IODP Expedition 399: Building Blocks of Life, Atlantis Massif

Week 5 Report (14–20 May 2023)

Operations

Hole U1601C

Week 5 began on 14 May with the recovery of Core U1601C-124R at 614.7 meters below seafloor (mbsf). At 1715 h, after cutting Core U1601C-132R to 658.4 mbsf, the coring bit had accumulated 54 h on bottom and we decided to retrieve it. In total, coring bit run 2 retrieved Cores U1601C-56R through 132R, recovering 316.9 m of the 378.4 m cored, with core recoveries ranging from 24% to 112% (average recovery 84%). 30 bbl mud sweeps were pumped every ~10 m, and a final 50 bbl sweep was pumped with 2× the open hole volume. Rig servicing was conducted during the pipe retrieval and the bit cleared the rig floor at 2230 h, ending coring bit run 2 (overall bit run 3 in Hole U1601C).

With the science party still being enthusiastic about deepening this phenomenal hole, the rig crew began reassembly of the bottom-hole assembly (BHA) with a new C7 bit for the next coring run. Deployment of the drill string began at 0030 h on 15 May. The subsea camera was launched at 0043 h, the pipe was tripped to the seafloor, and Hole U1601C was reentered for the third time (third coring bit run; overall bit run 4 in Hole U1601C) at 0212 h. The camera was back on deck at 0310 h and the bit was lowered down the hole until the top of a soft fill was tagged at 636 mbsf. A core barrel was dropped, and the hole was washed to total depth at 658.4 mbsf, which resulted in high pressure readings. A second core barrel was dropped, and the pressure normalized. At 0830 h coring resumed with Core U1601C-133R at 658.4 mbsf.

Coring proceeded without incident through 20 May, when the bit had reached 50 h on bottom and we decided to retrieve it. In total, coring bit run 3 retrieved Cores U1601C-133R through 197R (658.4–973.6 mbsf), recovering 233.5 m of the 315.2 m cored, with core recoveries ranging from 15% to 112% (average recovery 74%). Down to Core 178R (881.5 mbsf), 30 bbl mud sweeps were pumped every ~10 m. Subsequent sweeps used 20 bbl of mud every ~10 m to conserve mud. At 1230 h on 20 May, after a final 30 bbl mud sweep was pumped with 2× the open hole volume, the pipe was pulled out of the hole and cleared the seafloor at 1535 h.

We used this opportunity to test the Elevated Temperature Borehole Sensor (ETBS), which malfunctioned on previous deployments and had been repaired in the meantime. The test deployment inside the drill string was concluded at 1815 h and the drill string was retrieved, with the bit clearing the rig floor at 2000 h. This ended coring bit run 3 (overall bit run 4) in Hole U1601C. The used coring bit was missing 16 tungsten carbide teeth, a degree of wear considered acceptable and not traceable to any particular event. The ETBS returned valid temperature data,

following closely the temperature profile measured by the Conductivity-Temperature-Depth (CTD) sonde ~6 h later outside the drill string, and is ready again for downhole deployment.

A 4-stand BHA with a new C7 bit was reassembled and the rig was serviced until 2200 h. The drill string was deployed for the fourth coring run in Hole U1601C. The subsea camera frame was launched at 2305 h. At midnight and the end of the week, the bit was at 830.6 meters below rig floor (mbrf).

