

IODP Expedition 399: Building Blocks of Life, Atlantis Massif

Week 4 Report (7–13 May 2023)

Operations

Hole U1601C

Week 4 began on 7 May with the recovery of Core U1601C-36R at 187.9 meters below seafloor (mbsf). We waited on weather due to intermittently high waves from 0100 h to 0445 h, during which time the rig crew slipped and cut 100 m of coring line. On 8 May, with the recovery of Core 55R to a depth of 284.9 mbsf, the first coring bit (second bit run in Hole U1601C) had accumulated 50 h on bottom. Despite having exceeded the planned penetration of 200 m at this site, the science party decided to begin a second coring run. The first coring run recovered a total of 156.9 m of the 261.9 m cored interval (60% average recovery). 30 bbl mud sweeps were conducted every ~10 m, with a final 50 bbl sweep at total depth. The subsea camera was launched at 1310 h, while the drill string was being retrieved. At 1456 h a clean exit of the bit from the reentry cone was observed, confirming that the reentry system installation was fully successful. From 1500–1530 h we navigated over Holes U1601A and U1601B, identified the cutting cones, and confirmed that the seafloor was clear of any artifacts. The drill string was retrieved, clearing the rig floor at 1830 h. At 2215 h, after conducting rig servicing activities, the crew began to reassemble the 4-stand bottom-hole assembly (BHA) with a new C7 coring bit for the second coring run.

At 0030 h on 9 May, the subsea camera was deployed while the drill string with the second coring bit for Hole U1601C was lowered to the seafloor. Hole U1601C was reentered for the second time at 0200 h. The camera was back on board at 0300 h, the rig floor was reassembled at 0330 h, the top drive was picked up, and the bit was lowered to 266.0 mbsf where a bridge or fill was tagged. At 0430 h the core barrel was deployed, the soft fill was washed to 284.9 mbsf, and coring resumed. The remainder of the week was spent recovering Cores U1601C-56R through 123R to 614.7 mbsf with excellent recovery. 30 bbl mud sweeps were pumped every ~10 m.

Due to concerns about a potential health hazard associated with asbestiform chrysotile minerals observed in the veins of serpentinized peridotite cores, much of the core processing was on hold for days while safety amendments to the core handling procedures were drafted and sent to management. Several processes were delayed or on hold, including core splitting and section half subsampling. On 9 May, after a pause of 5 days, splitting of core sections resumed under special safety protocol and with the help of scientists. Rapid core description methods had to be established to catch up with the backlog and the rapid core recovery. Subsampling for shipboard and shorebased analysis is not happening due to the confluence of safety concerns and associated protocols, personnel constraints, and rapid core recovery.

Scientific results

Igneous Petrology

The original lithologies for Cores U1601C-19R through 100R, exclusive of 22R and 25R described last week, are harzburgite and orthopyroxene-bearing dunite, with lesser dunite and variably thick and variably altered crosscutting gabbroic veins and bodies. The gabbroic lithologies varied widely in mineral proportions and included gabbro, olivine gabbro, gabbronorite, and troctolite. Several different sulfide minerals were encountered in and around the gabbroic units.

Alteration Petrology

The dominant lithology in Cores U1601C-2R through 79R is serpentized harzburgite with subordinate amounts of serpentized dunite and altered gabbro. The peridotite is commonly cut by hydrothermally altered magmatic veins. Serpentinization varies in extent from ~40 to >90 vol% and forms mesh texture after olivine and bastite after orthopyroxene. Crosscutting relationships of veins with distinct mineralogical and textural features, including mesh-forming serpentine-magnetite veins, fibrous and massive chrysotile, and massive picrolite indicate that serpentinization was episodic and characterized by variable chemical and thermal conditions. Late carbonate veining is locally observed. Both serpentine and carbonate veins are in some instances associated with sulfide mineralization. Variably altered gabbroic rocks and magmatic veins intercalated within the serpentinite are mainly composed of primary clinopyroxene and plagioclase, and secondary minerals including amphibole, chlorite, prehnite, secondary plagioclase, and late zeolite.

