IODP Expeditions 367 and 368: South China Sea Rifted Margin

Expedition 368 Week 5 Report (7–13 May 2017)

The fifth week of the IODP South China Sea Expedition 368 consisted of rotary core barrel (RCB) coring and downhole logging operations in Hole U1502B. All times in this report are in ship local time (the same as in Hong Kong, UTC + 8 h).

Operations

This week started while recovering RCB Core U1502B-16R from 825.1 m. RCB coring continued in Hole U1502B through Core 21R (846.8 m) when the driller noticed significant torque on bottom. With the bit already at 48.8 h, it was decided to round trip the pipe and change bits. While recovering the drill string, the driller experienced an overpull of 60 klb between 740.3 and 728.3 m. The interval was reamed several times before pulling the bit into the casing. The underwater camera system was deployed when the bit reached 27.3 m to verify that the reentry cone was visible, and it was, but the cone was filled with cuttings. The driller circulated for about 20 min and cleared the cone. The camera was recovered and the bit was raised to the surface, clearing the rotary table at 1345 h on 8 May.

A new 9⅞ inch RCB bit and mechanical bit release were made up to the bottom-hole assembly and the core barrels were spaced out. The bit was then run back down to the seafloor, followed by the subsea camera, for reentry. The cone was clearly visible and Hole U1502B was reentered at 0240 h on 9 May. The bit was lowered into the hole to 728.3 m where it began taking weight. The top drive was picked up and a center bit was deployed. The bit was worked easily to the bottom of the hole. A mud sweep was circulated and the center bit was retrieved prior to resuming coring operations.

Coring continued to 858.4 m when the low clutch diaphragm failed for a second time on the expedition at 0115 h on 10 May. The bit was pulled to inside the casing to a depth of 715.3 m and the drill pipe was hung off the elevators. The clutch diaphragm was replaced and the drill string was lowered again by 0945 h on 10 May.

The driller noticed a spike in pressure while running in hole and a deplugger was dropped to clear any obstruction in the bit. The deplugger was retrieved and a center bit was deployed so that the bit could be worked to the bottom of the hole. Three meters of fill were cleared before reaching the total depth of the hole. Then the center bit was recovered and coring resumed from 858.4 m (Core U1502B-25R) to a final depth of 920.8 m (Core U1502B-37R). Recovery was generally high over this interval (82% to 101%), except for Cores U1502B-28R and 29R, which had a recovery of only 33% and 45%, and a higher rate of penetration of 2.76 and 375 m/hr, respectively. Following this, the hole was prepared for logging operations by circulating a high

viscosity mud sweep and performing a wiper trip. The bit was then released in the bottom of the hole and the end of pipe was raised to a logging depth of 747.3 m. This was done to ensure that the logging tools could bypass obstructions encountered by the bit when reentering the hole below casing.

A modified triple combo tool string, with the sonic tool added, was assembled and deployed on 13 May at 0200 h. The tool string tagged fill approximately 40 m above the total cored depth of the hole. The hole was logged from that point up. The logging string was then recovered to the surface at 1050 h, and the Versatile Seismic Imager (VSI) was rigged up; with the Protected Species Observers on watch, it was deployed to conduct seismic check shots at 1445 h. The VSI was lowered through the casing but could only reach 3 m past the casing shoe. Six check shots were conducted successfully inside the 10¾ inch casing between 630 and 290 m. Check shots below 690 m were not attempted because of poor coupling of the casing with the formation, as determined by the gamma ray logs. The tool string was then recovered to surface and laid out. The Schlumberger equipment was then rigged down and the crew began recovering the drill string. The bit cleared the seafloor at 2235 h on 13 May.

A total of 36 RCB cores in Hole U1502B penetrated from 727.7 to 920.8 m and recovered 126.9 m (66%).

Science Results

Scientists continued acquiring and analyzing data from Site U1502, and documenting these results in their site reports. They presented their latest findings in daily crossover meetings and lively discussions.

Lithostratigraphy, Petrology, and Structural Geology

Cores U1502B-5R to 37R were described this week and the interval was defined as the Lithostratigraphic Unit VI. The cores predominantly sampled moderately to highly altered basalt. However, the cores show variations in the lava morphology and in the degree and type of chemical and structural alteration of the rocks. Cores U1502B-5R to 13R (748.3 to 810.5 m) show highly brecciated basalts and basaltic breccias with minor occurrences of chert- and claystone clasts. The deformation process governing brecciation is interpreted to represent hydrofracturing, and does not involve major shear movements along the fractures and veins. Cores U1502B-14R to 35R (810.5 to 911.2 m) show highly altered, sparsely to highly plagioclase phyric basalts with alternating intervals dominated by either pillow lava or sheet lava flows. Color variations range from gray to bluish gray in moderately to highly altered basalt, to greenish gray to light greenish gray in the most heavily altered rocks. The last two cores (Cores 36R and 37R) consist of mostly aphyric moderately altered basalts.

