IODP Expedition 396: Mid-Norwegian Continental Margin Magmatism

Week 4 Report (29 August–4 September 2021)

During Week 4 of the International Ocean Discovery Program (IODP) Expedition 396, Mid-Norwegian Continental Margin Magmatism, we completed coring and logging operations at Hole U1569A (proposed Site VMVM-55B) and coring operations at three holes at Site U1570 (proposed Site VMVM-56A). The week ended operating at Hole U1570D.

Operations

Week 4 began while rotary coring at 234.3 m below seafloor (mbsf) in Hole U1569A. Coring using the rotary core barrel (RCB) continued with full-length core advances through Core U1569A-30R to a depth of 293.1 mbsf. Cores 31R-34R (293.1 to 322.5 mbsf) were cored with half-length advances to improve recovery across a key stratigraphic interval. From 322.5 mbsf to the hole's final depth of 404.6 mbsf, full-length advances were used for coring. The final core, 44R, was on deck at 0320 h on 30 August 2021. Following coring, the hole was swept clean of cuttings with a 50-barrel sweep of high viscosity mud. After circulating the mud through the hole, the rotary shifting tool (RST) was run in on the coring line to release the RCB C-4 coring bit. The bit was released, and the RST was run again to reposition the bit shifting sleeve back to the circulating position in the mechanical bit release (MBR). After shifting the sleeve in the MBR, the RST was pulled back to the surface and the sinker bars were removed. The volume of the hole was displaced with 125 barrels of 10.5 ppg mud. The end of the drill string was pulled back to 361.6 mbsf with the top drive installed. High torque was experienced at the bottom of the hole before pulling pipe. The top drive was set back, and the drill string was pulled back to 84 mbsf for wireline logging operations. The rig floor personnel and the Schlumberger engineer met to review safety issues surrounding the upcoming logging operations, and then rigged up the triple combo tool string.

The triple combo tool string was deployed and a downhole log was collected from just above sea floor to 127.4 mbsf where an obstruction was encountered. After numerous unsuccessful attempts to pass the obstruction, logging was terminated. The tool string was brought back to the surface and rigged down by 1505 h on 30 August. No damage was found to any of the logging tools from the single deployed tool string. The logging equipment was secured, and the rig floor crew began tripping operations.

The drill string was pulled out of the hole to 2133.7 m below sea level (mbsl) at 1554 h. The pipe trip was halted to perform a routine slip and cut of the drilling line. The retrieval of the pipe string resumed at 1800 h and the vessel was moved in dynamic positioning (DP) mode to proposed alternate Site VMVM-56A (U1570) while the pipe was brought to the surface and stored. At 2038 h, the vessel completed the 1514 m transit to Site U1570. Four stands of drill collars were racked back in the derrick and the outer core barrel components were disassembled,

inspected, and laid out. The top half of the MBR cleared the rig floor at 2220 h on 30 August, ending Hole U1569A. The time spent on Hole U1569A was 74.25 h or 3.1 days.

The operations plan for Site U1570 was to core four holes along a transect of outcropping strata extending west of Site U1569, where deep stratigraphic targets were present at shallower subseafloor depths. The coring plan was the same for each hole: to rotary core to 200 mbsf and sample the Paleocene–Eocene boundary interval.

Coring in Hole U1570A began at 2220 h on 30 August at 2196.1 mbsl. Cores U1570A-1R to 36R penetrated from the seafloor to 200 mbsf and recovered 98.6 m of material (49.3%). The final core was brought on deck at 1035 h on 1 September. The time spent at Hole U1570A was 39.75 h or 1.7 days. At 1412 h, the vessel was moved in DP mode 1760 m west along the Environmental Safety and Protection Panel (EPSP) approved ribbon, that defined the boundaries of Site U1570, to Hole U1570B. Hole U1570B was spudded at 1610 h at a precision depth recorder (PDR) depth of 2270.9 mbsl and coring continued until 2345 h on 2 September. Cores U1570B-1R to 25R sampled from the seafloor to 163.6 mbsf and recovered 71.42 m of material (43.7%). Cores 5R–20R were cored with half-length advances to improve core recovery. After coring ended, the top drive was set back and the bit was pulled clear of the seafloor at 0100 h on 3 September, ending Hole U1570B. The bit was raised to 2197 mbsl and the vessel moved east in DP mode to Hole U1570C. The time spent on Hole U1570B was 37.0 h or 1.5 days. At 0234 h on 3 September, the vessel had moved the 1075 m to Hole U1570C. A reading with the PDR estimated a water depth of 2225.1 mbsl. The hole was spudded at 0405 h and the PDR water depth matched the driller's tagged depth; thus, it was used for the official water depth for the hole. Twenty-three cores were taken with the RCB system to a final depth of 200 mbsf with 49.6 m recovered (25% recovery). Cores U1570C-8R to 11R were cored with half-length advances to improve recovery. After the final core was retrieved, the drill string was raised, clearing the seafloor at 0030 h on 4 September and ending Hole U1570C. The bit was pulled back to 2196.7 mbsl and the drilling knobbies were installed through the guide horn. The vessel was moved 350 m east in DP mode to Hole U1570D, which was positioned approximately halfway between Holes U1570A and U1570C. The time spent on Hole U1570C was 23.50 h or 1.0 day. Hole U1570D was spudded at 0250 h on 4 September. The official water depth for the hole was 2207.7 mbsl based on the driller's tagged depth. RCB coring continued with full-length core advances from the seafloor to Core U1570D-9R to 80.9 mbsf. Cores 10R–23R were cored with half-length advances to 149.2 mbsf to improve recovery. Cores 24R–26R were full-length advances to 178.4 mbsf. At the end of the week, we were coring with the RCB coring system from a depth of 178.4 mbsf in Hole U1570D with a 200 mbsf target depth.