Core handling remained challenging but kept improving during the course of this week. Core splitting with special personal protective equipment (PPE), with technicians, scientists, and operations personnel participating, became a routine and on 15 May had caught up with core recovery. Rapid core description had caught up with core splitting the next day. This allowed us to discuss, both onboard and with shore management, strategies for reestablishing subsampling. It was decided to start describing the working halves rather than the archive halves, so that shipboard samples could be identified each day without excessive core handling, and sampled after shrink wrapping but before storage in the hold. On 19 May, subsampling of section halves for shipboard analysis resumed using the following procedure: immediately after splitting, the archive section halves are shrink-wrapped and racked for paleomagnetic measurements, which can be done without removing the shrink-wrapping, and some physical properties measurements that require time to process. The working section halves are kept damp while being described over the ~24 h after splitting. When the rapid core descriptions are complete, the section halves are shrink-wrapped and made available for subsampling for another ~24 h. The scientists select ~30 samples from no more than 16 sections each day based on the core descriptions and enter them in a shared spreadsheet. After review and approval, the samples are extracted daily in a ~1 h operation, and the sections are subsequently taped shut as necessary and moved to storage. Some of the shipboard samples will be analyzed on board, others will be shipped to shore for further processing.

Scientific Results

Igneous Petrology

The primary lithologies of Cores U1601C-101R through 186R are mainly harzburgite and dunite, with minor amounts of gabbroic rock types. Peridotite serpentinization is on average lower than in the upper part of the hole, particularly in Core U1601C-149R, which preserves the freshest primary features. These peridotites contain abundant granular orthopyroxene and relicts of unaltered olivine in serpentinite mesh texture. The relative amount of gabbros recovered in Cores 101R through 186R is higher (~20%), compared to the average in the entire hole (~18%) and these gabbros exhibit larger complexities in mineralogy, texture, deformation, and alteration than the gabbros above this interval. Large gabbroic intervals contain different generations of gabbro intrusion that occasionally show crosscutting relationships and various extents of

alteration and deformation. Troctolites have been observed either as discrete patches within gabbro units or at the boundary between gabbros and ultramafic lithologies. Millimeter- to centimeter-scale gabbroic veins are ubiquitously found infiltrating the harzburgites and dunites as either discrete or diffuse veins with variations in mineralogy. New thin sections from Holes U1309D and U1601C were fully described. Downhole lithological variations in Hole U1601C were compiled and presented to the science party.

Alteration Petrology

The dominant lithology in Cores U1601C-80R through 177R is serpentinized harzburgite with subordinate amounts of serpentinized dunite and altered olivine-bearing and/or oxide-bearing gabbro. In addition to meter-sized gabbroic intrusions, serpentinized peridotite is commonly crosscut by hydrothermally altered magmatic veins that range in size from <1 mm to >10 cm. Clinopyroxene and plagioclase are partially to completely replaced by amphibole, chlorite, prehnite, and secondary plagioclase. Late talc-carbonate-prehnite-sulfide veins are also commonly observed in gabbro. Secondary mineral assemblages suggest hydrothermal alteration from high temperature, amphibole facies down to subgreenschist conditions. Serpentinization varies in extent from ~40 to ~90 vol%. Cores 149R through 151R show a gradual increase of the extent of serpentinization toward a fractured gabbroic intrusion. The gabbroic intrusion has a chilled margin toward the serpentinite; however, the serpentinite shows no evidence of deserpentinization, suggesting that the gabbro intruded peridotite prior to serpentinization. Moreover, the increase in the extent of serpentinization toward the fractured gabbro tentatively suggests that the fractured gabbro served as a pathway for hydrothermal fluid.

The team also examined and documented microscopic observations made in thin sections of gabbroic rocks from Cores U1601C-22R through 35R. Clinopyroxene is partially to completely altered to green amphibole in gabbro, indicating pervasive alteration and ductile deformation under high-temperature conditions. In undeformed gabbroic rocks, clinopyroxene and orthopyroxene is replaced by green to colorless amphibole; olivine is replaced by serpentine, talc, amphibole, sulfide (pyrrhotite and chalcopyrite), and clay mineral(s). These alteration minerals are associated with localized monomineralic (e.g., amphibole, chlorite, and zeolite) hydrothermal veins indicative of variable temperature conditions.

