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Microanalysis of volcanic matrix tracks melt composition across space and time

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Reconstructing the compositional evolution of magmatic systems through timescales ranging from millions of years to months and days is crucial to assessing variations in magma sources, storage and ascent, and their impact on eruption behaviour and associated hazards [1]. Bulk rock analysis provides valuable information on the overall chemical budget of magmas, however volcanic rocks are often laden with crystals transported from storage regions, which skew bulk chemical signatures [2]. To resolve subtle chemical variations in erupted liquids, we optimised rapid analysis of volcanic matrix via in situ laser ablation mass spectrometry [3]. The laser approach makes it possible to target microcrystalline to glassy rock groundmass in lava flows and tephras, avoiding phenocrysts. The aerosol is analysed via quadrupole Q-ICP-MS for major and trace elements, and multi-collector MC-ICP-MS for Sr isotopes [3,4].

Application of the method to samples spanning the entire 2021 La Palma eruption resolves discrete magma injections driving the onset, evolution, and termination of volcanism [3]. Magma composition has a direct effect on the temperature and viscosity of erupted products and over the course of the 3-month-long eruption, observed chemical variations in basanite liquids correlate with variations in lava flow behaviour and impact, as well as monitoring signs [3]. In addition, the matrix compositions can be assessed in terms of equilibrium with coexisting minerals and used as liquids in thermobarometry [3]. The method is rapid and versatile and can provide a monitoring technique to combine with geophysical and geochemical data. Analysis of early tephra, which may be sampled with the help of local communities, can provide rapid insight into the type of erupted liquids and their hazard potential. Continued analysis of volcanic products can help assess the development of eruptions and their potential end. More broadly, the method can be applied to explore variations in magma chemistry across range of spatial and temporal geological scales.

[1] Halldórsson et al. 2022 Nature. [2] Ubide et al. 2022 Geology. [3] Ubide et al. 2023 Science Advances. [4] Mulder et