IODP Expedition 349: South China Sea Tectonics
Site U1434 Summary

Background and Objectives

Site U1434 (proposed site SCS-4E) is located about 40 km northwest of Site U1433 and is directly on the uplifted shoulder of the relict spreading center in the Southwest Sub-basin. This site is also located just south of a large seamount that formed near the relict spreading center after the termination of seafloor spreading. During coring at Site U1433, we decided to use some of our remaining time to core at a second site in the Southwest Sub-basin to obtain basement samples located more proximal to the extinct spreading center. Site U1434 also offered the opportunity to sample volcaniclastic material from the nearby seamount, which can be compared to the seamounts located near Site U1431 in the East Sub-basin.

Sites U1434 and U1433 form a short sampling transect in the Southwest Sub-basin, and with age controls from these two sites, the evolution of the Southwest Sub-basin can be better understood. Coring at these sites should help to explain the sharp differences in magnetic amplitude between the East and Southwest Sub-basins and test the existing opening models for the Southwest Sub-basin (e.g., Pautot et al., 1986). Coring will help determine the age of this sub-basin near the end of the spreading and correlate ages from magnetic anomalies with biostratigraphic, magnetostratigraphic, and radiometric ages. The apparent weak magnetization in basement rocks (Li et al., 2008) will be examined via petrological analyses of chemical compositions and measurements of magnetic susceptibility. Rock samples cored here will place immediate constraints on mantle evolution and oceanic crustal accretion, terminal processes of seafloor spreading, and the timing and episodes of post-spreading seamount volcanism in the relict spreading center.

Operations

After an 18 nmi transit from Site U1433 averaging 10.3 kt, the vessel stabilized over Site U1434 at 0048 h (UTC + 8 h) on 20 March 2014. This alternate site was originally planned to core from the seafloor with the advanced piston corer/extended core barrel (APC/XCB) system to refusal, drop a free-fall funnel, change to the rotary core barrel (RCB) system, and then core 100 m into basement. Because of time considerations, the plan was modified to drill without coring to ~200 mbsf, RCB core into basement as

deeply as time permitted, and then conduct wireline logging on hole depth and conditions. Hole U1434A was drilled without coring from the seafloor to 197.0 mbsf and then cored with the RCB system. Basement was encountered at ~280 mbsf and the hole was advanced by rotary coring to a final depth of 312.5 mbsf. The hole was terminated due to poor hole conditions and poor core recovery. The RCB system was deployed 14 times, recovering 26.43 m of core over 115.5 m of penetration (23% recovery).

Principal Results

The cored section at Site U1434 is divided into four lithostratigraphic units, three sedimentary and one igneous. Lithostratigraphic Unit I (197.00–235.10 mbsf) is a 38.1 m thick sequence of upper Miocene dark greenish gray claystone interbedded with black volcaniclastic sandstone and occasional breccia. The fine-grained sediment is mottled greenish and light buff brown in color, with the browner colored sediment preferentially found in burrows. This unit is marked by strong bioturbation within the claystone intervals that make up around 40% of the total sediment. The types of trace fossils seen within the claystone intervals are consistent with sedimentation in deep water (i.e., lower bathyal or abyssal depths, >2000 m), with assemblages dominated by *Chondrites* and *Zoophycos*, although more vertical burrows are also noted. Sandstone beds are typically dark gray or black in color and are volcaniclastic in composition. These volcaniclastic sandstones and breccias are interpreted to be part of the sedimentary apron of a nearby seamount, as they contain abundant volcanic glass fragments, scoria, and basalt clasts, as well as crystal fragments of plagioclase, olivine, and biotite.

Lithostratigraphic Unit II (235.10–254.59 mbsf) contains upper Miocene greenish gray nannofossil-rich claystone, with very thin claystone with sand interbeds. The color of the sediment varies at the decimeter scale due to changes in the amount of carbonate and clay content. The sediment is locally a light greenish gray color, reflecting higher biogenic carbonate content over those intervals. Unit III (254.59–278.27 mbsf) consists of dominantly massive yellowish brown claystone with nannofossil- or foraminifer-rich claystone of latest middle to late Miocene age. This unit is primarily distinguished from Unit II by its color, which tends to be more yellowish or reddish brown compared to the greenish gray tones associated with the overlying sequence.

Analysis of calcareous nannofossils and planktonic foraminifers in core catcher samples and additional samples from split cores indicates that the sediment succession recovered

at Site U1434 spans the uppermost middle to upper Miocene, with the base of the sequence younger than 11.9 Ma. Calcareous nannofossils are generally common to abundant, but decrease in abundance downhole, and preservation is poor to moderate. Planktonic foraminifers vary from common to absent with good to poor preservation, but are frequently fragmented. Radiolarians are present in only one sample. Although none of the species present are biostratigraphic index taxa, the radiolarian assemblage is consistent with the late Miocene age based on nannofossils and foraminifers. Correlation of microfossil biohorizons and paleomagnetics data suggest a sedimentation rate of ~1.6 cm/k.y. for the sediment sequence recovered at Site U1434.

