IODP Expedition 396: Mid-Norwegian Continental Margin Magmatism

Week 2 Report (15–21 August 2021)

Week 2 of the International Ocean Discovery Program (IODP) Expedition 396, Mid-Norwegian Continental Margin Magmatism, consisted of (a) rotary core barrel (RCB) coring Sites U1565 and U1566, and (b) downhole logging of Hole U1566A.

Operations

This week began while we were RCB coring in Hole U1565A. Cores 1R to 4R penetrated from the seafloor to 28.0 mbsf (4.21 m recovered; 15%). As we encountered altered granitic basement immediately below the soft sediment cover, we decided to drill a second hole approximately 140 m towards the west to verify the lateral continuity of the basement rocks recovered in U1565A, rather than spending time deepening the hole at a very low penetration rate. At Hole U1565B, Cores 1R to 5R penetrated from the seafloor to 31.7 mbsf recovering 15.45 m (48.7%). Core U1565B-5R sampled altered granitic basement, and coring operations were ended for the site on 16 August. We raised the bit to 2020 mbrf and moved the ship under dynamic positioning mode to the coordinates of Site U1566. At 0525 h on 16 August, we started RCB coring in Hole U1566A. Cores U1566A-1R to 33R penetrated to 181.7 m and recovered 100.5 m (55.3%). Following the retrieval of the last core, we prepared the hole for wireline logging by conducting a 50-barrel high viscosity mud sweep to clean the hole and then circulated the hole with salt water. We released the RCB drill bit at the bottom of the hole, raised the end of the pipe to 50 mbsf, and completed a full downhole measurements program that included four tool strings: a modified triple combo, the Versatile Seismic Imager, the Formation MicroScanner (FMS-sonic) and the Ultrasonic Borehole Imager (UBI).

Science Results

Scientists acquired and analyzed data from Holes U1565A, U1565B and U1566A, and began to summarize these for the reports. On Saturday 21 August, we held two meetings, one for the night shift and one for the day shift, where the Co-Chief Scientists presented the scientific and operational objectives for Sites U1567 (proposed site VMVM-31A) and U1568 (proposed site VMVM-40B) which consist of coring one and two holes, respectively, to sample and characterize the age and lithology of Paleogene sediments and of a hydrothermal vent complex.

Lithostratigraphy

All cores from Holes U1565A and U1565B from Site U1565 were described. Cores from both holes consist of greenish gray to brownish gray clay with graded beds of silt and sand, and varying amounts of calcareous nannofossils and planktonic foraminifera. Igneous and

metamorphic dropstones are present occasionally at Hole U1565A. Dark grey polymetallic concentric nodules are observed at the base of the sedimentary section in Hole U1565A. Underlying the sediment at both holes, strongly altered coarse-grained granite was recovered. Lithologic description of the cores recovered from Hole U1566A at Site U1566 is ongoing. Cores U1566A-1R to 3R consist of clay and silty rich clay with various amounts of sand and clasts. Beginning with Core U1566A-4R to 29R, a succession of lava flows interbedded with sedimentary beds were recovered. The lava flows consist mainly of phyric basalt with varying vesicularity. Cores U1566A-15R to 19R yielded a succession of mostly aphyric basalt with varying vesicularity. Sedimentary layers comprise volcanogenic and sandstone beds with some weathered granitic clasts. A clay-rich layer interbedded with coarse sand observed between lava flows in Core U1566A-11R contained fossilized wood and charcoal-like wood fragments.

Biostratigraphy

All sedimentary core catcher samples from Holes U1565A, U1565B and U1566A were processed for siliceous, organic, and carbonate microfossils, and smear slides were made for these as well. The palynology team processed unconsolidated mud-rich samples mostly using dilute HCl and density separation. A single sample was processed using HF, and a heavily oxidized sample was soaked in dilute H_2O_2 to remove more volatile organic components. The concentration and preservation state of the microfossils varies greatly, with only the uppermost three core catcher samples from Holes U1565A, U1565B, and U1566A containing microfossils of Quaternary age. No biostratigraphic markers were found in any other samples. A sample obtained from a sedimentary layer interbedded in igneous facies in Core U1566A-11R yielded earliest Eocene pollen grains.

Paleomagnetism

All the archive sections from Holes U1565A, U1565B, and U1566A have been measured in the superconducting rock magnetometer (SRM). At Site U1565, magnetic susceptibility (MS) had low relative values that were consistent for the two lithologic units. Preliminary data showed no clear changes in polarity for the thin sediment overburden nor the underlying basement rocks. The discrete sampling was limited to only one sample in the sediments and two in the basement (granite). The alternating field (AF) demagnetization sequence used (up to 100 mT) seemed to demagnetize completely both the sediment and the granite; however, the granite was highly altered, which could have lowered the need for a higher AF field.

At U1566, MS was relatively low in Cores U1566A-1R to 3R, then showed a gradual increase between Cores U1566A-4R and 23R, then dropped back to low values. Cores U1566A-1R to 3R showed normal polarity, then switched to reversed polarity from Core U1566A-4H to the bottom of the hole, with some data points showing evidence of normal polarity. These changes need to be reviewed, based on lithological observations and further data cleaning.

