IODP Expedition 399: Building Blocks of Life, Atlantis Massif

Week 2 Report (23–29 April 2023)

Operations

Hole U1601A

On 23 April, assembly of the reentry system for Hole U1601B (proposed Site AMDH-02A) continued. The ~22 m long 13⅜ inch casing string, hydraulic release tool (HRT), landing platform, and free-fall funnel (FFF) were prepared in the moonpool area. The stinger bottom-hole assembly (BHA), including mud motor, underreamer, and 12¼ inch bit, were assembled and tested. The underreamer arms opened at 35 strokes/min and 300 psi pump pressure, and they closed at 0 strokes/min. All parts were assembled, and the reentry system was lowered to the seafloor at 1015 h. Drilling in Hole U1601B began at 1455 h. Sepiolite mud sweeps were pumped every ~4 m. At 1215 h on 24 April, we reached the target depth of 26.0 meters below seafloor (mbsf). The go-devil trigger tool for the HRT was dropped at 1225 h and pumped down the drill string with 25 strokes/min until it landed at 1235 h, with a pressure drop indicating that the release occurred. However, several attempts to pull the stinger subassembly out of the casing subassembly were unsuccessful despite turning the pumps on and off several times to work the underreamer. It appeared that the underreamer arms didn't fully retract and were caught on the bottom of the casing. At 1430 h the decision was made to retrieve the subsea cameras and then the entire reentry assembly back to the rig floor. The camera was back at 1525 h. The drill string with the reentry system was pulled at reduced pipe tripping speed and was in the moonpool at 1845 h. The rig crew started to disassemble the reentry system, with the stinger bit at the rig floor at 2353 h. The mud motor had suffered severe damage; the lower section of the housing holding the bearing support, a 12 inch long cylindrical piece, had broken off and was missing.

The rig crew needed time to assess the situation, identify an alternative method for deploying a reentry system at Site U1601, and build that system. We decided that while this was happening, we would move to Hole U1309D to conduct the fluid sampling program and, depending on conditions, initialize coring. The fluid sampling included the Niskin bottles on the subsea camera frame for bottom water samples, the Novel Multi-Temperature Fluid Sampler (MTFS), the Kuster fluid sampler, and the Elevated Temperature Borehole Sensor (ETBS) attached to the latter two downhole tools.

Hole U1309D

The ship began its 2 nmi dynamic positioning (DP) move to Hole U1309D at 2353 h and arrived at 0116 h on 25 April. A BHA was assembled with a 9¼ inch clean-out bit (4⅛ inch inner diameter) and without a float valve to deploy the MTFS and the Kuster fluid sampler, both with the ETBS, on the coring line. The drill string was lowered at 0830 h and the subsea camera with

Niskin water sampling bottles was deployed at 1115 h. The ship was offset ~20 m from Hole U1309D to pump the "pig" tool to clean rust from the inside of the newly deployed drill string. The bit reentered Hole U1309D at 1455 h. The reentry cone was partly filled and blocked by a soft particulate deposit that was easily displaced upon drill entry into the cone. The Niskin bottles were triggered and the camera frame with the bottles was returned to the rig floor by 1620 h. The MTFS and ETBS were prepared on the catwalk, rigged up, and lowered down the drill pipe at 1815 h. The MTFS assembly descended in the open hole at a rate of 10 m/min, with 3 min temperature check stops every 100 m. The tool string tagged bottom at 1389 mbsf, indicating a 26 m thick fill at the bottom of Hole U1309D, and then ascended at a rate of 15 m/min in the borehole and 30 m/min in the water column. The tools arrived back on the rig floor at 0043 h on 26 April.

