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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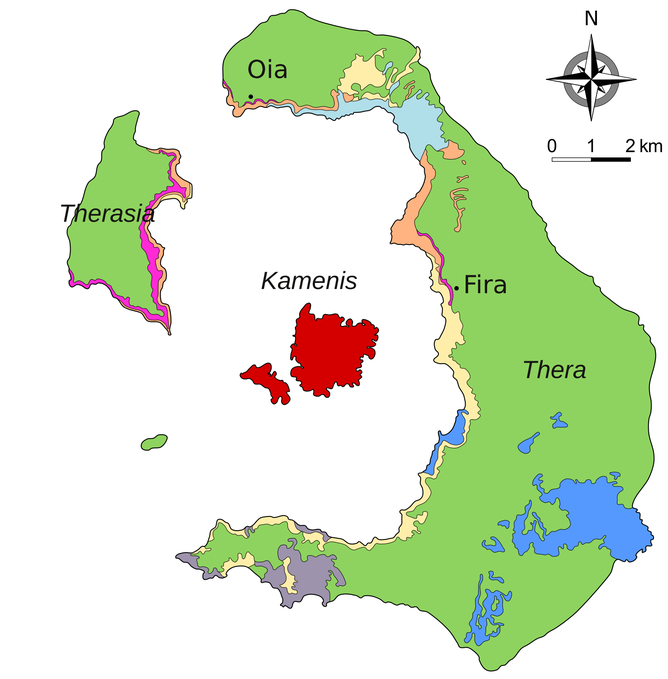
1. Introduction

Large, silicic, explosive eruptions are among the most destructive phenomena on Earth. Their magma reservoirs were thought to grow incrementally over long periods of time. Recent studies have, however, begun to cast doubt on this interpretation, favouring instead short periods of high magma input and rapid reservoir growth.



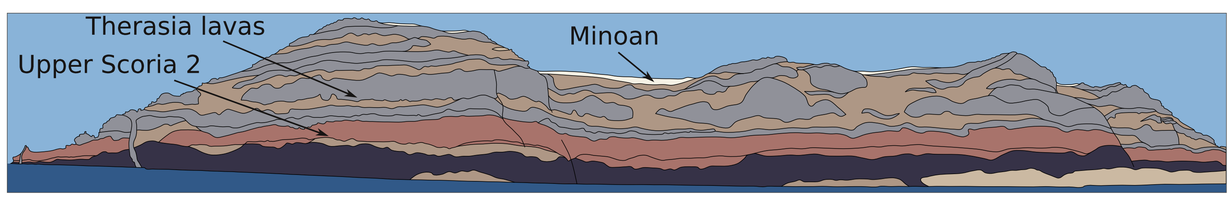
Here, we look at the "precursory leaks" of a silicic caldera-forming eruption in an attempt to shed light on the processes that occur during the build-up to these large eruptions. "Precursory leaks" are small, effusive or minor explosive eruptions that precede a caldera-forming eruption. They have a similar composition to the products of the climactic eruption. They erupt from diffuse vents, suggesting that the regional stress field is perturbed locally by the presence of a large, shallow magma reservoir.

Santorini

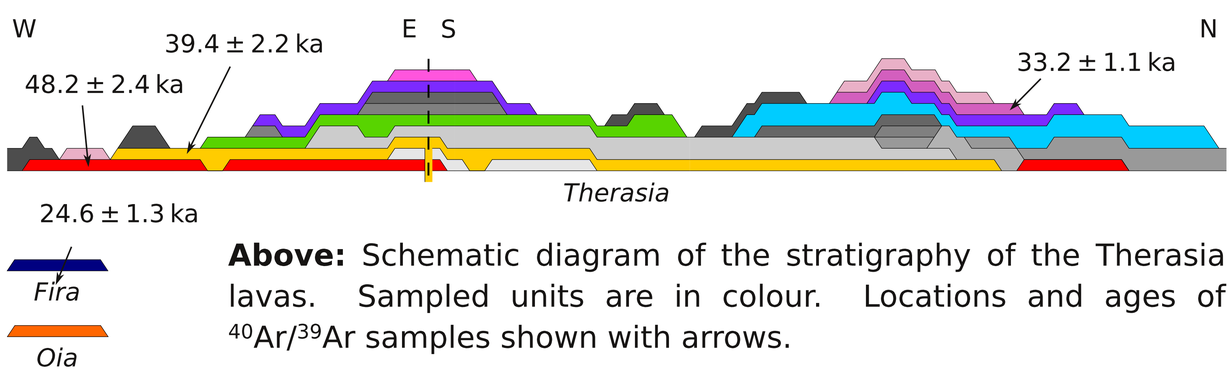
Santorini lies on the Hellenic Volcanic Arc in the Aegean Sea and has been active since 650 ka. In this study we concentrate on the build-up to the 22 ka caldera-forming Cape Riva eruption, which discharged at least 10 km^3 of mainly dacitic magma. Between the Cape Riva and the previous Plinian eruption (Upper Scoria 2, 54 ka) a series of mainly dacitic lavas were erupted to form the Therasia Dome Complex. These have been considered "precursory leaks" of the Cape Riva, and we have used them to study the evolution of the plumbing system prior to this major eruption.

