IODP Expedition 401: Mediterranean–Atlantic Gateway Exchange

Week 8 Report (28 January–4 February 2024)

During Week 8 of Expedition 401 we completed coring Hole U1611A from 1194.6 to 1281.9 meters below seafloor (mbsf), and after drilling down, we cored Hole U1611B from 744.9 to 1069.9 mbsf. The last core of the expedition, Core U1611B-66R, came on deck at 2330 h on 4 January.

Operations

At the start of the week, we were coring Core U1611A-73R from 1194.6 mbsf. We switched from half-length to full-length rotary core barrel (RCB) core advances with Core 77R. Core 79R returned empty, so we ran the bit deplugger and switched back to half-length advances for Cores 80R to 83R, each of which recovered less than 10 cm. At 1945 h we started a wiper trip to clear bridges in the hole prior to further coring and downhole logging. Overpulls of 20,000 to 30,000 lb were observed at 1104.9, 949.4, 881.7, and 872.0 mbsf before the bit could be raised to the casing shoe. On washing down, 12 tight spots were encountered and 6 m of fill was found at the base of the hole. From 0730 to 1030 h on 29 January, we washed out the fill and swept the hole with 30 bbl sepiolite mud in preparation for coring. Cores U1611A-84R to 86R penetrated to 1281.9 mbsf, the final depth of the hole, and recovered 13.2 m (68%).

At 1545 h we started to prepare the hole for downhole logging. The bit was released at the base of the hole, the hole was displaced with barite-weighted mud, and the end of pipe was raised to 672.7 mbsf. The rig floor team assembled the triple combo logging tool string, without the source, and started lowering it down the pipe at 2145 h. The tool string reached an impassable obstruction at 909.6 mbsf, and made a repeat and main pass, which together cover the interval from 672.7 to 909.6 mbsf. Borehole diameter varied between narrower than 6 inch to wider than the maximum extent of the caliper measurement, 17 inch, and the logged interval of the borehole was inclined from the vertical by between 10° and 15°. The triple combo tool string was back on deck at 0410 h on 30 January and a sonic-inclinometry tool string was assembled for the second logging run. This tool string was lowered into the borehole but could not pass below 743.6 mbsf. It recorded data for the short interval up to the bit, was back on deck by 0910 h, and the logging equipment was disassembled by 1100 h. The bottom-hole assembly (BHA) was raised back to the ship, clearing the rotary table at 1400 h and ending Hole U1611A. A new mechanical bit release (MBR) and polycrystalline diamond compact (PDC) RCB bit were added to the BHA and were lowered below the ship.

The ship was offset to the northwest and Hole U1611B was started at 1725 h on 30 January at a water depth of 784 meters below sea level (mbsl). We drilled ahead from 211.6 to 744.9 mbsf and pumped 30 bbl sepiolite mud sweeps after adding every two stands of pipe to keep the hole clear. When the center bit was retrieved, 1.7 m of sediment was found behind it in the core barrel, which was curated as a wash core, Core U1611B-2W. Coring started at 1830 h on 31 January. Cores U1611B-3R to 4R made 91% recovery, but the following two cores, Cores 5R and 6R, returned nearly empty, so we ran the bit deplugger and then switched to half-core RCB advances. Coring proceeded with half-core advances for the next three days, until operations needed to stop to start preparing for the transit to Napoli, Italy. Core U1611B-66R arrived on the catwalk at 2330 h on 4 January and was the last core of the site and the expedition. Cores U1611B-3R to 66R penetrated from 744.9 to 1069.9 mbsf and recovered 77.3 m (89%). All cores were half-core RCB advances out of choice.

Science Results

Lithostratigraphy

Four main lithologies were described in Site U1611: (calcareous) mud, (calcareous) silty mud, sandy silt, and silty sand. Minor lithologies include sandy mud, conglomerate, breccia, and cemented carbonate (e.g., dolostone, limestone). On the basis of lithological changes, Holes U1611A and U1611B are divided into three stratigraphic units. Contacts between these units and the lithologies within them are mainly gradational in the upper parts, characterized by subtle changes in color and grain size, and become more commonly sharp with depth, associated with distinct color changes and frequent laminations. The coarser silts and sandier beds typically have sharp to erosive basal contacts.

