

## **IODP Expedition 349: South China Sea Tectonics**

### **Week 3 Report (8–14 February 2014)**

#### **Operations**

Week 3 of Expedition 349 (South China Sea Tectonics) began while cutting Core U1431E-2R from a depth of 507.0 mbsf. After cutting this core with no recovery, the center bit was dropped and drilling without coring continued from 516.7 mbsf to 575.0 mbsf. The center bit was then retrieved by wireline, a core barrel dropped, and continuous coring started with Core U1431E-4R from 575.0 mbsf. The next three cores (U1431E-4R to -6R [575.0–603.3 mbsf]) did not recover any material. Coring continued with good recovery from Cores U1431E-7R to -36R (603.3–894.3 mbsf). Core U1431E-36R was the first to recover basalt, with several small pieces present in the core catcher. Coring then continued into acoustic basement from Cores U1431E-37R to -47R (894.3–991.4 mbsf). Penetration rates varied between 1.6 m/h and 4.7 m/h over this interval, except for a sediment section in Core U1431E-45R that cored more quickly than the basalt. With torque becoming higher and erratic, the decision was made to make a wiper trip to allow any debris collecting around the drill collars to fall into the hole. After pumping a sweep from the bottom of the hole, the drill string was pulled back to 862 mbsf. The bit was then run back to the bottom of the hole where it encountered nearly 19 m of fill (at ~972 mbsf). A core barrel was dropped and the bit was worked back to the bottom of the hole with circulation and rotation without difficulty. The core barrel was retrieved and ghost Core U1431E-48G recovered 0.65 m of material. Another 50-barrel high viscosity mud sweep was pumped after reaching the bottom of the hole and a core barrel dropped. Coring continued from 991.4 mbsf to the final depth of 1008.8 mbsf (Cores U1431E-49R and -50R). Just prior to finishing coring, a 50-barrel high viscosity mud sweep was pumped to clean and condition the hole for logging. The total depth (TD) of Hole U1431E was reached at 0740 h on 14 February 2014. Hole U1431E obtained a total of 47 RCB cores over a 443.5 m interval (55% recovery, excluding the single 0.65 m long ghost core).

In preparation for wireline logging, the rotary shifting tool (RST) was deployed to activate the mechanical bit release and the bit was dropped into the bottom of the hole. The end of the drill pipe was raised to 648.78 mbsf with the top drive in place. The hole was displaced from 648 mbsf to the seafloor with 11.4 ppg high viscosity mud to improve logging conditions. The top drive was set back and the end of the pipe raised to 149.62 mbsf for logging operations. After holding a logging safety meeting for rig floor personnel, the logging equipment was rigged up and the triple combo tool string assembled. The tool string started to run in the hole (RIH) at 2055 h on 14 February 2014 and at the end of Week 3 it was still being RIH.

## Science Results

Cores from Hole U1431E were described using a combination of visual core description (VCD), microscope inspection of smear slides and thin sections, core imaging, and scanning for color spectra and magnetic susceptibility. The sediment recovered in this hole is completely lithified. The upper part (~200 m thick) comprises greenish black or black volcanoclastic breccia with significant but subsidiary interbeds of sandstone and claystone. The thick-bedded volcanoclastic breccia is typically massive, ungraded, and poorly sorted, with basaltic clasts and minor reworked mudstone and sandstone clasts. The lower part of the sedimentary section is composed mainly of dark greenish gray sandstone, siltstone, and claystone with minor intervals of volcanoclastic breccia. At the bottom of the sedimentary sequence, brown to yellowish brown claystone immediately overlies basalt and was also found in a 3.5 m thick interval between basalt flows.