2. Field architecture

Above: Photomontage of the cliffs of Therasia, which was used to produce the sketch below.

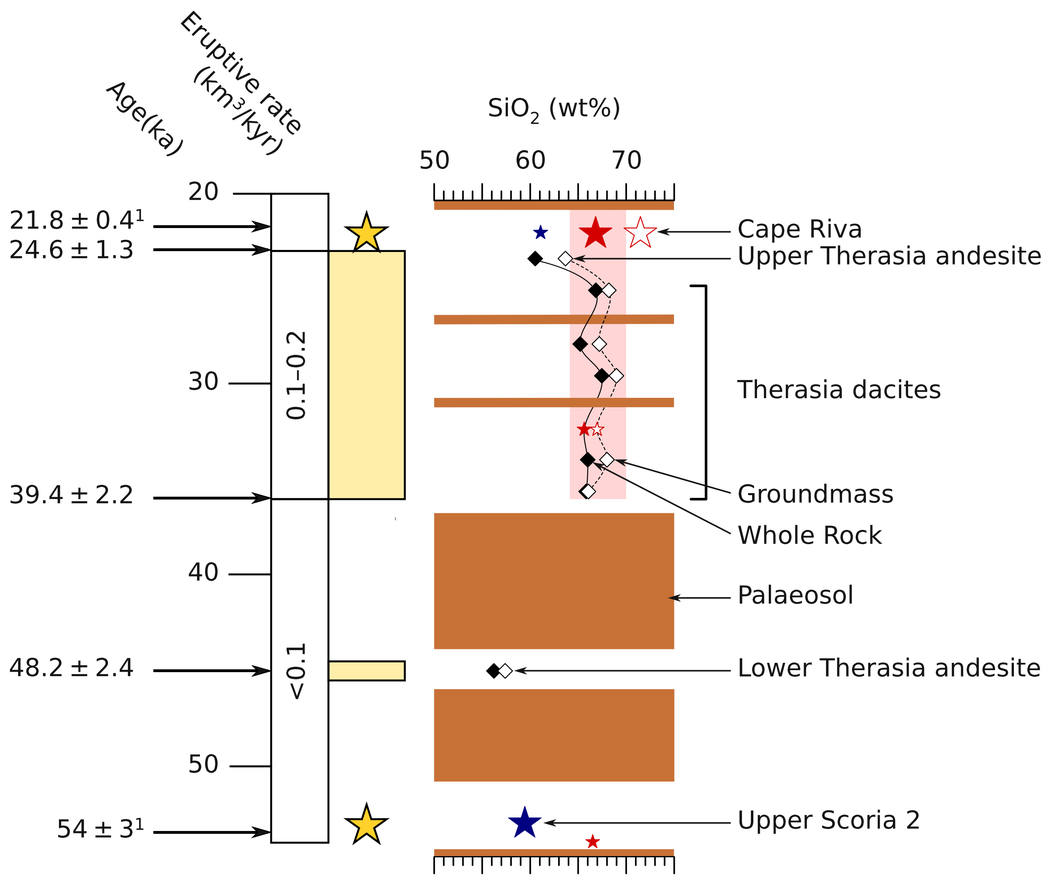


Above: A Sketch of the cliffs of Therasia. Several such sketches were combined to produce the schematic diagram below.



