Linking the timescales of magmatic processes and unrest at La Soufrière de Guadeloupe

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Signals of volcanic unrest do not usually provide insights into the timing, size and style of a future eruption, but clues to eruptive behaviour can be determined from past eruptions. Here we examine a series of basaltic-andesitic to andesitic eruption deposits from La Soufriere de Guadeloupe which cover a range of eruption styles and ages. This work is timely because La Soufrière has shown increasing unrest over the last 25 years, with the strongest seismic event since the 1976-77 volcanic crisis recorded in 2018.

Through crystal-specific analyses of past eruptions, we constrain timescales of magmatic processes across a range of eruption styles and magnitudes. We closely examine four different eruptions using Fe-Mg diffusion in orthopyroxenes. We use backscattered electron images as a proxy for Fe-Mg composition, which varies due to crystal melt diffusion, and from which we calculate the timescale between the last recharge/mixing and eruption.

Our preliminary results demonstrate single crystal timescales range from days to years at La Soufrière. Specifically, the last magmatic eruption - vulcanian style (1657 CE) records timescales ranging from 0.2 to 165 days, while the most recent Plinian eruption (1010 CE), shows a range from 8 days to 20 years. We compare timescale data by fitting a probability distribution for modelling random processes which provides the expected ("mean") timescale and its error. The 1657 CE and 1010 CE eruptions have very different expected timescales of 25 days and 410 days, respectively.

Our results suggest that La Soufrière can buffer episodes of magma injection into the deeper parts of the system, until a last critical recharge rapidly produces a large explosive eruption. The timescales indicate that unrest could spike only a few weeks before an eruption. Longer term changes of the magmatic system may not be detected in unrest signals, such as seismic and geodesy data, due to the screening effect provided by the hydrothermal system. This is critical when considering, the necessity of near-real time data, early warning systems, crisis response management, and long-term planning.