

IODP Expedition 402: Tyrrhenian Continent–Ocean Transition

Week 1 Report (9–17 February 2024)

The first week of the International Ocean Discovery Program (IODP) Expedition 402, Tyrrhenian Continent–Ocean Transition, was occupied with port call activities and rotary core barrel (RCB) drilling of sediment and basement material in Hole U1612A.

Operations

IODP Expedition 402 began in Napoli, Italy, Berth 5 Molo Angioino, at 0818 h on 9 February 2024. Offgoing scientists and staff disembarked, and oncoming staff joined the vessel. The oncoming science party and ship's crew boarded the vessel on February 10. Port call activities included receipt of refrigerated and frozen chemical shipments, loading of additional sepiolite and barite drilling mud, and bunkering 1000 metric tons of marine gas oil. Catering provisions as well as surface and air freight deliveries were also loaded, while Expedition 401 cores were offloaded. All personnel took a COVID-19 antigen test on 13 February as part of the COVID mitigation protocol. One staff member who had previously tested COVID-positive after developing symptoms was already in a quarantine berth. A second staff member tested positive several days later and was also quarantined.

The ship departed Napoli on 14 February, with the pilot boarding at 0651 h and the last line released at 0724 h. The pilot disembarked at 0755 h and the ship completed the 86.6 nmi transit to proposed Site TYR-09A (Site U1612). While in transit, all personnel participated in a fire and boat drill. The ship arrived on site at 1530 h and transitioned from cruise mode to dynamic positioning mode. A 181.1 m long bottom-hole assembly (BHA) for the RCB drilling system was made up and deployed with a C4 RCB bit. The precision depth recorder (PDR) reading determined the seafloor to be at 3572.6 meters below sea level (mbsl). Pipe was tripped to 3543 meters below rig floor (mbrf), the top drive was picked up, and a “pig” was pumped through the drill pipe to clear any interior rust or debris. Hole U1612A was spudded at 0800 h on 15 February and the water depth was determined to be 3573.8 m.

RCB drilling in Hole U1612A advanced through the sediment column with a formation change to basement at 333 meters below seafloor (mbsf) in Core U1612A-35R. Core recovery throughout the sediment column was poor (72.5 m or 22%). Seventeen cores had no recovery or recovery of <0.5 m of core material, including Cores 1R and 2R at the seawater/sediment interface. Recovery improved near basement; Cores 32R through 34R had an average of 98% recovery. At the end of the week, we had

advanced 10.7 m into basement to a total depth of 343.7 mbsf (Core 38R), recovering ~20% of cored basement material. Overall recovery was 74.4 m (22%). Formation temperature measurements were taken with the Sediment Temperature 2 (SET2) tool at 103.4, 160.4, and 198.4 mbsf. All cores were taken with nonmagnetic core barrels.

Science Objectives

Expedition 402 will explore the nature and genesis of a continent–ocean transition (COT) made of exposed mantle. The thin sediment cover of the Tyrrhenian Sea provides an optimal location to test COT formation models by drilling. We will drill six sites in total, including an east–west transect that targets the progression from magmatic crust to exposed mantle and a north–south transect that will map the fault zone that exhumed the mantle. Drilling will sample the complete sediment section including Messinian deposits, the sediment/basement interface, the mantle, associated magmas, and the products of syntectonic or possibly ongoing fluid-rock interactions to evaluate geochemical exchange between the lithosphere and hydrosphere.

Two high-priority sites in the Vavilov Basin will recover the complete sedimentary section, two copies of the sediment/basement interface, and will penetrate 140 m into basement, crossing the exhumation fault zone around ~100 m in basement. Drilling at the other two Vavilov Basin sites is also expected to yield mantle peridotites, but penetration into basement will be only 70 m. At one site, a relatively thick sediment sequence (estimated at 626 m) will be completely recovered via the advanced piston coring/extended core barrel (APC/XCB) system for paleoceanographic, geochemical, and microbiological research objectives. The easternmost and westernmost sites sit on the Cornaglia and Campania Terraces, respectively, and will recover basalt formed by magmatic accretion prior to mantle exhumation in the Vavilov Basin. At both of those sites, a single RCB hole will recover the sedimentary section and 70 m of basement.

