IODP Expedition 401: Mediterranean–Atlantic Gateway Exchange

Week 7 Report (21–27 January 2024)

During Week 7 of Expedition 401, we completed the casing installation to 652.6 meters below seafloor (mbsf) and cored to 1194.6 mbsf in Hole U1611A.

Operations

Week 7 of the expedition began on 21 January 2024 with 10¾ inch casing being drilled into Hole U1611A from 138.7 mbsf. We continued to drill the casing into Hole U1611A until the reentry cone base landed on the seafloor at 810.1 meters below sea level (mbsl) with the bit at 654.6 mbsf and the casing shoe at 652.6 mbsf. The subsea camera was deployed to observe the release of the casing, and at 0405 h on 22 January the casing assembly was released from the pipe and bottom-hole assembly (BHA). The bit was raised back to the ship, clearing the rig floor at 1103 h and completing the casing portion of operations at Hole U1611A. The rig floor team then assembled the rotary core barrel (RCB) BHA with a polycrystalline diamond compact (PDC) bit, lowered it to 584.9 mbsl, and deployed the subsea camera again to guide reentry into the hole.

Hole U1611A was reentered at 1832 h, and the top of the cone was confirmed to be at 807.3 mbsl and the seafloor at 810.1 mbsl, very close to the precision depth recorder (PDR) estimate of seafloor depth at 810.2 mbsl. The bit was lowered down the casing to 613 mbsf, where it took weight, probably sediments that had come up into the casing. The top drive was installed and the bit washed down to 656.3 mbsf, followed by a 30 bbl mud sweep to clear any remaining loose sediment from the casing. At 0000 h on 23 January, the core line winch electrical controller failed, specifically the Veeder-Root counter in the unit. It was replaced and the winch was back online by 0545 h. The first run on the core line was the Sediment Temperature 2 tool (SET2). The Icefield MI-5 core orientation tool, usually run to orient advanced piston corer (APC) cores, was run by piggybacking on the SET2 tool deployment to estimate any deviation of the casing from vertical. It showed a small angle at the top of casing, deviating to 10° at the base of casing. This result will be tested by the downhole logging inclinometer. Coring started at 0815 h with Core U1611A-2R, but it recovered only 3 cm of sediment and we ran the bit deplugger. Recovery improved for subsequent cores. Cores U1611A-2R to 24R penetrated from 656.3 to 879.4 mbsf and recovered 223.1 m (74%). Cores 25R and 26R returned nearly empty, probably because coarse-grained sediments in the formation are difficult to recover and can enter the base of the pipe. The bit deplugger

was deployed again. We made five 30 bbl mud sweeps per day to flush cuttings and loose sediment out of the borehole, and coring continued with moderate to good recovery. At 0815 h on 26 January, following Core 44R, we switched to half-core advances, which improved core recovery (on 26 January, full-core advances yielded 69% recovery and half-core advances yielded 87%). By the end of the week, Core 72R reached 1194.6 mbsf. Cores U1611A-2R to 72R penetrated from 656.3 to 1194.6 mbsf and recovered 538.3 m (71%).

Science Results

Lithostratigraphy

Cores U1611A-3R to 40R (666.0–1020.0 mbsf) were described and the following units were tentatively defined.

Unit I (Core 3R to Section 10R-2, 666.0–736.2 mbsf) contains alternating calcareous mud and calcareous silty mud, in addition to minor calcareous sandy mud, calcareous sandy silt, and calcareous silty sand. Bioturbation is sparse to moderate, and occasionally abundant. Calcareous mud is typically greenish gray (GLEY1 5/5GY), while calcareous silty mud appears both greenish gray and dark greenish gray (GLEY1 4/5GY, GLEY1 5/5GY). Coarser-grained lithologies typically appear a darker shade of greenish gray (GLEY1 4/5GY). Contacts between lithologies are typically gradual, but occasionally sharp. Trace fossils include *Chondrites* and *Planolites*, and rare *Thalassinoides*, *Palaeophycus*, and *Zoophycos*. The age of these sediments is estimated to be between 3.8 and 4.5 Ma.

Unit II (Sections 10R-3 to 24R-CC, 736.8–875.7 mbsf) contains alternating calcareous mud and calcareous silty mud with minor coarser-grained lithologies, such as dolomitic sandy silt and conglomerate, in addition to calcareous sandy silt and calcareous silty sand. Calcareous mud is typically greenish gray (GLEY1 5/5GY, GLEY1 5/10Y), and occasionally dark greenish gray (GLEY1 4/10Y), very dark greenish gray (GLEY1 3/10Y), or very dark grayish brown (10YR 3/2). Calcareous silty mud appears both greenish gray and dark greenish gray (GLEY1 4/5GY, GLEY1 4/10Y, GLEY1 5/5GY). In general, lithologies appear noticeably darker with depth. Coarser-grained lithologies typically appear a darker shade of greenish gray (GLEY1 4/5GY), dark gray (5Y 4/1), or very dark grayish brown. Contacts between lithologies are typically gradual, but occasionally sharp. Bioturbation becomes sparser with depth, gradually transitioning from sparse to moderate, and occasionally abundant in Cores 10R–18R (Core 19R was not recovered), to sparse to absent in Cores 20R–24R (Cores 25R–27R were not recovered). Trace fossils are dominated by *Chondrites* and *Planolites*, with occasional

Thalassinoides, *Palaeophycus*, and *Zoophycos*. The age of these sediments is estimated to be between 4.5 and 5.3 Ma.

