IODP Expeditions 367 and 368: South China Sea Rifted Margin

Expedition 367 Week 8 Report (26 March–1 April 2017)

After rotary core barrel (RCB) coring to 1415.9 m in Hole U1500B at the end of last week, we started this week recovering the drill string to install a new bit to continue coring in basement. Unfortunately, when lowering the new bit into the hole, the drill bit became blocked, and we had to recover the entire drill string again. We resumed RCB coring with the second bit at 1745 h on 29 March. RCB Cores U1500B-62R to 73R penetrated from 1415.9 to 1475.9 m (60.0 m) and recovered 46.4 m (77%) of basalt. As the week ended, we were recovering the drill string to replace the bit again. All times in this report are in ship local time (UTC + 8 h).

Operations

Once the bit was pulled out of Hole U1500B and was just above the seafloor, we paused operations for 2 h to conduct routine rig servicing (drill line slip and cut). We then finished recovering the drill string with the bit arriving on the rig floor in good shape at 0845 h on 26 March. We attached a new RCB bit for basement coring (C-7) and lowered it to the seafloor. Once the bit was at the seafloor along with the camera system, we started searching for the reentry funnel. After a short search, we saw streaks of cuttings on the outside of the mound of drill cuttings around the hole. We moved the bit over the reentry funnel and reentered Hole U1500B at 1755 h. We lowered the bit through the casing (extends to 842 m) and into the open hole below. As we were doing this, we had the float valve shifted into the open position, which allows water to easily pass through the bit. If it’s in the closed position, we have to stop periodically to fill the drill string with water as we lower it. As we lowered the bit, it encountered a bridge at ~1067 m, and sediment appeared to block flow through the bit. We then pulled up and deployed a core barrel to try to clear the obstruction in the bit and to close the float valve so we could wash/drill back down the hole to resume RCB coring.

The core barrel that we dropped to clear the obstruction in the bit did not land properly at the bottom of the drill string. We deployed the core line to retrieve the core barrel and found that it had landed ~42 m above the bottom of the drill string. We made three unsuccessful attempts to pull the core barrel out. We then raised the bit from 1018 m up to 454 m inside the casing (above the top of the weighted mud) but still could not free the core barrel and reestablish circulation. We made two more unsuccessful attempts with the bit at 249 m and then above the seafloor. We decided the only way to fix the problem was to retrieve the entire drill string. At 0000 h on 28 March, the bit had reached 58 m below the rig floor. We spent most of the early morning of 28 March recovering the final parts of the bottom-hole assembly (BHA) on the rig floor, as well as cleaning out sediment (cuttings, sand, etc.) that filled the lowermost ~40 m of the BHA and had worked its way up above the core barrel. At 0700 h on 28 March, we started reassembling the

RCB BHA and lowering it to the seafloor. We deployed the camera system, dropped a core barrel to close the float valve, and started to position the bit over the reentry funnel. We reentered Hole U1500B at 1930 h, recovered the camera system, and lowered the bit down to 804.3 m in the casing. However, at 0045 h on 29 March we discovered a problem with the top drive (one of the counter balance cylinders). After repairing it, at 0400 h on 29 March we resumed lowering the bit. After exiting the base of the casing (842 m) and down into the open hole, the bit started encountering some resistance at ~1066 m. We washed from there back down to the bottom of the hole at 1415.9 m, pumping 30 barrels of mud at 1008, 1115, 1203, 1232.4, and 1300.52 m. At the bottom of the hole, we pumped 35 barrels of weighted (11.0 ppg) mud to clean the cuttings out of this deep hole. We plan to continue using weighted mud in Hole U1500B as we penetrate deeper. We recovered the core barrel that was in place while getting the bit back to bottom (ghost Core 61G, 2.36 m recovered), deployed a fresh core barrel at 1745 h on 29 March, and resumed RCB coring. Core 62R arrived on the rig floor at 2230 h on 29 March after penetrating 2.5 m (1415.9 to 1418.4 m) and recovering 2.36 m (94%). This shorter penetration was necessary to adjust pipe connections at the rig floor.

Although Core 63R recovered 3.6 m of very nice basalt, it took much longer to cut (8 h), and the core pieces had become stuck inside the plastic core liner and in the core catcher sub. It is likely that the recovered material came from the upper part of the cored interval, then jammed, and the rest of the core was ground up, washed away, and never entered the core barrel. This may have also contributed to the slow penetration rate (at least after the core jammed off). Therefore, we decided to cut only half-length cores. Cores 64R to 73R then penetrated from 1428.0 to 1475.9 m and recovered 40.0 m (84%). Although the cores took from 2.3 to 4.7 h to cut, the recovery and core quality of the basalts were excellent.

