

IODP Expedition 398: Hellenic Arc Volcanic Field

Week 7 Report (22–28 January 2023)

During the seventh week of the International Ocean Discovery Program (IODP) Expedition 398, we drilled Site U1593 (Hole U1593C), Site U1594 (Hole U1594A) and Site U1595 (Hole U1595A) in the southern basin of the caldera of Santorini, Site U1596 (Hole U1596A) and Site U1597 (Hole U1597A) in the northern caldera basin, Site U1598 (Holes U1598A and U1598B) in the Christiana Basin, and Site U1599 (Holes U1599A and U1599B) in the Anafi Basin.

Operations

Week 7 of the expedition began on 22 January 2023 with high torque observed at 192.6 meters below seafloor (mbsf) during the drill down in Hole U1593C. The hole was circulated and conditioned. The drill string was worked up from 189.3 to 173.1 mbsf. During the attempt to work the drill string back to bottom, excessive torque was still observed. The drill string lifted again, from 192.6 to 123 mbsf this time; however, there was observed overpull and a loss of rotation. Attempts to free the string with mud sweeps and circulation proved fruitless. Overpulls were increased to a final attempt at 150,000 lb, still with no success. At 0930 h, the drill string was severed at 37.0 mbsf, and the drill string immediately regained rotation. The severing tool was retrieved and laid out. The drill string was tripped up with the top drive and the pipe cleared the rotary table at 1320 h. Next, the drill floor was secured, and thrusters were raised starting at 1646 h. The vessel was switched to bridge control at 1648 h. All thrusters were up and secured and the sea passage toward the caldera of Santorini and Site U1594 (proposed Site CSK-07B) began at 1700 h.

At 1830 h the vessel arrived at Site U1594, in the southern basin of the caldera. All thrusters were down and secure at 1848 h. The vessel was switched to dynamic positioning (DP) control and Site U1594 began at 1850 h on 22 January. The rig crew assembled an advanced piston corer/extended core barrel (APC/XCB) bottom-hole assembly (BHA) with a bit. Hole U1594A was spudded on 22 January at 2310 h. The core was shot from 297.0 meters below rig floor (mbrf) with a recovery of 4.2 m, establishing the seafloor at 291.0 meters below sea level (mbsl). APC coring continued into 23 January, from Core U1594A-2H (4.2 mbsf) to 6H at 51.7 mbsf, the final depth for Hole U1594A. Excessive torque was observed, indicating a collapsing hole. The driller worked the drill string, but the tight conditions persisted. The drill string was pulled up with the top drive and the bit cleared the seafloor at 0350 h on 23 January.

The decision was made to offset to an alternate site in the southern caldera, proposed Site CSK-08B. The vessel was moved 0.7 nmi southwest to Site U1595 in DP mode, starting at 0445 h, marking the end of Site U1594.

With the DP transit completed at 0530 h on 23 January, the pipe was tripped down. Hole U1595A was spudded at 0635 h. With a recovery of 3.6 m in Core U1595A-1H, the calculated seafloor was 291.6 mbsl. APC coring continued to Core 11H to 98.6 mbsf, the final depth for Hole U1595A. At 1315 h, the hole collapsed suddenly. The pressure spike in the hole sent the sinker bars up, slamming into the oil saver, knocking it off and up into the top drive. The coring line separated from the rope socket and came spooling out. With no core barrel in the pipe, the sinker bars were lost in the hole. The drill string was worked free and pulled out of the hole with the top drive, with the bit clearing the seafloor at 1636 h. The rig crew was eventually able to remove the oil saver from the top drive after ~2 h. The bit cleared the rotary table at 2131 h.

A new APC/XCB BHA was assembled. At 2300 h, the vessel began a 4.6 nmi DP move from Site U1595 to Site U1596 (proposed Site CSK-06B), in the northern basin of the caldera. The DP move was completed at 0330 h on 24 January while the crew completed assembling the BHA.

Hole U1596A was spudded at 0650 h on 24 January. The recovery of 3.9 m in Core U1596A-1H gave a calculated seafloor of 382.0 mbsl. Coring continued through Core 5H to 41.9 mbsf, the final depth for U1596A. Excessive torque was encountered before shooting Core 6H. The decision was made to pull out of the hole and move to the primary Site CSK-05C. The 0.34 nmi DP move started at 1102 h, ending Site U1596, and was completed at 1136 h, starting Site U1597.

The string was run down with the top drive to 356.8 mbsf. Hole U1597A was spudded at 1240 h on 24 January. Core U1597A-1H had a recovery of 5.6 m and the seafloor was calculated as 382.3 mbsl. Coring continued with the APC to Core 5H and a final depth of 43.6 mbsf. Again, excessive torque started building, necessitating the end of the hole. The bit cleared the rotary table at 1728 h. The floor was secured for transit and the thrusters were raised starting at 1815 h. The vessel was switched to bridge control at 1818 h. All thrusters were up and secure and the start of the 15 nmi sea passage to Site U1598 began at 1824 h, ending Site U1597.