At the end of the week, the sedimentologists had divided the sedimentary sequences at Site U1431 into eight lithologic units. Unit I consists of approximately 100 m of Pleistocene dark greenish gray clay and silty clay. This is underlain by 165 m of Pliocene to lowermost Pleistocene dark greenish gray clay, clay with nannofossils, and silty clay of Unit II. Volcanic ashes are prevalent in Unit I and the upper part of Unit II. Unit III consists of approximately 60 m of Pliocene dark greenish gray clay and light greenish gray nannofossil ooze. Coarser lithologies increase downhole, with Unit IV composed of ~85 m of dark greenish gray clay and silty sand that is latest Miocene to earliest Pliocene in age. Unit V was poorly recovered and likely consists primarily of nearly 200 m of Upper Miocene sands. Recovered intervals are composed of dark greenish gray silty sand/sandstone with interbeds of clay with nannofossil ooze. This is underlain by nearly 200 m of middle to Upper Miocene greenish black volcanoclastic breccia and sandstone with clay interbeds (Unit VI). Unit VII consists of approximately 90 m of middle Miocene dark greenish gray sandstone, siltstone, and claystone, with the latter often highly burrowed. Unit VIII consists of less than 5 m of dark olive brown to yellowish brown claystone of middle Miocene(?) age found immediately above the basalts. Additional lithologic units will be defined for the remainder of the rocks cored in Hole U1431E.

The biostratigraphers analyzed core catcher samples and additional samples from within cores from Hole U1431E. Planktonic foraminifera and calcareous nannofossil biostratigraphy indicates that the sedimentary succession recovered in Hole U1431E covers the last ~8 Ma to ~13 Ma, with the middle/late Miocene boundary present in Core U1431E-28R. Nannofossils are generally poorly preserved, frequent, or common in the upper interval, but rare or absent downhole. Foraminifera are also poorly preserved and rare in the upper section, with barren samples becoming more frequent in the lower section. Poorly preserved radiolarians occur only in a few samples near the base of the hole, including in the claystone intercalated between basalt flows. The presence of radiolarians and absence of calcareous microfossils in these rocks indicate deposition below the carbonate compensation depth (CCD). Additional work is needed, but

preliminary results indicate an age of late early to early middle Miocene for the claystone of lithologic Unit VIII.

The igneous petrologists described the basalts in the bottom of the hole and the volcanoclastic clasts found in the volcanoclastic breccias of lithologic Unit VI. The volcanoclastic clasts are composed of highly vesicular aphyric basalt, non-vesicular to sparsely vesicular aphyric basalts, trachytic basalts, as well as rare pumice. The highly vesicular basalt clast abundance decreases with depth. Variations in clast color reflect different degrees of alteration, which increases with depth.

Massive basalt units were cored beginning in Section U1431E-36R-CC to the base of the hole (Core U1431E-50R), with the exception of a single ~3 m thick interflow bed within this interval. The petrologists completed macroscopic and preliminary microscopic description of these basalts. The basalts are primarily aphyric and microcrystalline to medium-grained, with a few intervals of sparsely to moderately phyrical olivine basalt. The groundmass consists mostly of thin needles of plagioclase, with traces of clinopyroxenes that increase in size and abundance within the medium-grained basalts. Alteration is variable, with most intervals moderately altered, some highly altered, and others only slightly altered and mostly fresh. Initial analysis based on textural changes and a few pieces with glassy margins suggests that the cored interval spans at least eleven distinct lava flow units.

The structural geologists described the dip orientation and angle of 131 fractures and veins in the basalts of Hole U1431E. Most fractures resulted from drilling; however, a few fractures have obvious alteration or veins associated with them. Two types of fractures occur in the sequence: curved/arched and linear. The arched veins and fractures show decreasing alteration from the margin to the center. Many of the linear fractures are associated with the curved fractures and appear to be radiating, suggesting that the fractures formed as hot magma cooled. Some of these fractures later filled with calcite.

Three samples from the upper part of the basalt sequence have been analyzed for major and minor element concentrations using inductively coupled plasma-atomic emission spectroscopy (ICP-AES). The low  $K_2O$  (0.1–0.3 wt%) and  $TiO_2$  (~1.0 wt%) suggest that these samples are mid-ocean ridge basalts (MORB). The geochemists also completed running most samples from Site U1431 for carbon, nitrogen, and inorganic carbon analysis. The carbonate content and total organic carbon (TOC) can be derived from these results. Carbonate content varies significantly at the site, ranging from 0% to 57%. The TOC content in Hole U1431D is very low in the upper ~200 m, but increases somewhat below, varying between approximately 0.25 wt% and 4 wt%. TOC contents in the deeper section obtained in Hole U1431E were much lower, possibly due to organic matter degradation. Carbon/nitrogen ratios in Hole U1431D vary significantly, with some intervals showing a mix of marine and terrestrial sources of organic matter.

