

IODP Expedition 401: Mediterranean–Atlantic Gateway Exchange

Week 6 Report (14–20 January 2024)

During Week 6 of Expedition 401, we cored two holes at Site U1385, extending the paleoceanographic record to 8 Ma following previous coring at this site during Expedition 397 in 2022, which reached ~5.3 Ma. After bad weather stopped operations at Site U1385, the ship transited into the Mediterranean Sea and started to install casing in Hole U1611A.

Operations

Hole U1385K

Week 6 of the expedition began on 14 January 2024 with coring continuing in Hole U1385K. Cores U1385K-5X and 6X returned nearly empty, so we ran the bit deplugger to ensure that the bottom of the bottom-hole assembly (BHA) was free from loose sediment, which may have entered during the preceding drill down. Recovery improved in subsequent cores and we continued coring until Core 21X at 1035 h on 15 January, having reached the age target of 8 Ma. Cores U1385K-5X to 21X penetrated from 402.4 to 552.5 meters below seafloor (mbsf) and recovered 150.1 m (85%). We pulled up the pipe, clearing the seafloor at 1328 h on 15 January and ending Hole U1385K.

Hole U1385L

The ship was offset 20 m to the north, and we started Hole U1385L at 1455 h on 15 January, drilling ahead without coring to 376 mbsf. Coring began at 0330 h on 16 January and Cores U1385L-2X to 8X penetrated from 376.0 to 443.9 mbsf, recovering 58.4 m (86%). We stopped coring at 1645 h and began to pull the bit out of the hole before the forecasted high wind and wave conditions began. The bit cleared the seafloor at 1835 h and pulled up to a depth of 332 meters below sea level (mbsl) while the ship began waiting on weather (WOW). After coring Hole U1385K, we had a choice between going directly to the next site or staying to core Hole U1385L; we prioritized collecting core from Hole U1385L, knowing that it would mean WOW the following day.

The ship began WOW at 2315 h on 16 January. At midmorning on 17 January, the average wind speed reached 35 kt, gusting to 65 kt, then it eased throughout the day. After WOW for 28.25 h, at 0330 h on 18 January we were able to resume operations. The BHA was raised, disassembled, and stowed. The thrusters were raised at 0720 h,

and at 0736 h we started the transit to Site U1611 (proposed Site WAB-03A), ending operations at Site U1385.

On the morning of 19 January, the *JOIDES Resolution* sailed through the Strait of Gibraltar, one of the Mediterranean–Atlantic Gateways in the title of Expedition 401. The 333 nmi transit to Site U1611 in the Alboran Basin of the Mediterranean Sea took 29.8 h at an average speed of 11.2 kt. We arrived on site at 1315 h on 19 January. We lowered the thrusters at 1324 h and switched to dynamic positioning (DP) mode at 1338 h, starting operations at Site U1611. The rig crew performed a cut and slip of the drilling line and picked up the drill collars. At 1745 h, high winds made it unsafe for the derrickman to work at the monkey board in the derrick. We waited until 2015 h for the wind to drop before resuming operations (a 2.5 h delay).

The hydraulic release tool (HRT) running tool was assembled, the upper guide horn was set aside, and the rig floor team assembled ~650 m of 10¾ inch casing and hung it below the ship. From 0900 to 1200 h on 20 January, they made up the casing stinger BHA, including the bit, underreamer bit, and mud motor. The underreamer and mud motor were tested and found to operate well. The BHA and drill pipe were lowered down through the casing until the bit and underreamer extended below the casing by 3 m. The HRT running tool was attached to the casing and the funnel was welded on. The funnel was lowered through the moonpool at 1540 h, and the whole casing system was lowered down to 792.1 mbsl before installing the top drive. Hole U1611A was started at 1730 h, and by midnight the system was drilled to 138.7 mbsf.

Science Results

Lithostratigraphy

Cores U1385K-2X and 7X to 21X (385.0–552.65 mbsf), and Cores U1385L-2X to 8X (376.0–442.6 mbsf) were described, and the following units were defined.

Units I to IV are characterized by alternating light-colored (light greenish gray, GLEY1 6/1, GLEY1 7/1) and dark-colored (greenish gray, GLEY1 5/1, GLEY1 6/1; and gray, 5Y 6/1, 5Y 5/1, 10YR 6/1) beds composed of clayey calcareous ooze and calcareous clay with lighter and darker shades and gradational and sharp boundaries. Minor lithologies include clay-rich and pyrite-rich intervals and horizons exhibiting multiple hues, including shades of orange-brown and blue-green. Trace fossils include *Chondrites*, *Planolites*, *Thalassinoides*, and *Zoophycos*, and rare *Asterosoma*, *Palaeophycos*, and *Schaubcylindrichnus*. Pyrite nodules and shell fragments are disseminated throughout. Sediments are initially interpreted as deepwater hemipelagic deposits.

