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The impact of magma rheology on dyke ascent dynamics

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The rheology of magma is of fundamental importance to intrusive and extrusive volcanic phenomenon. Magma ascends through the crust via an interconnected network of dykes and sills. The intrusion dynamics of these magma-filled fractures can be monitored real-time using geophysical monitoring networks. The host-rock damage and solidified magma of ancient volcanic plumbing systems record evidence of past intrusive events, where magma flow dynamics are interpreted from petrographic textures, magnetic fabrics and geochemical variations in the melt phase and crystal cargo. Laboratory experiments are an important tool to help bridge the diverse information available from studying magma intrusions in nature and to test magma ascent models.

We present results from laboratory experiments where a range of Newtonian and non-Newtonian magma analogues are used to explore the impact of magma rheology on dyke propagation. The fluids represent a spectrum of magmas from melt-rich to crystal- and/or bubble-rich. An experimental dyke is created by injecting the fluid at constant flux into the base of a homogenous elastic medium (gelatine) that represents the Earth's crust. Passive-tracer particles in the fluid are fluoresced by a laser sheet, and post-processing of the experimental images using particle image velocimetry (PIV) quantifies the evolving flow velocities within the growing dyke. The PIV patterns reveal channelization, recirculation and jet-instability within the growing dyke. We compare our experimental results with case studies from the Isle of Skye (UK) and Utah (USA) and demonstrate how our results have wide implications for interpreting petrographic and magnetic evidence of magma propagation in nature.