

IODP Proposal Cover Sheet

932 - Full

Hellenic Arc Volcanic Field

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Title	Volcanism and tectonics in an island-arc rift environment (VolTecArc): Christiana-Santorini-Kolumbo marine volcanic field, Greece		
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Abstract

Subduction-related volcanism impacts life and the environment around the edges of continents. Better understanding of island-arc volcanism and associated hazards requires study of the processes that drive such volcanism, and how the volcanoes interact with their marine surroundings. What are the links and feedbacks between crustal tectonics, volcanic activity and magma genesis? What are the dynamics and impacts of submarine explosive volcanism and caldera-forming eruptions? How do calderas collapse during explosive eruptions, then recover to enter new magmatic cycles? What are the reactions of marine ecosystems to volcanic eruptions?

The Christiana-Santorini-Kolumbo (CSK) volcanic field on the Hellenic Volcanic arc is a unique system for addressing these questions. It consists of three large volcanic centres (Christiana, Santorini, Kolumbo), and a line of small submarine cones, founded on thinned continental crust in a 100-km-long rift zone that cuts across the island arc. The CSK volcanic field is notable for Santorini caldera and its Late Bronze Age eruption, an iconic event in both volcanology and archaeology. Kolumbo seamount erupted in 1650, causing many deaths from gas release and tsunami impact. The caldera unrest at Santorini in 2011-12 raised awareness of eruption threat at this major tourist destination.

The marine rift basins around the CSK field, as well as Santorini caldera, contain volcano-sedimentary fills up to several hundreds of metres thick, providing rich archives of CSK volcanic products, tectonic evolution, magma genesis and palaeo-environments accessible only by deep drilling backed up by seismic interpretations. We propose to drill four primary sites in the rifts basins and two additional primary sites inside Santorini caldera. The science has five main objectives, each with a leading testable hypothesis, and two secondary objectives. The proposal addresses all three science themes, and six of the fourteen challenges, of the IODP Science plan.

Existing onland volcanological research, sea-floor mapping, shallow coring and dredge sampling, combined with a dense network of seismic profiles and a recent seismic tomography experiment, make drilling at the CSK volcanic field very timely. Deep drilling is essential to identify, characterise and interpret depositional packages visible on seismic images, to chemically correlate primary volcaniclastic layers in the rift fills with their source volcanoes, to fill in the many gaps in the onland volcanic records, to provide a tight chronostratigraphic framework for rift tectonic and sedimentary histories, and to sample deep subsurface microbial life.

Scientific Objectives

We propose six sites (and associated alternate sites) for deep-sea drilling at the rift-hosted Christiania-Santorini-Kolumbo (CSK) volcanic field on the Hellenic island arc in Greece, with five primary objectives:

1. Arc volcanism in an active rift environment: To reconstruct the volcanic history of the CSK volcanic field since the Pliocene by exploiting a >3.8 My marine volcano-sedimentary archive [IODP Science Plan challenges 11, 12].
2. The volcano-tectonic connection: To reconstruct the subsidence and tectonic histories of the rift basins, and use the rift as a natural experiment for studying the relationship between CSK volcanism and major crustal tectonic events [challenges 11, 12].
3. Arc magmatism in a region of extending crust: To document magma petrogenesis at the CSK volcanic field in space and time, and to seek effects of crustal thinning on magma storage, differentiation and crustal contamination [challenges 8, 11].
4. Unravelling an iconic caldera-forming eruption: To document the processes, products and potential impacts of the late Bronze-Age eruption of Santorini [challenge 12].
5. Volcanic hazards from submarine silicic eruptions: To study the histories, dynamics and hazards of Kameni and Kolumbo submarine volcanoes [challenge 12].

Each objective is presented with a leading hypothesis, the testing of which requires ocean drilling and detailed core analysis. We also include two secondary drilling objectives: 6. Transition from continental to marine environments in the southern Aegean [challenge 11]; 7. Biological systems reactions to volcanic eruptions and seawater acidification [challenges 5, 6, 7]

Non-standard measurements technology needed to achieve the proposed scientific objectives

Proposed Sites (Total proposed sites: 13; pri: 6; alt: 7; N/S: 0)