Based on the macro- and microscopic observations of the core sections, it was determined that the vein filling, as well as matrix alteration of the rocks consists of minerals such as epidote, chlorite, Ca-, Mg-, and Fe-carbonates, zeolites, sulfides, and clay minerals. This paragenesis is consistent with hydrothermal alteration at greenschist facies conditions between ~300 and 500°C. Abundant polymineralic veins were characterized in terms of frequency, composition, and orientation within the core reference frame, and their true dip angle was calculated. According to predominant mineralogy, five vein categories were established, namely epidote-, silica-, epidote + pyrite-, silica + epidote-, and carbonate + silica veins. Several episodes of veining can be distinguished considering orientations and crosscutting relationships. For example, carbonate + silica veins show shallow dips and consistently crosscut steep epidote veins.

In addition to the visual and microscopic core descriptions, scientists were trained and instructed in the safe use of the handheld X-ray fluorescence (XRF) analyzer, and they began to use this device to carry out systematic chemical analyses on selected core sections.

Biostratigraphy

The micropaleontology team took advantage of a week of hard rock core recovery to revise and expand their shipboard report for Site U1501, finalize the biostratigraphic examination of samples from Site U1502 (which were mostly barren of microfossils), and examine samples from the basal section of Site U1500 (from Expedition 367). They conducted a detailed examination of the benthic and planktonic foraminifera assemblages from Samples U1501C-41X-CC (260 m) through 62X-CC and U1501D-2R-CC through 5R-CC (460 m) to reconstruct the paleobathymetric history of Site U1501. The results, which include a multiproxy approach using the planktonic/total foraminifera ratio, agglutinated benthic foraminiferal abundance, and ostracod records, indicate a stepwise shoaling of the water depth at the site from the late Oligocene to the middle/late Eocene.

Paleomagnetism

All archive section halves from Hole U1502B were measured on the superconducting rock magnetometer (SRM). 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. The demagnetization behaviors primarily depend on degree of alteration of the basaltic rocks. The center of pillow structures tends to display a magnetically softer behavior compared to the rims, which is most likely related to its physically coarser grain size. Magnetic susceptibility (MS) (whole-round and point measurements) shows a prominent decrease toward the margins of pillow structure.

Stepwise demagnetization was conducted on 30 discrete samples of sediments from Hole U1502A (thermal demagnetization) and 52 samples from Hole U1502B (eight thermal and 44 AF). Samples were chosen to represent different lithologies, colors, and physical grain sizes. AF

magnetization has proven to be more effective in basalts from Hole U1502B, likely because the main carrier is a titanomagnetite. The thermal instability of the sedimentary rocks, combined with the lack of paleomagnetic laboratory shielding, prevented the use of thermal demagnetization to determine magnetic polarities. However, basalts from Hole U1502B are characterized by a much stronger NRM at room temperature (three to four orders of magnitude) and yield a stable signal during both AF and thermal magnetization.

Inclination gathered from discrete samples was plotted along inclinations from archive sections in order to validate the SRM measurements. Intervals of normal and reverse polarity are observed and seem to correspond broadly with major lithological units or basaltic flows from Hole U1502B.

Geochemistry

After encountering basalt and detecting no methane in any of the igneous rock samples, headspace gas monitoring was concluded for Hole U1502B. Likewise, interstitial water squeezing was also concluded for the basalt. Preparation for and processing of solid samples for ICP analysis became the main focus of the geochemistry team. Separate principal components analyses (PCA) were applied to sediment and rock data sets from Sites U1502 (Expedition 368) and U1499 (Expedition 367), as well as selected sites from IODP Expedition 349. Relative to the other expeditions, samples from Site U1502 are highly enriched in earth alkalis such as sodium, magnesium, and aluminum. For the rock samples this corresponds well with hydrothermal alteration. Relative to other rock samples, Hole U1502B samples are impoverished in both iron and magnesium.

