

IODP Expedition 398: Hellenic Arc Volcanic Field

Week 8 Report (29 January–4 February 2023)

During the eighth week of the International Ocean Discovery Program (IODP) Expedition 398, we drilled Site U1595 (Holes U1595B and U1595C) and Site U1596 (Hole U1596B) in the Santorini Caldera, Site U1599 (Hole U1599C) in the Anafi Basin, and Site U1600 (Holes U1600A and U1600B) atop the Anhydros Horst.

Operations

Week 8 of the expedition began on 29 January 2023 with the pipe trip out of Hole U1599B in progress. At 0100 h, the bit cleared the seafloor and the rotary table at 0255 h. All thrusters were up and secure, the vessel under bridge control, and the 8.4 nmi sea passage started at 0336 h, ending Site U1599.

The vessel arrived on location at Site U1600 (proposed Site CSK-24A) at 0430 h. The vessel was switched to full dynamic positioning (DP) mode and on autocontrol at 0450 h, beginning Site U1600. The rig crew started assembling the advanced piston corer/extended core barrel (APC/XCB) bottom-hole assembly (BHA). Hole U1600A was spudded with Core U1600A-1H from 332.0 meters below rig floor (mbrf) at 0710 h. The recovery of 4.0 m gave a calculated seafloor depth of 326.2 meters below sea level (mbsl). Coring continued with APC from Cores U1600A-2H to 4H. Prior to 4H, two misfires (pins did not shear) were experienced with the APC. An XCB barrel was run as a deplugger. Core U1600A-4H fired on the third attempt with good recovery, but with 45,000 lb overpull and a completely fractured liner.

The half-length advanced piston corer (HLAPC) was deployed for Cores U1600A-5F to 10F to a depth of 60.7 meters below seafloor (mbsf). Core 10F experienced an overpull of 50,000 lb. Coring continued with the XCB from Cores 11X to 13X at 84.4 mbsf, the final depth of Hole U1600A. The recovery for the XCB was extremely poor and the decision was made to repeat the piston-cored section in Hole U1600B. The drill string was pulled up with the top drive from 84.4 mbsf to 309.1 mbrf, clearing the seafloor at 1905 h, ending Hole U1600A. The ship was positioned 50 m southwest of Hole U1600A.

Hole U1600B was spudded with Core U1600B-1H at 2005 h. Recovery of 6.8 m established the water depth at 326.3 mbsl. Coring switched to HLAPC from Core U1600B-2F to 19F to a depth of 91.4 mbsf, the final depth for Hole U1600B. The drill string was tripped up with the top drive and the bit cleared the seafloor at 0735 h on 30 January. The bit cleared the rotary table at 0900 h and the drill floor was secured for transit. The crew started raising the thrusters at 0954 h. The vessel was under bridge control at 0956 h. All the thrusters were up and secure and the 18.4 nmi sea passage started at 1000 h, ending Site U1600.

The vessel came onto location in the northern caldera of Santorini at 1142 h. The thrusters were lowered and were down and secure at 1154 h. The vessel was switched to DP mode at 1200 h, ending the sea passage and setting up for a personnel transfer. A launch was alongside the vessel at 1215 h. The Expedition 398 microbiologist and a Siem Offshore crewmember boarded. Two pallets of fresh food were delivered and brought on by hand. The launch was clear at 1230 h. All thrusters were raised and secured, and the 24.6 nmi sea passage to Site U1599 (proposed Site CSK-23A) began at 1242 h.

The vessel arrived at Site U1599 at 1500 h on 30 January. The thrusters were down and secure at 1518 h. The vessel was switched to DP control at 1520 h and positioned 50 m southwest of Hole U1599A. A rotary core barrel (RCB) BHA with a new C4 bit was made-up. The BHA was run to 573.0 mbrf. The top drive was picked up, the drill string was spaced out, and a center bit was dropped. Hole U1599C was spudded at 1925 h. A seafloor depth of 604.0 mbrf was determined by offset. The hole was drilled to 223.0 mbsf. RCB coring commenced with Core U1599C-2R and proceeded into 1 February with Core U1599C-25R from a depth of 455.5 mbsf. The drill string was tripped from 455.5 mbsf to 55.6 mbsf. The rig crew pulled the upper guide horn (UGH) in preparation for launching a free-fall funnel (FFF). The FFF was assembled and welded in the moonpool. The FFF was launched at 2005 h and immediately chased with the vibration isolated television (VIT) camera at 2015 h. Once at the seafloor, the VIT camera verified the FFF had landed successfully. The pipe was tripped up, out of the hole, from 55.6 mbsf to 516.7 mbrf. The bit cleared the seafloor at 2117 h and left the FFF undisturbed. The VIT was back on deck at 2209 h. The rig crew then reinstalled the UGH and reassembled the rig floor. The bit cleared the rotary table at 0025 h, the rig floor was secured, and the vessel was switched to bridge control at 0130 h on 2 February. All thrusters were up and secure, with the start of the 28.2 nmi sea passage to Site U1595 at 0142 h, ending Site U1599.