Science Results

The scientists acquired and analyzed data from Holes U1569A, U1570A, U1570B, U1570C, and U1570D and continued to prepare site reports. On 2 September, they held the science summary

meeting for Sites U1567 and U1568 with virtual participation of the onshore members of the science party. On 3 September, the Co-Chief Scientists presented the scientific and operational objectives for Sites U1569 and U1570.

Lithostratigraphy

The core description team described and measured all the cores from Holes U1569A, U1570A, U1570B, and U1570C, and began processing cores from Hole U1570D. Some of the lithologies described for these holes are very similar to those found at Sites U1567 and U1568. The core describers identified eight preliminary lithostratigraphic units in Hole U1569A that mostly correlated with the lithostratigraphic units observed across the Site U1570 holes. Lithostratigraphic Unit I is glacial/interglacial clay with silt and trace dropstones. Unit II consists of consolidated clay and silt. Unit III is similar to Unit II, but with rare ash. Unit IV consists of consolidated clay with nodules. Unit V lies below an unconformity and comprises well consolidated clay with silt, barren of diatoms and lightly bioturbated. Unit VI is dark gray clay- to siltstone with common glassy ashes and extensional veining. Unit VII is similar to Unit VI, but with more altered ash beds and a higher degree of pyritization. Unit VIII is similar to Paleocene units described at the previous sites, consisting of dark greenish gray claystone with moderate to heavy bioturbation.

Biostratigraphy

The biostratigraphy team continued to provide biostratigraphic age control and paleoenvironmental interpretations on recovered sediments. All the samples from core catcher Sections U1569A-25R-CC to U1569A-44R-CC, U1570A-1R-CC to U1570A-36R-CC, U1570B-1R-CC to U1570B-25R-CC, U1570C-2R-CC to U1570C-23R-CC, and U1570D-2R-CC to U1570D-25R-CC were examined for microfossil and palynological content. Microfossil abundance and preservation was highly variable within and between holes.

Sediments include calcareous microfossils only in the upper ~30 m, underlain by an unconformity to Miocene sediments. The stratigraphic attributions are based mostly on dinocysts and diatoms. Samples containing very hard rock, including igneous units, were not processed. Mid-Miocene sediments are identified by diatoms and dinocysts in Holes U1569A and U1570A–U1570C, with a small amount of upper Oligocene recognized in Hole U1569A. They are underlain by an unconformity above lower Eocene and Paleocene sediments. Rare, poorly preserved nannofossils occur in the Miocene sections and near the bottom of Hole U1570C (Paleocene), as well as in Quaternary muds. Reworked Cretaceous palynomorphs are common in the lowermost set of samples in both Holes U1570B and U1570C.

Paleomagnetism

The archive half sections of cores from Holes U1567C, U1569A, and U1570A–U1570C were measured on the superconducting rock magnetometer (SRM). After measuring the natural

remanent magnetization (NRM), the cores were subjected to a series of stepwise, in-line alternating field (AF) demagnetization steps at 5, 10, 15, and 20 mT for sediment, and 2, 4, 6, 8, 10, 15, and 20 mT for sedimentary and volcanic rocks and/or indurated sediment.

The magnetic field in the SRM was measured to ensure a null field was present in the measurement region. All axes were less than 16 nT within the superconducting quantum interference device (SQUID) measurement region, and little change was noticed between the initial field trapped at the start of the expedition and the current field.

A total of 12 discrete samples were collected for Hole U1569A, 16 for Site U1570 (seven for Holes U1570A and U1570B, respectively, and two for Hole U1570C), to compare results of AF demagnetization from the SRM cores in the JR-6A spinner magnetometer. Except for six samples from Hole U1569A, all the samples were measured for magnetic susceptibility (MS) in the KappaBridge KLY4S magnetic susceptibility meter. After measuring the NRM, AF demagnetization was performed on all samples following an AF sequence of 5, 10, 15, 20, 30, 40, 50, 60 and up to 70, 90, and 100 mT, using the DTECH D-2000 AF demagnetizer.

