IODP Proposal Cover Sheet

932 - Pre

Hellenic Arc Volcanic Field

Received for: 2018-04-02

Title	Volcanism and tectonics in an island-arc rift environment (VolTecArc): Christiana-Santorini-Kolumbo marine volcanic field, Greece
Proponents	Timothy Druitt, Christian Hübscher, Paraskevi Nomikou, Dimitrios Papanikolaou, Jan Behrmann, Philipp Brandl, Ralf Gertisser, Jörg Geldmacher, Emilie Hooft, Stephanos Kilias, Martijn Klaver, Steffen Kutterolf, Costas Papazachos, Raphael Paris, Paraskevi Polymenakou, David Pyle, Christopher Satow, Masako Tominaga, Maria Triantaphyllou, Aradhna Tripati
Keywords	Volcanism, tectonics, arc, rift, caldera
Area	Hellenic island arc

Proponent Information

Proponent	Timothy Druitt
Affiliation	University Clermont-Auvergne
Country	France

☑ Permission is granted to post the coversheet/site table on www.iodp.org

Abstract

Subduction-related volcanism plays an important role in society through its impact on life and the environment. Better understanding of island-arc volcanism and mitigation of associated risk requires study of the processes that drive such magmatism, and how volcanoes interact with their marine environments. What are the interactions and feedbacks between tectonics and volcanism, and do changes in sea level modulate eruptive activity? How do magma genesis and composition evolve through time? What are the dynamics and impacts of explosive volcanism and caldera collapse? What are the nature of caldera-hosted hydrothermal systems and their associated ecosystems?

The Christiana-Santorini-Kolumbo (CSK) volcanic field on the Hellenic Volcanic arc of Greece is a unique system for addressing these questions. It lies in a rift system that trends oblique to the island arc, maximising the likelihood of an influence of rifting on magmatism. The rift system is one of the most volcanically and seismically active regions of Europe, and poses an important threat to the Eastern Mediterranean region. The Santorini eruption of the Late Bronze Age is an iconic event in volcanology and archaeology. Unrest at Santorini caldera in 2011-12 raised awareness of eruption threat at an island archipelago visited by 1.5 million tourists per year.

The results of extensive onland volcanological research, sea floor mapping, shallow coring and dredge sampling, combined with a high-quality site-survey database of multichannel seismic profiles and a recent seismic tomography experiment (PROTEUS), make deep 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 Santorini-derived volcanic layers in the rift fills with the dated onshore stratigraphy, to provide a tight chronostratigraphic framework for marine successions, and to sample ancient shallow marine hydrothermal systems, pore waters and microbial colonies. We propose to drill four primary sites in the thick volcano-sedimentary fills of the rifts to access a near-continuous record of volcanism, sedimentation and basin subsidence since the onset of rifting in the Pliocene, and to seek relationships between volcanism, tectonics and sea level. Two additional primary sites are proposed inside Santorini caldera to address fundamental questions about how arc calderas form, and to investigate the nature of a funnel-shaped zone of low seismic velocity identified by seismic tomography beneath the focus of ground inflation in 2011-12. The objectives address eight out of the fourteen challenges of the IODP Science plan.

932 - Pre

Scientific Objectives

The objectives are to investigate the interactions between island-arc volcanic centres and their environments, using the rift-hosted Christiana-Santorini-Kolumbo volcanic field as a natural laboratory.
1. Document the history of tectonics, subsidence, sedimentation and volcanism in an arc-rift environment, and how volcanism has evolved spatially and temporally since rift initiation [SP objectives 9, 11, 12];
2. Determine how the genesis and compositions of magmas and their associated volatiles have evolved in time and space over the lifetime of the rift [SP objectives 8, 9, 11];
3. Document the dynamics and environmental impacts of arc eruptions and calderas, including eruption frequencies, magnitudes and rates, the mechanisms of caldera collapse, and the origin of caldera unrest events [SP objective 12];
4. Document the occurrence and nature of caldera-hosted hydrothermal systems and ecosystems, and the influence of volcanic eruptions upon them [SP objectives 5, 6, 7, 14].
None of these objectives can be fully addressed without drilling data and samples. Some specific hypotheses to be tested are:
- Rifting has played a role in initiating volcanic centres, driving migration of volcanism along the rift zone, causing changes in eruptive regime, and/or triggering large eruptions;
- Heterogeneities in magma sources beneath the rift zone relate to changing patterns of mantle flow through time, driven by subduction rollback and tearing;
- Santorini is a multiple caldera resulting from collapse during at least four eruptions over 200,000 y;
- The hydrothermal system in Santorini caldera is an environment analogous to that of Precambrian banded-iron formations.

