

IODP Expedition 399: Building Blocks of Life, Atlantis Massif

Week 3 Report (30 April–5 May 2023)

Operations

Hole U1309D

Week 3 began on 30 April while coring in Hole U1309D. On 1 May the bit had accumulated 50 h of coring and we decided to retrieve the bit. This third bit run (first coring bit run) in Hole U1309D on this expedition advanced Hole U1309D by 63.6 m, from 1415.5 to 1498.0 meters below seafloor (mbsf). Cores U1309D-279R through 313R recovered a total of 40.8 m, with core recoveries ranging from 26% to 98% (average of 64% recovery). 30 bbl mud sweeps were pumped every ~5 m to keep the hole clean. At 1145 h we began retrieving the drill string and the bit cleared the seafloor at 1620 h.

This was a good opportunity to test the Elevated Temperature Borehole Sensor (ETBS), which had malfunctioned on previous runs and had been worked on since. With the bit several meters above the seafloor, we installed the top drive again, installed the sinker bars, and deployed the ETBS to the end of pipe for ~10 min. The test results were negative and repair efforts will continue. At 1900 h we continued to retrieve drill string and the bit cleared the rig floor at 2245 h, officially ending this bit run.

Hole U1601C

We decided to return to Site U1601 and set a reentry system in a new hole, U1601C. This was a different system from the one we were not able to release in Hole U1601B. It had neither a mud motor, an underreamer, nor a casing release tool. Instead, the plan was to drill a 14³/₄ inch, ~22 m deep hole, deploy and reentry a 9⁷/₈ inch coring bit into the hole, drop a casing-cone assembly by letting it free-fall into the hole using the drill string as a guide, and begin coring. By 2254 h on 1 May the ship had moved the 2 nmi from Hole U1309D to Hole U1601C in dynamic positioning (DP) mode. Hole U1601C is located 20 m northeast of Hole U1601B. At 0130 h on 2 May, assembly of the bottom-hole assembly (BHA) with a 14³/₄ inch drilling bit was complete. After reinstalling the upper guide horn once more, deployment of the drill string began at 0315 h, was paused at 0400 h for general rig servicing, and was complete at 0630 h.

Drilling the initial 14³/₄ inch wide and 23 m deep hole for the reentry system in Hole U1601C progressed slowly but steadily and was complete at 0615 h on 3 May. The drill string was retrieved, with the bit clearing the rig floor at 1025 h. Two joints of 10³/₄ inch casing, with a 10³/₄ inch to 13³/₈ inch crossover at the top, were welded together and staged in the moonpool area. A rotary core barrel (RCB) BHA with a new 9⁷/₈ inch C7 bit was made up and deployed through the casing, starting at 1345 h. The subsea camera was launched at 1610 h. As the ship

was maneuvered to the Hole U1601C coordinates, we passed Hole U1601B, which had a hole in the center of a cuttings cone. At the Hole U1601C coordinates, 20 m to the northeast, a “pond” of white sepiolite slurry came into sight, but the hole was not visible. After a short period of poking into the “pond,” the bit reentered Hole U1601C at 1925 h and reached the bottom of the hole without detecting any fill. The bit was raised 8.7 m and the camera frame was retrieved, arriving on the rig floor at 2125 h. The rig crew installed the free-fall funnel (FFF) around the drill string and attached it to the top of the 13³/₈ inch casing crossover. At 2334 h, the casing-cone assembly was dropped into the moonpool and down the drill string. At 0005 h on 4 May, the subsea camera was launched to confirm that the reentry assembly had properly landed in the predrilled 23 m deep hole, which was visually confirmed. The Niskin bottles on the camera frame were triggered and returned to the moonpool by 0105 h. The first core barrel was dropped and indicated unusually high pressure, which could have resulted from plugged jet nozzles. A second barrel was dropped without incident, and coring began.

The remainder of the week was a remarkable coring bonanza with an unanticipated high penetration rate and relatively good recovery. At the end of the week, we had recovered Cores U1601C-2R through 35R to a depth of 187.9 mbsf. We recovered 72.6 m of the 164.9 m cored interval, with core recoveries ranging from 12% to 91% (44% average recovery). 30 bbl mud sweeps were conducted every ~5 or ~10 m. Hole U1601C is approaching the depth of the deepest ocean drilling hole in serpentinized peridotite (Ocean Drilling Program Hole 920D, 200.8 mbsf), and favorable drilling conditions offer a good chance to exceed it.