From Hole U1569A (east) to Hole U1570B (west) there is a reduction of the average MS captured by the Whole-Round Multisensor Logger (WRMSL), from ~48 × 10^{-5} SI to ~27 × 10^{-5} SI, that is seen across the transect for this region.

Geochemistry

The geochemistry team sampled cores from all holes from Sites U1569 and U1570 (except for Hole U1570D) for interstitial water and sedimentological geochemical analyses. In addition, they subsampled selected core catcher samples for carbonate analyses as previous results from Sites U1567 and U1568 suggested that total nitrogen content corresponded well with the lithostratigraphic units.

Site U1569 showed substantial downhole chemical variations that were different to previous sites. Sulphur concentrations increased steadily with depth at Sites U1567 and U1568, but at Site U1569 there are periodic increases at ~100, ~180, and ~300 mbsf. Nitrogen shows significant downhole variations that appear lithologically controlled. Carbonate concentrations are generally very low except in discrete horizons. This pattern repeats in the samples from Hole U1570A, but not at Hole U1570B, where both sulphur and nitrogen are low throughout the entire cored section. The chemical composition of the pore water at Site U1570 is similar to that at Sites U1567 and U1568, suggesting that the porewater preserves the original chemical signal and it is not overprinted by later fluid flow.

Physical Properties and Downhole Measurements

All whole-round core sections from Holes U1569A and U1570A–U1570D were run through the loggers for physical properties. Discrete samples were measured for bulk density, porosity, dry

density and moisture content, and *P*-wave velocity at a minimum of one sample per core. *P*-wave velocity measurements also were performed on the working half sections of split cores. Thermal conductivity was measured on suitable samples (i.e., coherent pieces at least 10 cm long).

Downhole logging was attempted in Hole U1569A, but because of the encountered obstruction in the hole, the data set is very limited. The raw logging data were sent to the Lamont-Doherty Earth Observatory for processing and quality control. Throughout the week, the team further evaluated the wireline logging data for the Sites U1566, U1567, U1568, and U1569.

Education and Outreach

Outreach activities during this week focused on updates to the IODP social media channels: a blog post on joidesresolution.org (*Postcards from the Field*), Twitter, Facebook, and Instagram.

Technical Support and HSE Activities

Laboratory Activities

- JRSO staff processed cores from Hole U1569A and Site U1570 and assisted scientists in the laboratories.
- A power outlet in the Chemistry Laboratory used for the carbon-hydrogen-nitrogen-sulful analyzer (CHNS) lost electrical power. The Siem Offshore Electronics Staff checked it and found a melted wire in the transformer installed in the ceiling near the ashing furnace. Both the ashing furnace and the CHNS are wired through this transformer. A loose wire was found to be the cause of the overheating/melting incident.
- The freeze drier in the Thin Section Laboratory was cleaned to improve its vacuum. It is still drawing to only ~0.7 mbar (0.2 mbar is the ideal). Troubleshooting of this instrument continues.
- A preliminary inventory for the cold sample shipments was conducted.
- The X-ray core image logger lost power and had to be restarted.

IT Support Activities

- A computer monitor failed for the underwater camera system in the DP room. The monitor is being replaced by a spare unit.
- Most of the spare laptops on board were charged and updated.
- We continued to review folder and file permission changes in the Tomcat application server on test server Uluru. A video meeting was held to discuss Tomcat issues with shore personnel.
- We continued working with Commvault to investigate VMware VM backups. The problem was brought up to their engineering/programing group.

- We continued investigating Yellowstone Logging file transfer process. We were able to transmit downhole logging files to LDEO/Columbia University but not to receive them. Some progress has been made but the problem is still ongoing.
- Updated TAMU equipment to latest Zoom version.

Developer Support Activities

- Work on the SADR project continues.
- Investigated changes needed for MUT to support the new KappaBridge instrument (ongoing).
- Fixed a bug in the Catwalk application.
- Worked with the Marine Computer Specialists and shore personnel to get file and directory permissions properly set on our servers. When the permissions were not properly set, several applications were impacted:
    - LIVE was not displaying images.
    - IODPLauncher was unable to install/update software.
    - LDAQ applications (e.g., Catwalk) were not able to retrieve updated modules.
    - DESClogik, MUT, other applications were not able to log files to ASMAN.
    - LORE was unable to retrieve files when the user clicks on a link.
    - Developers were not able to deploy products, review server logs, etc.
- Shortly after the server crash recovery last week, errors with these permissions resulted in all the above issues over a period of days. It was then discovered that neither the developers nor the Marine Computer Specialists have the ability or knowledge to configure this.
- A meeting with developer and IT management was held to resolve this permission error and to plan for future events of this type.
- Completed a small LDAQ demo application to be presented in the developer code review this week.

Health and Safety Activities

- An abandon ship and fire drill was held at 1300 h on 5 September.
- The emergency shower and eye wash stations were tested.