

IODP Expedition 398: Hellenic Arc Volcanic Field

Week 4 Report (1–7 January 2023)

During the fourth week of the International Ocean Discovery Program (IODP) Expedition 398, we drilled Hole U1590A at the Kolumbo volcano and Holes U1591A, U1591B, and U1591C in the Christiana Basin.

Operations

Week 4 of the expedition began with changing out the rotary core barrel (RCB) bottom-hole assembly (BHA) for an advanced piston corer/extended core barrel (APC/XCB) BHA. At 0115 h on 1 January 2022, the trip in the hole started with the APC/XCB BHA.

Hole U1590A was spudded with Core U1590A-1H from 403 meters below rig floor (mbrf) at 0425 h. The recovery was 4.3 m, giving a calculated seafloor of 397.1 meters below sea level (mbsl). Coring continued to 89.8 meters below seafloor (mbsf). Various levels of overpull were observed on the barrels, with a maximum of 50,000 lb. The advanced piston corer temperature (APCT-3) tool was run on Core 4H, with good results.

From 1230 h to 1500 h the driller attempted to free the drill string from fall-in. Despite the efforts, the drill string was stuck with little to no vertical movement and no rotation. The driller continued to work the pipe while preparing for a severing operation. The BHA was severed at the top of the tapered drill collar (TDC) at 1700 h. The severing tool was retrieved to the rig floor and tied back. The drill string was pulled up and clear of the seafloor at 1735 h. The drill string cleared the rotary table at 2025 h. The vessel was secured for transit, the thrusters were raised beginning at 2136 h, and the sea passage started at 2148 h to Site U1591 (proposed alternate Site CSK-20A), ending Hole U1590A and Site U1590.

On 2 January, all thrusters were down and secured at 0006 h. The vessel was switched to dynamic positioning (DP) mode and on autocontrol at 0014 h, marking the start of Site U1591. At 0015 h the drill crew began making up the APC/XCB BHA with a new bit. At 0740 h Hole U1591A was spudded, and Core U1591A-1H recovered 3.8 m, for a calculated seafloor of 514.6 mbsl. Coring with the APC continued to Core 11H at 98.8 mbsf.

Tight hole conditions were again observed, and the decision was made to pull the BHA and remove the TDC and the nonmagnetic (stainless steel) drill collar (NMDC), both relatively expensive compared to the rest of the BHA and also in short supply onboard. The string was pulled out of the hole with the top drive to 508 mbrf, clearing the seafloor at 1512 h. The bit cleared the rotary table at 1700 h, ending Hole U1591A. A reconfigured APC/XCB BHA was assembled with the same bit.

Hole U1591B was spudded at 2150 h on 2 January. The recovery of 3.8 m indicated a seafloor of 513.8 mbsl. Coring with the APC continued into 3 January and Core U1591B-8H from 64.6 mbsf.

The APC was pulled and an XCB center bit was dropped. The intention was to drill through a pumice section identified in Hole U1591A. The driller established the slow circulation rates and proceeded to drill from 74.1 mbsf to 98.8 mbsf without recovery.

Following the drilled down interval, the half-length advanced piston corer (HLAPC) was deployed from Core U1591B-10F at 98.8 mbsf to 13F at 112.9 mbsf. Coring was switched to XCB with Core 14X at 117.6 mbsf and continued to Core 16X at 146.7 mbsf. However, all three XCB cores had ~0 m recovery.

The switch was again made back to HLAPC for Cores U1591B-17F and 18F (146.7 to 151.4 mbsf). Despite the poor core recovery from rotary coring, hole conditions were better when coring with the XCB. It was decided to switch back to XCB coring to reach the target depth of the hole.

Cores U1591B-19X to 43X were recovered from 156.1 to 389.2 mbsf. During Core 43X, the XCB cutting shoe sheared off in the hole, ending coring operations at Hole U1591B. The bit cleared the rig floor at 0950 h on 5 January, ending Hole U1591B. The crew laid out the APC/XCB BHA components and proceeded to make up an RCB BHA with a new bit.

