IODP Expedition 395: Reykjanes Mantle Convection and Climate

Week 3 Report (25 June–1 July 2023)

Operations

Week 3 of IODP Expedition 395 began while coring in Hole U1564D (59°51.0483′N, 23°16.0080′W; 2208.2 m water depth). Cores U1564D-67X to 74X (584.9 to 657.3 meters below seafloor [mbsf]) were recovered. Mud sweeps were used to clean the hole following the recovery of Cores 69X and 72X. The rate of penetration slowed and recovery in the final three cores was less than the rest of the hole (33%), due to the water jets in the cutting shoe getting clogged with sediment. The hole was terminated at a final depth of 657.3 mbsf. A total of 73 cores were collected in Hole U1564D over a 655.3 m interval, with a recovery of 632.42 m of core (97%).

The drill pipe was pulled out of the hole, with the bit clearing the seafloor at 2015 h on 25 June 2023, ending Hole U1564D. The vessel was offset 20 m east and Hole U1564E (59°51.0485′N, 23°15.9876′W) was spudded at 2306 h. Core U1564E-1H recovered a 5.8 m mudline core with the advanced piston corer (APC) system, establishing a seafloor depth of 2207.3 meters below sea level (mbsl). Coring continued from 5.8 to 205.3 mbsf with Cores U1564E-1H to 22H. It required 70,000 lb of overpull to free the core barrel from the formation on Core 22H, and the extended core barrel (XCB) system was deployed for the remainder of the hole. Cores U1564E-23X to 28X extended the hole to 263.5 mbsf. Following Core 28X, the decision was made to end the hole. A total of 273.7 m of sediment was recovered from the 263.5 m cored interval at Hole U1564E (104%).

At 0030 h on 27 June, the drill bit cleared the seafloor, and at 0545 h the bit cleared the rig floor. At 0640 h, the ship was secured for transit. The thrusters were raised and the transit to Site U1554 began at 0700 h, ending Hole U1564E. Following a 104 nmi transit, the ship arrived at Site U1554 at 1800 h. The thrusters were lowered, and the vessel switched to dynamic positioning (DP) mode, beginning Hole U1554G (60°7.5037′N, 26°42.1129′W) at 1842 h. An APC/XCB bottom-hole assembly (BHA) was made up and the drill string lowered to 1876.0 meters below rig floor (mbrf). Hole U1554G was spudded at 0340 h on 28 June. Core U1554G-1H recovered 5.43 m of sediment, establishing a seafloor depth of 1868.7 mbsl. Cores U1554G-1H through 22H were advanced to a depth of 202.90 mbsf, recovering 210.3 m of core (104% recovery).

The average ship heave was >2 m throughout the day on 28 June, creating challenging coring conditions. The advanced piston corer temperature (APCT-3) tool was run during Core U1554G-4H, but it produced noisy, poor measurements. Subsequent APCT-3 runs were postponed to Hole U1554H. Cores 9H–13H were “misfires,” with the shear pins releasing early. The core orientation tool was removed on Cores 12H to 14H to see if that could be contributing to the misfires; the tool was redeployed beginning with Core 15H. Coring continued from 202.9 to 288.4 mbsf with Cores 23H to 31H. Cores 30H and 31H were partial strokes, and Core 31H

experienced high overpull and was drilled over with the bit and BHA. After reaching refusal of the APC system, the half-length APC was deployed for Cores 32F to 34F (288.4 to 302.5 mbsf). All three cores were partial strokes. XCB coring advanced the hole from 302.5 to 355.0 mbsf, recovering Cores 35X to 40X. The target depth of the hole was achieved, and the drill string was pulled out of the hole with the bit clearing the seafloor at 1745 h on 29 June, marking the end of Hole U1554G. A total of 40 cores were taken in Hole U1554G over the 355.0 m cored interval. Core recovery was 102% and 362.3 m of sediment was collected.

The ship was offset 20 m south of Hole U1554G. Hole U1554H (60°7.4952′N, 26°42.1188′W) was spudded at 2135 h, with Core U1554H-1H recovering 9.4 m. The seafloor was calculated at 1866.7 mbsl. Cores 1H to 30H advanced to 280.1 mbsf and temperature measurements using the APCT-3 were collected on Cores 4H, 7H, 10H, 13H, and 16H. Core 7H was a 4.7 m advance; however, the bit was lifted off bottom to shoot the core barrel and the APCT-3 temperature tool was deployed for this core. The combination of the ship heave, the core barrel sitting in the formation for several minutes collecting temperature data, and the half-empty core barrel resulted in sediment getting sucked into the barrel and a recovery of 9.41 m (200%). The temperature measurement for this core was not usable.