Site Name	Position (Lat, Lon)	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
CSK-01A (Primary)	36.7293 25.6482	505	756	9	765	CSK-01A targets the plio-quadernay volcano-sedimentary fill of the Anhydros Basin, to the depth of the Alpine basement. The site lies near the basin axis in a position downstream of Santorini and Kolumbo Volcanoes. The aim is to use the core (and seismic profiles) to reconstruct the volcanic, sedimentary and tectonic histories of the basin, and to access a near-continuous time series of volcanism in the area since rift inception. The hole will transect and characterize all six seismic packages of the Anhydros rift basin (B1 to B6).
CSK-02A (Alternate)	36.7438 25.7146	511	437	10	447	CSK-02A targets the plio-quadernay volcano-sedimentary fill of the Anhydros Basin, to the depth of the Alpine basement. The site lies near the basin axis in a position downstream of Santorini and Kolumbo Volcanoes. The aim is to use the core (and seismic profiles) to reconstruct the volcanic, sedimentary and tectonic histories of the basin, and to access a near-continuous time series of volcanism in the area since rift inception. The hole will transect and characterize all six seismic packages of the Anhydros rift basin (B1 to B6).
CSK-03A (Primary)	36.5549 25.4398	397	566	0	566	CSK-03A lies in the Anhydros Basin on the NW submarine flank of Kolumbo Volcano. The aim is to penetrate four seismically recognized volcanic eruption units from Kolumbo (K2, K3, K5 and the thin lateral continuation of K1), as well as many eruption units from Santorini. This will enable characterisation of the products of the Kolumbo eruptions, as well as construction of a coherent stratigraphy for Santorini and Kolumbo together.
CSK-04A (Alternate)	36.5728 25.4092	403	545	0	545	CSK-04A lies in the Anhydros Basin on the NW submarine flank of Kolumbo Seamount Volcano. The aim is to penetrate seismically recognized volcanic eruption units from Kolumbo, as well as many units from Santorini. This will enable characterisation of the products of the Kolumbo eruptions, as well as construction of a coherent stratigraphy for Santorini and Kolumbo together. However this site only clearly transects one Kolumbo eruption unit (K5), and has been replaced since the pre-proposal by site CSK-04B, which is better placed for our objectives.
CSK-04B (Alternate)	36.5068 25.5053	300	730	0	730	CSK-04B lies in the Anhydros Basin on the SE submarine flank of Kolumbo Seamount Volcano. The aim is to penetrate seismically recognized volcanic eruption units from Kolumbo (K1, K3, K5), as well as many units from Santorini. This will enable characterisation of the products of the Kolumbo eruptions, as well as construction of a coherent stratigraphy for Santorini and Kolumbo together. This site replaces CSK-04A (pre-proposal alternate) as the favoured alternate to site 03A, since CSK-04A only transects one Kolumbo eruption unit whereas CSK-04B samples three.
CSK-05A (Primary)	36.4355 25.3805	385	360	0	360	CSK-05A is sited in the northern basin of Santorini caldera. The aim is to penetrate intracaldera seismic units S1, S2, and S3 in order to characterise them and confirm (or not) published hypotheses, as well as to penetrate below unit S3 (probably intracaldera tuff of the LBA eruption). The hole is located north of a low-velocity seismic anomaly detected by the PROTEUS seismic tomography experiments and centered on the focus of caldera floor uplift during the unrest period of 2011-12.
CSK-06A (Alternate)	36.4424 25.3751	383	381	0	381	CSK-06A is sited in the northern basin of Santorini caldera. The aim is to penetrate intracaldera seismic units S1, S2, and S3 in order to characterise them and confirm (or not) published hypotheses, as well as to penetrate below unit S3 (probably intracaldera tuff of the LBA eruption).
CSK-07A (Primary)	36.3890 25.4171	292	400	0	400	CSK-07A is sited in the southern basin of Santorini caldera. The aim is to penetrate intracaldera seismic units S1, S2, and S3 in order to characterise them, as well as to penetrate below unit S3 (probable intracaldera tuff of the LBA eruption). This site is complementary to sites CSK-05A/06A in the northern caldera basin, as together they will provide a complete understanding of the caldera fill and collapse history.
CSK-08A (Alternate)	36.3816 25.4061	293	400	0	400	CSK-08A is sited in the southern basin of Santorini caldera. The aim is to penetrate intracaldera seismic units S1, S2, and S3 in order to characterise them, as well as to penetrate below unit S3 (probable intracaldera tuff of the LBA eruption). This site is complementary to sites CSK-05A/06A in the northern caldera basin, as together they will provide a complete understanding of the caldera fill and collapse history.

Proposed Sites (Continued; total proposed sites: 13; pri: 6; alt: 7; N/S: 0)

Site Name	Position (Lat, Lon)	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
CSK-09A (Primary)	36.5656 25.7613	694	585	10	595	CSK-09A is sited in the Anafi Basin. The aim is to penetrate the entire volcano-sedimentary fill of this basin as far as the Alpine basement. The basin potentially records the full volcanic history of Santorini (and any older centres) since rift inception, but not of Kolumbo Volcano. The hole will reconstruct the subsidence and sedimentary history of this basin, to compare with that of the Anhydros Basin. It will transect all six seismic units present in the basin (B1 to B6).
CSK-10A (Alternate)	36.5494 25.7714	672	368	9	377	CSK-10A is sited in the Anafi Basin. The aim is to penetrate the entire volcano-sedimentary fill of this basin as far as the Alpine basement. The basin potentially records the full volcanic history of Santorini (and any older centres) since rift inception, but not of Kolumbo Volcano. The hole will reconstruct the subsidence and sedimentary history of this basin, to compare with that of the Anhydros Basin. It will transect the topmost five of the six seismic units present in the basin (B2 to B6).
CSK-11A (Primary)	36.3897 25.2142	408	823	0	823	CSK-11A is sited in the Christiana Basin. This basin is deeper than the Anhydros and Anafi Basins, and is located SW of Santorini. Its volcano-sedimentary fill potentially records the earlier volcanic history of the CSK volcanic field (including the products of Christiana and early Santorini), as well as younger Santorini and possibly Milos Volcano. The hole will pass through three prominent volcanic units (PFI to PFIII) seen on seismic records. This site may move slightly following planned acquisition of new seismic data in the Christiana basin.
CSK-12A (Alternate)	36.3842 25.2352	367	836	0	836	CSK-12A is sited in the Christiana Basin. This basin is deeper than the Anhydros and Anafi Basins, and is located SW of Santorini. Its volcano-sedimentary fill potentially records the earlier volcanic history of the CSK volcanic field (including the products of Christiana and early Santorini), as well as younger Santorini and possibly Milos Volcano. The hole will pass through three prominent volcanic units (PFI to PFIII) seen on seismic records. This site may move slightly following planned acquisition of new seismic data in the Christiana basin.