Laboratory modelling of magma mingling*

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Magma mingling is the process in which two separate magmas interact in a dynamic environment to cause some stirring with each other, but distinct boundaries are preserved between them. This differs from the process of magma mixing, where the resulting magma is a homogeneous rock with intermediate composition. The dynamics of magma mingling and mixing depend primarily on density and viscosity contrasts, rheology and the geometry and vigour in which one magma intrudes into another.

A series of laboratory based experiments were conducted to study the effect of magma mingling when a viscous felsic magma chamber is intruded by a localised injection of denser, intermediate to mafic magmas. A motivation of this study was to understand the dynamics of formation of a particular outcrop of the Holyrood Intrusive Suite in Eastern Newfoundland. Here, a coastal exposure shows metrescale rounded blobs of a medium-grained intermediate rock within a medium to coarse-grained felsic host. The experiments were conducted in transparent decimetre scale tanks, and experimental materials were chosen to have density and viscosity contrasts analogous to those of magmas of differing compositions. Density contrasts were controlled by the use of aqueous salt solutions (such as $NaNO_3$) having varying weight percentages, while viscosity contrasts were controlled by varying concentrations of oxyalkene polymers (PEG 600 wax) or cellulose ethers (MethocelTM and NatrosolTM). The effect of crystals in magmas was replicated by the use of small plastic and/ or glass beads having a diameter between 0.09–0.35 mm. The experimental tank was filled with the host analogue magma, and denser analogue magma, dyed blue for visual contrast, was introduced by pump from below, by syringe from above, or more commonly by emplacing a blob-like aliquot from above.

Depending on the physical properties of the two materials, many different behaviours of the injected material were observed, including slow drips, turbulent plumes and crater-forming impacts on the bottom of the tank. The best match to the Holyrood Granite outcrop was obtained when the introduced 'blob' contained 25–50% beads (analogue crystals) and was only slightly denser than a high-viscosity host. This resulted in blobs which maintained their shape as they slowly sank without mixing with the surrounding fluid. This result is consistent with recent models of the Holyrood Granite outcrop blobs based on petrographic observations.

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