Since the bit had accumulated 44 h of rotating time, hole conditions remained good, and we planned to continue to core deeper into basement and collect downhole logs, we decided to stop coring to change the bit. After cutting Core 73R, we circulated cuttings out of the hole with two 35 barrel weighted mud sweeps, and raised the bit up to 1387.8 m where we removed the top drive. We then raised the bit up to 1242.1 m and filled the hole with 235 barrels of weighted mud to stabilize it while we changed the bit. Once the mud was in place, we raised the bit up to just below the seafloor (45.7 m) and deployed a secondary reentry (free-fall) funnel on top of the first one that we previously drilled into the seafloor with the casing. This secondary reentry funnel is intended to minimize the large pile of cuttings around the hole falling back in while we continue our Hole U1500B operations. After the funnel was dropped at 2208 h on 1 April, we continued to circulate to minimize the amount of cuttings in the seafloor structure while the secondary funnel landed.

Science Results

This week scientists worked on basement cores from Hole U1500B. The laboratory groups also gave presentations of their Site U1500 summaries on 31 March and 1 April. Scientists from the next Expedition 368 joined the meeting using the shipboard videoconferencing system.

Lithostratigraphy

The lithostratigraphy team assisted the petrologists in describing and scanning the basalts in Lithostratigraphic Unit VIII. We took smear slides from sedimentary rock inclusions within the basalt, which commonly occurred in veins and alongside glass. We identified all smear slides as claystone, though carbonate content increases from low to high with depth. In Section U1500B-66R-3, authigenic calcite and calcareous nannofossils are dominant constituents of the sedimentary rock. We also refined our unit boundaries in the overlying sedimentary section, shifting the transition between Subunits VA and VB from the top of Section U1500B-47R-6 to the top of Section U1500B-46R-1, based on additional carbonate data. Our final XRD samples from Cores U1500B-37R to 59R were analyzed. Although most samples contain dominant quartz and kaolinite + chlorite in sedimentary sections from Units IV to VII, Subunit VB has higher calcite (10%–27%) and Units VI–VII have higher montmorillonite (20%–44%). A brownish claystone inclusion within basalt in Section U1500B-57R-2W (44–47 cm) also contains high quartz (67%) and montmorillonite (29%). In addition, we drafted our Site U1500 chapter and created a presentation of our site results to share with all Expedition 367 and 368 participants.

Igneous Petrology

Core U1500B-62R is made up of sparsely to moderately plagioclase phyric, nonvesicular basalt. Four hypohyaline chilled margins have been identified in this core with the uppermost one (Section 1, Interval 59–62 cm) marking the transition from Subunit 1d to 1e. Subunit 1e is characterized by more frequent glassy chilled margins and an increase in average phenocryst grain size. Cores U1500B-63R to 66R continue with the same phenocryst abundance of plagioclase oikocrysts (up to 20 mm in size) in an ophitic to subophitic groundmass that also contains interstitial oxides and altered glass. Occasionally, phenocrysts of olivine (≤1%) have been identified as well as possibly minor clinopyroxene pheno- or xenocrysts. Cores U1500B-67R and 68R show an increase of plagioclase phenocryst abundance of up to 35%, ranging overall from sparsely to highly phyric. The basalt of these cores shows sparse vesicularity and reveals several glassy margins associated with hyaloclastites and baked sediment, which partially occurs as vein-filling material. However, the major vein constituents are carbonate and iron oxides. Vein haloes are common. Cores 70R to 73R are aphyric to highly phyric basalt with numerous glassy chilled margins that are associated with hyaloclastite. Besides plagioclase, which is the major phenocryst mineral phase (up to 25%) throughout these cores, olivine is also present as minor phenocrysts in Core 70R (from 1%–10%). From Core 72R downhole, the overall abundance of plagioclase phenocrysts decreases again. In all cores, slight to moderate alteration is mainly restricted to veins and surrounding haloes. The textural and structural features of the basalt in Subunit 1e suggest they were emplaced by pillow lava flows.

Geochemistry

Four basalt samples were prepared for ICP-AES analysis this week. Standards, drift standards, and a check standard were prepared as well. In spite of the difficulties fusing the samples, the unknowns have reasonable totals between 97% and 99%. The check standards appear to have reasonable accuracy and precision. Plots of total alkalis versus silica and V versus Ti indicate the basalts are subalkaline, MORB-like in composition.

Biostratigraphy

This week the biostratigraphy group analyzed samples from Cores U1500B-57R to 63R. At the same time, all Hole U1500B micropaleontological data were revised and some additional samples analyzed. The preservation is poor to moderate throughout Hole U1500B and half of the samples are barren. However, new analyses allow a substantial revision of the age assigned to the lowermost sedimentary section because two samples from Core U1500B-56R-1 contain a Middle Miocene foraminiferal assemblage. Two nannofossil samples contain only rare specimens and it is difficult to assign a definitive age. A total of 12 bioevents have been used to construct the age model for this site. The biostratigraphic data suggest that the sediment recovered at Site U1500 spans from Late Miocene to Middle Miocene.