Structural Geology

Cores U1601C-93R through 187R are dominated by serpentinized harzburgite and dunite, cut by intervals of olivine and olivine-bearing gabbro, gabbronorite, oxide and oxide-bearing gabbro, and diabase. A 30–40 m thick, variable dip (5°–75°) zone of ductile deformation (protomylonite to ultramylonite) with dominantly reverse-sense of shear was recovered between Cores 128R and 135R (637 to 670 mbsf). Mantle fabrics defined by the shape preferred orientation of orthopyroxene host a gentle to moderate dip above ~670 mbsf and increase to steep dips (>70°)

below this depth to 715 mbsf (Core 145R). The interval hosts variably oriented veins, cut by late, often subhorizontal, thin (<1 mm) white, chrysotile veins.

Thin section observations of gabbroic rocks from Hole U1309D exhibit semibrittle and brittle greenschist facies deformation, syntectonic with tremolite-actinolite vein formation.

Geochemistry

The Fluid Geochemists continued to collect water from the core catcher and analyzed it for dissolved hydrogen and are preparing for the additional water collection near the end of the expedition. Fifty-one samples of serpentinized peridotite and gabbro from Hole U1601C, collected for microbiology studies, were processed for shipboard analysis. Five additional gabbro samples were selected separately from Hole U1601C for shipboard geochemistry analyses. Eighty-eight samples of serpentinized peridotite and gabbro from Site U1601 and Hole U1309D were analyzed by inductively coupled plasma–atomic emission spectroscopy (ICP-AES) for major and minor elements. Forty-six samples of serpentinized peridotite and gabbro from Site U1601 and Hole U1309D were analyzed for carbon and water contents. The results are currently being assessed.

Microbiology

Microbiology samples were collected from most of the Cores U1601C-125R through 195R (53 microbiology samples [MBIO]). Potentially contaminated exteriors of microbiology rock samples were chiselled away in a fume hood with a KOACH air purifier and an air ionizer for static dust removal. Interior zones of the samples were crushed to millimeter-scale, and the exteriors were returned to the core. The crushed interior core material was subsampled for future microbiological analyses including DNA sequencing, enumeration of microbial cells, microscope imaging, metabolic activity assays, enrichment culturing, and organic geochemistry.

Microbiological analyses, including enumeration of microbial cells, single-cell activity assays, and filtering for DNA sequencing, were conducted with bottom water near Hole U1601C that was sampled with Niskin bottles during recovery of the drill bit and after reentry of the hole. In addition, microbiological subsamples for enumeration of microbial cells and single-cell activity assays were collected from small volumes of water collected from core liners.

Petrophysics

The Physical Properties team measured bulk density, magnetic susceptibility (MS), and natural gamma radiation (NGR) on whole-round sections of Cores U1601C-121R through 197R (600–960 mbsf). Bulk density ranges from 2.3–2.4 g/cm^3 in serpentinized peridotite and between 2.5 and 2.7 g/cm^3 in gabbro. MS is generally higher and more variable in serpentinized peridotite; however, oxide-gabbro, which has the highest MS values, occurs in this interval and is more abundant than was observed shallower in the hole. The highest MS measured thus far is upwards

of 25,000 IU in a coarse-grained oxide gabbro in Section U1601C-164R-1. NGR is typically low for all rock types with values <2 counts/s other than a few intervals that approach 4 counts/s.

Discrete samples were analyzed from the intervals between Cores U1601C-2R through 6R and 19R through 102R. These samples are pieces from microbiology samples and are not cubes, which results in very rough pieces not suitable for *P*-wave velocity measurements or porosity calculations. However, grain density calculations are still valid. Grain density generally increases with depth in serpentinized peridotites with a range between 2.5 and 2.7 g/cm^3. A few grain density values are higher—for example, an orthopyroxene-bearing dunite with a grain density of 2.96 g/cm^3 in Section 20R-3. Gabbro has a higher grain density with a range from 2.8–3.0 g/cm^3 and an average of 2.93 g/cm^3.