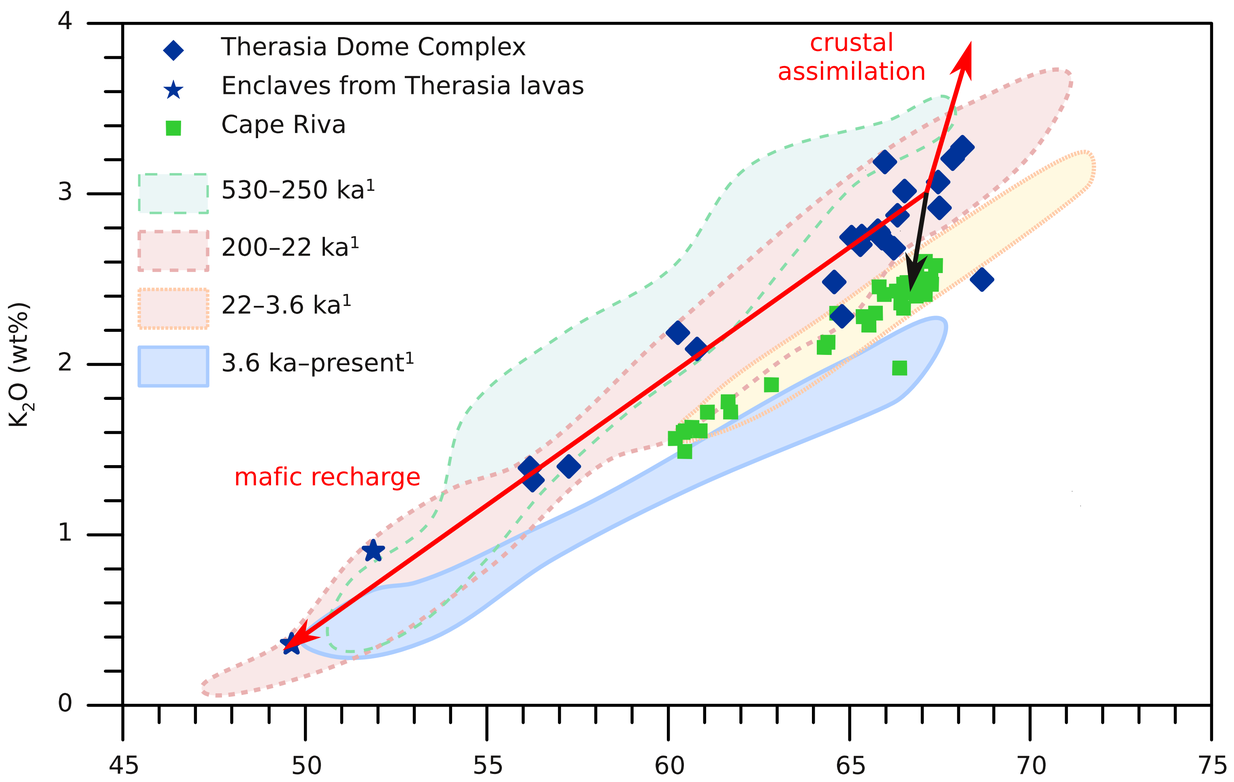
Above: Schematic diagram of the stratigraphy of the Therasia lavas. Sampled units are in colour. Locations and ages of $^{40}Ar/^{39}Ar$ samples shown with arrows.

3. Chronology



- There are very few eruptions recorded between ~54 and ~39 ka. The system began to stagnate.
- The eruption of dacite commenced 39.4 ± 2.2 ky ago. The eruptive rate remained low compared to the long-term average (~1 km^3/kyr).
- Very little mafic magma reached the surface until the upper Therasia andesite; any mafic magma injected into the crust must have been trapped at depth.
- The youngest lava dated was erupted 24.6 ± 1.3 ky ago, just 2800 ± 1400 y before the Cape Riva eruption.

4. Chemistry



- The Cape Riva and Therasia dacites are very similar in terms of most major elements, as are the Cape Riva and upper Therasia andesites.
- However, the Cape Riva magma is depleted in incompatible elements (e.g. K, Zr, Rb, La, Ce, Nb) relative to the Therasia magmas. This change consistent with a long-term temporal trend on Santorini towards depleted compositions, which is probably due to changes in the source region.
- The short period between the youngest dated Therasia lava and the onset of the Cape Riva eruption demonstrates that the change in magma composition must have taken place over at most 2800 ± 1400 y.
- Crustal assimilation and mafic recharge would not result in the observed change.
- The Cape Riva eruption followed the arrival, in the shallow crust, of a new batch of silicic magma from depth (>10 km^3 in <4200 y).

[1] data taken from the literature

References

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