volcanic plumbing system. Several basaltic dykes, volcanic diatremes and plugs crop out through Cretacous sediments at an estimated emplacement depth of 500 m. This relatively unexplored region offers an excellent opportunity to study the relationship between a volcanic plumbing system and the volcanic vents it produces.

Scaled laboratory experiments enable field-driven hypotheses to be tested using real and analogue materials, and testing the thermo-mechanical properties of field samples will enhance our understanding of what leads to the formation of a feeder dyke. Dyke orientation may be stress controlled, where the dyke propagates in the direction of maximum compressive stress. Pre-existing weak planes within the crust such as faults, joints or bedding planes provide a structural control that may be intruded, depending on their orientation and the magma overpressure (Delaney et al. 1986). However, dyke emplacement often also involves the creation of new rock fractures, releasing seismic energy and causing deformation of the free surface (e.g. Sigmundsson et al. 2014). The mechanics of ascent are likely to be different under these contrasting scenarios, impacting the tendency for magma to erupt or stall at depth.

## Project Summary (max 700 words inc introduction):

The project involves three components: 1) a field study of the geometry and physical relationships between dykes and volcanic vents, 2) analogue laboratory experiments, and 3) measurement of thermo-mechanical fracture properties of rock samples.

The field study will be carried out at the Cherro Chivo volcanic field in Argentina with collaborators in Argentina, Canada, Switzerland, New Zealand and USA. Scaled analogue experiments will be used to document the propagation dynamics of dykes in the University of Liverpool's MAGMA lab using gelatine as a crustal analogue (Kavanagh et al. 2013). The sub-surface strain changes will be mapped using digital image correlation (Figure 2; Kavanagh et al. 2015; Kavanagh et al. in review), and the internal stress distribution and evolution will be imaged using polarized light. An overhead laser scanner will map the surface deformation associated with the experimental dyke intrusion. The aims of these experiments will be to measure the impact variably weak horizons within an elastic material have on the rates and geometry of experimental dyke propagation. The mechanics of host rock deformation related to magma intrusion will be investigated in experiments that measure the elasticity and fracture toughness of rock samples as a function of fracture state and temperature. These experiments will aim to constrain the role of temperature and host rock alteration in preconditioning rock in advance of magma propagation. Rock specimens will be sourced from Cherro Chivo and the BGS rock core store.

This project is suitable for applicants with a degree in Geology, Geophysics or a related discipline. Experience working in a research laboratory is desirable.

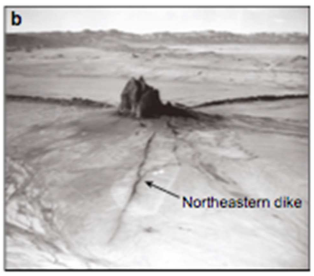


**Image 1–** Photo of Ship Rock, New Mexico, where linear dikes surround a cylindrical plug that likely fed volcanic eruptions (Townsend et al. 2015).

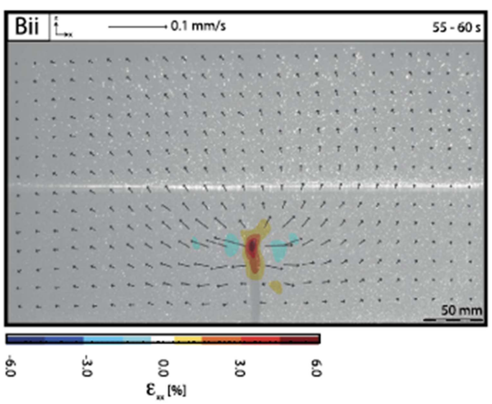


**Image 2** Analogue experiment with mapped sub-surface strain during dyke intrusion (Kavanagh et al., 2015).

### References


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