IODP Expedition 349: South China Sea Tectonics

Week 2 Report (1–7 February 2014)

Operations

Week 2 of Expedition 349 (South China Sea Tectonics) began with the start of advanced piston corer (APC) coring at Site U1431 (SCS-3G). The bit was spaced out to 4248 m below rig floor (mbrf) and the APC barrel was run in the hole (RIH) with wireline and landed. Hole U1431A was spudded at 0040 h on 1 February 2014. The mud line core recovered 9.45 meters of sediment and seafloor was calculated to be 4248.1 mbrf (4237.3 m below sea level [mbsl]). Non-magnetic core barrels were used for APC coring from Core U1431A-1H through -3H. Hole U1431A was terminated after Core U1431A-3H at a final depth of 4276.5 mbrf (28.4 m below seafloor [mbsf]). At the conclusion of coring the drill string was pulled from the hole. The bit cleared the seafloor at 0345 h on 1 February 2014, ending Hole U1431A. A total of three piston cores were taken over a 28.4 m interval and recovered 28.39 m of core (100%). The total time spent on Hole U1431A was 21.00 h.

After the bit cleared the seafloor, the vessel was offset 20 m to the east of Hole U1431A. To support the microbiological analyses from Hole U1431B, the perfluorocarbon tracer (PFT) pump was turned on, the drill string displaced with contamination testing fluid, and the pumps remained on for the remainder of coring in this hole. The bit was spaced out to 4245.5 mbrf in an attempt to recover approximately 7.0 m on the mud line core. The mud line core recovery was 7.5 meters. The seafloor depth was calculated to be 4247.5 mbrf (4236.7 mbsl). Hole U1431B was spudded at 0415 h on 1 February 2014. Non-magnetic core barrels were used for APC coring from Core U1431B-1H through -2H to a final depth of 17.0 mbsf. At the conclusion of coring the drill string was pulled from the hole. The bit cleared the seafloor at 0620 h on 1 February 2014, ending Hole U1431B. A total of two piston cores were taken over a 17.0 m interval in Hole U1431B and recovered 17.16 m of core (101%). The total time spent on Hole U1431B was 2.58 h.

After clearing the seafloor, the vessel was offset 20 m to the south of Hole U1431B. The bit was spaced out to 4245.5 mbrf. The mud line core recovery was 4.7 m, but the core liner was split. The seafloor depth was calculated to be 4250.3 mbrf (4239.5 mbsl). Hole U1431C was spudded at 0700 h on 1 February 2014. Non-magnetic core barrels were used for APC coring from Core U1431C-1H through -2H to a final depth of 14.2 mbsf. The PFT pump remained running during Hole U1431C. Hole U1431C was terminated when it was determined that the mud line core would not meet sampling requirements. At the conclusion of coring the drill string was pulled from the hole. The bit cleared the seafloor at 0845 h on 1 February 2014, ending Hole U1431C. A total of two piston cores were taken over a 14.2 m interval in Hole U1431C and recovered 14.45 m of core (102%). The total time spent on Hole U1431C was 2.42 h.

After clearing the seafloor, the vessel was offset 20 m to the west of Hole U1431C. The bit was spaced out to 4245.0 mbrf. The mud line core recovery was 3.22 m. The seafloor depth was calculated to be 4251.3 mbrf (4240.5 mbsl). Hole U1431D was spudded at 0925 h on 1 February 2014. Non-magnetic core barrels were used for APC coring from Core U1431C-1H through -19H to a depth of 168.9 mbsf. Temperature measurements were taken with the APC temperature tool (APCT-3) on Cores U1431D-4H, -7H, -10H and -13H with good results. After six partial strokes of the APC coring system, the coring system was switch over to the extended core barrel (XCB) coring system. XCB coring continued from Core U1431D-20X through -67X to a final depth of 4868.3 mbrf (617.0 mbsf). While cutting Core U1431D-67X, the rate of penetration dropped severely and the core barrel was retrieved after a 2.7 m advance. While recovering the core barrel at the surface, it was discovered that the cutting shoe, core catcher sub assembly and the break off sub were missing from the XCB coring assembly. With approximately 1 m of junk metal in the hole, the decision was made to pull out of the hole, offset and begin a new hole with the rotary core barrel (RCB) coring system. The top drive was then set back and the bit tripped from the hole, clearing the seafloor at 0355 h on 6 February 2014. The bit was back on the rig floor at 1415 h, ending Hole U1431D. A total of 19 APC cores were taken over a 168.9 m interval on Hole U1431D with a total recovery of 165.61 m of core. A total of 48 XCB cores were taken over an interval of 448.1 m and recovered 236.50 m of core. Overall core recovery for Hole U1431D was 402.11 m over an interval of 617.0 m (65%). The total time spent on Hole U1431D was 127.9 h.