The tools were rigged down and the ETBS was removed from the MTFS and connected to the two Kuster samplers. The two Kuster sampler clocks were set to sample at 411 mbsf (0310 h) and 739 mbsf (0330 h). The Kuster assembly was lowered down the drill pipe at 0207 h and was back at the rig floor at 0500 h. A second run of the Kuster assembly was configured to sample at 1111 mbsf (0823 h) and 1320 mbsf (0846 h). It was lowered down the drill string at 0706 h and was back on the rig at 1225 h. On descent, the Kuster tools with ETBS traveled at a rate of 20 m/min, slowing to 15 m/min within 40 m of the desired sample depth to minimize hole disturbance. The tool was recovered at a rate of 10 m/min with 3 min stops every 100 m for temperature check measurements. The drill string was retrieved with the bit clearing the rig floor at 1620 h on 26 April, ending BHA run number 1 in Hole U1309D.

Next, we needed to remove a few tens of meters of fill from previous drilling in Hole U1309D on Integrated Ocean Drilling Program (IODP) Expeditions 304 and 305, as well as a logging caliper presumed to have been left in the hole at the end of IODP Expedition 340T. A BHA was made up with a 9⅞ inch concave mill and two junk baskets, and lowered to the seafloor at 1845 h. At 2120 h the subsea camera and two Niskin water samplers were deployed. At 0000 h on 27 April, Hole U1309D was reentered for the second time on this expedition. The camera and Niskin water sample bottles were recovered, and the drill string was run further into the hole. At 0800 h the bit tagged the top of the fill at 1379 mbsf (~37 m of fill). Milling and washing downhole proceeded expeditiously, the first 7–8 m at 8 m/h, and the remainder at 30 m/h. At 1007 h, the bit was ~1.5 m above the previously reported bottom of Hole U1309D (1415.5 mbsf). The first 10 min of milling near the bottom indicated erratic torque, presumed to be the result of encountering metal pieces lost on a previous expedition. The subsequent 3.5 h of milling indicated low and steady torque. The pipe was raised and lowered repeatedly for one hour to fill the junk baskets, and a 30 bbl mud sweep completed cleaning operations in Hole U1309D. Retrieval of the drill string began at 1515 h, and at 2200 h the mill bit arrived at the rig floor where the junk baskets were emptied. Amongst dozens of rock pieces and bags of cuttings created during previous drilling on Expeditions 304 and 305, the junk baskets also recovered several metal pieces, including three 5 × 5 cm chunks. The metal pieces are from the Versatile

Seismic Imager (VSI) wireline logging tool that was damaged in Hole U1309D during Expedition 340T ~11 y ago.

At 2315 h the rig crew began assembling the rotary core barrel (RCB) BHA with a new C7 bit, which was complete at 0130 h on 28 April. The drill string and subsea camera were deployed, and at 0525 h Hole U1309D was reentered for the third time on this expedition. The camera was retrieved and the bit lowered to a hard tag at 1410.0 mbsf. We dropped a core barrel, washed to 1415.5 mbsf, and began deepening Hole U1309D from where IODP Expedition 305 left it. By the end of this week, we had recovered Cores U1309D-297R through 304R from 1415.5 to 1454.6 mbsf. We recovered a total of 27.1 m of gabbroic rocks from the 39.1 m interval cored, with core recoveries ranging from 26% to 98% (average of 69% recovery). 30 bbl mud sweeps were pumped every ~5 m.

Scientific results

Igneous Petrology

The Igneous Petrology team completed the core and thin section descriptions for Hole U1601A and wrote a first draft for the site report. The results were presented to the science party. The first cores from Hole U1309D were also described. Cores U1309D-299R through 302R comprise a gabbroic plutonic unit crosscut by diabase dykes and veins of various compositions.

