IODP Expedition 375: Hikurangi Subduction Margin

Week 3 Report (18–24 March 2018)

Operations

This week we completed coring and started observatory operations at Site U1518.

Hole U1518F

Coring continued in Hole U1518F. Cores 8R–32R penetrated from 255.2 to 494.9 m with 44% recovery. Nonmagnetic core barrels were used for all cores. Coring was terminated so that observatory operations could start based on a forecast of deteriorating weather conditions. The bit was raised from the seafloor and reached the rig floor at 0110 h on 20 March 2018, ending Hole U1518F.

Hole U1518G

The vessel was offset 35 m north of Hole U1518F (and 5 m south of Hole U1518B). This offset is based on the fault depths indicated by the logging-while-drilling (LWD) data collected during Expedition 372 and the core data collected during Expedition 375. A reentry system consisting of a reentry cone and a mud skirt was moved to the center of the moonpool. A bottom-hole assembly with a 14¾ inch drill bit was lowered to the seafloor.

Drilling in Hole U1518G was started at 1050 h on 20 March 2018 and continued until the bit reached 433 m at 0230 h on 22 March. A 40-barrel mud sweep was circulated to clean the hole of cuttings, and the bit was raised to 53 m below the seafloor. At 0430 h, the reentry cone and its base were released from the moonpool and allowed to free-fall down the drill string to the seafloor. After the subsea camera was deployed to check that the reentry cone had landed properly, we pulled the drill string out of the hole at 0615 h and tagged the top of the reentry cone to check the seafloor depth. With this new information, the scientists made a final adjustment to the depth of the observatory's middle screen that will span the fault zone. The subsea camera was brought to the surface at 0745 h, and we continued to recover the drill string until the bit cleared the rig floor at 1320 h.

The next several hours were spent connecting the observatory wellhead to the hydraulic release tool (HRT) and securing them in the derrick. An umbilical reel consisting of three ¼ inch diameter stainless steel tubes was placed near the moonpool, and the area was staged to attach the umbilical to the casing and wellhead. At 2000 h, we started assembling the 422 m long ACORK casing string. Its primary components are 31 joints of 10¾ inch casing, two shorter (pup) joints used to adjust the total length, a casing shoe joint, three casing joints with pressure screens, and the umbilical secured on the outside of the casing. As the ACORK casing string was assembled from the bottom up, the umbilical was connected first to the bottom 2 m screen, then to the 8 m screen wrapped around a perforated joint of casing, and finally to the top 2 m screen. The three screens are positioned at 393, 323, and 218 m, respectively, to monitor pressure from below the fault, the fault zone, and above the fault. Assembly of the casing string was completed at 1700 h on March 23 and landed in the moonpool.

Next, we started assembling the drilling assembly to help get the casing into the predrilled hole. The drilling assembly was composed of a 9⅞ inch drill bit, an underreamer to clear any obstacles in the predrilled hole, and a mud motor to rotate the bit and underreamer in isolation from the ACORK casing. The underreamer arms were tested at 1915 h on March 23, and the drilling assembly was completed and landed inside the casing at 2130 h.

The umbilical was connected to the valves and loggers on the ACORK wellhead at 0400 h on 24 March, the wellhead was submerged briefly with the valves in the open position to purge the lines of air, and the wellhead was brought back to the surface to set the valves to their deployment (closed) position. The wellhead was submerged for the last time at 0510 h and the entire assembly with the HRT running tool, wellhead, ACORK casing and umbilicals, and drilling assembly was lowered to the seafloor between 0615 and 1030 h on 24 March. The subsea camera was then lowered to the seafloor to assist with the reentry of Hole U1518G. During our attempt to reenter Hole U1518G, unexpected heave caused the bit to hit the reentry cone at 1215 h. This resulted in the cone being offset from the hole, making reentry into the predrilled hole impossible.

Hole U1518H

With the underreamer and drill bit inside of the ACORK casing, we decided to drill in the ACORK assembly at the new location of the reentry cone. Hole U1518H was started at 1245 h on 24 March at a distance of ~7 m northeast (032°) from Hole U1518G. By midnight and the end of the week, the drill bit had reached 257 m.

Science Results

Science activities during Week 3 included finalizing the drafts of the Methods sections for the expedition *Proceedings,* processing and measurements of Site U1518 core sections and shipboard samples, and collecting personal samples for postcruise research.

Lithostratigraphy

Cores U1518E-23F to 32X consist of mudstone alternating with thin sandy silt layers. The silt beds display moderate sorting, ripple cross-laminae, and plane-parallel laminae. Cores U1518F-2R to 12R have the same lithology but show an increase in tectonic deformation features.

The facies change from the hanging wall to the footwall (between Cores 12R and 13R) is subtle. Cores 13R to 19R consist of alternating mudstone and nannofossil-bearing mudstone layers that show extensive deformation. Thin, silt-rich beds are sparse but display erosional bases and cross laminae. Poor recovery of the silty beds hampers reliable analysis of their distribution relative to interpretations of LWD data over the same depth interval.