After offsetting the vessel 20 m to the west of Hole U1431D, an RCB bottom hole assembly (BHA) was assembled with a new RCB C-4 bit. The core barrels were then spaced out at the surface and the 172.07 m BHA was assembled. The BHA was then lowered to 4163.22 mbrf and the rig crew performed a slip and cut (115 ft) of the drilling line. After the drill pipe was RIH to 4221.46 mbrf, the top drive was picked up and spaced out to spud Hole U1431E. A center bit was then dropped and pumped to land out in the bit. Hole U1431E was spudded at 0650 h on 7 February 2014. The seafloor depth for the hole was determined to be 4251.3 mbrf and was calculated using an offset depth from Hole U1431D. Hole U1431E was advanced by drilling without coring from the seafloor to 507.0 mbsf. The center bit was retrieved and an RCB core barrel was dropped to take a spot core from 507.0 mbsf.

Science Results

Site U1431 (proposed site SCS-3G) is located in the East Sub-basin of the South China Sea (SCS), near the relict spreading center and the youngest magnetic anomaly. The primary objective at this site is to date the termination age of seafloor spreading in the East Sub-basin of the SCS. In addition, the composition and magnetic susceptibility of basement rocks will be important for understanding the sharp differences in magnetic amplitudes and strike between the

East Sub-basin and the Southwest Sub-basin. The thick sediment sequence on top of basement will provide constraints on the evolution of the ridge and late-stage volcanism in the area.

Cores from Holes U1431A, U1431B, U1431C, and U1431D were described using a combination of visual core description, microscopic inspection of smear slides, core imaging, and scanning for color spectra and magnetic susceptibility. The first three holes penetrated <30 mbsf, whereas Hole U1431D cored just over 600 m of sediments that are dominated by dark greenish gray clay and silty clay. The upper 100 m of the sediment column shows cycles of clay-rich and silt-rich sediments that we interpret as turbidite deposits because of their sharp, erosive bases and fining upward grain size variation. These silty units are generally less than 30 cm thick and comprise ~25% of the sedimentary unit. Interbedded within these deposits are common, thin volcanic ash layers (both silicic and mafic) and nannofossil oozes, which are also graded and often have coarse foraminifer sands at the base.

Below 100 m the sediment is more dominantly clay rich and the occurrence of volcanic ash layers decreases sharply. Silt and especially nannofossil-rich beds continue to occur but are volumetrically small. Calcareous graded units increase in abundance again within the muddy background below ~275 mbsf, and then below ~310 mbsf these sediments are also interbedded with quartzose silt and even sandy silt of a graded and parallel-laminated turbidite facies. Deeper than ~400 mbsf recovery is poor but what was recovered indicates the presence of increasing volumes of mostly mafic volcanic silt and sand within the clay-rich deposits. The muddier sediments through the entire section are generally more heavily bioturbated and show *Chrondrites* and other trace fossils typical of sedimentation on a deep abyssal plain.

Planktonic foraminifera and calcareous nannofossil biostratigraphy indicates that the succession in Hole U1431D covers the last ~8 Ma, with the Pliocene/Pleistocene boundary present in Core U1431D-15H and the Miocene/Pliocene boundary in Core U1431D-35X. Nannofossils are less common in the upper 89 m, but generally well preserved and more abundant downhole. Foraminifera are more abundant in the upper part of the hole, decreasing in abundance and becoming more poorly preserved in the clastic-rich sediments. Radiolarians are abundant and well preserved in the upper 22 m of the hole, decreasing downhole to rare and then absent.

Shipboard paleomagnetic studies for Site U1341 consisted of continuous measurements and progressive demagnetization of all archive half sections and representative discrete samples to establish a magnetostratigraphy for the site and to observe the magnetic properties of the different lithologies recovered. As with previous ocean drilling expeditions, remagnetization imparted by the coring process was commonly encountered: natural remanent magnetization (NRM) inclinations are strongly biased toward vertical (mostly toward +90°) in a majority of cores. Upon alternating field (AF) demagnetization to 20 mT, a significant decrease in intensity (about an order of magnitude) and a shift of inclination toward shallower or negative values occurred. For the top ~200 mbsf, we identified several relatively well-defined polarity intervals in the magnetostratigraphic data. We were able to tentatively correlate the magnetic polarity

intervals recorded in the sediments with the geomagnetic reversal time scale over the last 3.5 Ma. Overall, the paleomagnetic data for this interval are reasonably robust and are also in excellent agreement with biostratigraphic ages.

For the interval cored with the extended core barrel (XCB) system below ~200 mbsf, the level of AF demagnetization on the ship's cryogenic magnetometer could not remove the remagnetization. Analysis of discrete samples to isolate the primary magnetization recorded by these sediments is ongoing.

