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Modelling volatile-driven conduit flow and lava lake convection at Mt. Erebus

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Persistently degassing volcanoes emit significantly more volatiles than they erupt magma. To explain this observation, two contrasting models have been suggested. In one limit, the exsolved volatile vapours are thought to segregate from the magma soon after they form, and to coalesce to large, conduit-filling bubbles or gas slugs that rise through an otherwise stagnant magma column. In the contrasting limit, bubbles are thought to be sufficiently small at depth that they remain fully entrained in the silicate melt, thus providing buoyancy and causing the upwelling of magma through the conduit as a bubbly suspension. This latter regime implies that magma that has lost its vapour content near the surface must sink back down into the conduit, resulting in a bidirectional conduit flow. Here, we are using numerical and analytical models to take a closer look at this latter regime.

Mt. Erebus, Antarctica, is an example of a low-viscosity, persistently degassing volcano featuring a long-term stable lava lake in its crater. With its excellent observational record, it provides an ideal study site to test models of volatile-driven conduit dynamics. Observations of gas flux and composition, heat flux, and surface velocity at the lava lake surface show strongly correlated, episodic cycles with an approximately 10 minute period. To find an explanation for these observations, we investigate the regimes of bidirectional conduit flow and lava lake convection that may. We find that bidirectional flow is the prevalent flow regime in low-viscosity volcanic systems. This regime is prone to wave-like instabilities, and may switch between two configurations associated with distinctly different upwelling rates. Furthermore, our lava lake models predict that even for an entirely stable conduit flow pattern, the internal dynamics of the lava lake may introduce episodicity. In the future, we aim to distinguish between instabilities in conduit flow and lava lake convection as the cause of episodic degassing by comparing modelled variations in gas composition emerging from either model scenario to the observational data record.