Processes leading up to the 22 ka silicic caldera-forming eruption of Santorini (Greece): Constraints from crystal trace-element fingerprinting and diffusion chronometry

Gareth N Fabbro[1], Timothy H Druitt[1], Fidel Costa[2]

[1]Clermont Université, Université Blaise Pascal, Laboratoire Magmas et Volcans, BP 10448, France,
[2]Earth Observatory of Singapore, Nanyang Technological University, Singapore

E-mail: g.fabbro@opgc.univ-bpclermont.fr

Caldera-forming eruptions are amongst the most destructive phenomena on this planet. Constraining the processes that occur before these eruptions, as well as the timescales of those processes, is vital for forecasting the behaviour of the volcanoes responsible for them. The 21.7±0.2 ka caldera-forming Cape Riva eruption of Santorini Volcano discharged at least ~10 km^3 of dacitic magma (along with a minor basalt-dacite hybrid andesitic component), and caused caldera-collapse. The eruption was preceded by a ~13 ky period of dacitic effusive and minor explosive volcanism. This effusive activity constructed the 1-2 km^3, <200-m-thick Therasia dome complex, centred on the site of the subsequent Cape Riva caldera. The major element geochemistry of the Therasia dacite is very similar to that of the Cape Riva dacite, but its lower incompatible element concentrations (e.g. K, Zr, Rb, La, Ce and Nb) demonstrate that it is a different magma batch. This difference is also apparent in the concentrations of La and Ce in plagioclase crystals from the two magmas. La and Ce diffuse very slowly through plagioclase (<100 μm in 10^7 y at 900°C), and therefore reflect the concentration of those elements in the parent magma on the timescale of our system (<10^5 y). The contrasting trace element compositions of the whole rocks and crystals seem to rule out a simple interpretation that the Therasia dacites were leaks from the growing Cape Riva magma chamber. Modelling of diffusion gradients of relatively fast-diffusing elements such as Mg and Sr in plagioclase crystals provides estimates of the residence times of those crystals at magmatic temperatures. Preliminary results also show that plagioclase crystals in the Therasia dacites have maximum residence times of the order of 10^2-10^3 years. This is short compared to the total 13 ky duration of effusive volcanism, suggesting that the Therasia lavas may represent the repeated ascent, partial crystallisation and eruption of multiple, small parcels of dacitic magma over a long period of time. Field and $^{40}Ar/^{39}Ar$ constraints tie down the arrival of the Cape Riva dacite batch in the shallow plumbing system less than 4000 y prior to the Cape Riva eruption. Preliminary diffusion chronometry results for Cape Riva crystals suggest residence times for some plagioclase crystals as short as 10-10^2 years. This supports the idea that major influx of new, silicic magma occurred shortly before the eruption, and possibly provides more a precise constraint on the timing of this influx.