Paleomagnetism

This week we measured the basalts recovered from Cores 57R to 66R of Site U1500. The moment of the natural remanent magnetization (NRM) and the magnetic susceptibility (MS) increase abruptly by several orders of magnitude in the basalts. We fine-tuned the alternate field (AF) treatment steps of the archive-half sections to obtain better quality paleomagnetic data. The steps range from 0 to 10 mT at 2 mT steps and then 5 mT steps from 10 to 25 mT. The demagnetization of the archive-half sections reveals intervals with negative inclinations. To elucidate the demagnetization behavior, we took three discrete samples from Cores 57R, 58R, and 60R, and subjected them to a combination of stepwise AF (up to 10 mT) and thermal demagnetization (at 50°C steps from 100°C to 680°C). The demagnetization of the discrete samples reveals at least three distinct components. The first component (AF treatments below 5–7 mT) is closely related to the drilling overprint; the second component (AF 8 to 10 mT and low temperature steps below 300°C) could clearly constrain whether the sample is reversed or not, but did not reach the endpoint; the third component (300°C to 450°C) is interpreted as the characteristic remanent magnetization (ChRM). At higher demagnetizations, the samples often become scattered and are not reliable for ChRM calculation. Negative inclinations observed in the basalts often coincide with fractures as well as changes in magnetic mineralogy evidenced by a decrease in MS and the effectiveness of AF demagnetization.

Petrophysics

This week, we measured physical properties on Cores U1500B-53R to 68R for whole-round measurements of MS, gamma ray attenuation (GRA) density, and natural gamma radiation (NGR). Split-core measurements of *P*-wave velocity using caliper (PWC) were done up to Core 64R, while those of thermal conductivity (TCON) and moisture and density (MAD) on discrete samples were completed up to Core 60R. The flow of measurements was adjusted for the basalt samples (Cores U1500B-57R to 68R). A few MAD samples were shared with paleomagnetists, and TCON measurements were performed in a seawater bath.

In the calcareous sediments atop the basalt (between 1300 and 1360 m), PWC and MAD bulk density values decrease (2.7 to 2.0 km/s, 2.2 to 2.1 g/cm^3, respectively), whereas NGR, MS, and porosity values increase (40 to 60 cps, 10 to 20 × 10^{-5} SI, 32 vol % to 38 vol%, respectively). Generally, the physical properties measurements in the basalt are consistent with those of previous drill sites (Sites U1431 and U1433). Transition into the basement (at Core U1500-57R) yields a remarkable step in MS values from 20 to 3000 × 10^{-5} SI, while PWC values show an abrupt increase from 2.0 to 5.0 km/s, and up to 5.7 km/s deeper in the section (Core U1500-63R). Density values from GRA measurements also present a notable increase from 2.1 to 2.7 g/cm^3. In contrast, NGR values drop down sharply to less than 10 cps, as well as porosity from MAD measurements decreasing to less than 10% in the basalt. Despite avoiding fractures in the samples, thermal conductivity measurements became more unreliable in the deeper sections, but range from 1.6–1.7 W/(m·K) in the basalt.

We used the PWC values from Site U1500 to calculate the time-depth relation (TDR), which was applied to seismic correlation. The comparison of TDR from Site U1500 with those from Site U1499 and other IODP and ODP sites in the South China Sea shows substantial agreement. The comparison between the seismic reflectors, the variations in physical properties, and lithology characteristics using the computed Site U1500 TDR presents a good correlation in both the sedimentary section as well as for the sediment/basalt interface. The main physical properties changes related to the top of the basalt correlate well to the strong reflector observed at ~6.4 s in the seismic profile.

Education and Outreach

This week the Education and Outreach Officer continued scheduling and planning live video-outreach events, including testing connection before the broadcasts, sending the teachers educational materials about the IODP program and the *JOIDES Resolution,* and conducting post-event surveys. The E/O Officer continued with the contest for the schools about the depth at which we will reach the basement in Hole U1500B. Routine posting to social media and to the *JOIDES Resolution* blog (http://joidesresolution.org) continued, including interviews with scientists and IODP personnel and crew staff to create blog entries and educational material. The

E/O Officer also started an email exchange with an important scientific radio broadcast in Italy and was interviewed together with another Italian scientist during a live broadcast on 31 March.

Technical Support and HSE Activities

Technical Support Activities

- The technical staff continued processing core and performing routine operational laboratory, IT, and data management issues.
- The application developers continued working on the ongoing LIVE project.
- Technical staff have begun the end of expedition preparations.

HSE Activities

- Eye wash and safety showers were tested.
- A fire and boat drill was held.