Cores U1554H-31X to 38X (280.1 to 354.9 mbsf) were collected using the XCB system. After reaching the target depth for the hole, the drill string was pulled out of the hole. The drill bit cleared the seafloor at 0640 h on 1 July, ending Hole U1554H. A total of 38 cores were collected from Hole U1554H, with 370.1 m of core recovered across a 354.9 m interval (104%).

With the drill bit ~54 m above the seafloor, the vessel transited in DP mode to Site U1562. Following a 6.1 nmi transit, the vessel arrived at the site coordinates at 1210 h on 1 July, marking the start of Hole U1562C (60°06.3015′N, 26°30.0754′W). Hole U1562C was spudded at 1500 h. The mudline Core U1562C-1H recovered 5.37 m, establishing a seafloor depth of 2002.7 mbsl. Cores U1562C-1H to 13H advanced the hole to 110.8 mbsf. One drilled interval of 1 m (U1562C-5-1) was used to offset coring gaps as observed by the stratigraphic correlators. All cores were oriented.

Science Results

Sedimentology

From Site U1564, Cores U1564D-41X to 74X (338.9 to 652.96 mbsf) were described. Cores 41X to 50X are predominantly silty clay. In Core U1564D-51X, a transition to cycles, including sediments composed of nannofossil silty clay and nannofossil ooze with silty clay, occurred. Deeper in the core, these calcareous-rich sediments transitioned to chalk (approximately Core 57X). At Hole U1564E, Cores U1564E-1H to 28X (0.0 to 255.66 mbsf) were described. These contained similar sediments to depth coeval cores at Hole U1564D, primarily silty clay and silty clay with biogenics and/or carbonate.

From Site U1554, Cores U1554G-1H to 40X (0.0 to 354.92 mbsf) and Cores U1554H-1H to 21 (0.0 to 193.30 mbsf) were described. The sediments are predominantly silty clay, with some minor intervals of silty clay with biogenics. Biosilica and carbonate are present throughout, although in very minor amounts. Bioturbation is generally moderate. Green and dark gray mottling and color banding are present throughout, with no discernable compositional difference. Cycles with thin (<5 cm) bands of slightly lighter brown layers at the base were observed in several cores down to ~175 mbsf; these lighter brown bands are nearly barren of biogenic components. Some clasts were observed; these were of highly variable composition, including volcaniclastic, metamorphic, and sedimentary rocks such as slate, sandstone, basalt, and amphibolite.

Examination of smear slides at Site U1554 indicates the sediments contain fewer microscopic glass shards compared to Site U1564. Grains at Site U1554 are predominantly terrigenous. Quartz, feldspar, and opaque grains make up the majority of the sediment, whereas pyrite, glauconite, and FeMn oxides are also routinely observed in small amounts. Biogenic components are generally present but in low abundance (<10%), with the exception of the thin lighter brown layers that are nearly to completely barren.

Igneous and Alteration Petrology

The petrology group spent the week working on site reports, analyzing thin sections, and assisting in the core laboratories.

Micropaleontology

The micropaleontologists sampled, processed, and observed 47 core catcher samples. These samples spanned ~70 m and ~350 m of sediment recovered from Holes U1564D and U1554G, respectively. Both calcareous nannofossils and planktonic foraminifers were recovered in moderate to high abundances near the bottom of Hole U1564D. At Hole U1554G, calcareous nannofossils are moderately abundant, with some intervals of high abundance occurring within the uppermost 20 core catcher samples, and several intervals with very few nannofossils occurring across the entire studied section. Preservation of calcareous microfossils was mostly good to excellent, with occasional samples of moderate to poor preservation, which mostly occurred in samples where abundances were low. A series of detailed biohorizons for both groups was established going back to 8.8 Ma at Hole U1564D and spanning the last ~2 My at Hole U1554G. Sedimentation rates are constrained as approaching 5 cm/ky between 3.8 and 7.1 Ma and falling to 1 cm/ky between 7.1 and 8.8 Ma at Hole U1564D. Sedimentation rates at Hole U1554G are estimated to be ~15 cm/ky. Abundant diatoms, radiolarians, siliceous dinoflagellates, silicoflagellates, and sponge spicules are present in most samples at Hole U1554G.

