IODP Expeditions 367 and 368: South China Sea Rifted Margin

Expedition 368 Week 2 Report (16–22 April 2017)

The second week of the IODP South China Sea Expedition 368 consisted of (a) continued advanced piston corer (APC) and extended core barrel (XCB) coring to final total depths of 9.5 m in Holes U1501A and U1501B, and 461.9 m in Hole U1501C, (b) an 11 h repair to the drawworks, and (c) rotary core barrel (RCB) coring from 433.5 to 625.21 m in Hole U1501D. All times in this report are in ship local time (the same as in Hong Kong, UTC + 8 h).

Operations

This week began while spudding Hole U1501B from 2863 mbrf at 0100 h on 16 April. Core 1H recovered 9.83 m of sediment. The full core barrel suggested that the APC was fired at or below the seafloor for a second time, so we decided to terminate the hole and attempt to recover a better mudline core that would provide a reliable seafloor depth. The vessel was offset 10 m to the east of the site coordinates and the bit was raised to 2843 mbrf in an attempt to start Hole U1501C, but the core barrel was retrieved empty. We then lowered the bit to 2848 mbrf for a second spud attempt at 0300 h, and another empty core barrel was retrieved. We lowered the bit to 2856.4 mbrf and Hole U1501C was successfully spudded at 0510 h, recovering 9.3 m of core and establishing a seafloor depth at 2856.7 mbrf (2845.8 mbsl).

Hole U1501C was cored to 156.8 mbsf using the full length APC coring system. The half-length advanced piston corer (HLAPC) was deployed to deepen the hole to HLAPC refusal at 257 mbsf. We changed to the XCB system and deepened the hole to a final depth of 469.1 mbsf. Nonmagnetic core barrels were used on all cores. All full-length APC cores were oriented using the IceField tool. The APC system recovered 156.5 m of core (99.8%). Temperature measurements were taken on Cores U1501C-5H (47.3 m), 8H (75.8 m), 11H (104.3 m), and 14H (132.8 m). Partial strokes were recorded on Cores U1501C-16H and 17H (151.8 and 156.8 m, respectively). The HLAPC system cored an interval of 100.2 m with 88.54 m of recovery (88.4%). Partial strokes were recorded on Cores U1501C-22F (180.3 m), and Cores U1501C-25F through U1501C-39F (189.7–257 m). The bit was advanced 4.7 m after each core despite the partial strokes. The bit was advanced 1.5 m after Core U1501C-39F.

The XCB system was deployed to core to refusal, recovering 199.5 m (97.4%). A hard layer was met at 383.5 mbsf (Core 53X) and a small piece of sandstone was recovered in the cutting shoe after retrieving the core barrel. Core recovery after that consisted of mudstone. Three more hard layers were found at 447.1, 454, and 460 mbsf. Refusal was reached after no advancement was accomplished for approximately 10 min at 469.1 mbsf. There were no indications that casing would be needed to core deeper using the RCB system at this site. The bit was then retrieved to

the rig floor, clearing the rotary table at 1420 h. Overall, 62 cores were taken over a 461.9 m interval with 444.8 m of recovery (96.3%). Time spent on Hole U1501C was 84.75 h or 3.5 d.

The APC/XCB components of the bottom-hole assembly (BHA) were laid out and secured. The vessel was offset 20 m to the west of Hole U1501C. While making up the RCB BHA, a leak was detected in the low clutch diaphragm, and the crew started repairs immediately. The diaphragm was replaced and operational in 11 h. Once the diaphragm was online by 0500 h on 20 April, the core barrels were prepared and spaced out, and the assembly of the RCB BHA was completed. The drill string was run into the hole to 2816 mbrf. The top drive was picked up and the bit spaced out to spud Hole U1501D.

Hole U1501D was drilled without coring to a depth of 433.5 mbsf and the center bit was retrieved. An RCB core barrel was dropped and coring began from that depth. A zone of fast penetration and very low recovery was encountered from 510.2 to 558.2 mbsf, which was inferred to be unconsolidated sands with occasional thin sandstone layers. Drilling slowed and recovery increased to approximately 50% when a section of mudstone was encountered from 558.2 to 606.1 mbsf. At 606.1 mbsf, the rate of penetration dropped to under 2 m/h, but recovery increased to 95%. By midnight on 22 April, Hole U1501D was cored to a depth of 625.2 mbsf (Core 23R).

Science Results

This week scientists acquired and analyzed data from Holes U1501A, U1501B, U1501C, and U1501D, and began summarizing their results for presentations and reports. On 21 April we held a meeting for our Expedition 368 laboratory groups to present a summary of the data for Holes U1501A–U1501C. At this meeting, we hosted ~10 scientists from the previous South China Sea Expedition 367, who joined the meeting using the shipboard videoconferencing tools.