Science Results

The Expedition 402 science party includes shipboard scientists from eight IODP member countries, shore-based scientists from four member countries, and two shipboard Outreach Officers from the United States. During port call, scientists oriented to the ship and laboratories, including ship and laboratory safety trainings and a presentation on life at sea. The expedition Co-Chief Scientists gave presentations on the science objectives, and scientists presented and discussed their individual research plans. Scientists learned about shipboard computing resources, core flow and curation processes, and the different drilling techniques and downhole tools that will be used

during the expedition. The core description and micropaleontology laboratory groups received an overview of the GEODESC description software, while other laboratory groups trained on laboratory-specific instrumentation such as the physical properties track systems or the portable X-ray fluorescence spectrometer (pXRF) device. Laboratory groups developed their methods for collection and analysis of shipboard data, finalizing their methods reports drafts on 15 February.

In the three days of operations thus far in Hole U1612A, the science party has processed and described cored material, including the collection of shipboard and personal samples from the sediment sections. Preliminary results from each laboratory group are described below.

Lithostratigraphy

Cores U1612A-1R to 34R (0–323.7 mbsf) were described both macroscopically and microscopically (via smear slides). Two lithological units were tentatively defined.

Unit 1 extends from 0 to 238.8 mbsf (Cores U1609A-1R to 26R). This unit is composed of gray nannofossil ooze with variable content of volcanoclastic material. Contacts between lithologies are mostly gradational and marked by subtle color changes. Bioturbation is sparse to moderate.

Unit 2 extends from 238.8 to 323.7 mbsf (Core U1609A-26R to 34R). It is composed of nannofossil chalk with siltier horizons rich in Radiolaria and diatoms that interrupt the deposition of the calcareous chinks. Bioturbation is moderate, occasionally abundant. There are few shell fragments and pyrite precipitates, as well as black organic matter patches. Several sapropel and tephra layers were noted, including a faulted sapropel.

Much of the cored material was slightly to severely disturbed, including biscuiting and cracking.

Biostratigraphy

The biostratigraphy of planktic foraminifers as well as calcareous nannofossils was analyzed from core catcher (CC) samples in Hole U1612A during the first week of Expedition 402. Twenty-six CC samples were collected as a part of the sediment drilling, with additional toothpick samples for nannofossil analysis taken from Cores 33R and 34R to refine the age of the oldest sediments recovered (32 samples total).

From planktic foraminifer analyses, four biostratigraphic ages from Holocene through Pleistocene were identified, coinciding with the most common occurrence biozones of some marker species. Microfossil preservation across all groups is very good. Many CC

samples contain substantial amounts of volcanogenic clastic material, lithic fragments, and volcanic glasses without the presence of any foraminifers. Nannofossil biostratigraphy is in general agreement. Samples from Cores U1612A-1R to 16R were referred to the late Calabrian–Holocene time interval, while Core 27R is likely early Calabrian. By Section U1612A-34R-CC, nannofossils are absent and dolomite granules are present. Sample U1612A-33R-6, 127 cm, contains well-preserved nannofossils that are Piacenzian in age.

Paleomagnetism

The superconducting rock magnetometer (SRM) and AGICO JR-6A spinner magnetometer were tested with a variety of parameters to determine proper measurement sequences for archive half sections and discrete samples, respectively. Alternating field (AF) demagnetization of natural remanent magnetization (NRM) of a 1.5 m archive half section is set up to 20 mT in four steps to remove secondary magnetization such as drilling overprint. AF demagnetization of NRM of discrete samples is up to 100 mT in eight steps to reveal characteristic remanent magnetization (ChRM). Measurements on archive half sections of Cores U1612A-1R to 31R (~294 mbsf) have been completed. While several geomagnetic reversals are expected over this interval, all inclinations show normal polarity. ChRM of discrete samples suggests that a secondary component, likely drilling overprint, can be removed around 20 mT, supporting the results of archive half sections. However, recovery in Hole U1612A was very low, which may account for the fact that no reversals have been measured.

Igneous and Metamorphic Petrology

The igneous and metamorphic petrology team worked on developing their methods for core description. They finalized the GEODESC template for the igneous and igneous/metamorphic spreadsheets and defined the workflow that the team will follow in the expedition. Basic igneous petrologic observations will be the first-order descriptions and will be captured in the igneous GEODESC spreadsheet. If core lithologies show evidence of alteration, a second round of description will be captured in the metamorphic spreadsheet.

The main findings were igneous material interpreted as volcanoclastic layers or sills intruded into the sediments in Cores U1612A-27R through 30R. Thin sections were requested from these cores that capture the main lithologic variations to confirm the mineralogy and texture of the igneous minerals. The formation change at 333 mbsf in Core 35R is interpreted as the sediment/basement interface. The recovered material in that core includes serpentized peridotite clasts in association with gneisses, granite, metamorphic rocks, and basalts. The basalts are the primary contact with sediments.