The vessel arrived at Site U1598 (proposed Site CSK-14A) at 1945 h on 24 January. The vessel was under full DP control at 2015 h, marking the start of Site U1598. The APC/XCB BHA was assembled and Hole U1598A was spudded at 2350 h. Core U1598A-1H recovered 3.7 m, establishing the seafloor at 521.5 mbsl. Coring continued into 25 January to Core 8H. The switch was made to half-length advanced piston corer (HLAPC) for Cores 9F to 10F (70.2–79.6 mbsf). High torque was observed and the drill string was worked. The decision was made to pull out of the hole. The drill string was tripped up and out of the hole with the top drive, with the bit clearing the seafloor at 0715 h on 25 January, ending Hole U1598A. The vessel was offset 50 m southwest.

Hole U1598B was spudded at 0805 h, using the offset water depth of 532.8 mbfr. The hole was drilled ahead to 75.6 mbsf. At 1015 h, coring commenced with the HLAPC from Core U1598B-2H to 6F at 98.8 mbsf, the final depth for U1598B. Excessive torque was again observed, and the

decision made to abandon the hole. The bit cleared the rotary table at 1645 h. All thrusters were up and secure and the 33.3 nmi sea passage started at 1730 h, ending Site U1598.

At 2045 h on 25 January, the vessel arrived at Site U1599 (proposed Site CSK-23A). The vessel was under full DP control at 2115 h, marking the official start of the site. On 26 January, following 12.75 h of awaiting approval to operate at the site, permission was granted at 1315 h. The APC was fired for Core U1599A-1H from 599.0 mbrf. Once retrieved, it was discovered the core barrel had parted at the mid connection. A second attempt was made with the APC, unfortunately with the same result—a parted core barrel. An XCB barrel was dropped and Hole U1599A was spudded at 1535 h with a solid tag at 602.5 mbrf. After retrieving the barrel, the core had no recovery, but it was apparent that the coring system had penetrated the seafloor. Still unsure of the stiffness of the formation, the switch was made to HLAPC for Core U1599A-2F from 9.7 mbsf with 97% recovery. It was assumed there was a tightly-compacted layer at the mudline, preventing a successful hole initiation using piston coring. Coring was switched back to APC with Core 3H to 9H. The formation stiffened up quickly, forcing the change to HLAPC from Cores 10F to 44F at 245.4 mbsf, the final depth for U1599A. There was an unsuccessful overpull of 60,000 lb on Core 44F. An attempt was made to drill over the barrel for ~30 min. The driller applied 100,000 lb overpull, which freed the barrel. The decision was made to terminate the hole.

The hole ended at 1945 h when the vessel was offset 50 m northeast of Hole U1599A. The seafloor was tagged at 604.0 mbsf. Hole U1599B was spudded at 2330 h on 27 January with Core U1599B-1X to 9.7 mbsf. Coring was switched to the APC from U1599B-2H to 11H. Coring was again switched, this time to HLAPC, for U1599B-12F from to 40F at 241.0 mbsf, the final depth for Hole U1599B.

The week ended at midnight on 28 January with a pipe trip out commencing and the bit at 214.1 mbsf in Hole U1599B.

Science Operations

All Expedition 398 laboratory groups completed their Site U1592 reports and most of the site reports for Sites U1593–U1597.

Lithostratigraphy

The Sedimentology group described all cores from Sites U1594 to U1598, and Cores U1599A-2F to 44F and U1599B-2H to 11H.

All sites drilled in the caldera of Santorini (Sites U1594–U1597) consist of one lithostratigraphic unit. On top of all records is a thin layer of mud with a high percentage of biogenic material. Below that follows an interval of volcanic and tuffaceous sediments. All cores consist of mud, tuffaceous mud, ash, lapilli, and lapilli-ash with coarse pumice.

The material recovered at Site U1598 is one lithological unit with three subunits (Ia, Ib, Ic) that is sedimentary, unlithified, characterized by dominantly volcanic lithologies (ash/tuff, lapilli-ash, lapilli, and tuffaceous mud/ooze), and lesser quantities of nonvolcanic sediments, like calcareous mud and ooze.

The cores at Site U1599 consist of nannofossil ooze, tuffaceous ooze, organic-rich ooze, ash, gravel, calcareous tuffaceous mud, lapilli, lithic crystal lapilli, and gravelly sandstone with shells.

The average core recovery was 93% in Hole U1594A, 73% in Hole U1595A, 91% in Hole U1596A, 94% in Hole U1597A, 68% in Hole 1598A, 34% in Hole U1598B, 83% in Hole U1599A, and 83% in Hole U1599B.