Chaotic disruption of beds increases between Cores 20R and 30R. Manifestations of soft-sediment deformation include contorted bedding with widely varying dips, fragmentation of beds, ductile flow, and incorporation of lighter mudstone clasts in a darker mudstone matrix. Provisional interpretation relates the soft-sediment disruption to mass transport processes.

Finally, Cores 31R–32R consist of alternating siltstone and mudstone, but with a noticeable reduction of disturbed mudstone clasts. Silt laminae are common at biscuit contacts, indicating that the beds were thicker in situ but were only partially recovered. Bioturbation varies from slight to moderate.

Biostratigraphy

Site U1518

Planktonic foraminifers and calcareous nannofossils show a change in age between Cores U1518F-12R and 13R, with an older Pleistocene sequence (>0.52 Ma) in the hanging wall and a younger Pleistocene sequence (<0.52 Ma) in the footwall. Biostratigraphic dating is consistent with the inferred magnetostratigraphy, even though reworking continues to be a problem, especially for calcareous nannofossils.

Site U1517 (Expedition 372)

Preliminary planktonic foraminifer dating of core samples previously obtained on Expedition 372 suggests that the cored sequence down to the bottom of Hole U1517C is no older than mid-Pleistocene (<0.54 Ma). Reworking is common.

Paleomagnetism

Paleomagnetic investigations focused on constraining a magnetic polarity record. We completed measurements of archive-half core sections from Holes U1518E and U1518F and started demagnetization and rock magnetic experiments of discrete samples from working-half core sections. The upper sediments yield negative inclinations, which are consistent with normal polarity near the seafloor. A reversal boundary at ~125 mbsf has been interpreted as the transition from the Bruhnes normal polarity chron to the Matuyama reversed polarity chron (C1n–C1r.1r). The base of C1r.1r is transitional and has been positioned at ~200 mbsf, in the drilled interval between Holes U1518E and U1518F.

A large proportion of the discrete samples subjected to alternating field (AF) demagnetization were affected by the acquisition of a gyro-remanent magnetization (GRM), which manifests in the growth of a strong overprint that is aligned roughly perpendicular to the direction of the applied field in the demagnetizer. The GRM overprint is indicative of authigenic greigite as one of the magnetic carriers. However, we have developed a method that will allow us to separate the GRM overprint from the primary remanent magnetization.

Structural Geology

The rotary core barel (RCB) cores recovered from Hole U1518F preserve a suite of deformation structures spanning the lower hanging wall, main fault zone, and footwall. Gently to in steeply dipping beds are observed within the hanging wall, including locally overturned beds. These are crosscut by steeply dipping fractures that occur with increasing frequency closer to the fault zone. Rare normal faults are also preserved.

The main fault zone is recognized by the onset of intense brecciation and the occurrence of ductile shear zones in soft sediments. Several of these deformed zones are overprinted by brittle structures.

The footwall of the fault is characterized by relatively undeformed hemipelagic sediments with modest dips, and a few normal faults and fractures. This package is cut by another zone of more intense deformation and brecciation in Cores 18R–19R. Below this, bedding dips are generally gentle and deformation structures are sparse.

Geochemistry

We processed 82 whole-round (WR) pore water samples from Site U1518 and analyzed them for salinity, alkalinity, and chlorinity in near-real time. Headspace hydrocarbon samples were collected from two sections per core and void gases were sampled where present, mainly within the upper 175 m. Headspace and void gas was also analyzed for methane, ethane, and propane concentrations in near real-time.

Pore water samples were subdivided and preserved for a range of shore-based and shipboard chemical analyses. Samples were analyzed shipboard for Ca, Mg, K, Na, SO_4, and Br concentrations via ion chromatography; PO_4, NH_4, and H_4SiO_4 concentrations by colorimetry; and Ca, Mg, Na, K, B, Fe, Mn, and P concentrations via inductively coupled plasma–atomic emission spectroscopy (ICP-AES). There were problems with the lithium concentration analyses on the shipboard ICP-AES, and the shipboard geochemists and technicians are currently troubleshooting the issue. Minor contamination from drilling fluid during extended core barrel (XCB) and RCB coring was corrected based on analysis of the drilling fluid composition and the presence of sulfate in the pore water samples below the sulfate–methane transition. We finished the sediment total carbon, $CaCO_3$, organic carbon, and total nitrogen analyses.

Each core below 50 m was scanned with an infrared (IR) camera on the catwalk to identify the presence of methane hydrates, indicated by anomalously cold sections resulting from endothermic methane hydrate dissociation during core recovery. Based on this information, we collected and processed two WR samples spanning IR anomalies to quantify methane hydrate concentrations. These pore water-based estimates will be useful for comparison with methane hydrate saturations calculated from Expedition 372 LWD resistivity data.