P-wave velocity measurements continued on 40 ultramafic rock samples, 16 gabbro samples, and one leucocratic diorite sample from the archive section halves of Cores U1601C-57R through 122R (294–605 mbsf). Values range from 3.49 km/s (dunite; Section 60R-2 at 305.9 mbsf) to 6.49 km/s (olivine gabbro; Section 100R-1 at 498.4 mbsf). Velocity in ultramafic rock samples ranges from 3.49 km/s to 5.37 km/s, and gabbro samples have a range of 3.65 km/s to 6.49 km/s. The 50 m moving average velocity in ultramafic rocks gradually increases from 4.5 km/s at the top of this interval to 4.6 km/s at the bottom of this interval.

Thermal conductivity of 10–15 cm pieces was measured from Cores U1601C-62R through 137R (315–680 mbsf). Hole U1601C now has 43 thermal conductivity measurements for a variety of lithologies including 30 samples of serpentinized harzburgite, 5 samples of serpentinized dunite, 7 samples of gabbro, and 1 gabbronorite. All samples are moderately to highly altered. Values for all samples range from 2.156–3.874 W/(m·K) with a mean of 3.049 W/(m·K) and a standard deviation of 0.621 W/(m·K). Values for serpentinized peridotite range from 2.198–3.874 W/(m·K) with a mean of 3.094 W/(m·K) and a standard deviation of 0.355 W/(m·K). Values for gabbro and gabbronorite range from 2.156–3.766 W/(m·K) with a mean of 2.862 W/(m·K) and a standard deviation of 0.621 W/(m·K).

Paleomagnetism

Measurements of natural remanent magnetization (NRM) and remanences following stepwise alternating field (AF) demagnetization were conducted on archive section halves of Cores U1601C-44R through 126R using the superconducting rock magnetometer (SRM). Initial magnetizations were progressively demagnetized up to 50 mT. Histograms of NRM distributions show that most samples are demagnetized >90% by 30 mT. Several sections were demagnetized to test if the SRM would be capable of detecting iron sulfides. The test was inconclusive, highlighting the need to use discrete samples. Special core handling procedures prevented the cutting of cube samples during this week.

Downhole plots of the NRM inclination, declination, and intensity show that at the top of the hole, inclination values are clustered around the expected polarity (-45°) albeit slightly shallower (~−42). However, starting at ~200 mbsf, inclination values begin to display more complex behavior. Inclinations fluctuate, migrating from expected polarity to ~0° and back again. Intensity values also vary widely, though appear to be correlated with lithology. Altered peridotite intervals display the strongest magnetizations whereas olivine gabbro and troctolite intervals display the weakest magnetizations. Plots of the Koenigsberger ratio were taken for each SRM measurement point. Most points displayed ratios above 1, indicating that most of the magnetization for the collected samples is remanent rather than induced.

Outreach

This week, the shipboard Outreach Officer team posted on Instagram, Facebook, and Twitter, provided ship-to-shore broadcasts, edited videos, interviewed members of the expedition, and wrote posts for the expedition log.

Social Media

- The shipboard Outreach Officer team posted to Twitter with 22,464 impressions (−43%), 3.8% engagements (+0.5%), and 36 profile visits.
- Facebook has received 3 new photo posts, 1 new story, and 2 new reels, has reached 43,300 accounts (−24%), engaged 68,400 accounts, and has 12,000 followers.
- Instagram received 2 new photo posts, 1 new story, and 5 new reels, reached 3,140 accounts (−13.7%), engaged 275 accounts (−30.6%), and has 4,000 (+0.5%) followers. Total number of views for Instagram in week 5: 6,900**.**

Ship-to-Shore Broadcasts

During Week 5, we led 7 ship-to-shore broadcasts for ~1,050 people in 3 states (US), Italy, Japan, and an open house.