The paleomagnetists measured core sections from Hole U1431E using the cryogenic magnetometer. They also conducted alternating field and thermal demagnetization experiments

on discrete samples to verify the polarity patterns revealed from the pass-through measurements and to determine magnetic mineralogy. Preliminary magnetostratigraphic results are in good agreement with the biostratigraphy. Work on additional demagnetization of discrete samples and data analysis is ongoing.

The physical properties specialists measured bulk density, magnetic susceptibility, and natural gamma radiation on whole round cores from Hole U1431E using the Whole-Round Multisensor Logger (WRMSL) and the Natural Gamma Ray (NGR) logger. They also measured thermal conductivity on one section per core for Hole U1431E. Physical properties measurements on discrete samples are ongoing. As these samples are strongly lithified, they are left in seawater under vacuum for 24 h to become saturated with water before measurement of wet mass. The volcanoclastic breccias, sandstones, and silt/claystones show a large range of values for *P*-wave velocity, density, and porosity measurements. There is a distinct difference in natural gamma radiation and density between the sedimentary and igneous sequences.

The microbiologists collected 33 microbiology whole-round samples from Hole U1431E for post-expedition microbial community analysis (lipids and DNA). Four additional samples were taken at interfaces. All samples were indurated enough to require the use of a saw for splitting in the core lab; therefore prior to splitting, the whole-round cores were shaken out on to sterile liners in the splitting room, at which point a whole-round piece (usually 5 to 8 cm long) was selected for microbiological studies in consultation with a sedimentologist or petrologist. In most cases, the whole-round sample was hard enough to require a chisel and hammer to break off the contaminated exterior portions. Then the SPEX 3624B X-Press instrument was used to crack the sample to obtain material from the interior that was less likely to be contaminated. The pressure required to break the samples was usually less than seven tons.

Microsphere tracers were added to the core catcher for Cores U1431E-12R through -42R. These cores were sampled for microspheres by preserving scrapings from the surface and taking a subsample from the interior of each microbiology whole round sample. In two select cases, two exterior scrapings were acquired to determine whether there was a difference in the concentration of microspheres after the first scraping. Six sets of fluid community tracers (FCT) were obtained during coring at Hole U1431E by collecting drilling fluids from the drill floor at least once a day. The microbial communities present in these samples will be compared to those present in the cores to ascertain whether the communities are notably different and also to determine whether there are unique species that qualify as indicator organisms. Analyses of perfluorocarbon tracers (PFTs) used in Holes U1431B and U1431D were completed and indicate that one of the cores had significant levels of the tracers on the inside of the cored material.

The microbiologists also prepared cultivations to grow microbes that use reduced iron from olivine for four of the basalt samples. Eighteen and eleven samples were prepared for fluorescent in situ hybridization (FISH) and single cell genomics (SCG), respectively.

The logging staff scientist and Schlumberger logging engineer began logging operations in Hole U1431E with a modified triple combo tool string to measure natural gamma radiation, porosity, density, resistivity, and magnetic susceptibility. This tool string was being lowered into the hole for the first logging run at the end of the week.

## **Education and Outreach**

We hosted our first ship-to-shore live video events this week. We connected with the University of Nebraska State Museum during their annual Dinosaurs and Disasters day and reached ~80 children and adults during two separate broadcasts. The second event was particularly exciting because the children got to see one of our cores arrive on deck! We also connected with approximately 30 children at the Hamagin Space Science Center in Yokohama, Japan. Other events included broadcasts to two high school classes, one in Florida and one in Maryland, as well as a group of ~20 undergraduate and graduate students at the Indian Institute of Technology Bhubaneswar in Odisha, India. We concluded the week with a 15-minute event in conjunction with Swiss Drilling Day at the University of Bern, where we briefly explained our scientific objectives and gave a quick tour of the labs to approximately 70 scientists. The two Swiss representatives in the science party also spoke and introduced their roles on the expedition.

Our Dragon TV reporter prepared several new videos concentrating on some of the results to date. One piece highlighted our achievement of collecting the first basement cores from the South China Sea.

## **Technical Support and HSE Activities**

The following technical support activities took place:

Laboratory:

- The shipboard labs have been processing cores.
- The thin section lab is busy processing thin section requests.

The following HSE activities took place:

- The safety showers and eyewash stations were tested.