We measured physical properties on all whole round cores (>40 cm in length) from Holes U1431A (28.39 m recovered), U1431B (17.16 m), U1431C (14.45 m) and U1431D (402.11 m) using the Whole Round Multi-Sensor Logger (WRMSL) and the Natural Gamma Ray (NGR) logger. These included measurements of gamma ray attenuation bulk density, magnetic susceptibility, *P*-wave velocity, and natural gamma radiation. We also measured thermal conductivity on one section per core for Hole U1431D, as well as *P*-wave velocity on the working halves of every section for the first 16 cores, and then every second section below. Shear strength was measured once per core on working halves, most often on Section 4, using the automatic vane shear. The bulk density (MADMax), *P*-wave velocity (caliper), natural gamma radiation, and shear strength generally increase with depth. The MADMax porosity shows the opposite trend, decreasing from 80% to 50% over the first 150 mbsf. To better understand the correlation between *P*-wave velocity and bulk density with porosity, we applied a polynomial fitting. The results show good inverse correlation between *P*-wave velocity and porosity as a second-order polynomial function and a linear inverse trend between bulk density and porosity. This indicates sediment compaction dominates the physical properties variations above 150 mbsf.

We collected samples for shipboard analyses of headspace gas, interstitial water (IW) chemistry, and sediment bulk chemistry from Holes U1431A and U1431D. Some analyses are complete, although IW measurements, inductively coupled plasma-atomic emission spectroscopy (ICP-AES) analysis of sediment, and total carbon analyses are ongoing. ICP-AES analysis of water samples will be conducted after all sediment and hard rock samples from the site are completed. A total of 53 headspace gas measurements for the site show extremely low methane values (<5 ppm) throughout Hole U1431D. In Hole U1431A, the alkalinity gradually increases with depth, coupled with a gradual decrease in sulfate, indicating that sulfate reduction caused by sedimentary organic matter degradation contributed to alkalinity in IW. In Hole U1431D, analysis suggests that the pore waters were contaminated by drilling fluids below ~375 mbsf. Future whole round samples will be subjected to increased cleaning and trimming to remove drilling contamination before analyzing the interstitial water.

A total of 67 whole-round samples were collected from Holes U1431B and U1431D for microbiological and lipid analysis. These samples were taken on the catwalk and brought immediately to the microbiology lab for processing. Each whole round was aseptically subcored

using 30 cc sterile syringes and spatulas inside of a glove bag to minimize exposure to oxygen. The subsamples were frozen (–80ºC) or refrigerated (4ºC) depending on the final analyses. An additional 76 samples were taken across interfaces (e.g., ash layers, turbidites) as soon as the cores were split. Below ~200 mbsf, XCB coring resulted in significant drilling disturbance, so only one sample was taken below that depth. Delays between core arrival on deck and processing of the interface microbiological samples ranged from 24 to 63 h, averaging 47.7 h. PFTs were circulated in the drilling fluid beginning with Hole U1431B and ending after Core U1431D-23X. We collected 12 PFT samples from six different cores for contamination testing in the upper part of Hole U1431D. Initial results from blanks run in the gas chromatograph indicate significant contamination of PFTs in the laboratory, so the core samples have been sealed and await analysis after the background level of PFTs drops to a reasonable level. In addition, we collected 15 samples of drilling fluid on a daily basis to track the microbial communities typical of seawater and other mud constituents. DNA and lipids from these samples will be compared to those from the core samples to determine if there are reliable contaminant microbes that can be tracked.

The downhole measurements group analyzed four temperature measurements from the APCT-3 tool, which indicate a geothermal gradient of ~15ºC/km. This, coupled with the measured thermal conductivity of 1.14 W/m·C°, suggests a heat flow of 17 mW/m^2. The logging staff scientist and Schlumberger engineer also began testing the logging tools that will be deployed next week after the end of coring operations in Hole U1431E.

Education and Outreach

We began to prepare for the live ship-to-shore video events that will happen throughout the remainder of the expedition, with the first scheduled for early in week 3. We contacted the organizers of these events and scheduled Zoom video meetings for those that fall during the upcoming week. We also started to organize science party members to lead these events.

Our Dragon TV reporter prepared several videos showing the coring process and the work done in the labs. The co-chiefs, operations superintendent, lab officer, and staff scientist reviewed these videos before they were sent off the ship.

Technical Support and HSE Activities

The following technical support activities took place:

Laboratory:

- The shipboard labs have been processing cores.

Miscellaneous:

- Thermo Forma-86 ULT Freezer (IODP property sticker #90419) failed. This freezer is the older one located in the pallet stores. It is being looked at by our electronics specialists.

The following HSE activities took place:

- A boat and fire drill was held on 7 February.