Unit III (Cores 28R to 40R, 903.6–1014.4 mbsf) contains a mix of lithologies, predominantly calcareous mud, with frequent coarser-grained intervals (e.g., sand, sandy silt, conglomerate), and occasional dolomitized sediments. Compared to the other units, Unit III has decreased carbonate content, higher organic content, and is not bioturbated. There are common horizontal laminations and occasional large-scale (>1 m) slump-like structures throughout. Transitions between lithologies are typically sharp, and occasionally gradational and accompanied by a distinct color change. Overall, lithologies are darker colored, ranging from gray (GLEY1 5/N, 5Y 5/1), dark gray (GLEY1 4/N), and very dark gray (GLEY1 3/N) to greenish gray (GLEY1 5/10Y), dark greenish gray (GLEY1 4/10Y), and black (GLEY1 2.5/N, 5Y 2.5/2). Although a majority of Unit III lacks bioturbation, there are rare occurrences of *Planolites* trace fossils in Cores 39R and 40R. The age of these sediments is estimated to be older than 5.3 Ma.

Biostratigraphy

Micropaleontologists sampled, processed, and observed 66 core catcher (CC) samples from Cores U1611A-2R to 72R. Microfossil abundances range from barren to very abundant, with poor to good preservation.

Planktonic foraminifer species are identified from Samples 2R-CC to 17R-CC, followed by a significant decrease in their abundances between Samples 18R-CC and 36R-CC; this trend coincides with an increase in clastic input. The gradual reappearance of planktonic foraminifers starts in Sample 36R-CC, with the occasional influx of detrital material until Sample 78R-CC. Calcareous nannofossils are present in all CC samples, except in Samples 30R-CC, 31R-CC, and 34R-CC.

The benthic foraminifer assemblages were also analyzed in the CC samples. There are abundant benthic foraminifers in the >150 µm fraction of the processed samples down to Sample 18R-CC, after which the number of calcareous microfossils lessens. The finer fraction of the processed samples, ranging from 63 to 150 µm, were analyzed when almost no benthic foraminifers were observed in the coarser fraction. A few suboxic infaunal bovinids are present in the finer fractions. A few microfossils are present in laminated sediment layers but are completely absent in the dark, coarse-grained lithified horizons. Although planktic foraminifers gradually reappear downhole starting in Sample 36R-CC, benthic foraminifer abundance remains low, with only a few shallow water species present in the finer fraction. The benthic assemblage below Sample 36R-CC is restricted to two to three species, *Elphidium macellum, Bolivina spathulata,* and/or *Cibicides lobatulus*.

Biostratigraphers recorded the last occurrence (LO) of *Globorotalia puncticulata* between Samples 8R-CC and 9R-CC, giving an age of 4.52 Ma. The highest occurrence (HO) of *Ceratolithus primus* (4.50 Ma) was identified between the same samples. No other reliable bioevent was recognized by the end of the week. Based on the rapid decrease of calcareous microfossil abundance below Sample 18R-CC, the Miocene/Pliocene boundary is estimated to be between Samples 18R-CC and 21 CC (821.2–850.3 mbsf).

Paleomagnetism

This week the paleomagnetists measured 48 cores (202 archive section halves) from Hole U1611A. Pass-through paleomagnetic measurements were performed using the superconducting rock magnetometer (SRM) to investigate the natural remanent magnetization (NRM). Alternating field (AF) demagnetization was performed on the SRM by applying stepwise peak fields of 5, 10, 15, and 20 mT, with measurement of the remaining magnetization taken at 2 cm resolution.

In addition, we collected 114 discrete samples (74 standard plastic cube samples and 40 sawed cubic rock samples) of the working half split core sections. We measured the anisotropy of magnetic susceptibility (AMS) and bulk magnetic susceptibility (MS) using the MFK2 KappaBridge unit and the NRM on the AGICO JR-6A spinner magnetometer on the plastic cube samples. Stepwise AF demagnetization was performed at successive peak fields of 0, 5, 10, 15, 20, and 30 mT, up to a maximum of 60 mT. The cubic rock samples still need to dry before they can be properly measured. Intensities are mostly below 1×10^{-3} A/m and no clear inclination reversals could be identified in either SRM or discrete sample data, possibly because of a pervasive overprint.