In the morning of 6 May, shipboard processing of cores at various stages was suspended due to concerns about a potential health hazard resulting from the handling of cores with asbestiform chrysotile vein mineralization in serpentinized peridotite material. The first Cores U1601C-2R through 7R, and the later gabbroic Cores 22R, 25R, 35R, and 36R, were fully processed according to standard procedures but subsamples were not further processed and analysed. Cores 8R through 18R were split but not subsampled. All subsequent cores were sealed in core liners as whole-round sections: Cores 19R through 26R were washed and binned, 27R through 39R were neither washed nor binned, 40R through 53R were binned but not washed, 54R and 55R were neither washed nor binned. Petrophysical whole-round measurements were carried out on all cores; however, splitting, imaging, detailed description, and analysis was put on hold starting with Core 19R. Proposed core handling procedures for the serpentinized peridotite were sent to management and we are waiting for further advice.

Scientific Results

Igneous Petrology

Cores U1309D-303R through 313R and their available associated thin sections were described. The section is a continuation of the gabbroic plutonic unit documented last week, with crosscutting diabase dykes and a myriad of veins.

The original lithologies of the strongly altered Cores U1601C-2R through 18R are harzburgite and orthopyroxene-bearing dunite, with lesser dunite and rare crosscutting gabbroic veins. Cores 22R and 25R were also available for description and consist of gabbro and gabbronorite with variable grain sizes.

Alteration Petrology

Cores U1309D-297R through 313R and their available associated thin sections consist dominantly of slightly altered olivine gabbro, composed mainly of partially to completely altered olivine, clinopyroxene, and plagioclase. The observed alteration minerals include amphibole, talc, serpentine, prehnite, chlorite, clay minerals, zeolite, magnetite, and sulfides (pyrrhotite or pyrite). Olivine is commonly altered to talc, amphibole, and minor sulfide (pyrite or pyrrhotite), and partially overprinted to clay minerals. Olivine relicts commonly display incipient mesh texture formation, with serpentine-magnetite veins along former grain boundaries of and fractures through olivine. Green to white amphibole forms after clinopyroxene, while chlorite and prehnite form after plagioclase. Total alteration intensity is typically <10%; however, in some intervals subjected to cataclastic deformation, high density veining or patchy bleaching, the extent of alteration can exceed 50%. Crosscutting relationships of alteration minerals and veins indicate an alteration sequence of variable temperatures from amphibolite to greenschist facies and zeolite facies conditions.

Structural Geology

The week was spent finalizing GEODESC templates for structural observations, thin section descriptions for samples from Holes U1309D and U1601C, and core descriptions.

Cores U1309D-300R through 313R consist of olivine gabbro and olivine-bearing gabbro, thin intervals of diabase, and diorite. They host an isotropic magmatic fabric with intervals of grain size layering or shape preferred orientation of plagioclase and/or clinopyroxene, often with subvertical, diffuse boundaries. A zone of cataclastic deformation and significant vein density was recovered in Cores 304R through 306R with poor recovery, delimiting an anastomosing semibrittle to brittle fault system >10 m thick.

Cores U1601C-2R through 18R host significant protogranular to protoclastic serpentinized harzburgite with lesser dunite, and rare websterite. Mantle fabrics defined by shape preferred orientation of orthopyroxene and/or spinel trains have shallow to moderate (20°–55°) dip angles.

Well-developed serpentine mesh texture is common. Sections of medium to coarse-grained leucodiorite and gabbronorite with a localized crystal-plastic fabric were recovered in Section U1601C-16R-3 (93.8 mbsf). Contacts with the host harzburgite are subvertical. The entire cored interval is cut by variably oriented veins, cut by late, often subhorizontal, thin (<1 mm) white veins.

Geochemistry

Chemical analyses for the water samples collected in the Niskin bottles, Multi-Temperature Fluid Sampler (MTFS), and Kuster Flow-Through Sampler (FTS) were completed. Analysis of these data in comparison to previously collected borehole fluids, including Deep Sea Drilling Project Hole 504B, is ongoing.