Thirty-three discrete samples were taken from Hole U1566A with a focus on the basaltic flows (30 samples) and unaltered samples, with one for sediments and one for the granite unit (granite). For this site, the hard rock samples were shared with the Petrophysics Laboratory for moisture and density (MAD) analyses, so it was intended to reach the highest AF field possible before handling them, without causing a major delay in the workflow. The AF sequence reached up to 200 mT for most basaltic samples, with the possibility that further steps are needed in the future to fully demagnetize the samples, including thermal.

Geochemistry

Headspace gas content of 9 samples taken from Holes U1565A, U1565B, and U1566A was less than 2 ppmv methane. Four interstitial water (IW) samples and the two mudlines taken from Site U1565, and the mudline sample and two IW samples taken from Hole U1566A, were analyzed.

No further IW measurements were made once basement granite or basalt was reached. Total carbon (TC), nitrogen, sulfur, and hydrogen were determined by elemental analyzer, and total inorganic carbon (TIC) was determined by coulometer (six samples from Hole U1565B). Organic carbon was inferred by measuring the difference between TC and TIC. Hard rock samples from Holes U1565B and U1566A were measured for major and minor element analysis, and the samples are being prepared for analysis by inductively coupled plasma–atomic emission spectroscopy.

All natural gamma radiation (NGR) measurements collected on the whole-round cores were converted into K, Th, and U concentrations. The geochemistry team used the collected data to create figures and to write the report for Site U1565, and started to write the Site U1566 report.

Physical Properties and Downhole Measurements

The physical properties team undertook an extensive suite of geophysical and petrophysical analyses of core materials retrieved from Holes U1565A, U1565B, and U1566A. The workflow routine continues to be refined and optimized to meet the range of core properties to be measured and to cope with the limited manpower in the laboratory. All whole-round core sections of sufficient length were measured using the Whole-Round Multisensor Logger (WRMSL), X-ray, and NGR systems with the help of JRSO technicians. Calibration tests were carried out for the gamma ray attenuation density logger of the WRMSL logger. Core diameters for key lithologies were measured and tested against previously used corrections to appraise the standard approach (errors within ~5%). It was noted that the Gantry *P*-wave X-caliper system gave far superior signals and results when run on individual pieces of half-core without the core liner. We implemented this procedure for all hard rock core and collected multiple data points for each hard rock core section (typically 3–8 samples).

Sampling of shallow sediments for V_P measurements were done at every core section. An ambitious program of discrete sample measurements including MAD (at least one per section) was carried out with hard rock cubes collected and shared with the paleomagnetics team (prior to

drying). The Gantry X-Caliper tool has been used to measure velocity in three orientations on discrete cubes. Density measurements were made with the method C and D of the MAD entry system. We followed the standard MAD processing methods; however, we performed several additional tests to assess the sensitivities of the methodology for hard rocks such as granite and consolidated sediments. Thermal conductivity was performed via probe for the recent sediments at all holes, whereas measurement on half-round sections was undertaken for one sample every core.

The team continues to measure core material from Hole U1566A. The physical properties team was also aided by the shipboard geochemists to keep up the pace with the extensive analytical workflow.

Logging was initiated at the end of the week and the physical properties team is engaged in discussions with the Co-Chief Scientists, Staff Scientist, Schlumberger Logging Engineer, and the JRSO Operations Superintendent regarding optimal and principal logging objectives. Four wireline logging runs were completed without operational problems: A modified triple combo, the Versatile Seismic Imager, the Formation MicroScanner (FMS-sonic) and the Ultrasonic Borehole Imager (UBI). The pipe was set at 50 mbsf, and a bridge prevented the tool from proceeding deeper than 145 mbsf. Vertical seismic profile data were typically noisy as the pipe generated acoustic noise due to ship heave. In total, the logging operations lasted for 28.25 h. Data were sent to Lamont-Doherty Earth Observatory at Columbia University for postprocessing.

Education and Outreach

This week we held one YouTube Live event hosted by members of the science party. Routine postings to social media continued.

Technical Support and HSE Activities

The JRSO technical staff were engaged in port call logistics, cruise planning, and safety training.

Laboratory Activities

- JRSO staff received and processed RCB cores from Sites U1565 and U1566 and helped the scientists throughout the laboratories.
- The light bulb of the Section Half Imaging Logger (SHMSL) was replaced and resulted in high white background integration time. To remediate this, the light source was replaced, and the integration time went down to an acceptable range. The shutter on the original light source was found stuck partially closed.
- The Special Task Multisensor Logger (STMSL)/X-ray Imager track motor stalled while using the IMS samples loading function. The belt motor was tightened but no

improvement was noted. After the home and top of the core positions were redefined in IMS, the loading function started working properly.

- The SHMSL Mut failed to upload data while reporting a missing sample ID error. After rebooting the system, we found that the user login credential was expired. The login credential was reset and Mut started to function properly.
- The Spex shatter box failed to start. The Siem Offshore electronics department was solicited to help troubleshoot the equipment. Four issues were found and repaired.
- Performed inventory on vacuum pumps.

IT Support Activities

- The X-ray diffraction data from Aries are uploaded to LIMS in a file format that currently cannot be opened on the computers near the smear slide station. These files have to be converted to a .xy file type in order to be read in the EVA software.

Developer Support Activities

- The 360 Image quadrant files were not showing in LIVE. The Applications Developer made changes to make the files become available in LIVE before the composite can be loaded. Staff can now use LIVE to check if 360 images are completed before splitting cores while the Imaging Specialist is off shift.

Health and Safety Activities

- An abandon ship and fire drill was held at 1300 h on 22 August.