Hole U1591C was spudded at 1500 h. The hole was advanced without recovery to 149.3 mbsf. The center bit was retrieved at 1915 h and Cores U1591C-2R to 13R were recovered (149.3 to 265.0 mbsf). A second interval was drilled from 265.0 to 350.0 mbsf. RCB coring continued from Core 15R to 41R (265.0 to 611.9 mbsf) at the end of the week.

Science Operations

All Expedition 398 laboratory groups finalized the Site U1589 Summary report chapters.

Lithostratigraphy

The Sedimentology group described Cores U1590A-1H to 11H, U1591A-1H to 11H, U1591B-1H to 43X, and U1591C-3R to 35R.

The general lithofacies encountered at Site U1590 are similar to those of Site U1589: tuffaceous mud, extensive layers of pumice lapilli, ash, and nannofossil ooze. Site U1591 was subdivided into two lithological units. Unit I (Hole U1591A and Cores U1591B-1H to 17F) consists of ash, lapilli, pumice lapilli, tuffaceous sediments, mud, and prominent nannofossil oozes. Unit II (Cores U1591B-18F to 43X and U1591C-3R to 35R) are the lithified equivalents of Unit I. Hole U1591C was drilled without recovery to 149.3 mbsf. Following U1591C-13R a second interval was drilled without recovery from 265.0 to 350.0 mbsf. Lithologies encountered in Hole U1591C

resample and continue those of Unit II from Hole U1591B. Average core recovery was 61% (Hole U1590A), 66% (Hole U1591A), 43% (Hole U1591B), and 50% (Hole U1591C).

The main structures observed at Site U1591 are horizontal bedding up to 9° in the upper part of the site that continuously steepen to 20°–85° toward the deeper end. In addition, several sediment slumps and sediment-filled vein structures were observed, potentially caused by shock events (e.g., earthquakes, volcanic tremor, mass wasting, etc.).

Biostratigraphy

The Biostratigraphy group analyzed 101 core catcher and multiple discrete (toothpick) samples from Sites U1590 and U1591 for planktic and benthic foraminifers as well as calcareous nannofossils. Biostratigraphic markers identify crucial individual ages that enable a precise age-depth correlation throughout the holes. Two distinctive hiatuses in Holes U1591B and U1591C were barren of microfossils. These intervals correlate to volcanoclastic formations. However, between these pumice layers the stratigraphy is straightforward without any biostratigraphic age reversals. Paleowater depth reconstructions show a less pronounced but similar picture to analyses from Site U1589. The paleobathymetry of Sites U1590 and U1591 indicates several pulses of basin development. Toward the bottom of the interval described in Site U1591 by the end of the week, water depths progressively shoal, though the signal is less pronounced than described in Site U1589. Terrestrial conditions were thus far not observed in Site U1591.

Many samples show a considerable amount of reworked material, most likely coming from outcrops on the surrounding islands. Microfossil preservation across all groups is very good in general. Due to the volcanogenic nature of the cored sequences, residues from washed samples contain significant amounts of volcanoclastic particles.

Paleomagnetism

The Paleomagnetism group continued to measure natural remanent magnetization (NRM) on archive half core sections from Holes U1590A, U1591A, U1591B, and U1591C. In Hole U1590A, seven discrete samples were analyzed, but without finding a meaningful signal. At Site U1591, 85 discrete samples were measured, with a focus on Hole U1591C. The RCB cores are less prone to biscuiting, and thus yield better results than the XCB cores from Hole U1591B.

The automated analysis of demagnetization plots continues to significantly improve the analysis of extensive datasets. Looking further into the greigite problem encountered last week, the group found publications from IODP Expedition 350, where so-called ghost reversals were described. These occurred when bioturbated intervals or foraminifers with chambers filled with greigite or pyrite affected the paleomagnetic signal, causing reversals in intervals where none should be.