Unit I ranges from 656.3 to 820.4 mbsf in Hole U1611A, and from 746.4 to 814.2 mbsf in Hole U1611B. In Hole U1611A, Unit I comprises three subunits, consisting of alternating calcareous mud and calcareous silty mud. The interval 733.9 to 772.3 mbsf contains more occurrences of coarser lithologies including conglomerates and calcareous sandy silt. In Unit I in Hole U1611B, calcareous muds also alternate with calcareous silty muds, with the frequency of coarser lithologies increasing with depth.

Unit II ranges from 820.4 to 996.5 mbsf in Hole U1611A, and from 814.2 to 996.9 mbsf in Hole U1611B. In Hole U1611A, Unit II is characterized by the presence of laminated beds alternating with nonlaminated and sometimes coarse graded beds. Unit II consists of two subunits. Subunit IIa (820.4–964.3 mbsf) is composed of lithologies with variable carbonate content, including mud, calcareous mud, calcareous silty mud, sandy silt, and

silty sand, with minor aragonite, cemented carbonate, breccia, and conglomerate. Subunit IIb (971.5–996.5 mbsf) is composed of similar lithologies as Subunit IIa, but with a lower carbonate content, with beds of calcareous muds and calcareous silty muds alternating with muds, sandy silts, and sands. In Hole U1611B, Unit II mostly consists of the same lithologies as in Hole U1611A, with a generally lower calcareous content with increasing depth. However, in Hole U1611B more silty muds were described in the deeper part of Unit II, and in general there are more coarser beds.

Unit III ranges from 1000.6 to 1275.9 mbsf in Hole U1611A, and from 997.1 to 1069.69 mbsf in Hole U1611B. In Hole U1611A, Unit III consists of two subunits. Subunit IIIa (1000.6–1144.9 mbsf) consists of frequent alternations of silty mud and calcareous silty mud in the shallower parts, with numerous intervals of sandy silt and silty sand. The proportion of calcareous silty mud is lower in the deeper part of Subunit IIIa. There is also minor conglomerate typically associated with contorted, slump-like sediment deformation, and cemented carbonate. Subunit IIIb (1146.1–1275.9 mbsf) consists of similar lithologies to Subunit IIIa, except that Subunit IIIb lacks the rapid interbedding of calcareous silty mud and silty mud, and contains more frequent occurrences of coarser-grained intervals (e.g., sandy silt and silty sand). In Hole U1611B, Unit III is similar to the upper part of Subunit IIIa in Hole U1611A, except that there is a notable thick conglomerate (8.5 m) that was not recovered in Hole U1611A. Unit III is characterized by the presence of laminated beds alternating with nonlaminated and normally graded beds, but the laminations appear subtler than in Unit II.

Biostratigraphy

The site features diverse lithologies, including muds, silts, sands, conglomerates, and cemented carbonates. Notably, some intervals were poor in microfauna, particularly planktonic foraminifers. However, despite some core catchers (CC) being barren in foraminifers, the samples were rich in fish teeth and scales, wood fragments, and shell fragments, providing valuable understanding of the site’s paleoenvironment.

Both holes were drilled down with the intent to start coring sediments that are early Pliocene in age. Based on the calcareous nannoplankton and foraminifer assemblages recovered at the top of both sequences, an age belonging to the early Pliocene was estimated for the first CC.

From Samples 401-U1611A-18R-CC (821.2 mbsf) and 401-U1611B-14R-CC (815.7 mbsf), close to the Lithological Unit I/II boundary, a major downward change in the planktonic foraminifer assemblages was recognized. With rare exceptions, planktonic foraminifers are not present in the fraction >150 µm, although they continue to be present in the 63–150 µm fraction. There is also a significant change in the type of

sediment, with almost no biogenic particles in the coarse fraction, with the exception of some fish or wood fragments. We relate this change with the Miocene/Pliocene boundary. The presence of *Nicklithus amplificus* and *Reticulofenestra pseudoumbilicus* at the bottom of the sequence provides an age estimate of younger than 6.82 Ma.