18 samples of gabbro, olivine-gabbro and gabbronorite from Hole U1309D were selected and processed for shipboard analyses. Hole U1309D gabbroic rocks had relatively low loss on ignition (LOI: -1.63–1.08 wt%) indicating low background alteration except for one altered gabbronorite sample (LOI: 4.11 wt%). The method for analyzing the total carbon and water contents of igneous rocks using the shipboard elemental analyzer was successfully tested.

Microbiology

Bottom water near Hole U1601C was sampled with a Niskin bottle after reentry of Hole U1601C and subsampled for microbiological analyses including enumeration of microbial cells and DNA sequencing.

Microbiology samples were collected from Cores U1309D-307R, 311R, and 313R, and from all but two of Cores U1601C-2R through 21R. 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. The 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.

Microbiology whole-round samples were selected from all but two of Cores U1601C-22R through 35R and stored at 4°C. Subsampling of these cores for microbiological analyses was delayed by >48 h, with unknown impact in the success of the experiments. Time-sensitive microbiological experiments including metabolic activity, cultivation, incubations, single-cell activity assays, and preservation for the enumeration of microbial cells have not been conducted on these cores, with unknown impacts on the scientific goals.

Petrophysics

Bulk density measured on whole-round Cores U1309D-297R through 313R has values mostly near $\sim 2.8 \text{ g/cm}^3$, with values closer to $\sim 2.75 \text{ g/cm}^3$ in the shallower cores and values progressively rising to $\sim 2.9 \text{ g/cm}^3$ in deeper cores. Magnetic susceptibility (MS) is overall low

(<1000 IU for whole-round measurements; <4000 IU for point measurements) but does have significant variations. Natural gamma ray (NGR) values are low (1.5 counts/s).

Discrete cube samples from Hole U1309D (30 from gabbro and 1 from diorite) have grain densities of $\sim 3.0 \text{ g/cm}^3$ and porosities between 0.5% and 2%. One discrete cube sampled from a feldspar-rich interval has a grain density of $\sim 2.55 \text{ g/cm}^3$ and a porosity of 5%. *P*-wave velocity measurements conducted on 30 cubes of gabbro ranges from 4965 m/s to 5895 m/s, with an average of 5476 m/s. The apparent anisotropy of *P*-wave velocity ranges from 4.1% to 7.0%.

Thermal conductivity measured six times on each of eleven $\sim 10\text{--}20$ cm long gabbroic section half pieces from Hole U1309D averaged 2.194 to 2.632 W/(m·K). All measurements together averaged 2.424 W/(m·K) (standard deviation of 0.142), without a clear trend with depth.

Bulk density measured on whole-round cores from Hole U1601C has values of $\sim 2.35 \text{ g/cm}^3$ near the top of the hole and steadily increases to $\sim 2.5 \text{ g/cm}^3$ at ~ 144 mbsf. Part of this pattern is due to the increasing proportion of gabbroic rocks downhole having a higher density than serpentinized peridotite. MS also varies based on rock type with most gabbroic rocks having extremely low values and serpentinized peridotite having higher and variable values.

Paleomagnetism

Anisotropy of magnetic susceptibility (AMS) and natural remnant magnetization (NRM) measurements were carried out on 36 discrete cube samples from Hole U1309D. The distribution of principal susceptibilities (κ_{max} , κ_{int} , and κ_{min}) indicates that the dominant types of ellipsoid shapes were oblate, planar. The mean susceptibility (κ_{m}) value was 3.62×10^{-3} A/m, whereas the maximum and minimum susceptibility values were 1.9×10^{-2} and 4.04×10^{-4} A/m respectively. Negative magnetic inclination values were consistently observed in all of the NRM measurements. Two dunks of liquid nitrogen pretreatments were performed on all paleomagnetism (PMAG) samples before alternating field (AF) and thermal demagnetizations. AF demagnetizations of up to 200 mT were carried out on all of the moisture and density (MAD) samples. Most of these discrete samples had consistent inclinations within the range of -25° to -40° . The peak AF of 200 mT was insufficient to completely remove the magnetic remanence for the respective samples, placing a further emphasis on thermal demagnetization experiments capable of removing the remanence. Thermal demagnetization experiments for Hole U1309D samples have begun with bulk susceptibility measurements taken after each temperature step.

