IODP Expedition 402: Tyrrhenian Continent–Ocean Transition

Week 6 Report (17–23 March 2024)

Week 6 of the International Ocean Discovery Program (IODP) Expedition 402, Tyrrhenian Continent–Ocean Transition was spent installing casing and a reentry system at Site U1616 to facilitate drilling of the sediment/basement interface and underlying basement rocks with the rotary core barrel (RCB) system. Site U1616 was selected for casing installation because of the presence of brecciated peridotite at the bottom of Hole U1616B, cored with the advanced piston corer/extended core barrel system. The initial attempt to install a Dril-Quip (DQ) reentry cone and 64.64 m of 16 inch casing in Hole U1616D did not go smoothly; we were unable to unlatch the running tool from the reentry system and casing, and were therefore required to recover the entire installation. During the process of pulling out of the hole, the 16 inch casing string below the 20 to 16 inch swage was lost. The reentry cone, with ~5 m of the 20 inch casing and 219.4 m of the 13⅜ inch casing, was successfully installed in Hole U1616E. At the end of the week, coring in Hole U1616E was getting underway.

Operations

The vessel completed the final 7 nmi of the 40.1 nmi transit to Site U1616 from Site U1617 at 0112 h on 17 March 2024 at a speed of 8 kt. After arriving on site, the vessel transitioned to dynamic positioning mode. We began preparations for a jet-in test to verify that the full 64.64 m of 16 inch casing planned as the first casing string could be washed in. The upper guide horn was removed and a bottom-hole assembly (BHA) with an 18½ inch tricone bit was made up. We tripped pipe toward the seafloor and spudded Hole U1616C at 1115 h on 17 March. The jet-in test succeeded, penetrating 76.9 m into the sediment in ~3 h. Pipe was tripped back to the surface and the bit was recovered to the rig floor at 2215 h, ending Hole U1616C. Preparations then began for the reentry system and casing installation planned for Hole U1616D.

With the reentry cone positioned on the moonpool doors, the 64.64 m of 16 inch casing that comprised the first casing string was run through the moonpool and hung in the reentry cone. The string consisted of five joints of 16 inch casing and several 16 inch pup joints that will extend the length of the string, past a layer of volcaniclastic gravel ~60 meters below seafloor (mbsf) that may cause hole instability. The stinger with the running tool and BHA were made up and latched into the reentry cone with the DQ running tool, the moonpool doors were opened, and the reentry system was lowered toward the seafloor. The vibration isolated television (VIT) camera system was launched to monitor the installation of the reentry cone on the seafloor and the release of the running tool from the reentry cone. An extra stand of pipe that was accidentally inserted into the drill string resulted in the bit and casing being run into the seafloor. The stand was taken back out of the drill string and the top drive was picked up to jet in the casing.

Hole U1616D was spudded at 2000 h on 18 March and the casing was successfully jetted in to 64.64 m, such that the reentry cone was sitting on the seafloor. From 0430 to 0545 h on 19 March, we attempted to unlatch the running tool from the DQ reentry cone and casing, but we were unable to rotate it. Consequently, we made the decision to recover and inspect the reentry system and then redeploy in Hole U1616E. The casing was pulled out of the hole, experiencing strong overpull at ~10 mbsf. The VIT camera system was recovered and pipe was tripped back toward the surface. At 1400 h on 19 March, the reentry cone was brought back up through the moonpool and landed on the moonpool doors. The 16 inch casing string below the 20 to 16 inch swage was lost. It is likely that the overpull experienced while pulling out of Hole U1616D was due to the casing detaching. The bit was recovered onto the rig floor at 1800 h, ending the hole. Two bent drill collars were removed from the BHA prior to making up a new BHA and latching it back into the reentry cone.

The reentry cone with the remaining ~5 m of 20 inch casing was lowered through the moonpool and we began tripping pipe toward the seafloor to install the reentry cone in Hole U1616E. The VIT, with the Conductivity-Temperature-Depth (CTD) sensor and Niskin water sampler attached to the frame, was launched at 2330 h and was lowered to observe casing installation and release. Hole U1616E was offset 40 m west of Hole U1616D to avoid encountering any of the lost casing string that might be lying on the seafloor.

