Geophysical Research Abstracts
Vol. 20, EGU2018-19240, 2018
EGU General Assembly 2018

Laboratory modelling using gelatine as a crustal analogue to understand the effect of spatial variation and offset on dyke propagation

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Magma propagation is one of the fundamental processes within volcanic plumbing systems. However, the challenges observing magma propagation in nature mean the physical processes involved are still relatively unconstrained. Laboratory modelling using analogue materials of known properties helps in overcoming some of these difficulties by allowing real-time observations and measurements of experimental magma intrusions, their ascent, and their developing geometries to be recorded. This is especially pertinent when attempting to understand the interactions between multiple dyke intrusions and their surrounding host rock, and how the evolution of stress fields within the system affects the propagation behaviour of the intruding dykes.

Gelatine is a viscoelastic material and its rheological properties allow it to be scaled experimentally to model crustal intrusion by magma. At a concentration of 2.5 wt.% and a temperature of 5-10^{o}C, gelatine behaves as an elastic material. Our experiments are conducted in a 40x40x30 cm^3 clear square-based Perspex tank with multiple injection ports on the base, which allow the spacing and offset of simultaneous injections to be varied. This port configuration allows two simultaneous injections of identical fluid to be injected at a constant volumetric flux. The tank configuration allows for a range of spacing from 4 cm to 10 cm to be used, and a displacement range from 3.5 cm to 7 cm. The geometries of the growing dykes are recorded using high definition video cameras. The stress-strain evolution within the host is monitored in real-time with the aid of polarising light which allows the camera to record changes in the form of evolving colour fringes. The gelatine solid is also seeded with fluorescent tracer particles, which allows us to quantify the stress-strain evolution observed by using Digital Image Correlation (DIC). DIC produces a displacement map of the fluorescent particles in the form of vectors.

When the injector needles are positioned parallel to one another, the injection of fluid forms two penny-shaped dykes which grow at slightly different rates. Under polarised light, it is observed that the stresses surrounding the tips of the dykes are interacting with each other, where the tip of the dyke with the greater stress fields inhibits the other dyke from growing vertically. Upon eruption of the first dyke, the stresses dissipate, allowing the second dyke to grow at a faster rate.

Similar observations occur when the injector needles are offset from one another. The simultaneous injections show very little overlap, but when overlapping does occur a mutual attraction is observed and the lateral tips "couple".

We observe that changes in the spacing and lateral offset between intruding dykes influences their propagation dynamics significantly. Preliminary results show that the closer the spacing between dykes the greater their interaction, and the closer the offset, the greater the influence of the propagation direction, suggesting that stress-strain fields induced by dyke intrusion may play on important role controlling the simultaneous and sequential propagation of dykes in the crust.