The metamorphic petrologists with the structural geologists decided on the split line of the first gneissic basement rocks parallel to the stretching lineation. From Core 36R through 38R, the cores contained locally deformed granitic material.

Sediment and Porewater Geochemistry

The sediment and porewater geochemistry team collected samples in Hole U1612A for both shipboard and postexpedition research. For shipboard analyses, these samples included (1) sediment plugs and small pieces of concretions and/or rocks for measuring hydrocarbon gas concentrations and distribution to ensure safety from all cores recovered (from Core U1612A-1R to 35R), (2) 5 cm long whole-round samples taken from 13 cores to extract the interstitial water (IW) by squeezing, and (3) sediments from different layers identified by sedimentologists during shipboard discrete sampling.

Only very small concentrations of methane were measured between 0 and 323.7 mbsf, varying from 0.20 to 3.06 ppmv. While the salinity of the IW remained roughly stable (from 37 to 39) between 20.8 and 319.7 mbsf, alkalinity and pH decreased with depth, ranging from 0.8 to 8.7 mM and from 7.4 to 7.9, respectively. IW samples will also be used to measure the concentrations of (1) major anions (SO_4^{2-} , Br^- , and Cl^-) and cations (Na^+ , Ca^{2+} , Mg^{2+} , and K^+) by ion chromatography, (2) dissolved ammonium (NH_4^+), phosphate (PO_4^{3-}), and total sulfides ($\Sigma\text{H}_2\text{S} = \text{S}^{2-} + \text{HS}^- + \text{H}_2\text{S}$) using a spectrophotometer, and (3) major and minor elements by inductively coupled plasma-atomic emission spectrometry (ICP-AES). All sediments, including squeeze cakes and an additional sample per core chosen according to changes in lithology, will be freeze-dried, ground to a fine powder and homogenized using an agate pestle and mortar, and then analyzed for (1) total inorganic carbon content, (2) percentage of total carbonate content, (3) total carbon, nitrogen, and sulfur content, and (4) total organic carbon and matter content.

Igneous Geochemistry

Week 1 consisted mostly of assisting organic/inorganic geochemists with IW and headspace sampling as well as assisting microbiology with oxygen measurements, and learning laboratory and instrumentation protocols. We conducted pXRF analyses on IW squeeze cakes and section halves adjacent to squeeze cakes to better interpret sediment geochemical records. For pXRF rock standards, it was observed that lighter elements are measured as being lower in concentration than their known values. For instance, when analyzing pure SiO_2 , the pXRF indicated that the material was only 80% SiO_2 . To compensate, all available shipboard standards were measured with the pXRF and a correction curve was generated for each reported element. Seven discrete samples were selected for loss on ignition, ICP-AES, and X-ray diffraction (XRD). These samples are still being powdered and prepped.

Physical Properties

A complete set of physical properties measurements were made on core recovered from Hole U1612A during the first week of the expedition, including density, magnetic susceptibility, and *P*-wave velocity using the Whole-Round Multisensor Logger (WRMSL), thermal conductivity, X-ray imaging, and natural gamma ray (NGR) analysis. X-ray and NGR analyses were made immediately after core recovery, while cores were not run on the WRMSL until they had equilibrated to room temperature for at least 4 h.

After core splitting, an additional one to two samples per core were collected for moisture and density analyses. We also routinely measured thermal conductivity and seismic velocities on the section halves to study the thermal and acoustic properties of recovered sediments. Finally, we measured 3-D *P*-wave velocity using the Gantry bayonet (PWB) and caliper (PWC) system. We used PWB for z- and y-direction measurements, and PWC for x-direction measurements, on split cores when soft sediments were present. As sediments became compacted we used only the PWC system to prevent damaging large parts of the core sections that may crack when analyzed via the PWB.

The data acquired through WRMSL, combined with the readings of the NGR logger, allow for a confident interpretation of basic sedimentary units, such as hemipelagic mud and nannofossil ooze versus volcanoclastic layers. In addition, discrete samples were collected from every section half to tie V_P measurements to future in situ downhole sonic well logs.

For the X-ray imaging, the group compared results from whole rounds scanned at multiple angles (0° , 45° , 90° , and 135°) as well as section halves. The multiple-angle scans provided quality images of low-density fractures and their orientations. However, indentations on the core exterior left by the CC during the coring process obscured some of these images. In contrast, section-half X-ray scans of sedimentary cores at a single overhead angle yielded better images of sedimentary structures. Since the recovery of sediment cores is faster than hard rocks and the multiple angles are time consuming, we decided only to X-ray section halves for sediment cores and scan whole rounds at multiple angles for hard rock cores.