Thin section observations in gabbroic rocks from Cores U1309D-303R through 313R include amphibole, talc, chlorite, serpentine, secondary plagioclase, prehnite, zeolite, and clay minerals, indicating variable temperature conditions of alteration from amphibolite facies to greenschist and subgreenschist facies. Most gabbroic rocks show only incipient alteration. However, the intensity of alteration tends to increase in proximity to, or within, cataclastic zones.

Structural Geology

A new, simpler description template for structures was created to deal with the rapid core recovery in Hole U1601C and the core handling backlog created by the special procedures. Macroscopic descriptions were completed for Cores U1601C-18R through 93R. Thin section descriptions were completed for 26 samples from Hole U1309D. Several thin sections exhibited cataclastic textures. We developed an interim synthesis of observations from the deepest part of Hole U1309D, based on Cores U1309D-296R through 313R (1414 to 1497.8 mbsf).

Geochemistry

Assessment of the chemical data obtained from the Hole U1309D downhole samples continued. A plan is being developed for the next stage of borehole water sampling. Measurements of dissolved hydrogen on samples recovered from the core catcher in Hole U1601C continued.

Four gabbro samples from Hole U1601C were selected for shipboard analyses. In addition, 93 samples of serpentinized peridotites from Hole U1601C, selected for microbiology studies, were processed for shipboard analyses. Sixteen samples recovered from Hole U1601A (mainly serpentinized peridotites) and a subset of 10 igneous rocks from Hole U1309D (diabase and gabbro) were analyzed for total carbon and water content. Hole U1309D igneous rocks have low H₂O (0.7–1.30 wt%) and carbon (CO₂ <0.05 wt%) contents, consistent with their low loss on ignition (LOI: 0.22–1.08 wt%). Hole U1601A serpentinized peridotite samples have high water content (generally H₂O >13.45 wt%). They also have non-negligible carbon concentrations (CO₂: 0.07–0.3 wt%), the samples selected for microbiology studies being generally more carbon rich compared to the geochemistry samples. Two of the microbiology samples are distinguished by their particularly high carbon concentrations (CO₂: 2.5–2.6 wt%). These high carbon contents are interpreted as revealing the presence of carbonate. The inductive coupled plasma–atomic emission spectroscopy (ICP-AES) analyses of the samples recovered from Holes U1601A and U1309D started.

Microbiology

Microbiology samples were collected from most of the Cores U1601C-36R through 124R (78 microbiology samples [MBIO]). In addition, 10 previously collected cores (U1601C-23R through 37R), for which subsampling had been temporarily suspended last week, were subsampled this week for microbiological analyses. 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 bulk density of serpentinized peridotite in Cores U1601C-25R through 121R (134.6–605 mbsf) is $\sim 2.4 \text{ g/cm}^3$, whereas the bulk density of gabbro is $\sim 2.65 \text{ g/cm}^3$. Both values are minimum values. The whole-round magnetic susceptibility (MS) in the same cores is highly variable in the serpentinized peridotite, ranging from 2500 to upwards of 16,000 IU. The highest values occur in Cores 58R, 59R, and 88R. The gabbro has extremely low MS with values < 150 IU. Both rock types have similar trends in point MS values completed on section halves of 25R and 35R–37R. Natural gamma radiation (NGR) is very low, typically < 1 counts/s, for both gabbro and serpentinized peridotite, except for Cores 27R–30R (144.3–161.6 mbsf), which includes thin gabbro interfingering with serpentinized peridotites, where 5–10 counts/s were measured. The higher density and extremely low MS make it easy to identify.

Thermal conductivity was measured on 14 pieces from Hole U1601C, including 10 serpentinized peridotite and 4 gabbro samples. Values were higher in the serpentinized peridotite, ranging from 2.64–2.91 W/(m·K) with a standard deviation of 0.103, and lower in the gabbro samples, ranging from 2.20–2.53 W/(m·K) with a standard deviation of 0.291. No significant change with depth is observed. *P*-wave velocity was also measured on 40 samples (11 cubes from working section halves and 29 pieces from archive section halves), including 6 gabbro and 34 serpentinized peridotite samples. Values range from 3.4 km/s in serpentinized harzburgite (Section U1601C-49R-4) to 6.6 km/s in gabbro (Section 32R-2).