Lithostratigraphy

Cores from Holes U1501A–U1501C and most of Hole U1501D (Cores 2R–20R) were described using a combination of visual core description (VCD), microscope inspection of smear slides, core imaging, and core scanning for color spectra and magnetic susceptibility. The sedimentary sequence sampled in Holes U1501A–U1501C has been divided into two lithologic units. Unit I (Intervals U1501C-1H-1, 0 cm, through 45X-1, 51 cm) is dominated by greenish gray to light brownish gray clay-rich nannofossil ooze and nannofossil ooze with clay. Grain size is generally well sorted. Bioturbation ranges from moderate to heavy. One ash layer was observed in Section U1501A-1H, and a small patch of ash was observed at an approximately equivalent depth in Section U1501C-3H. Unit II (Intervals U1501C-45X-1, 51 cm, through 62X-CC) consists of carbonate-poor silty clay to unconsolidated sand and sandstone with abundant glauconite and mollusk shell fragments. Several sandy intervals show fining upward sequences. The contact

between Units I and II is abrupt with a sharp color change, which is interpreted as an erosive surface and abrupt transition from hemipelagic to pelagic conditions. Small offset normal faults can be observed in Unit II, while Unit I is basically devoid of any deformation structures. XCB coring disturbance (e.g., biscuiting) was pervasive in nearly all XCB cores (Core U1501C-40X to 62X).

By the end of the week, RCB coring of Hole U1501D had sampled from 433.5 to 586.6 m. The sedimentary sequence consists of alternating unconsolidated clayey silt with sand and silty sand with abundant quartz, glauconite, and small shell fragments in Cores 2R and 3R; fine- to coarse-grained sandstone, with cobble-size clasts, abundant quartz, and occasional small mollusk shell fragments, benthic foraminifers, and ostracods in Cores 4R and 5R; and interbedded calcite-rich fine- to coarse-grained sandstone with abundant quartz and dark gray organic-rich, slightly lithified clayey silt with occasional lignite in Cores 6R to 18R. Cores 19R to 20R contain poorly sorted feldspar-rich coarse-grained sandstone.

Biostratigraphy

The paleontology team examined ~84 core catchers from Site U1501 for planktonic foraminifera, calcareous nannofossils, and diatom biostratigraphic studies. Additionally, toothpick samples were taken from selected intervals of the working-half cores to refine the biostratigraphic model. Foraminifer and nannofossil preservation is moderate to good in Holes U1501A–U1501C, with some samples containing reworked species; it ranges from moderate to poor, and mostly barren, in the core catcher samples from Hole U1501D. Diatoms were found only in the uppermost five core catchers in Holes U1501A–U1501C, and in some burrows deeper in the succession. An age-depth model was created for the upper 458 m of Hole U1501C using 14 planktonic foraminiferal and 24 calcareous nannofossil bioevents. The biostratigraphic results suggest that the sequence recovered in Hole U1501C spans from the late Eocene to the late Pleistocene. An age determination for Hole U1501D has not been possible because all core catchers studied are barren of planktonic microfossils.

Paleomagnetism

All the archive-half cores from Holes U1501A, U1501B, and U1501C (Cores 1H–48X) have been measured on the superconducting rock magnetometer (SRM) at a 2.5 cm measurement spacing. After measuring the natural remanent magnetization (NRM), the cores were subjected to a series of step-wise in-line alternating field (AF) demagnetization steps at 5, 10, 15, and 25 mT. Due to the high rate of recovery, only three demagnetization steps (5, 15, and 25 mT) were performed after Section U1501C-7H-4. Due to low magnetic intensity of the cores, only NRM was measured starting from Section U1501C-44X-3A. Declinations from Holes U1501A, U1501B, and Cores 1H through 17H from Hole U1501C were corrected using orientation data acquired with the IceField tool. Inclination and declination were plotted against depth to determine a preliminary magnetostratigraphy. A peak in magnetic properties corresponds to an ash layer in Section U1501A-1H-7. Discrete samples were taken from each even section for

Holes U1501A–U1501C, taking two specimens from each sampled section to perform and compare results of AF and thermal demagnetization. A total of 262 samples were collected: eight from Hole U1501A, eight from Hole U1501B, and 246 from Hole U1501C (70 of which were taken for thermal demagnetization). We stopped collecting samples for thermal demagnetization after Core U1501C-21F. After measuring the NRM, AF magnetization was performed on 100 samples at 5, 10, 20, 30, 40, and 50 mT using the DTECH AF demagnetizer.