Physical Properties

The physical properties team measured cores from Holes U1564E, U1554G, and U1554H. X-ray images were collected on the whole-round (WR) core sections at all three holes. Additionally, for Hole U1564H, the split working halves were imaged. The Special Task Multisensor Logger continued to be run for stratigraphic correlation. Scanning with the Natural Gamma Radiation Logger (NGRL) became the slow point for core flow, and the decision was made to decrease the resolution to 20 cm (one position) for Hole U1554H cores.

Moisture and density, *P*-wave velocity, and thermal conductivity were measured on the working section halves. In Hole U1554G, porosity ranges from ~85% at the top of the hole to ~60% at the base (~350 mbsf). Porosity is slightly lower at the top of Hole U1564E, with values between 71% and 79%. After several days of testing and troubleshooting, the thermal conductivity measurements appear to be reliable.

Stratigraphic Correlation

Stratigraphic correlation continued for Site U1564. Preliminary shipboard correlations using magnetic susceptibility (MS) suggest that a continuous splice for Site U1564 down to ~230 mbsf was achieved. There are several intervals below with potential (small gaps, <1 to 2 m), and a larger gap (~3 to 4 m) near ~430 mbsf based on comparison with the downhole logging MS profile obtained from Hole 395C-U1564C. Below ~430 mbsf, it may be possible to construct a continuous splice between Holes 395C-U1564C and 395-U1564D to ~630 mbsf.

Holes U1554G and U1554H were drilled to ~350 mbsf to further extend the existing splice constructed during Expedition 384 for the first ~70 mbsf. The splice for Site U1554 can successfully be extended to ~200 mbsf. For the remainder of the section, there are core overlaps down to ~350 mbsf. Holes 395C-U1554E and 395-U1554H have a more similar physical properties record compared to that of Hole 395-U1554G, which is likely due to the poor weather conditions while coring this hole.

For both Sites U1564 and U1554, the MS signals are roughly comparable with downhole logging profiles from Expedition 395C and Ocean Drilling Program Sites 983 and 984.

Paleomagnetism

Natural remanent magnetization (NRM) of archive half core sections of Cores U1564D-33X through 74X and Holes U1564E and U1554H were measured every 2.5 cm. For Holes U1564D, U1564E, and U1554H, alternating field (AF) demagnetization was performed at 10, 15, and 20 mT, with measurement of the remaining NRM being taken after each step. Cores from Hole U1554G were measured every 5 cm. Only NRM was measured on core sections from Hole U1554G to preserve a copy for postcruise work. Overall, >1000 m of core were measured on the superconducting rock magnetometer in the past week.

The NRM intensity varies from 1.27 to 4.5 × 10^{-3} A/m and the average is 0.24 A/m. At the maximum magnetization step measured (20 mT), these values decrease, ranging from 0.67 to 3.8 × 10^{-3} A/m. NRM intensity roughly mimics the trend of MS.

Preliminarily, the NRM inclinations remaining after 20 mT demagnetization were used to identify magnetic reversals. In Hole U1564D, up to 12 normal and 12 reverse polarity chrons were recognized. The inclinations from the discrete samples, collected from 470 to 640 mbsf at Hole U1564D, confirm the polarities suggested by the section half inclination values. In Hole U1564E, four normal and four reverse polarity chrons were recognized. In Hole U1554G, 10 normal and 10 reverse polarity chrons were tentatively recognized using the NRM values.

A total of 27 discrete oriented paleomagnetic cubes were collected from Cores U1564D-55X to 73X. All the discrete samples were measured first for anisotropy of magnetic susceptibility and bulk susceptibility. The NRM was consequently measured and then demagnetized with nine or 10 steps up to 80 mT (5, 10, 15, 20, 25, 30, 40, [50], 60 and 80). The characteristic remanent magnetization could be recognized in 22 samples and calculated using Principal Component Analysis between 25 or 30 and 80 mT steps for most cases. The NRM intensity measured on the discrete samples varies from 0.95 to 0.04 A/m, with an average of 0.22 A/m. The NRM intensity after 20 mT demagnetization increases in most cases (after removing a drilling overprint?) and then is reduced between 30 and 80 mT.