The ship arrived at Site U1595 at 0415 h, 50 m from Hole U1595A towards proposed Site CSK-18A. All thrusters were down and secure at 0430 h on 2 February. The vessel was in full DP control at 0440 h. The rig crew began assembling the APC/XCB BHA. Next, the BHA was tripped in to 270.9 mbsf. From 0745 h to 0915 h the vessel awaited media and guests. The launch, with eight people, was alongside at 0900 h. The launch was away at 0915 h. Safety orientations were done and the film crews set up equipment at the drill floor, catwalk, and in the laboratory.

Hole U1595B was spudded at 1010 h with Core U1595B-1H recovering 3.7 m. The seafloor was calculated at 291.4 mbsl. Coring continued with the APC from Core U1595A-2H to 13H to 117.7 mbsf. The eight guests disembarked to the launch just after 1415 h. The launch was away at 1425 h. At 1900 h, the change was made to HLAPC with Cores 14F to 15F to 127.1 mbsf, the final depth for Hole U1595B. The decision was made to end the hole due to maximum overpull and high amps on the bit. The drill string was tripped up with the top drive clearing the seafloor at 2320 h on 2 February, ending Hole U1595B. The vessel was again offset 50 m toward proposed Site CSK-18A.

Hole U1595C was spudded at 0005 h on 3 February, with Core U1595C-1H shot from 297.0 mbrf. The recovery of 3.8 m established the seafloor at 291.3 mbsl. A center bit was dropped for a 49.2 m drilled interval. With the drill down completed to 53.0 mbsf, coring was picked up again, with the HLAPC from Core U1595C-3H to 11F at 95.3 mbsf. A launch with fifteen guests and media arrived at 0910 h. After the visitors boarded, the launch was away at 0920 h. Interviews and filming continued, primarily in the laboratory, the bridge, and on the forward fo'c's'le deck. After Core U1595C-11F, the hole was drilled without recovery to 104 mbsf. However, high torque led to the drill string stalling. A 100,000 lb overpull was applied with no success. The drill pipe was worked, and after about 30 min it regained rotation. The decision was made to abandon the hole.

The string was pulled out of the hole with the top drive to 299.5 mbrf, clearing the seafloor at 1115 h. The bit cleared the rotary table at 1347 h and the rig floor was secured at 1415 h.

Just after 1410 h, the fifteen guests disembarked to the launch. The launch was away at 1430 h.

The DP move to Site U1596 (proposed Site CSK-06B), in the northern caldera, began at 1430 h, ending Site U1595. The ship arrived on location, 50 m northwest of Site U1596A, at 1615 h on 3 February. The APC/XCB BHA was assembled and Hole U1596B was spudded at 1915 h. A recovery of 4.2 m gave a calculated seafloor depth of 381.9 mbsl. APC coring continued to Core U1596B-5H at 42.2 mbsf, the final depth for the hole. The bit cleared the rotary table at 0105 h and the drill floor was secure at 0145 h. The sea passage to Site U1600 started at 0154 h, ending Site U1596.

The vessel arrived at Site U1600 (proposed Site CSK-24A) at 0330 h on 4 February. The vessel was on full DP control at 0400 h. The transit from Site U1596 took 1.9 h, covering 17.8 nmi at an average speed of 9.4 kt. The rig crew assembled the RCB BHA. Hole U1600C was spudded at 0655 h on 4 February. The hole was advanced without recovery to 75.0 mbsf. RCB coring was initiated with Core U1600C-2R from a depth of 75.0 mbsf. The week ended at midnight on 4 February with Core U1600C-12R at 179.7 mbsf in Hole U1600C.

Science Operations

All Expedition 398 laboratory groups completed their Site U1593 and U1598 reports and most of the site reports for Sites U1594–U1597.

Lithostratigraphy

The Sedimentology group described all cores from Holes U1595B, U1595C, U1596B, U1599C, U1600A, U1600B, and Cores U1600C-3R to 9R.

Both sites drilled in the caldera of Santorini (Sites U1595–U1596) consist of one lithostratigraphic unit. The uppermost sediment 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 Hole U1599C consists of dolomitic marl, organic-rich marl, marl, tuff, organic-rich sandstone, and bioclastic marl. As the vessel will reoccupy Hole U1599C, no lithological units were assigned yet.

The cores at Site U1600 consist of nannofossil ooze, tuffaceous ooze, organic-rich ooze, ash, lithic ash, gravel, lapilli ash, lapilli, lithic lapilli, muddy ash, bioclastic sand, calcareous sand, and calcareous tuffaceous sand. Following the complete analysis of Hole U1600C, lithological units will be assigned to Site U1600.

The average core recovery was 58% in Hole U1595B, 46% in Hole U1595C, 87% in Hole U1596B, 53% in Hole U1599C, 61% in Hole U1600A, and 75% in Hole U1600B.

Structural geology analyses were not possible in the caldera sites (Sites U1595 and U1596). A total of 102 structures in Hole U1599A and 69 structures in Holes U1600A and U1600B were measured. Most of the structures observed and measured are beddings, with additional observations of deformation bands and wing structures.