We calculated the characteristic remanent magnetization (ChRM) for discrete samples from Holes U1501A, U1501B, and U1501C (down to Core U1501C-33F) using the PuffinPlot software and principal component analysis. Adding the discrete sample inclinations to the depth plots allowed us to validate the polarity observed in the core sections with the SRM data. For Hole U1501C we have developed an age-depth model in conjunction with the paleontology group. The paleomagnetic and paleontological ages match well. We were able to determine polarity for the interval above 162 mbsf where we have constraints based on both inclination and declination.

Geochemistry

Headspace gas samples were collected from each core for routine safety program, but methane levels were below the detection limit. We collected a total of 45 interstitial water samples and split each sample into aliquots for shipboard and postcruise work. All the shipboard analyses, except minor element measurements by ICP-AES, were competed. Alkalinity, sulfate, phosphate, and ammonia concentrations decrease with depth in the upper 50 m, indicating the degradation of organic matter. Sharp decreases in Na, Cl, and Br concentration below 300 m suggest fluid migration in the sandy layers. Sediment samples for carbonate, TOC, and TN content, and major and minor element analysis were collected, and analyses are ongoing.

Physical Properties

The petrophysics group measured bulk density, *P*-wave velocity, magnetic susceptibility (MS), and natural gamma radiation (NGR) on all cores recovered from Site U1501. One thermal conductivity measurement per core on the whole-round sections was conducted down to Core U1501C-51X. Four formation temperature measurements (APCT-3) were made in the uppermost part of the sediments, which can be used together with the thermal conductivity measurements to calculate the thermal gradients and to estimate heat flow values.

The section-half velocity measurements using the Y and Z gantry bayonets on the section halves were stopped when the cored sediments became too brittle at Core U1501C-23F. We made *P*-wave velocity measurements on hard rock samples without core liners and on discrete samples (shared with moisture and density [MAD] measurements) as needed. Our results show:

- An overall increase of *P*-wave velocity with depth (from 1451 m/s at the surface to 2460 m/s at 457 m);

- A smooth increase of bulk density with depth (from 1.37 g/cm^3 at the surface to 2.1 g/cm^3 at 451 m in Hole U1501C);
- Lower NGR for the upper carbonate ooze unit compared to the underlying clay-rich layers below ~300 m in Hole U1501C;
- An overall decrease in porosity with depth;
- A gradual increase in MS from the seafloor to ~180 m, follow by an abrupt drop and then low, constant values to the base of Hole U1501C.

Formation temperature measurements provide a thermal gradient of 81.4°/km, and a heat flow value of ~100 mW/m^2.

Education and Outreach

The U.S. Education/Outreach Officer spent the week conducting live broadcasts (five schools in the U.S. and one in Italy), scheduling future education and outreach broadcasts, coordinating scientists' blogs, and publishing blogs, stories, videos (one for National High Five day), and pictures about Expedition 368 at http://joidesresolution.org, and on social media (Facebook (https://www.facebook.com/joidesresolution), Instagram (http://instagram.com/joides_resolution), and Twitter (https://twitter.com/TheJR, #exp368). Two short promotional videos and one scientist interview were produced about the expedition. Together with the two journalists from China, they started scientists' interviews for blog posts by developing and providing questions. The Chinese journalists produced several news media pieces including news articles, broadcasts, and daily diary columns. One article was published on the first page of Science and Technology Daily on 18 April. In addition, they took drone footage of the ship and edited a clip for use in promotional videos that they shared with the U.S. educator. They also posted blogs and news on Weibo, the Chinese microblogging website, and produced and broadcast several videos, including short TV news reports for SMG News in China.

Technical Support and HSE Activities

Port Call Activities

Crew crossover and freight logistics were completed without issue. In addition to normal port call activities, a service call and several repairs were made and are described below.

Laboratory Activities

- The new *P*-wave logger hardware has been assembled and is being tested on the special task whole-round multisensor track.

- The hardware for the planned check shot survey has been assembled and is ready for the upcoming downhole measurements.

Application and IT Support Activities

- Code changes to software requested by 2G during port call service of the superconducting rock magnetometer inadvertently introduced a bug, which was identified and corrected.
- An error in the code extracting the RGB data from core images was recognized and repaired. We are working on the process to correct past day, which also includes the previous expedition.
- Designed Coulometer controller and workflow, and created documentation for the design.
- Changed LORE–SRM expanded report to include additional components.
- Worked on close-up, photomicrograph, and thin section image tiling automation process.
- Fixed a bug in LIVE that prevented the view of core catchers when recovery is over 100%.

HSE Activities

- The weekly fire and boat drill was held as scheduled.