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

Proposed Sites (Total proposed sites: 12; pri: 6; alt: 6; 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	500	0	500	CSK-01A targets the plio-quaternay 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 Volcano, Kolumbo Volcano and 22 cones of the submarine Kolumbo Volcanic chain. The aim is to use the core to reconstruct the tectonic, sedimentary and volcanic histories of the basin, and to access a near-continuous time series of volcanism in the area since rift inception.
CSK-02A (Alternate)	36.7438 25.7146	511	400	0	400	CSK-02A targets the plio-quaternay 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 Volcano, Kolumbo Volcano and 22 cones of the submarine Kolumbo Volcanic chain. The aim is to use the core to reconstruct the tectonic, sedimentary and volcanic histories of the basin, and to access a near-continuous time series of volcanism in the area since rift inception.
CSK-03A (Primary)	36.5549 25.4398	397	490	0	490	CSK-03A lies in the Anhydros Basin on the NW submarine flank of Kolumbo Seamount Volcano. The aim is to penetrate all five 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.
CSK-04A (Alternate)	36.5728 25.4092	403	490	0	490	CSK-04A lies in the Anhydros Basin on the NW submarine flank of Kolumbo Seamount Volcano. The aim is to penetrate all five 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.
CSK-05A (Primary)	36.4355 25.3805	385	130	1070	1200	CSK-05A is sited in the northern basin of Santorini caldera. The aim is to penetrate intracaldera seismic units 1, 2, and 3 in order to characterise them, as well as to penetrate below unit 3. The hole is located north of a vertical, funnel-shaped low-velocity seismic anomaly detected by the PROTEUS seismic tomography experiments and centred on the focus of caldera floor uplift during the unrest period of 2011-12. The hole will therefore enable us to determine the relationship between the seismic layers and the funnel structure, and thereby better understand its origin, and hence the origin of unrest in 2011-12.
CSK-06A (Alternate)	36.4424 25.3751	383	90	1110	1200	CSK-06A is sited in the northern basin of Santorini caldera. The aim is to penetrate intracaldera seismic units 1, 2, and 3 in order to characterise them, as well as to penetrate below unit 3. The hole is located north of a vertical, funnel-shaped low-velocity seismic anomaly detected by the PROTEUS seismic tomography experiments and centred on the focus of caldera floor uplift during the unrest period of 2011-12. The hole will therefore enable us to determine the relationship between the seismic layers and the funnel structure, and thereby better understand its origin, and hence the origin of unrest in 2011-12.
CSK-07A (Primary)	36.3890 25.4171	292	190	73	263	CSK-07A is sited in the southern basin of Santorini caldera. The aim is to penetrate intracaldera seismic units 1, 2, and 3 in order to characterise them, as well as to penetrate below unit 3. This site may not be necessary if holes CSK-05A or CSK-06A are totally successful, with high degrees of recovery.
CSK-08A (Alternate)	36.3816 25.4061	293	145	100	245	CSK-08A is sited in the southern basin of Santorini caldera. The aim is to penetrate intracaldera seismic units 1, 2, and 3 in order to characterise them, as well as to penetrate below unit 3. This site may not be necessary if holes CSK-05A or CSK-06A are totally successful, with high degrees of recovery.
CSK-09A (Primary)	36.5656 25.7613	694	450	0	450	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 older centres since rift inception, but not of the Kolumbo chain. The hole will reconstruct the subsidence and sedimentary history of this basin, which differs from that of the Anhydros Basin.
CSK-10A (Alternate)	36.5494 25.7714	672	270	0	270	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 older centres since rift inception, but not of the Kolumbo chain. The hole will reconstruct the subsidence and sedimentary history of this basin, which differs from that of the Anhydros Basin.

Proposed Sites (Continued; total proposed sites: 12; pri: 6; alt: 6; N/S: 0)

Site Name	Position (Lat, Lon)	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
CSK-11A (Primary)	36.3897 25.2142	408	675	0	675	CSK-11A is sited in the Christiana Basin. The aim is to penetrate the volcano-sedimentary fill. This basin is deeper than the Anhydros and Anafi Basins, and is located SW of Santorini. Its fill potentially records the (older) volcanic history of Christiana, as well as of Santorini and possibly Milos volcanoes. The hole will pass through three prominent volcanic units seen on seismic records.
CSK-12A (Alternate)	36.3842 25.2352	367	563	0	563	CSK-12A is sited in the Christiana Basin. The aim is to penetrate the volcano-sedimentary fill. This basin is deeper than the Anhydros and Anafi Basins, and is located SW of Santorini. Its fill potentially records the (older) volcanic history of Christiana, as well as of Santorini and possibly Milos volcanoes. The hole will pass through three prominent volcanic units seen on seismic records.