Paleomagnetism

Anisotropy of magnetic susceptibility (AMS) and natural remnant magnetization (NRM) measurements were carried out on 21 discrete cube samples from Cores U1601C-2R to 6R, 22R, 25R, 35R, and 36R (early serpentinite cores, later gabbro cores). The distribution of principal susceptibilities (κ_{max} , κ_{int} , and κ_{min}) indicate that the dominant type of ellipsoid shapes is oblate planar. The mean susceptibility (κ_{m}) value is $19.14 \times 10^{-3} \text{ A/m}$.

Measurements of NRM and remanences following stepwise alternating field (AF) demagnetization were conducted on archive section halves of Cores U1601C-19R through 43R using the superconducting rock magnetometer (SRM). Initial magnetizations were progressively demagnetized up to 50 mT. Results indicate that there are consistent inclination values within the range of -20° to -40° observed in the measured sections.

AF demagnetization experiments were carried out on 7 discrete cube samples from Hole U1601C. All samples contain at least two primary magnetization components. Additionally, isothermal remnant magnetization (IRM) acquisition and backstep experiments were carried out for 22 samples from both Holes U1309D and U1601C. These experiments were meant to get baseline hysteretic properties of the samples, such as the characteristic H field. Samples varied quite a lot in terms of the characteristic H field, ranging from 15 mT to 60 mT. This indicates

heterogeneous magnetic grain size distributions in the samples from both Holes U1309D and U1601C.

Education and Outreach

This week, the shipboard Outreach Officer team has 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

- We posted to Twitter with 39,103 impressions (+279%), 3.3% engagements, and 93 profile visits (+182%).
- Facebook received 4 new photo posts and 1 video and reached 85,100 accounts (+11%), engaged 70,200 accounts (+0%), and has 63 new followers (+43%).
- Instagram received 5 new photo posts, 5 new stories, and 3 new reels, reached 3,136 accounts (-7.2%), engaged 448 accounts (+27.2%), and has 4,000 (+0.5%) followers. Total number of views for Instagram in week 4: 10,300.

Ship-to-Shore Broadcasts

We led 7 ship-to-shore broadcasts for ~1200 people in 4 states (US), Australia, the UK, and an international online school.

- University of Queensland, Queensland, Australia
- Charlotte Country Day School, Charlotte, NC, USA
- South Bronx Preparatory, South Bronx, NY, USA
- Lamont-Doherty Earth Observatory, Palisades, NY, USA
- Astra Nova School, remote/online school
- Oak Grove, Hattiesburg, MS, USA
- Be Curious, Leeds, Yorkshire, UK

Expedition Log (blog posts)

Expedition 399 Log has 1 new blog post:

- Approaching the Halfway Point (11 May 2023): <https://wp.me/p9RTBK-akr>

Feedback from Community

“Thank you so much for the calls—my students (and co-teachers and I) really enjoyed getting to see the ship and talk to you all! It was a great end to our unit.” (South Bronx)

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

Core Handling

- Enclosures for both the Super Saw and the parallel saw were fabricated and installed to keep the operator(s) splash-free.

Paleomagnetism

- The spare JR-6 magnetometer was tested and set up to measure discrete samples in parallel with the main JR-6. Both are currently functioning properly.
- All broken JR-6 cubic sample holders were harvested for parts. Other sample holders were disassembled, extensively cleaned, reassembled, serviced, and tested.

Scanning Electron Microscope (SEM)

- The Hitachi SEM was fixed. We cleaned some of the parts, then swapped the new filament out for another new one. Images are comparable to last reference images from Expedition 378.

Geochemistry and Microbiology

- We moved the Shatterbox to the Paleomagnetism Laboratory, which has a sediment drain, secured it to the wall, and made a closed-off work area. We also made 6 gaskets for the shatterbox sample holders.
- The LN2 nitrogen generator is working well again after repairs.
- Started to design a new water chemistry sample report as the existing interstitial water (IW) report is not handling borehole and bottom water samples correctly.

IRIS

- With the completion of the Driller's Worksheet app, work is now focused on debugging all of the iRIS applications working as a system and sharing data.
- Work has started on the Operation Interface as part of the above testing.

Safety

- The weekly fire boat drill was held.