Paleomagnetism

Pass-through paleomagnetic measurements were performed using the superconducting rock magnetometer (SRM) to investigate the natural remanent magnetization (NRM) of all the archive half split core sections of Hole U1611A and started with Hole U1611B. 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 discrete samples of all the working half split core sections of Hole U1611A. 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. Stepwise AF demagnetization was performed at successive peak fields of 0, 5, 10, 15, 20, 30, and up to a maximum of 60 mT. In addition, we performed stepwise thermal demagnetization up to a maximum temperature of 600°C on six sawed samples. The paleomagnetic results are weak and we are not sure if we are measuring the primary magnetic signal or a pervasive overprint. The thermal demagnetization shows the presence of iron sulfides in the sediment.

The AMS results from Hole U1611A show an overall vertical direction of the κ_{min} axis with a scatter on the order of 10°, in agreement with observations of subhorizontal strata in the split cores.

Geochemistry

At Hole U1611B, the geochemistry team collected headspace gas samples at a rate of one per recovered core or one every other half advance, as Hole U1611B was ~1300 m from Hole U1611A. Gas content at Hole U1611B remained within the safety range. Samples for geomicrobiology and interstitial waters (IW) were collected from every other recovered core or every fourth half advance. The inorganic geochemistry team sampled IW samples from Hole U1611B and measured salinity, pH, and alkalinity. Salinities again increased in the subsurface to double that of seawater as drilling approached the Messinian. The major ion chemistry was used to interpret the origins of these saline IW.

Sediment samples were obtained from the squeeze cake residues where IW was taken in Holes U1611A and U1611B and from select lithologies on the core description table. The organic geochemistry team processed sediment samples that were dried, ground,

and weighed toward subsequent batch geochemical analysis. Comparison of carbonate concentrations with lithology and physical properties data continued for Site U1611 and for the expedition as a whole.

Physical Properties and Downhole Measurements

The whole-round physical properties match well in the large-scale between Holes U1611A and U1611B, but the same horizons are approximately 5 to 15 m shallower in Hole U1611B compared to Hole U1611A. Coarser lithologies tend to have lower natural gamma radiation (NGR) values. Cemented carbonate layers are distinguished by low NGR and MS values and relatively high gamma ray attenuation (GRA) density values.

Downhole logging in Hole U1611A was only partially successful, with the triple combo tool string reaching 909 mbsf, logging a 236 m open hole interval. The sonic-inclinometry tool string reached 743 mbsf. The borehole was characterized by washouts, bridges, and ledges. According to both the General Purpose Inclinometry Tool (GPIT) logs, at the end of the pipe the borehole was inclined at ~9° from vertical and the inclination increased with depth to more than 12° at 750 mbsf. The log data provide useful stratigraphic information because the logged interval covers the Miocene/Pliocene boundary at ~815 mbsf and some poorly-recovered intervals of the Messinian strata in Hole U1611A.

Outreach

Outreach activities continued this week with social media posts, including two “Science in 60 Seconds” videos featuring geochemistry and physical properties scientists.

Ship-to-shore tours concluded at the end of the week. A total of 75 ship tours were held over the course of the expedition.

Technical Support and HSE Activities

Laboratory Activities

- Staff processed cores and samples from Holes U1611A and U1611B. Total recovery for Expedition 401 is 2605 m of core.
- Logging for Hole U1611A was not ideal as the hole diameter varied wildly. A check shot survey could not be carried out.
- The T-shirt logo pressing party took place.

- Working to conceal the Thin Section Laboratory lap wheel inside a disposable glove bag for Expedition 402 sample preparation.
- Preparing for end-of-expedition activities.

IT Activities

- Continued troubleshooting visual display unit (VDU) streaming issues on new switches.
- Reviewed and revised IT presentation for the Expedition 402 science party.
- Troubleshooting SnapTV set top box communications issues with server. Determined that the issue was with Siem Offshore's server/network and resolved the issue.
- Remediating Linux servers.
- Matlab license server has stopped working due to license issues. We are working with shore to get new licenses.
- Troubleshooting issue with RigWatch receiving the core line depth data from iRIS.
- Preparing for end-of-expedition activities.

Developer Activities

- Continuing work on iRIS, including three extra iRIS reports.
- Continuing work on the Hyperscan project.

HSE Activities

- Emergency shower and eye wash stations were tested.
- A boat drill was held on Sunday, 28 January.