Hole U1616E was spudded at 0445 h on 20 March, with the 20 inch casing set at a depth of 5.5 mbsf. At 0545 h, the running tool successfully unlatched from the casing. We then pulled out of the hole, recovered the VIT, and tripped pipe back to the surface. A new BHA was made up with a 14¾ inch tricone bit for drilling ahead to 250 mbsf in Hole U1616E in preparation for the installation of ~220 m of 13⅜ inch casing. This depth of rathole will allow for successful casing, even if there is substantial fall-in from unstable layers higher in the sediment column.

We began tripping pipe toward the seafloor, and at 2130 h we launched the VIT to guide reentry. The hole was reentered at 0120 h on 21 March and the VIT camera system was recovered. The drill ahead finished at 1130 h and the hole was swept with sepiolite mud and then displaced with 170 bbl of barite heavy mud to keep the hole open during casing installation. We then pulled out of the hole and began tripping back to the surface. The VIT was deployed to monitor the bit clearing the reentry cone and the position of the cone on the seafloor, given the shallow depth of the first casing string.

The 13⅜ inch casing intended for installation in Hole U1616E was rigged up and run, and the casing landed on the moonpool doors. The stinger and BHA were made up and run through the casing, and the stinger was latched into the casing hanger. We then began tripping pipe toward the seafloor, stopping at 60 stands of pipe to launch the VIT camera system to facilitate reentry in Hole U1616E. We finished tripping pipe to the seafloor and reentered Hole U1616E at 1658 h on 22 March. The casing was washed in to a depth of 219.4 mbsf, landed in the reentry cone, and was released at 2045 h. This casing depth successfully sealed off the volcaniclastic gravel (~60 mbsf) and tuff (~196–206 mbsf) layers within the sediment that were predicted to pose a risk to hole stability.

Drill pipe was tripped back to the surface, the drill collars and casing running tool were laid out, and the upper guide horn was reinstalled in preparation for RCB drilling operations. A BHA with a 9⅞ inch RCB bit was made up and tripped toward the seafloor. Reentry occurred at 1628 h on 23 March, with the VIT camera system deployed to facilitate the process. The VIT was then recovered prior to drilling. We washed down the distance from the end of the casing to the bottom of the drilled interval (250 mbsf), encountering fill just below the casing shoe. A center bit was deployed to aid in washing down through the fill, and a 40 bbl sweep of sepiolite mud was pumped at the bottom of the hole to further clear the hole. At midnight, Core U1616E-2R had been drilled to a hole depth of 259.8 mbsf and was being recovered.

Science Results

The science party spent Week 6 writing site reports for Sites U1615 and U1617 and finalizing reports for Sites U1613 and U1614. We held the Site U1617 summary meeting. Several laboratory groups did not have laboratory-specific results during this week, as no new cores were recovered.

Lithostratigraphy

After describing the complete sediment succession recovered in Hole U1617A, the sedimentology group identified three lithological units. Unit I is divided into three subunits. Unit IA is characterized by nannofossil ooze, intercalated by tephra, sapropel, and organic-rich mud layers. Unit IB is formed by the same lithologies found in Unit IA, but it is devoid of tephra layers. In Unit IC, nannofossil ooze is still the principal component, intercalated again with tephra layers and characterized by the increasing content of foraminifera. Unit II represents a predominant foraminifer-rich nannofossil ooze deposit, sometimes intercalated with layers characterized by minor foraminifer content. Unit III contains Messinian evaporite deposits that consist of oxide-rich and/or glauconite-rich mud or mudstone, gypsum, and anhydrite.

Biostratigraphy

Analysis of planktic foraminifera and calcareous nannofossils to refine the age of sediment at Site U1617 continued during Week 6. The sediment lithology was predominantly nannofossil ooze rich in well-preserved calcareous nannofossils and planktic foraminifera. Limited volcanogenic sediments are observed at this site.