- Clarkstown High School North, New York City, NY
- Templeton Academy, Washington DC
- Chieti-Pescara University, Chieti, Italy
- Mullen-Hall School, Falmouth, MA
- Japan Geoscience Society (JpGU), Japan
- Open House Tour, Location: Sign up link is
    - https://docs.google.com/forms/d/e/1FAIpQLScvNJWaqb-X1smw9i0ihRY2Gcs5T4j0wrl7k-tcXD0ceJfWew/viewform

Expedition Log (blog posts)

- Expedition 399 Log has 1 new blog post:
- Record Hole in Mantle Rock (21 May 2023)
    - https://joidesresolution.org/record-hole-in-mantle-rock/

Feedback from Community

"I wanted to thank you both for an incredible tour. My students absolutely loved it! You reached my students that are sometimes the hardest to get through to. Your time and effort are greatly appreciated, and your work truly makes a difference!" (Cerritos College)

Technical Support and Health, Safety, and Environment (HSE) Activities

General Core Handling and Curation

- We are still recovering cores with asbestiform chrysotile minerals and we continue to handle them with exposure mitigation procedures. After discussion with shore, limited sampling has been permitted and is in progress.
- Videos and photos of our special core handling procedures as well as questions regarding personal safety from the staff were sent to JRSO for evaluation and TAMU Health, Safety, and Environment (HSE).
- Questions in regard to shipping, laboratory cleaning and other activities remain to be answered.
- We are running very low on bin dividers and most pieces cannot therefore be confined to their location in the section half liner and are moving between the time they are curated, described, and sampled. Our priority is to separate MBIO whole-round samples and rubble in bins.
- Cores that appeared to contain large amounts of friable/fibrous material (thicker veins) were not curated prior to splitting. MBIO whole-round samples were taken, and whole rounds could also be taken for analysis by the petrology teams. This method was used for Cores U1601C-146R, 147R, 156R, and 162R. Cores 147R and 156R were later split on the super saw without further curation.
- Sampling for shipboard analyses resumed. Gabbroic rock samples are being cut and analysed as usual. Serpentinized samples (thin section billets, cubes) will be cut, but thin sections will not be generated on board.

Downhole

- The ETBS was successfully tested with a run inside the drill string. It is ready for downhole deployment.

- We started to deploy temperature-indicating strips inside the upper end of the core liner to estimate borehole conditions while coring, in preparation for upcoming logging runs.

Core Description and Scanning Electron Microscope (SEM)

- Starting with Core U1601C-131R (to current), scientists are describing and imaging the working section halves rather than archive halves. This decision was made to allow scientists to quickly evaluate and select samples while describing the cores and then sample them with minimal time lag.
- The filament on the Hitachi SEM required thorough cleaning and polishing of the Wehnelt cylinder and anode, followed by beam alignment, to restore image quality.

Physical Properties

- The Section Half Multisensor Logger (SHMSL) is no longer used on this expedition to reduce the core handling workload. The reduced control on piece curation (see divider issue above) reduces the SHMSL data usability and is another reason these measurements were deprioritized.
- On the velocity measurement gantry, loss of configuration due to loss of communication between IMS program and the actuator occurs randomly and the actuator can no longer be recognized. The reason is unknown as of today. Restarting IMS fixes the issue.

Developer and Application Support

- The new Sample Master Catwalk module suffered from slow performance. Some modifications and redeployment resolved the issue.
- The XSCAN LORE report was updated by adding the "About this report" section and an example data table.
- The LORE report menu hierarchy got out of order and was fixed and redeployed.

IT Support

- Completed updates on Windows servers, software on Windows and macOS computers, and servers.
- Continued working on security policy scripts for macOS computers.
- Activated new licenses for SonicWALL firewall.
- Started incident with TAMU Help Desk to address certificate expiration issue on ship exchange server.

IRIS

- The Driller's Worksheet and Driller's user interface (UI) are currently being tested.
- Work on OPS UI is nearly complete.

- Work on iRIS reporting is pending.

Safety

- The weekly fire boat drill was held.
- The eye wash and safety showers were tested.