Physical Properties and Downhole Measurements

In Holes U1518E and U1518F, porosity decreases from 65% to 50% within the upper 50 m below seafloor (mbsf). Between 50 and 500 mbsf, porosity is nearly constant with depth, ranging from 40%–50%. Increases in porosity with depth are clearly observed at 290–320 and 350–360 mbsf, coincident with depth ranges where extensive deformation is observed. Thermal conductivity is nearly constant from 0 to 500 mbsf with an average of 1.4 W/(m·K). Combined with downhole formation temperature (APCT-3) measurements, heat flow is estimated at 77 mW/m^2 and the temperature at 290–320 mbsf is estimated at 18°–19°C.

Core-Log-Seismic Integration

Efforts focused on continuing to integrate core measurements and descriptions from Holes U1518E and U1518F, LWD logs acquired at Hole U1518B during Expedition 372, and drilling parameters at all holes. The LWD data provide some insight into the characteristics and lithology of portions of the hole where RCB core recovery was poor. A preliminary correlation between Hole U1518B LWD data and Hole U1518F coring data (located 40 m apart), combined with a new seafloor depth estimate at Hole U1518B, suggests that analogous features in Holes U1518B and U1518F may be ~20 m apart in depth, with features in the cores located shallower than features in the LWD data. Analysis of seismic reflection data across the site is ongoing, currently focused on creating new synthetic seismic traces to tie logging and seismic data together.

Observatory

Before installing the ACORK at Site U1518, we reprogrammed the pressure logger to record at a 60 s sampling rate, and ensured all was operational just prior to deployment of the pressure sensors and logger on the ACORK wellhead. In preparation for deploying the CORK-II osmo and thermistor string, we completed all rope splices except for the final end loop, programmed the three weak links to their planned tensile strength by weaving through them with polypro, remeasured the lengths of each individual component, and calculated final placements and rope lengths appropriate for the designated fault target depth. We then started working on handling procedures and the detailed plan for deployment of the CORK-II instrument string.

Education and Outreach

Live Broadcasts

This week we conducted nine live broadcasts with schools in France, New Zealand, and the United States. These reached 340 people, from adults to children as young as five years old.

Social Media

We posted photos and videos (see below) on Facebook (https://www.facebook.com/joidesresolution), Twitter (https://twitter.com/TheJR), and Instagram (http://instagram.com/joides_resolution). Facebook statistics show that a total of 18,018 people were reached and we added 70 new followers. Twitter had 3,950 followers and Instagram had 1,066 followers.

Videos

Video footage was collected on core receiving, how the osmotic sampler experiments work, structural geology, casing and umbilical assembly, ACORK descent, and tours. Work continued on a longer Expedition 375 video with interviews and animations. Videos showing Core Receiving, the Life Cycle of a Core, Sampling of Cores, Reentry Cone Deployment, and Welding were posted on Facebook, YouTube, and in some of the blogs listed below. The Sampling of Cores video has reached 11,000 people.

Blogs

We posted several blogs to “Ship’s log” (on http://joidesresolution.org) on “Hikurangi,” “Core Science #1—What is coring and what does it tell us,” and “Core Science #2—Sampling the cores.” In addition, a blog was written for Science Learning Hub, a New Zealand science teaching web site, at https://www.sciencelearn.org.nz/resources/2592-hikurangi-subduction-zone-expedition-375-blog-1.

Postexpedition projects

Two interviews were recorded for a podcast project.

Technical Support and HSE Activities

The following technical support activities took place during Week 3.

Laboratory Activities

- Processed cores from Holes U1518F.
- Assisted in the assembly of the Site U1518 ACORK.
- Assisted scientists with diagnosing moisture and density (MAD) grain density deviations that were observed for different pycnometer cells.
- Replaced a hydraulic pump in one of the Carver pore water squeezing stations.
- Removed the X-ray diffraction (XRD) detector and controller after consultation with Bruker and prepared to send them to shore for repair via a work boat already scheduled to deliver items to the ship.

Application Support Activities

- Continued work on Cahn Balance program.
- Worked with Physical Property technician and Structural Geologist to obtain QA/QC report.
- Assisted staff with visual core description (VCD) printing utility.
- Discussed modifications of the Thermal Conductivity (TCON) uploader and LORE report with the Expedition Project Manager.

IT Support Activities

- Provided routine support to scientists and technicians and performed system maintenance.
- Received Petrel user guides from shore and delivered them to scientists.
- Resolved a 2 h loss of internet connectivity caused by a router upgrade at Texas A&M University.

HSE Activities

- The IODP JRSO technical staff Marine Emergency Training Squad (METS) participated in the fire drill as observers of the ship's emergency response procedures and teams.
- Held the weekly fire and boat drill as scheduled.
- Tested safety showers and eye wash stations.