Unit I extends from 385 to 430 mbsf in Cores U1385K-2X and 7X to 9X and from 376 to 430.5 mbsf in Sections U1385L-2X-1 to 7X-4, and comprises clayey calcareous ooze (light greenish gray) and calcareous clay (greenish gray). Unit II extends from 436 to 458.5 mbsf in Sections U1385K-10X-1 to 12X-2 and from 430.5 to 442.6 mbsf in Sections U1385L-7X-5 to 8X-CC. Unit III extends from 458.5 to 519.6 mbsf in Sections U1385K-12X-3 to 18X-4. Units II and III contain clayey calcareous ooze (light greenish gray) and calcareous clay (variable greenish gray and gray). Unit IV extends from 519.6 to 552.65 mbsf in Sections U1385K-18X-5 to 21X-CC and is dominated by calcareous clay (variable greenish gray and gray) with minor clayey calcareous ooze (light greenish gray).

Biostratigraphy

Micropaleontologists sampled, processed, and observed all core catcher (CC) samples from Holes U1385K and U1385L. Calcareous microfossils are typically abundant with moderate and good preservation, and planktonic foraminifera are well preserved with evidence of fragmentation in only a few samples. The age of the succession is constrained by eight nannofossil events and four foraminifera events. The highest occurrence (HO) of *Ortorhabdus rugosus* (5.23 Ma) and the lowest occurrence (LO) of *Ceratolithus acutus* (5.36 Ma) are recorded between Sections U1385L-4X-CC and 5X-CC at ~409 mbsf, constraining the Messinian/Pliocene boundary to be in Core U1385L-5X. The oldest bioevent we found was the base of the paracme of *Reticulofenestra pseudoumbilicus* (8.8 Ma) between Sections U1385K-19X-CC and 20X-CC at ~517 mbsf. The CC samples were also analyzed for benthic foraminifera content; the analyses are still in progress, but the assemblage seems well preserved.

Nannofossil smear slides from Site U1610 were reexamined for minerals and reworked coccoliths. Samples from Site U1610 were also investigated for shark teeth for postcruise neodymium isotope analysis, and select *Cibicidoides* species were picked for future carbon and oxygen isotope analyses.

Paleomagnetism

Pass-through paleomagnetic measurements were performed using the superconducting rock magnetometer (SRM) to investigate the natural remanent magnetization (NRM) on a total of 132 archive section halves (91 from Hole U1385K and 41 from Hole U1385L). 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 and measured 117 discrete samples of the working half split-core sections, between three to seven discrete samples from each core. First, the anisotropy of magnetic susceptibility (AMS) and bulk magnetic susceptibility (MS) were measured on all samples using the MFK2 KappaBridge

instrument. Next, the NRM of 61 cube samples, 47 from Hole U1385K and 14 from Hole U1385L, was measured on the AGICO JR-6A spinner magnetometer. Stepwise AF demagnetization was performed at successive peak fields of 0, 5, 10, 15, 20, 30, 40, 50, 60, and 70 mT, up to a maximum of 80 mT for the samples of Hole U1385K, and up to a maximum of 40 mT for Hole U1385L where the magnetic signal was weaker. When magnetization became erratic, demagnetization was stopped.

The AMS results of Holes U1385K and U1385L show an overall vertical direction of the k_{\min} axis, in agreement with a sedimentary fabric and a vertically drilled hole, unlike the previous site, Site U1610. Constrained by stratigraphic correlation to Hole 397-U1385J, the topmost core of Hole U1385L is <5 Ma. We then correlated the reversal pattern in inclination values of SRM measurements after 20 mT and JR-6A measurements after 20 mT to the most recent geomagnetic polarity timescale (GPTS). Based on this magnetostratigraphy, the base of Hole U1385K is slightly older than 8.2 Ma. We used our magnetostratigraphy to calculate sediment accumulation rates, which indicate an average accumulation rate of ~5 cm/ky for the Messinian part of the record.

Geochemistry

The geochemistry team completed data analysis including carbonate fraction geochemistry from Site U1610. The carbonate geochemistry shows lithology-dependent variations and clear signs of carbonate diagenesis.