Borehole Geophysics

During Week 1 of Expedition 402, the SET2 downhole instrument was deployed three times in Hole U1612A to measure in situ sediment temperatures. Two measurements appeared successful at 103.9 mbsf (Core 12R) and 198.9 mbsf (Core 22R), with equilibrium temperatures of 33.39°C and 48.45°C , respectively. These temperatures are coherent with an equilibrium seafloor temperature of 14.95°C , yielding a thermal

gradient of 15.25°C/100 m and a heat flow in the range of 152 mW/m² using an average 1.0 W/(m·K) for thermal conductivity. A third temperature measurement made at 160.9 mbsf (Core 18R) gave a reading of 15.92°C. However, given the granular lithology recovered in the following core, this data point is interpreted as an erroneous measurement caused by poor contact between the probe tip and the formation.

Microbiology

Whole-round samples and syringe plugs of core were collected on the catwalk for metagenomics, RNA, and viral counts. Metagenomic samples were frozen at –86°C after collection. Samples for viral counts were fixed in formaldehyde. Viral activity incubations were initiated for samples from Section U1612A-3R-4, and enrichments created for Section 9R-2.

Oxygen profiles for Hole U1612A were taken from Cores 3R, 4R, 9R, 10R, 16R, and 22R in either or both Sections 2 and 3, which were typically the least disturbed. Oxygen measurements are made on whole rounds immediately after core recovery, prior to temperature equilibration, by drilling two small holes in the core liner and inserting the oxygen and temperature probes into the undisturbed core center. Oxygen dropped to 0 µM in Section 4R-2 (between 27.4 and 36.9 mbsf). Core 22R was measured, but it was disturbed and the readings were unreliable. It was then not possible to insert probes into subsequent cores due to the hardening sediment lithology.

Outreach

The following outreach activities took place during Week 1.

- Multiple tours of the ship for ~100 local students and educators during the Napoli, Italy, port call.
- Research and brainstorming for *JOIDES Resolution* website blog posts.
- Introductory blog post published in partnership with “Reach the World,” an organization that creates online journeys for schools to follow along with scientific expeditions. Live event dates have been scheduled and confirmed.
- [Facebook](#): 10 posts with a reach of 64,748 and 77 new followers.
- [Twitter](#): 11 new tweets posted with 779 engagements.
- [Instagram](#): 14 new posts with 378 engagements; gained 71 new followers.
- Threads: 1 new post; engagements are not tracked.
- Two ship-to-shore broadcasts for ~30 people in Italy.

Technical Support and HSE Activities

The following technical support activities took place during Week 1.

Logistics Activities

- Offloaded Expedition 401 core and freight shipments.
- Loaded and distributed Expedition 402 freight and updated inventories.

Laboratory Activities

- Prepared laboratories for expedition activities.
- Science party participants received Life at Sea training, an overview of ship orientations, and were trained in their respective laboratories.
- Technical staff constructed enclosures for all rock cutting saws and prepared the splitting room for asbestos mineral handling procedures.
- Realigned one of the AGICO JR-6A spinner magnetometers.
- Technical staff are fully engaged in core processing and science support at Hole U1612A.

Developer Activities

- Completed the Beginning of Expedition (BOX) checklist.
- Deployed the latest version of GEODESC Data Capture so that core description scientists could develop description templates and complete core descriptions.
- Deployed a new version of the gcatW web services.
- Demonstrated the iRIS Driller user interface to the drilling personnel.
- Repopulated the x_sample_depth table for the X999 test expedition and QAQC samples, fixing an error caused during the BOX procedure.
- Troubleshooting of issues related to the MUT uploader for pXRF data.

IT Support Activities

- Performed BOX procedures.
- Onboarded staff and scientists to the shipboard computing environment.
- Updated the license for the Matlab License Server.
- Installed the PreSens software on a spare laptop and deployed it to DHML to use with the PreSens oxygen sensor.
- Marlink performed unscheduled and unannounced configuration changes which resulted in Starlink being unavailable for several hours on 15 February.

HSE Activities

- Emergency shower and eyewash stations were tested.
- Predeparture COVID-19 test was conducted.
- A lifeboat and fire drill was held on 14 February at 1300 h.
- Safety training and laboratory tours were completed for the science party and new JRSO staff.