Alteration petrology

The Alteration Petrology team observed thin sections of rocks from Hole U1601A using a petrographic microscope in transmitted and reflected light and described secondary minerals and replacement textures. The main findings can be summarized as follows: 1) Basalt and gabbroic rocks underwent high-temperature amphibolite to greenschist facies alteration with amphibole overprinted by lower-temperature assemblages including prehnite and chlorite; 2) In altered harzburgite and dunite, amphibolite facies alteration minerals are absent. Serpentine, magnetite, talc, chlorite, and variable amounts of iowaite formed at lower temperatures under greenschist facies conditions and are the dominant minerals in ultramafic rocks. A later-stage overprint led to the formation of carbonate veins. Complementary analyses using an X-ray diffractometer (XRD) and a scanning electron microscope (SEM) confirmed the presence of serpentine (lizardite, chrysotile, and antigorite), chlorite, aragonite, and iowaite, and also suggests the occurrence of minor stichtite in serpentinized peridotites. However, stichtite was only detected by XRD from the microbiology whole-round sample and its presence could not be verified in nearby thin sections. The team started macroscopic descriptions of Hole U1309D cores.

Structural Geology

The week was spent with continued improvement of GEODESC templates for structural observations, completion of the structural geology methods section, thin section descriptions for all sections from Hole U1601A, and completion and presentation of a draft report for Hole U1601A. The highlights of Hole U1601A are variably serpentinized harzburgite hosting subhorizontal, mantle fabrics, and serpentine mesh textures.

The olivine and olivine-bearing gabbroic rocks in Cores U1309D-296G through 299R were cut by rare diabase intrusions, locally with chilled margins, and with numerous thin (1–3 cm) diorite intrusions. The gabbro section is consistently cut by subhorizontal, white alteration veins, which in some cases developed into open fractures. We believe this may be the cause of the significant "biscuiting" of the recovered core.

Geochemistry

The MTFS was deployed for the first time ever in Hole U1309D. Eleven MTFS sampling units were assembled with the ETBS (temperature memory tool) and tagged fill at 23 m above the previous maximum penetration in Hole U1309D (1415.5 mbsf) at 141°C. Eight samplers triggered as planned; however, small particles of mud, rock, and rust were sufficient to restrict pistons from reaching their full stroke. The MTSF deployment was followed by two Kuster sampling tool and ETBS deployments, each with two water samplers. The valve on one of the Kuster water samplers did not close and the sample was lost. Recovered fluids have much lower alkalinities than seawater and lower pHs. Further geochemical analysis is ongoing.

Six serpentinized harzburgite rock samples from Hole U1601A and one gabbro and one diabase sample from Hole U1309D were selected and processed for shipboard inductively coupled plasma–atomic emission spectroscopy (ICP-AES) elemental analyses. The harzburgite samples have high loss on ignition (LOI) values of 13.8–16 wt%, consistent with the presence of hydrous minerals and/or carbonates in addition to serpentine.

Microbiology

Microbiology samples were collected from bottom water near Holes U1601B and U1309D with two Niskin bottles, from Hole U1309D borehole fluids with the MTFS and Kuster tools, and from Cores U1309D-297R through 302R. Potentially contaminated exteriors of microbiology rock samples were chiselled away on a clean bench, and the interior zones of the samples were crushed to millimeter-scale. Bottom water, borehole fluids, and crushed cores were subsampled for future microbiological analyses including DNA sequencing, enumeration of microbial cells, microscope imaging, metabolic activity assays, enrichment culturing, and organic geochemistry.

Petrophysics

The Physical Properties team completed discrete sample analyses including *P*-wave velocity, porosity, volume, and density calculations on 14 cube samples, in addition to thermal conductivity measurements on 9 section half pieces from Hole U1601A. The serpentinized peridotite samples show a range in grain density of ~2.58 to ~2.68 g/cm^3, a range in porosity of ~5% to ~13%, and a range in *P*-wave velocity of ~4800 m/s to ~3580 m/s. There is no trend in grain density with depth in the serpentinized peridotites. Porosity appears to increase with depth, whereas *P*-wave velocity generally decreases with depth. Thermal conductivity values range from 2.41 to 2.75 W/(m·K) for serpentinized peridotite, with a general increase with depth. A single mafic piece at the top of the section has a thermal conductivity value of 2.91 W/(m·K).