Geochemistry

This week the Geochemistry group was able to generate the first hard-rock inductively coupled plasma–atomic emission spectroscopy (ICP-AES) measurements for Sites U1590 and U1591. Ratios of different trace elements such as Ba/Rb vs. Ba/Zr, Ba/Y vs. Zr/Rb, but also SiO₂ vs. Na₂O + K₂O are valuable in helping us link discrete volcanoclastic layers to eruptions and volcanic centers. Standard interstitial water (IW) and headspace sampling continues at all sites. IW samples show an increase in salinity of up to 70 PSU (almost twice that of local ambient seawater) that matches maxima in Cl, Na, K, Ca, Mg, and SO₄. Headspace analysis from the lowermost cores of Hole U1591C show the first increase in methane values during the expedition. However, values are still extremely low and several orders of magnitude below critical levels.

Physical Properties

On all core sections from Hole U1590A and most sections from Site U1591A, the Physical Properties group measured gamma ray attenuation (GRA) bulk density and magnetic susceptibility (MS). *P*-wave velocity was only measured on cores from Holes U1590A, U1591A, and U1591B as the RCB core sections from Hole U1591C do not fully fill the core liners, rendering *P*-wave measurements useless. MS, GRA bulk density, and *P*-wave records for Hole U1591A were similar to the uppermost 11 cores in Hole U1591B. In agreement with measurements from the previous sites, MS values peak in volcanoclastic intervals and GRA density peaks in nannofossil oozes. Earlier in the week, the group focused on understanding the correlation of pumice porosity and grain densities in order to identify pumiceous intervals in physical properties data. According to measurements and simple models, the largest pumice grains should have the lowest grain densities, and intervals with grain densities lower than 2.5 g/cm³ were identified as pumiceous layers. In the second half of the week, the focus switched to the correlation of sapropel layers with climatic cycles, sea level lows, and volcanic eruptions.

Stratigraphic Correlation

The Stratigraphic Correlators' main activity focused on the correlation of Holes U1591A and U1591B to identify coring gaps and create a first, tentative splice between both holes. Following this, the focus shifted to the correlation of the small overlap between the deeper parts of Hole U1591B and the uppermost cores of Hole U1591C. The majority of the work done by the Stratigraphic Correlation group, however, was on remodeling seismic velocities based on *P*-wave analyses from the Physical Properties group. The new seismic models are informing our drilling strategy for the deeper parts of Hole U1591C.

Education and Outreach

We conducted two media interviews. A newspaper piece in the Abilene Reflector-Chronicle (Kansas, USA) published to a circulation of 3,800. A second story in the Cascadia Daily News

(Washington, USA) is being written and will publish in the next day or two to an audience of 20,000.

Across all social media platforms, we had 39,468 impressions and an average engagement rate of 8.63%. In addition to those activities, the Outreach Officer contacted 28 journalists—mostly local with a few national journalists mixed in—to offer online interviews with Expedition 398 scientists, and they are starting to schedule interviews with scientists and their hometown papers. We worked on two blogs and published one, and coordinated with our onshore Outreach Officer on several fact sheets and infographics she is producing.

Technical Support and HSE Activities

Laboratory Activities

- Staff processed cores and samples from Hole U1590A and Site U1591.
- Physical Properties Laboratory: New magnetic susceptibility point standards were made for the Section Half Multisensor Logger (SHMSL).
- Chemistry Laboratory: The water quality has not improved and continues to be monitored.
- Working on core logistics and special purchases for Expedition 399.

IT Support Activities

- Updated Linux servers with operating system patches for January.
- Investigating license changes to Adobe Creative Cloud.

Application Support Activities

- End of expedition (EOX) processes are under revision to support the transfer of expedition data to IODP onshore databases.
- Legacy components for laboratory gas (argon, helium) consumption monitoring were removed from the LIMS database on ship and shore.
- Data management:
 - Assisted with scanning electron microscope (SEM) upload of pictures from the SEM computer to the ship's database.
- GEODESC patches were staged in shipboard test environment for review. Production release is pending.
- LORE report definition changes were applied on ship and also applied to shore production environment.

Health, Safety, and Environment

- Emergency shower and eye wash stations were tested.