The AMS results of Hole U1611A show an overall vertical direction of the κ_{min} axis, in agreement with a sedimentary fabric of subhorizontal strata and a vertical hole close to vertical.

Geochemistry

The geochemistry team continued to collect headspace gas samples and interstitial waters (IW) in Hole U1611A at a rate of one per recovered core or one every other half advance. Gas content in Hole U1611A remained within a safe range. The inorganic geochemistry team sampled IW from Hole U1611A and measured salinity, pH, and alkalinity. Salinities reached a maximum of 70 from the IWs of Messinian age. Sediment samples for bulk chemistry were obtained from the IW squeeze cake residues. The organic geochemistry team dried, ground, and weighed sediment samples for subsequent batch geochemical analysis.

We reevaluated the comparison between physical properties data and carbonates across several expedition holes where carbonate wt% was anticorrelated with natural gamma radiation (NGR), and found the linear fit was improved by using NGR normalized by dry bulk density (NGR counts per mass) rather than the original NGR value (a per volume measurement). The pattern is common to Sites U1609 and U1385 off the western margin of Portugal, but there is a weak correlation at Site U1610, where carbonate wt% values are relatively invariant and other sediment components dilute the NGR-producing clay fraction.

Physical Properties and Downhole Measurements

Based on prominent variations in MS and NGR, the drilled depth was divided into four informal physical properties units, 650–850 mbsf, 850–900 mbsf, 900–1110 mbsf, and 1110–1195 mbsf. The first unit (650–850 mbsf) shows moderate MS and low NGR values, with 2 to 5 m scale relatively low amplitude MS cycles and moderate amplitude NGR cycles. The second unit (850–900 mbsf) contains higher MS and NGR values than the overlying and underlying units. In the third unit (900–1110 mbsf), overall MS and NGR decrease significantly, but the cycle amplitude increases. The fourth unit (1110–1195 mbsf) is characterized by thin peaks to high MS values, but no corresponding peaks in NGR at the same depths.

The SET2 tool provided a formation temperature measurement of 28°C at 657.3 mbsf.

Outreach

This week we held 15 virtual ship-to-shore tours, the most on this expedition to date. Tours were given to organizations in the United States, United Kingdom, China, India, Japan, and France. One of those tours was broadcast to primary school students around China and was viewed live by more than 460,000 people.

Expedition 401 Co-Chief Scientist Rachel Flecker was interviewed by the BBC World Service Science in Action radio show, highlighting the science of the expedition. Two blog posts were posted on the *JOIDES Resolution* website highlighting both of the scientists' most interesting finds in the cores so far, and the laser engraver on board the ship.

The post popular social media posts on each platform were:

- Facebook: Photos from the crew's Burns Night celebrations
- Instagram: A video featuring Expedition 401 scientists and their favorite rocks
- X: A Science in 60 Seconds video featuring one of the inorganic geochemists

- Threads: A video featuring the Expedition 401 scientists' favorite geology movies

One of the videos from earlier in the expedition of a timelapse of the thrusters being lowered at Site U1385 received a significant number of views this week. It now has nearly 1 million views.

Technical Support and HSE Activities

Laboratory Activities

- Staff processed cores and samples from Hole U1611A. Total recovery is 2338.9 m for the expedition.
- Staff ran the core orientation tool during an RCB deployment to determine the inclination of the hole.
- The programmers tested communication with the tracer pump using the new rig instrumentation system (iRIS), confirming that iRIS can communicate with the tracer pump. Setup details will be posted in the tracer pump user guide in Confluence and in the technical report. Following the test, the configuration was set back to the Rigwatch system.

IT Activities

- Repaired the Core Entry Zebra label printer with parts from the spare unit.
- Finished creating the Expedition 402 accounts for oncoming scientists and new staff.
- Worked with the staff scientist to revise the introductory IT presentation for Expedition 402.
- Preparing for macOS updates.
- Configured the tracer pump serial server for communication with iRIS for a function test.
- Continued troubleshooting the VSAT switch and video display unit (VDU) communication issues.

Developer Activities

- Worked on the Hyperscan project, including meetings with a shore developer.
- iRIS development. Communication was established with the tracer pump and we are working on getting iRIS to report correct depths.
- Assisted with an ongoing communication problem with the X-Ray Linescan Logger (XSCAN). For now the solution is to restart the XSCAN.

- Investigated an intermittent problem with database uploads from the Whole-Round Multisensor Logger (WRMSL), where there was sometimes a several-minute delay between completing the data files and the files being uploaded to the database.

HSE Activities

- Emergency shower and eye wash stations were tested.
- A boat drill was held on Sunday, 21 January.