Whole round section measurements were made on 9 cores of gabbro from Hole U1309D. Bulk density values are close to 3 g/cm^3. Magnetic susceptibility (MS) has a few peaks, but values are overall low, indicating few magnetic phases. Natural gamma ray (NGR) counts are very low (<2 counts/s), with a few spikes related to feldspar-rich dikes.

Downhole temperature data were acquired with the ETBS tool in Hole U1309D by moving slowly downhole and pausing every 100 m for 3–4 min to allow for partial equilibration of the sensor. Temperature increases downhole with apparent curvature in the upper half of the hole and apparent linearity in the lower half of the hole.

Paleomagnetism

Anisotropy of magnetic susceptibility (AMS) and paleomagnetic studies were carried out on 12 discrete cube samples from Hole U1601A. Based on the physical properties and lithological variation, the discrete samples were selected from Cores U1601A-2R and 5R through 12R. The natural remnant magnetization (NRM) and AMS were measured for each sample. NRM inclinations trend towards negative values, and MS values range from 0.1 to 3.5 A/m. AMS analysis was conducted on 24 samples, including the samples received from the Physical Properties team.

For isolation of remnant directions, the samples were treated with alternating field (AF) and thermal demagnetizations. Before demagnetizing, a pilot study of low temperature liquid nitrogen (LN2) treatment was performed on two adjacent samples of similar compositional appearance to test if it could remove the magnetic overprint imparted by the drill string. The treatment was effective at removing low coercivity remnant components. Subsequently, two-thirds of the samples underwent AF demagnetization, approximately half of which were first subjected to LN2 pre-treatment. The peak AF of 200 mT was insufficient to remove all magnetic remanence. These demagnetization studies revealed that samples contain both a high magnetization component with weak coercivity (comprising ~90% of the NMR) and a medium magnetization component with high coercivity. Additionally, a pilot study of thermal demagnetization was performed with bulk susceptibility measurements taken after each temperature step. In the basalt sample susceptibility increases with increasing temperature, whereas in the harzburgite and dunite samples, susceptibility decreases.

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 Outreach team posted to Twitter with 21,883 impressions (−70%), 3% engagements, and with 58 profile visits.
- Facebook received 5 new photo posts, 1 new story, and 3 new reels, and reached 76.4k accounts (+113%), engaged 66.6k accounts (+160%) and has 12,000 followers (+257%).
- Instagram received 2 new photo posts, 4 new stories, and 3 new reels, and reached 5,014 accounts (−3.5%), engaged 328 accounts (−19.3%) and has 4,000 (+0.9%) followers. Total number of views for Instagram in week 2: 6.,500.

Ship-to-shore Broadcasts

During Week 2, we led 11 ship-to-shore broadcasts for ~350 people in 8 states (US) and Ireland.

- Lawrence School, Falmouth, MA USA
- Kingswood Oxford, West Hartford, CT USA
- Penn State Brandywine, College Station, PA USA
- CBC Monkstown, Dublin, Ireland
- American Museum of Natural History Teacher Workshop, New York City, NY USA
- Springcreek Elementary School, Rockford, IL USA
- Cerritos Community College, Cerritos, CA USA
- Oregon State University, Corvallis, OR USA
- Northern Virginia Community College, Fairfax, VA USA

Expedition Log (blog posts)

Expedition 399 Log has 1 new blog post:

- Testing the Multi Temperature Fluid Sampler (30 April 2023) (https://joidesresolution.org/testing-the-multi-temperature-fluid-sampler/)

Feedback from Community

“Thank you!!!! The tour was really a wonderful experience for the students. The ‘sciencey’ students were super interested as they want to know about all kinds of science careers and opportunities. Also, it was great that other careers can be also science careers—like graphic design—a lot are interested or communications.” (Dunwoody High School)