Holocene–upper Zanclean (~4.11 Ma) sedimentary successions, concurrent with planktic foraminiferal biozones MPle2b–MPl3, were recognized from core catcher (CC) Samples 402-U1617A-1H-CC to 33X-CC. A hiatus of ~0.5 Ma was found to be present between CC Samples 13H-CC and 14H-CC, as planktic foraminiferal events corresponding to MPl6b biozone were not detected. Sedimentary successions above and below these intervals were found to be continuous. Sediments containing evaporite minerals such as gypsum were observed to be present, starting with CC Sample 36X-CC, and were later interpreted to be Messinian deposits based on previous research in and around these regions. Two CC samples, 34X-CC and 35X-CC, were taken to date the sediments above the Messinian deposits. However, these sediments contain entirely organic silt and oxide rich mud, which are barren of planktic foraminifera marker species. Additional samples for postcruise analyses were taken from the core sections of Cores 34X and 35X to further refine the age of the sediments deposited above the Messinian sediments.

Smear slide samples for nannofossil analysis were prepared from 35 CC samples. Samples from Cores U1617A-1H through 6H yield abundant and well-preserved nannofossil assemblages. These are assigned to the interval between biozone MNQ21 and subzone MNNQ19c of early Pleistocene–Holocene age (<1.24 Ma). Samples U1617A-7H-CC to 13H-CC are assigned to the biostratigraphic interval spanning the MNQ19d–MNQ19a biozones (early/middle Pleistocene), thus highlighting a repetition in the sedimentary succession. None of the samples are attributed to the ~0.2 Ma long MNQ18 biozone. From Sample U1617A-13H-CC downhole, we recovered an almost continuous sedimentary succession ranging from biozone MNQ17 (early Pleistocene, Gelasian) to MNN12 (early Pliocene, Zanclean). The boundary between Zanclean and Messinian sediments was detected in Section U1617A-34X-4.

Paleomagnetism

Rock magnetic experiments were conducted on discrete samples from Hole U1617A. The results show that the samples have less variable coercivity distribution from remanence applied in the laboratory (e.g., anhysteretic remanent magnetization and isothermal remanent magnetization) than that of natural remanent magnetization (NRM). This result suggests that the variation in NRM cannot fully be attributed to the change in intrinsic magnetic properties, and that postdepositional reworking may have played a significant role in setting NRM.

Igneous and Metamorphic Petrology

The igneous and metamorphic petrology team continued analysis of Expedition 402 thin sections via optical microscopy as well as scanning electron microscope–energy dispersive spectroscopy. Several generations of veins and host peridotites were defined and will be the subject of further analyses.

Sediment and Pore Water Geochemistry

Analysis of the 33 interstitial water (IW) and 55 sediment samples collected from Site U1617 was completed during Week 6. Sample depths range from 1.45 to 336.67 mbsf. For IW samples, the pH values have a narrow range between 7.3 and 7.6, while alkalinity (1.5–3.5 mg/L) exhibits an overall decreasing trend downhole through the cored interval. Pore water salinity varies significantly from 37.5 to 49.0 g/kg. Above the boundary between lithostratigraphic Unit I and II at 94.38 mbsf, salinity is approximately constant at 38.5 g/kg. Below that depth, salinity increases continuously and reaches the maximum of 49.0 g/kg at the base of the cored interval, in the presumed Messinian deposits. The IW concentrations of sodium (Na^+) and chloride (Cl^-) are high, varying from 494.87 to 620.02 mM and from 604.56 to 726.98 mM, respectively. As expected, their concentration-depth profiles correlate with salinity variations. Pore water sulfate (SO_4^{2-}) concentrations decrease with depth to 84.89 mbsf (23.54–59.85 mM), then increase again downhole. The concentration of magnesium (Mg^{2+}) varies from 51.02 to 60.81 mM, a more limited range than has yet been observed at other sites in this expedition. Ca, Li, B, and Sr all show elevated concentrations with depth, although the slope of the gradient differs, whereas there is a decreasing pattern for K and Mn with depth. The NH_4^+ content is significantly higher than PO_4^{3-}, with limited variations below 27.62 mbsf.