At Hole U1385K, the geochemistry team collected headspace gas samples and interstitial waters (IW) at a rate of one per recovered core. Gas content at Hole U1385K was within the safety range; only methane and ethane were detected, but no higher hydrocarbons. The inorganic geochemistry team sampled IW from Hole U1385K and measured salinity, pH, and alkalinity. Salinity remained invariant at 32 throughout the cored interval. IW major and trace elements were measured by ion chromatography (IC) and inductively coupled plasma–atomic emission spectroscopy (ICP-AES). Sediment samples were obtained from the IW squeeze cake residues in Hole U1385K and one sample per core from Hole U1385L to understand geochemical variations. Calcium carbonate abundance varies from 39 to 69 wt% and correlates well with NGR, showing that mixing of carbonate and siliciclastic fractions is controlling the observable cyclicity at this location. Sediment samples were dried, ground, and weighed to measure C, N, and CaCO₃.

Physical Properties and Downhole Measurements

The full suite of physical properties measurements was made on cores and samples from Holes U1385K and U1385L. Moisture and density measurements show a compaction trend with depth: bulk density increases from ~1.9 g/cm³ at 378 mbsf to

2.0 g/cm³ at 548 mbsf, and porosity decreases from 50% to 43% over the same depth interval. NGR and MS records contain cyclic alternations on a meter to sub-meter scale throughout the cored interval, with relatively higher amplitude cycles from ~420 to 505 mbsf. No downhole measurements were made this week.

Outreach

Ship-to-shore tours this past week reached more than 300 students in seven countries: Portugal, Australia, United Kingdom, United States, Spain, China, and India. Two tours were done with Centro Ciência Viva do Algarve, an exhibit in Faro, Portugal, that included our youngest audience for this cruise, five-year-olds. Two additional tours were held with theaters full of visitors to the Smithsonian National Museum of Natural History in Washington, D.C. A [blog post](#) published on the *JOIDES Resolution* website this past week discusses drilling the 12th hole at Site U1385. A [video](#) and [post](#) were created by an Outreach Officer on board, highlighting sketches of various equipment around the laboratories on board.

The top posts of the week on social media were:

- Facebook: Photos of passing through the Strait of Gibraltar.
- Instagram and Threads: A video featuring the science party's favorite geology movies.
- X: A video highlighting the ship heave compensator.

Technical Support and HSE Activities

Laboratory Activities

- Staff processed cores and samples from Holes U1385K and U1385L. Total Expedition 401 core recovery is 1920.5 m as of this report.
- Thermal Conductivity (TCON): while reviewing data in LIMS, it was noticed that several batches of tests were uploaded with no data and a time stamp of "1601-01-01 00:00:00." Each batch contains 30 to 100 repeated uploads of the same sample. After further investigation, we believe the operator failed to select the proper folder to direct the data in TCON software, which resulted in "ghost" tests being created. All ghost tests were canceled in LIMS.
- We made two small 60 cm long concrete half cores for the X-Ray Linescan Logger (XSCAN) instrument. These were made to test repeatability over time and to monitor for any potential degradation in the source. One is concrete only and the other is concrete containing small pieces of material with contrasting

densities (bolt, aluminum cylinder, glass, and rocks). A 150 cm long half core and a 46 cm whole-round core with nuts and glass inside were also made. Testing results will be reported in the expedition technical report.

- We tested various echo sounder power levels during the transit from Site U1385 to Site U1611, before we entered the Mediterranean Sea, increasing the power level from 1 to 4. The strength of the chirp was verified; however, perhaps due to ship's speed of over 11 kt, the signal strength showed minimal differences.
- The built-in monitor on the Zebra printer at the core entry station failed. The printer responds to network command and prints correctly. A spare is now installed while the Marine Computer Specialist (MCS) repairs the broken monitor.
- We connected the ship's vent to the Beuhler petrothin saw in the Thin Section Laboratory and confirmed that the forward sink and middle island sink drain into the ship's gray water system.

IT Activities

- Worked with an Extreme EXOS switch vendor to complete troubleshooting a Compass search issue, and we continue troubleshooting a stream playing issue.
- Started deploying January Linux server updates.
- Working with WifiGem to correct user experience issues with false quota denials and other connection issues.

Developer Activities

- Helped technicians fix a KappaBridge Report depth and offset issue.
- Migrated Sample Report and Extended Sample Report to Shore Test, per a request by a Staff Scientist on shore.
- Canceled TCON tests that were accidentally uploaded by the system.
- Continuing work on the Hyperscan project.
- Fixed a bug in LORE's web services that caused errors on some reports when many samples are involved in a search.

HSE Activities

- Emergency shower and eye wash stations were tested.
- A boat drill was held on Sunday, 14 January.