Geochemistry

Geochemical analyses continued at Hole U1564D on interstitial water (IW) samples taken from WR core sections (15 to 20 cm in length), on gas headspace samples (Cores 71X–74X), and on sediment samples. One additional IW sample was collected from the Hole U1564H mudline (Core 1H). At Hole U1554G, IW sampling was completed at a resolution of one per section for a total of six samples in the uppermost core (U1554G-1H), and at a resolution of one sample per ~10 m in subsequent cores. Headspace gases were measured at Hole U1554E on Expedition 395C, so no headspace sampling was conducted at Hole U1554G. Shipboard IW analyses include pH, alkalinity, ammonium, and phosphate by spectrophotometry, and major/minor elemental composition by ion chromatography and inductively coupled plasma–atomic emission spectrometry. Sediment samples from squeeze cake residues and from the working half of split cores were collected and measured for wt% total carbon, organic carbon, nitrogen, sulfur, and $CaCO_3$. Discrete samples for bulk elemental and mineralogical composition were also selected from the squeeze cakes for X-ray diffraction analyses. Microbiology samples were collected adjacent to the IW samples with a 5 ml syringe from APC cores or as a 2 cm WR subsample from IW samples from XCB cores, and processed shipboard for postexpedition analyses.

Downhole Measurements

Five APCT-3 temperature measurements were collected in Hole U1554H, with Cores 4H, 7H, 10H, 13H, and 16H. The APCT-3 measurement on Core 7H was of poor quality, but the remaining measurements are good.

Outreach

Week 3 saw the completion and posting of three videos to YouTube as well as the posting of a blog story that involved interviewing some of the Siem Offshore crew members. There were numerous social media posts and four successful ship-to-shore calls with two test video calls. Two more ship-to-shore events were scheduled. The Outreach Officer also helped in the Core Laboratory with imaging, scraping, wrapping, and storing core.

Social Media:

- Facebook: 13 posts and one event with 1790 engagements, and a reach of 20,035 people.
- Twitter: 29 posts with 2681 engagements, and a reach of 67,217 people.
- Instagram:10 posts and eight stories with 4637 engagements, and a reach of 3,854 people.
- YouTube: three new videos with 170 views, nine likes, and 15,210 engagements.
- Blog: two comments were posted.

Ship-to-shore Broadcasts:

There were four ship-to-shore broadcasts this week that reached an estimated 104 attendees. One of the broadcasts was to the Australian Earth Science Convention.

Expedition Log (blog posts):

One blog post, "The Sweat Behind the Science," was published. This covers the story of one of the Siem Offshore drilling crews and has a link to the video that explains how core is taken.

Feedback:

"Again, a big thank you to Gabriel, you and all the team of *JOIDES Resolution*. The tour and our chat were very instructive for our students."

"That was so cool! #paleoCAMP alumna @cejasper joined the Class of 2023 tonight virtually from @TheJR to talk with us about scientific ocean drilling and life at sea." Twitter

Technical Support and HSE Activities

- Staff received and processed cores from Holes U1564D, U1554G, U1554H, and U1562C.

Laboratory Activities

- The X-Ray Linescan Logger (XSCAN) started having issues and the unit stalled on return after an image scan. The frequency of these stalls increased through time. In addition, several hours' worth of scans produced files with 0 bytes of data. Various

troubleshooting methods were tried, including cleaning and turning the acrylic tube that holds the core sections. Personnel on shore were contacted for assistance. Finally, an error message appeared indicating the PC disc space was full. After removing all data from Expedition 399 and shore test files, and moving Expedition 395 data to Data1, the issue was resolved. We propose adding a protocol to transfer data to Data1 systematically to clear up disc space, and the Marine Computer Specialists will add a 1 TB hard drive to the computer.

- Thermal conductivity was plugged into an outlet in the Downhole Measurements Laboratory. The mini-puck is working fine now.
- Core liners shattered frequently during Hole U1554G.
- One of the Icefield MI-5 core orientation tools stopped recording following a shear pin overshot. The other two orientation tools are working fine.
- The software issue for the coulometer and Cahn balance has been temporarily resolved by reverting the entire PC back to an Expedition 399 version. All updates, Windows, OES, and Labview are restricted at this computer. Troubleshooting continues from shore.

IT Activities

- Reset the display resolution of Rigwatch in the Drill Shack after it was changed.
- Installed QAnalySeries on the Correlator workstation.

Developer Activities

- XSCAN: Thumbnails of X-ray images can now be imported to LIVE displays.
- Cahn balance and coulometer: The rollback to the Expedition 399 computer state has restored the stable operation for this software while solutions are being worked on.
- SCORS: Upload of affine and splice tables into LIMS are independent of expedition, allowing for splices created for a site cored on multiple expeditions to be loaded into the database.

HSE Activities

- Emergency shower and eye wash stations were tested.
- A lifeboat drill was held on 25 June.