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A view of the volcanic roots of Mt Liamuiga, Saint Kitts, using machine learning thermobarometry

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Accurately determining the pressure, temperature, and melt composition of magma underlying a volcano is critical for the interpretation of monitoring signals in the build-up to an eruption, and to quantitatively link eruption size, explosivity, and duration to the pre-eruptive storage conditions. However, reliable single-phase thermobarometers and chemometers, particularly involving amphibole, have remained elusive. We present a suite of amphibole and clinopyroxene thermobarometers and chemometers based on random forest machine learning. This approach allows us to intimately track the range of pre-eruptive conditions over the course of a millennial eruptive cycle on an island arc volcano (the Mansion Series from Saint Kitts, Eastern Caribbean).

We unveil the story of Mt Liamuiga, a stratovolcano that pops its upper-crustal (2 kbar), dacitic cork at the beginning of its eruptive cycle. This permits a progressive increase in the thermal maturity of the magma arriving at the surface from depth (4 kbar) through time. Chemometers reveal a liquid line of descent which is not evident from whole-rock geochemistry alone and raise questions about how representative magmas are as true liquids. These observations are coupled with the results from crystal population chronology of plagioclase to quantify the proportion of phenocrysts vs antecrysts in the erupted products.

A notable result is that our findings implicate amphibole as a reliable barometer (SEE = 1.7 kbar). Hence, we suggest it may be the regression strategy, as opposed to the abject insensitivity to pressure, that has hindered previous calibrations of amphibole only barometers. By recognising this, we have constructed a high-resolution, quantitative picture of the sub-volcanic region beneath a young arc volcano.