Structural geology analyses were not possible in the caldera sites (U1594–U1597). At Site U1598, a total of 28 structures were measured. All structures observed and measured are beddings.

Biostratigraphy

The Biostratigraphy group analyzed 24 core catcher samples from the caldera sites (U1594–U1597). Most of the analyzed samples were barren. A few planktic foraminifers and nannofossils were found that indicate an age of younger than 265 ka. This comes as no surprise as the caldera is filled with volcaniclastic material deposited since the Minoan Eruption around the year 1630 BCE. Eight and 63 core catcher samples were analyzed at Site U1598 and Site U1599, respectively. Planktic and benthic foraminifers, as well as calcareous nannofossils, were used to define the Holocene to upper Pleistocene stratigraphy of both sites.

Paleomagnetism

As the caldera of Santorini is filled with volcaniclastic material \leq 1630 BCE, all samples from Sites U1594 to U1597 fall within the Brunhes Chron. Analyses on Sites U1598 and U1599 are still ongoing at the end of this week.

Geochemistry

This week the Geochemistry group analyzed four tephra and four interstitial water (IW) samples from Site U1594, two tephra and five IW samples from Site U1595, five IW samples from Site U1596, and nine tephra and five IW samples from Site U1597.

In the same way as reported last week, the ratios of different trace elements such as Ba/Rb vs. Ba/Zr, Ba/Y vs. Zr/Rb, but also SiO₂ vs. Na₂O + K₂O are used to link discrete volcaniclastic layers to eruptions and volcanic centers.

A total of 25 headspace gas samples from Sites U1594 to U1597, 13 from Site U1598, and 26 from Site U1599 were analyzed by gas chromatography (GC). Methane, ethane, and propane

concentrations are below the detection limit throughout all holes. Preparations for inductively coupled plasma–atomic emission spectroscopy (ICP-AES) analyses of major, minor, and trace elements are continuing at the end of this week.

Physical Properties

There is a general trend of increasing *P*-wave velocity and magnetic susceptibility (MS), and decreasing natural gamma radiation (NGR) with increasing depth at all sites in the caldera (Sites U1594 to U1597). More than 40% of discrete samples have grain densities less than 2.0 g/cm³ and grain density decreases with increasing depth. Thermal conductivity is lower than typical values for sediments at similar depths.

At Site U1598, the volcanic lapilli of Unit Ic have distinctly lower density than the nonvolcanic, ooze-dominated lithologies of Units Ia and Ib. MS is highly variable within the volcaniclastic deposits at this site and can be very high, exceeding 2500 SI (dimensionless number reported in the international systems of units). High values of MS correspond to volcaniclastic layers. Two high *P*-wave velocity layers, one around 5 mbsf and the other at about 71 mbsf, both correspond to lapilli-ash layers in Hole U1598A.

Stratigraphic Correlation

As only one hole was drilled per site in the caldera, no stratigraphic correlation was necessary for Sites U1594 to U1597.

At Site U1599, the correlators were able to identify reliable correlations between most cores of Hole U1599A and U1599B until a depth of ~160 mbsf. From there on, low recovery, as well as strong lithological variations and the soupy nature of the recovered material, reduced the precision in the stratigraphic correlation.

Education and Outreach

This week we had two media interviews with the Stillwater News Press, Oklahoma, USA, with a circulation of 20,385. We also had thirteen live ship-to-shore tours this week, reaching approximately 2,753 students. This number was boosted by two tours with the UNESCO network of schools in Greece where we had ~40 classrooms connect simultaneously. Across all our social media platforms we had 49,305 impressions and an average engagement rate of 13.46%.

Technical Support and HSE Activities

Laboratory Activities

- Staff processed cores and samples from Holes U1593C, U1594A, U1594B, U1595A, U1595B, U1596A, U1597A, U1598A, U1598B, U1599A, and U1599B.
- In preparation for the arrival of the expedition microbiologist on 30 January, cleaning of the cold room and testing of the hard-shell anaerobic chamber were conducted in the Chemistry Laboratory.
- The laser engraver reported that the ABORT button (in software) did not work, but the physical STOP button works. After rebooting the PC, the issue no longer existed. All safety features checked out properly.

IT Support Activities

- Updated Windows OS workstations to account for recently released updates, patches, etc.
- Prepared network for telehealth support purposes and tested with the Siem Offshore Physician using the new telemedicine system.
- Collaborating with Siem Offshore personnel to evaluate the network infrastructure in the Mess Hall to install an IODP managed access point.

Application Support Activities

- Rework the organization of development documentation in Confluence.
- Working to achieve stable calibration of the pycnometer cell for larger samples.

Health, Safety, and Environment

- Emergency shower and eye wash stations were tested.