Outreach

This week, the shipboard Outreach Officer 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 10,370 impressions (-50%), 2.5% engagements, and 33 profile visits.
- Facebook received 3 new photo posts, 1 new story, and two new reels, reached 74,600 accounts (-2%), engaged 67,900 accounts (+2%), and has 12,000 followers.
- Instagram received 4 new photo posts and 5 new reels, reached 3,376 accounts (-32.7%), engaged 352 accounts (+7.3%) and has 4,000 (+0.7%) followers. Total number of views for Instagram in week 3: 7,900.

Ship-to-Shore Broadcasts

During Week 3, we led 11 ship-to-shore broadcasts for ~300 people in 5 states (US), Greece, and Japan.

- Kingswood Oxford, West Hartford, CT USA
- University of Southern Mississippi, Hattiesburg, MS USA
- Cal Poly, SLO, San Luis Obispo, CA USA
- Helioupolus Primary, Athens, Greece
- South Bronx Preparatory, South Bronx, NY USA
- Geological Museum, GSJ, AIST, Japan
- American Museum of Natural History, New York City, NY USA
- WHOI Marine Educators, Woods Hole, MA USA
- Asahikawa Science Museum Scipal, Asahikawa city, Hokkaido prefecture, Japan

Expedition Log (blog posts)

Expedition 399 Log has 2 new blog posts:

- End of an Era (4 May 2023): <https://joidesresolution.org/end-of-an-era-2/>
- Letter to the Science Party (7 May 2023): <https://joidesresolution.org/letter-for-the-science-party/>

Feedback from Community

“Thank you to both of you for going above and beyond for the students of Kingswood Oxford. They were quiet and not all questions were appropriate (apologies) but there have been multiple conversations after the fact.

We will be following the expedition for the rest of the school year and we wish you the best of luck in meeting and exceeding the expedition’s goals.” (Kingswood Oxford)

“What an outstanding and generously extensive tour with NVCC on Saturday!

Rave reviews from the students who loved seeing the cores and all aspects of the ship, including the pet wall and the dessert offerings. The interview with scientists really added a lot too. We appreciate all of the time they gave and the space that you gave them to answer our many questions. I really liked how you did the bird's eye view of the deck as you pointed out the pipes, cones, and other workings below.” (Northern Virginia Community College)

“Excellent video sequence of free-fall funnel deployment; Genius! What great outreach you are putting out there! You are certainly creative.” (Comments on Instagram post)

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

Downhole Laboratory

- After Bit Run number 1 in Hole U1309D, we deployed the ETBS inside the drill string to test the newly installed temperature probe, tip housing, and pressure port that failed during earlier deployment. Although multiple bench test results were encouraging, the downhole test result was negative.
- We are drafting the ETBS in Solidworks for future thermal equilibration modelling by scientists.

Core Description

- New versions of two GEODESC programs, Data Capture (v1.0.14) and Template Manager (v1.0.11), were deployed on the ship with bug fixes.
- Two scientists are now using the XSCAN (X-ray imager) routinely on working halves to support core description and sample selection. The raw images are most useful because the processed images have significant artifacts if the entire section composed of pieces is scanned.
- The problem of failed JPEG image download in ImageCapture was solved. However, we are still investigation the problem with downloading TIFF files.

Curation

- Material recovered from Hole U1601C has had curation stages halted at various points due to potentially hazardous asbestiform chrysotile found within some cores.
- We are troubleshooting the interstitial water (IW) Report, which displays data in the wrong line.

IRIS

- Driller's Worksheet (DWS) and Driller's App: a functional version of DWS was completed. Testing and integration with the Driller user interface (UI) is nearly complete. Rig floor testing is anticipated mid-week.

- iRIS UI and Tracer Apps: Updated to reflect recent data structure changes.
- Development of iRIS navigation report has started.

Safety

- We held the weekly fire boat drill.
- Safety shower and eye stations were tested.
- A preliminary safety policy for handling cored material with asbestiform chrysotile vein mineralization was submitted for management review.
- Dust samples from the splitting room and Core Laboratory HVAC return air filters were analysed by a scanning electron microscope (SEM) and the annotated images were sent to management. No asbestiform minerals were detected.