The percentage of calcium carbonate in sediment varies from 0.4 to 75.5 wt%. Sedimentary total organic carbon (TOC) and total nitrogen (TN) contents range from nondetectable to 5.3 wt% and from nondetectable to 0.32 wt%, respectively. Atomic TOC/TN ratios vary between 0.3 and 60.0. Atomic TOC/TN ratios of ~10.4 or higher are found in sapropel layers, confirming that this ratio is affected by organic matter diagenesis due to more labile algal-derived organic matter rather than by higher inputs of terrestrial derived organic matter. Total sulfur content, ranging from under detectable to 35.8 wt%, shows the highest values at 96.7 mbsf (13.3 wt%), 322.2 mbsf (35.8 wt%) and 331.8 mbsf (12.8 wt%).

Thirty-nine headspace gas samples were collected and measured for hydrocarbon abundances. Three samples with relatively high concentrations of methane were observed at 56.50 mbsf (5.9 ppmv), at 295.90 mbsf (8.2 ppmv), and at the interval 332.5–336.4 mbsf (13.6–18.5 ppmv). Methane is the only hydrocarbon gas identified in headspace samples, except for the deepest sample at 336.4 mbsf, in which ethene (0.8 ppmv) and ethane (0.9 ppmv) also occur at low concentration.

Igneous Geochemistry

Glass beads of the remaining Site U1614 samples were fused and analyzed via inductively coupled plasma–atomic emission spectroscopy. Due to the anomalously high CaO contents of some mantle lithologies recovered from Site U1614, we also analyzed the samples via X-ray diffraction, which indicated the presence of low-Mg carbonate.

Microbiology

The CTD and Niskin water sampler were deployed on the VIT camera system frame during casing installation operations in Hole U1616E. The Niskin water sampler collected 2 L of deep seawater at a depth of ~3540 meters below sea level (mbsl) for microbiological sampling. This sample was processed in the laboratory, with 5 mL distributed into 1 mL cryotubes and fixed with 4% formaldehyde for cell counts. The remaining water was filtered onto a 0.2 µm polycarbonate membrane filter, and the cells were retained and preserved by wrapping the entire filter in an aluminum envelope, bagging it, and freezing it at –86°C.

Outreach

The following outreach activities took place during Week 6:

- Completed 21 ship-to-shore broadcasts for ~625 people.
- Live event held in partnership with Reach the World on 21 March.
- Facebook: 21 posts with a reach of 25,990 and 48 new followers.
- X (Twitter): 16 new posts with 875 engagements.
- Instagram: 26 new posts with 393 engagements; gained 37 new followers.
- Threads: 2 new posts; engagements are not tracked.
- Planning blog posts/social media content on “Time,” comparing the *JOIDES Resolution* to the International Space Station.

Technical Support and HSE Activities

The following technical support activities took place during Week 6.

Laboratory Activities

- Technical staff processed core and provided sampling and science support for Hole U1617A.
- Technical staff oversaw the second half of the Hole U1614C hard rock sample party.
- Technical staff utilized the casing operations to prepare for end-of-expedition activities.

Developer Activities

- Deployed a new version of iRIS. After deployment, the cRio did not come back online and the depth indication for the VIT, core winch, and Schlumberger lines on Rigwatch and TV overlays were interrupted. This was resolved.
- Deployed the iRIS Driller interface to the Ops Engineer PC.
- Continued to troubleshoot issues related to uploading portable X-ray fluorescence spectrometer data to the database. Requested assistance from shore Application Developer.
- Fixing bugs found while testing the latest version of the ThermCon application. The original version of the application is in use and only has a minor bug that does not affect normal operations.
- Performed routine support and maintenance of the database and science applications.

IT Support Activities

- Upgraded Confluence to version 7.19.20 LTS to address security issues.
- Applied the Confluence 50 User Data Center License, which required reducing the list of users from 86 to less than 50 to comply with the license. Deactivated or deleted accounts for staff that will not be returning to the ship.
- Finished creating Active Directory, Exchange, and OES accounts for most Expedition 402T participants. School of Rock participants will be added once a finalized list is received.
- Worked with TAMU IT to get our Exchange Server updated with the latest monthly patches.
- Still in the testing phase of DriveMapper for Windows (beta).
- Recovered two accidentally lost or deleted files with Commvault.

HSE Activities

- Emergency shower and eyewash stations were tested.
- An abandon ship drill was held on 17 March at 1300 h, followed by the group photo.