“Thanks a million for the tour! If you're ever passing through Dublin, and fancy a tour of the school just give me a shout!” (CBC Monkstown)

“The tour was REALLY well done. I had a great time even though I’ve lived it. Attendees were also very impressed.” (American Museum of Natural History)

“Thank you both for such an excellent tour yesterday! The two of you together are such a dynamic duo and I love the energy. And it's great that you had so much scientist participation. I know not every OOO has been successful in getting the scientists to participate (part of it is how much core is out that needs to be worked on, COVID conditions, etc.). Who were the scientists we connected with? I think it was Kristin Dickerson, Gordon Southam, and...[Johan Lissenburg]? I'd like to send the three of them a thank-you note.

The students got so chatty after we disconnected—they were asking silly questions, like ”wait, we were just talking to a ship in the middle of the ocean?” “Ddid we really just see a piece of the mantle?” etc. They have an assignment they need to write up for me, where they have some general expedition/science questions to respond to, and then this:

I want you to pretend that you have an opportunity to go back and speak to your fifth grade teacher from elementary school. I want you to write up a summary for your teacher that they will understand about this expedition that they could share with their 5th grade classroom. Include some examples of the different types of careers involved in doing this research.

One of my course objectives is for students not just to know the ”what“ of ocean science, but ”why” this matters (which connects back to the Ocean Literacy Principles, the UN Ocean Decade Challenges, etc.), and how to share what they have learned with others. Both of you and the scientists gave perfect responses to the questions, and I can't wait to see what the students take away from this!

Thank you again! (especially for that other scientist name) Fair winds and following seas!” (Penn State Brandywine Oceanography)

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

Siem Offshore:

- Filtering chill water and removal of debris continued. The quality of the chill water has greatly improved.

Downhole Measurements

- The ETBS electronic module returned erratic data during the later runs in Hole U1309D. Troubleshooting resulted in a swap to the spare module, which tested well on deck. We are planning a downpipe test in the water column at the end of current bit run.
- The Kuster tools were serviced. We made new stabilizers due to the failure of the ones used in Hole U1309D.
- An Expedition 400 Petrel project file was created by uploading reflection seismic data and velocity models from the Site Survey Data Bank (SSDB), and 3D bathymetry from GEBCO.

Core Description

- New versions of two GEODESC programs, DataCapture (v1.0.13) and Template Manager (v1.0.10), were deployed on the ship with bug fixes.
- Some outstanding bugs in Data Capture and Template Manager are still being resolved but are not impacting the current description progress.
- We successfully ran the SEC SEM-energy dispersive spectrometry (EDS) with the Alteration Petrology team for EDS thin section analyses. We ran the Hitachi SEM with the microbiologists for imaging.

Magnetics

- We are recording new backgrounds and empty trays daily for both ongoing noise monitoring and current IMS testing.
- We are developing a measurement protocol that includes AF and thermal demagnetization, nitrogen dunking, isothermal remanent magnetization (IRM) acquisition, and back field experiments.

IT and Application Support

- Modified the *P*-wave velocity, caliper method (*P*-wave velocity [PWC]) LORE report by sorting it according to the test number.
- We held discussions on a potential enhancement to the real-time GEODESC data display in LIVE.

- Updates to Windows and Linux servers as well as Windows and macOS workstations were applied, and setup of the PowerStore SAN backup system continued.

IRIS

- Work continued on the Driller's Worksheet (DWS) app: changing the data management flow on the iRIS cRIO (CompactRIO, a real-time embedded controller by National Instruments) and Driller's user interface.
- Debugged the Driller's UI app caused by changes in the DWS development.
- Overhauling cRIO parameters to support DWS data. Fixed issues with response to pump rate and writing of backup file to the internal drive.
- Working with developers to define navigation file content and format from iRIS.

Safety

- We held the weekly fire and boat drill.
- We tested the safety shower and eye wash stations.