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Controls on Eruption Style at La Soufrière de Guadeloupe from Melt Inclusions and Mineral Diffusion Timescales.

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Signals of volcanic unrest do not usually provide insights into the timing, size and style of future eruptions. However, analysis of past eruptions provides useful information in order to understand the evolution, magma storage and onset of future eruptions, Here, we examine basaltic-andesitic to andesitic eruption deposits from La Soufrière de Guadeloupe, covering a range of eruption styles, ages and magnitudes. Our work is timely given unrest at this system has increased over the last 25 years, with a potential eruption capable of directly impacting ~70,000 people in Southern Basse-Terre.

Here, we study the geochemistry of pre-eruptive magmas and timescales of magmatic processes preceding four explosive eruptions: 1657 Cal. CE (Vulcanian), 1010 Cal. CE (Plinian), ca. 341 Cal. CE (Strombolian) and 5680 Cal. BCE (Plinian). Using diffusion timescale studies of orthopyroxene phenocrysts, we constrain the timing of magma injections into the La Soufrière de Guadeloupe magmatic reservoir. These range from 35 ± 0.37 to 848 ± 0.4 days before eruption. Diffusion timescales do not appear to correlate with eruption style/size, but may correlate with other parameters (e.g., magma interactions in the reservoir and/or volatile content of the magma).

Major element concentrations in whole rock (WR), groundmass glasses (GM) and melt inclusions (MI) show a strong linear trend. However, this evolution cannot be resolved through fractional crystallisation alone, as there is no clear temporal trend. MIs reveal a relatively homogenous melt composition from the first to the most recent eruptions, ranging from 63.6 – 78.7 wt% SiO2. Volatiles, including H_2O (2.3-4.4 wt%), CO_2 (35-866 ppm) and sulphur (30-202 ppm), are also consistent across the various eruptions. MIs are often more evolved than the GM, indicating they cooled prior to their entrainment. This, along with the different crystal populations observed, suggests a recharge magma has intruded through a mush system and entrained crystals stored there. Crystals in different regions of the mush therefore experience different interactions with magmatic processes.

The major element compositional homogeneity across the eruptions indicates that composition does not have a large control on eruption style at this system. However, MI pre-eruptive volatile contents are more concentrated in the larger Plinian eruptions (e.g., CO_2 – 866 ppm) than the smaller Vulcanian and Strombolian eruptions (e.g., CO_2 – 674 ppm). Volatile emissions calculated

through the petrologic method also differ, with higher total volatile emissions observed in the Plinian eruptions (12 Mt) than the smaller eruptions (0.1 Mt). The Plinian eruptions also have a faster magma ascent rate (0.3-22 m/s) than the vulcanian eruptions (3 m/s) as calculated from mass flux estimates.

Though the composition of the La Soufrière de Guadeloupe system has remained constant over time, changes in eruption style can result from variations: (i) in the way magma interacts with the mush system, (ii) in the pre-eruptive volatile contents and (iii) in the ascent rates. Understanding the controls on eruption style is important, especially during the current phase of unrest, in order to improve early-warning system efficiency, forecast models, eruption scenario crisis response and long-term risk reduction planning.