Processes leading up to the 22 ka silicic caldera-forming eruption of Santorini (Greece): Constraints from field, $^{40}Ar/^{39}Ar$ and chemical data

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Large caldera-forming eruptions are commonly preceded by effusive eruptions whose magma chemically and petrologically resembles that of the climatic eruption. Studying these lavas can reveal processes that occur in the build-up to these often-catastrophic eruptions. On Santorini, the 21.7±0.2 ka caldera-forming Cape Riva eruption produced at least 10 km^3 of dacitic magma, along with a minor andesitic component. It was preceded by a period of effusive volcanism that discharged 1-2 km^3 of magma and built up the so-called Therasia dome complex. The Therasia dome complex is dominated by at least 12 different dacitic coulées and domes, which total up to 200 m in thickness. These are intercalated with the dacitic products of sub-plinian explosive activity, and are capped by an andesitic lava flow (the upper Therasia andesite). The Therasia lavas were fed by dykes, with vents located within the area that subsequently collapsed to form the Cape Riva caldera. The majority of the Therasia dome complex was erupted in a period of about 13 ky, starting 36.0±2.8 ka. The youngest lava has an age of 23.2±2.3 ka, less than 4000 y before the Cape Riva eruption. The Therasia dacites contain between 65 and 69 wt% SiO_2, and have 1-17 wt% phenocrysts of plagioclase, orthopyroxene, clinopyroxene and Fe-Ti oxides. This closely resembles the Cape Riva dacite, which has a similar phenocryst assemblage and 64-67 wt% SiO_2. The upper Therasia and Cape Riva andesites are also similar to each other. They are both hybrid andesites (60-62 wt% SiO_2) with crystals of plagioclase, orthopyroxene, olivine and Fe-Ti oxides, and formed by mixing ∼60 wt% dacite with ∼40 wt% basalt. The occurrence of hybrid andesites at the top of the Therasia sequence suggests that, for the first time since ∼36 ka, mafic magma was reaching shallow levels of the plumbing system under Santorini. Despite the similarities in the petrology and major-element chemistry of the Therasia and Cape Riva magmas, however, the Cape Riva dacite is depleted in incompatible elements such as K, Zr, Rb, La, Ce and Nb. This fits with the long-term trend towards more depleted magma compositions on Santorini, and implies that the Cape Riva and Therasia magmas were distinct batches. The two hybrid andesites (Therasia and Cape Riva) also exhibit the same differences in trace element composition. This could be explained by a large influx of silicic magma (and accompanying basaltic magma) into the shallow plumbing system in the short period between the end of the construction of the Therasia dome complex and the onset of the Cape Riva eruption. One implication of this interpretation is that the transition from prolonged effusive to major explosive activity coincided with this upward transfer.