Biostratigraphy

The Biostratigraphy group analyzed 28 core catcher samples from the caldera sites (Sites U1595 and U1596). Most of the analyzed samples were barren. One benthic foraminifer and a few planktic foraminifer and nannofossil taxa were found that indicate an age of younger than 265 ka. This comes as no surprise as the caldera is filled with volcanoclastic material deposited since the Minoan Eruption around the year 1630 BCE.

Eighty-five and 38 core catcher samples were analyzed at Site U1599 and Site U1600, respectively. Planktic and benthic foraminifers, as well as calcareous nannofossils, were used to define the Holocene to Pleistocene stratigraphy of both sites.

Paleomagnetism

As the caldera of Santorini is filled with volcanoclastic material ≤ 1630 BCE, all samples from Sites U1594 to U1597 fall within the Brunhes Chron. Analyses on Holes U1600A, U1600B, and U1599C are still ongoing at the end of this week. All measured sections, however, fall into the Brunhes Chron.

Geochemistry

This week the Geochemistry group analyzed 10 tephra samples from Hole U1599A, 11 interstitial water (IW) samples from Holes U1595A and U1595B, 3 IW samples from Hole U1596C, 15 IW samples from Hole U1599C, and 9 IW samples from Holes U1600A and U1600B.

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 volcanoclastic layers to eruptions and volcanic centers.

A total of five headspace gas samples from Hole U1595B, 20 from Hole U1599C, and 10 from Holes U1600A and U1600B were analyzed by gas chromatography (GC). Methane, ethane, and propane concentrations are below the detection limit throughout all holes. Measurements for inductively coupled plasma–atomic emission spectroscopy (ICP-AES) analyses of major, minor, and trace elements are ongoing and continuing 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 both sites in the caldera (Sites U1595 and U1596). Thermal conductivity is lower than typical values for sediments at similar depths.

The typical increases of bulk density and *P*-wave velocity with increasing depth are not clearly documented at Sites U1599 and U1600. MS can be high and highly variable in volcanoclastic layers and is generally low in the tuffaceous and ooze-dominated intervals.

Stratigraphic Correlation

To establish the composite depth scale, the Stratigraphic Correlators analyzed Holes U1595A–U1595C for their physical properties using the Whole-Round Multisensor Logger (WRMSL) for MS and gamma ray attenuation (GRA), and the gamma ray track (for NGR intensity), as well as photos once the cores were split into working and archive halves. In general, correlation was very challenging at this site and only the MS data allowed several reliable correlations, while NGR and GRA density measurements were strongly overprinted by the irregular distribution of core material in cores with low recovery and a high content of water.

All three holes recovered the mudline and Core U1595A-1H was used as the initial anchor for stratigraphic correlation. From thereon, the correlators attempted to determine the relative depth offset of each core by establishing affine ties between the holes based on the maximum correlation of all measured physical properties. Once the composite depth scale was established, selected sequences from Holes U1595A to U1595C were spliced to create the most complete and representative section possible. From the mudline down to ~69 mbsf, the splice is continuous.

To establish the composite depth scale at Holes U1600A and U1600B, cores were analyzed for their physical properties using MS, GRA, NGR, and core photos. The MS data showed to be the most reliable physical parameter for correlations. Since Hole U1600C had no overlap with Holes U1600A and U1600B, no correlation with this hole was possible. Both Holes U1600A and U1600B preserved the mudline, and Core U1600A-1H was used as the anchor for stratigraphic correlation. Using this anchor core, we attempted to determine the relative depth offset of each

core by establishing affine ties between the holes based on the maximum correlation of all measured physical properties.

Education and Outreach

This week, the Outreach Officer conducted 14 live ship-to-shore tours, reaching approximately 985 students and community members. Across all social media platforms we had 32,287 impressions and an average engagement rate of 7.66%.

The highlight of the week was a visit by the mayor of Santorini and his deputy, the commander of the port police authority, two eminent scientists, and members of the international media on 2–3 February. During these visits, we had 12 journalists on board—both writers and film crews—and they have already published two stories from their visit, with many more to come in the next year.

Technical Support and HSE Activities

Laboratory Activities

- Staff processed cores and samples from Holes U1595B, U1595C, U1596B, U1600A, U1600B, U1600C, and U1599C.
- Pycnometer cell #3 showed measurements either above or below expected value. The cell was cleaned and an O-ring was changed with no improvement. Currently, five working cells are sufficient to finish all measurements.
- Conducted perfluorodecalin (PFD) tracer test in Holes U1596B and U1599C. Results are being evaluated.
- Assisted in microbiology sampling.
- Media and Santorini city officials came onboard during 2–3 February. Staff processed cores in the meantime.
- Technical staff and scientists group photos were taken while in the Santorini caldera.
- Preparing for end of expedition (EOX).

IT Support Activities

- Working with Adobe support to address future licensing concerns for Adobe Creative Cloud.
- Fixed Matlab license server issue preventing users from using Matlab.
- Created user accounts for all Expedition 398P participants.
- Fixed communication issues between RigWatch and the tracer pump.

Application Support Activities

- No updates.

Health, Safety, and Environment

- Emergency shower and eye wash stations were tested.
- Provided laboratory safety training for the microbiologist who came aboard on 30 January.