Physical Properties

Physical properties measurements were performed on Cores U1502B-9R to 37R. MS and natural gamma radiation (NGR) are relatively low throughout this interval, with a mean value of ~30 × 10^{-5} SI and ~5 cps, respectively. However, MS values are as high as 2400–3200 × 10^{-5} SI in Cores U1502B-8R to 19R, 27R to 28R, 33R to 34R, and 36R to 37R. *P*-wave velocity (from ~3.2 to 5.2 km/s) and thermal conductivity (from ~1.8 to 2.4 W/[m·K]) gradually increase with depth (~780–920 m). Bulk density ranges from 2.5 to 2.8 g/cm^3 and porosity from 23% to 15% with increasing depth in Cores of U1502B-9R to 20R. The rock color reflectance and RGB values remain relatively stable throughout the record in Hole U1502B. A time-depth relationship model has been developed for Site U1502, and an initial T-D model for the next site (proposed Site SCSII-9B) has also been established for reference.

Downhole logging was conducted with two tool strings, i.e., a modified triple combo and the VSI. The triple combo reached ~876.0 m (~45 m above the bottom of the hole) and measured borehole sonic velocity, formation density, hole diameter (with caliper), and natural gamma radiation from 876.0 m to the casing shoe at 723.7 m. Following this, the VSI was deployed, and six check shots were successfully conducted inside the casing at 630.3, 590.3, 550.1, 450.3,

350.3, and 290.3 m, recording clear wave forms at all the stations. Two additional check shots were recorded at 715.2 and 695.2 m, but the records show large noise possibly because of poor coupling of the casing with the formation, as suggested by the gamma ray logs. The raw logging data were sent to the Lamont-Doherty Earth Observatory for processing and quality control.

Education and Outreach

The Education/Outreach team continued to interview scientists to create stories for blog posts and other media outlets. They held a brainstorming session for a creative video project with the scientists and began crafting the joint project. They coordinated a Reddit Ask Me Anything with the Expedition Project Manager and onshore support team so that students across the world could ask the shipboard scientists questions. This week the Chinese journalists conducted four broadcasts and reached 142 students in China. As of now the Education/Outreach team has coordinated the outreach to 877 students at schools and universities across the world during this expedition.

The U.S. Education/Outreach Officer scheduled other educational and outreach broadcasts, and communicated them to the crew and scientists through the weekly calendar. She produced blog stories daily and semidaily depending on the broadcast schedule at http://joidesresolution.org. She promoted Expedition 368 on social media (Facebook (https://www.facebook.com/joidesresolution), Instagram (http://instagram.com/joides_resolution), and Twitter (https://twitter.com/TheJR), #exp368). Additionally, she met with several scientists and colleagues for her research for the curriculum development project around microfossils, evolution, and climate change over time.

The Chinese journalists produced several news media pieces including news articles, broadcasts and live education/outreach broadcasts, and daily diary columns. They also posted blogs and news on Weibo, and produced and broadcast several videos, including short TV news reports for SMG News in China, and several articles for Science and Technology Daily.

Technical Support and HSE Activities

Laboratory Activities

- Underway Geophysics: Successfully deployed the seismic sources for vertical seismic profile experiment. Protected species watch was implemented and the seismic sources operated according to policy. No protected species was sighted during operations.
- Logistics: Continued stripping d-tubes out of damaged boxes as space opens up on the top shelf of the core reefer. We still have about 20 boxes left to remove.
- Thin Section Laboratory: Repaired minor plumbing issues.

- Handheld XRF: The handheld XRF was setup in the Downhole Measurements Laboratory, the radiation survey was conducted, and laboratory specific training was given to the science party.

Application and IT Support Activities

- Continued work on Coulometer project:
    - Worked on instrument and data uploader modules.
    - Conducted several meetings with shore developers to coordinate additional work on shore.
    - Revised sections of project management plan and submitted project status report.
- Created new LIVE template at request of scientists.
- Assisted laboratory technicians and Imaging Specialist in creating a user guide for 360° Composite Image Processor.
- Worked with Laboratory Officer to create new web service to retrieve information from IMS_ERROR_CODE table, for use in standardizing and reporting error messages on instrument tracks.
- Participated in biweekly GEODESC meetings.
- The Storage Area Network (SAN) was patched to address excess bandwidth usage.
- The print server was updated with new Windows 10 drivers.
- All Windows workstations and servers were verified to have Microsoft patches applied to mitigate ransomware risks.

HSE Activities

- Held the weekly fire and boat drill as scheduled.
- All safety equipment has been checked.
- Handheld XRF weekly safety survey conducted.