We cored 30.28 m into igneous basement below 278.37 mbsf in Hole U1434A, recovering 3.05 m of basalt (10% recovery). This basement succession is divided into seven igneous lithologic units, which are grouped into lithostratigraphic Unit IV. The basement at Site U1434 is comprised of a succession of small pillow basalt flows, or a thicker auto-brecciated pillow lava flow, with three occurrences of hyaloclastite breccia. The igneous basement comprises angular to subangular basalt fragments that are aphyric and have glassy to aphanitic groundmasses. The only phenocrystic phase is olivine, which appears as sparse euhedral-subhedral microphenocrysts throughout the core. The groundmass contains abundant plagioclase microlites, growing in spherulitic and variolitic patterns, with the majority of the groundmass consisting of variably altered mesostasis. Clinopyroxene is only observed in a few thin sections, growing in patches and filling the interstitial spaces between plagioclase microlites. Most of the basalts are nonvesicular to sparsely vesicular. The hyaloclastite breccia contains abundant fresh volcanic glass shards in a mostly carbonate matrix. All basalts have phase assemblages of olivine ± plagioclase, and some slightly coarser basalt pieces also have clinopyroxene in their groundmass. These resemble typical mid-ocean ridge basalt (MORB) crystallization assemblages.

Basalt alteration is typical of that of MORB. The basalt recovered is slightly to moderately altered. Pillow basalt pieces are altered in zones, with alteration color ranging from dark gray in the interior to light yellow brown in halos along the outer rims. Typical secondary minerals include saponite, Fe-oxides, carbonate, and celadonite, which constitute a low temperature alteration assemblage. Fresh basalt glass exists near some of the pillow basalt margins and in the clasts of hyaloclasite. Those basalt glasses are partly

altered to orange to brown palagonite. Most of the vesicles are empty or only partly filled with Fe-oxide, saponite, celadonite, and carbonate. Only two alteration veins were observed in this short basement section.

Most fractures observed in the sedimentary sequence at Site U1434 are drilling induced. One fracture shows some offset that suggests it occurred prior to consolidation of the sediments. Fractures are rare in the small amount of basalt recovered at this site. Several linear veins are present and filled with carbonate or Fe-oxide.

We measured alkalinity and pH on five interstitial water samples taken from 207.9 to 264.8 mbsf in Hole U1434A. Alkalinity increases from 0.5 at 208 mbsf to 3.5 at 257 mbsf, and then decreases in the two samples below that depth. The pH decreases from 7.9 at 208 mbsf to 7.2 at 265 mbsf and then increases slightly just above basement. Only methane was detected in very low concentrations (<3.1 ppmv) in the headspace gas samples taken at this site. The $CaCO_3$ content is low (<10 wt%) in lithostratigraphic Units I and II. Samples from the base of Unit III are higher in $CaCO_3$ (15–30 wt%). Total organic carbon (TOC) is also low (<0.5 wt%), with the highest values near the base of the sedimentary section. Inductively coupled plasma-atomic emission spectroscopy (ICP-AES) results from Site U1434 indicate that the basalt has somewhat higher K_2O than Sites U1431 and U1433, but is still tholeiitic in composition and representative of MORB.

We collected a total of six whole-round samples for microbiological analysis from depths of 208 to 275 mbsf in Hole U1434A. These samples were collected adjacent to samples for interstitial water measurements so that microbiological data and water chemistry data are proximal to each other. We also collected and preserved 13 samples from either the split cores on the sampling table or from basement samples shortly after the samples were retrieved from the catwalk to investigate the microbiology of interfaces. The whole-round and split core samples were preserved for shore-based characterization of the microbial communities (i.e., DNA, RNA, lipids, and cultivation-based studies).

We also collected samples for measuring contamination testing tracers, including microspheres and fluid community tracers. Microsphere tracers were placed in the RCB core catcher for cores collected between 208 and 303 mbsf. Two microsphere samples were collected from each of the cores collected between those depth intervals: one from scrapings of the core surface and one as a subsample from the interior of each sample.

Microscopic counts of the microspheres in these samples will be performed in shore-based labs. Six fluid community tracer (FCT) samples were collected from drilling fluids that drained from the core liners when cores arrived on the catwalk or from a sampling port near the mud pumps on the rig floor during active coring. The fluids collected for FCT samples correspond to cores obtained from depths ranging between 208 and 293 mbsf. Microbial community DNA and lipids from FCT samples will be compared to the same measurements made on the core samples to determine if the drilling fluids contain microbes that can be regularly tracked as recognizable contaminant taxa.

We conducted paleomagnetic studies at Site U1434 on both sediment and basement cores using pass-through magnetometer measurements on archive-half sections. The NRM intensity ranges from 0.001 to 0.1 A/m for the sediment units and increases to several A/m for the basalt units, suggesting that the basalts contain more iron oxides than the sediments. Due to the poor recovery at the site, only fragmentary patterns of magnetic polarity are observed. Available biostratigraphic data allow us to tentatively correlate certain parts of the magnetic polarity interval recorded in the sediments with the geomagnetic polarity timescale. Near the base of the sedimentary sequence, biostratigraphy indicates an age <11.9 Ma, which we use to correlate the negative inclinations at ~278 mbsf to Chron C5r (11.056–12.049 Ma). The long, dominantly positive inclinations between ~250 and 270 mbsf may represent the long positive sub-Chron C5n (9.984–11.06 Ma), the short positive polarity zone between ~235 and 240 mbsf appears to have recorded Chron C4An (8.771–9.015 Ma), and the positive polarity zone between 205 and 210 mbsf can be tentatively assigned to C4n around 7.15 Ma.

Cores from Hole U1434A were measured for physical properties on whole-round cores, split cores, and discrete samples. In general, the physical properties correlate well with lithology, composition, and the observed lithification. Because of the low recovery rate, measurements of physical properties show significant discontinuities between intervals. In Hole U1434A, the observed range of values for magnetic susceptibility (MS; 30–80 × 10^{-5} SI) and natural gamma radiation (NGR; 25–45 cps) in Units I–III are typical for clay material, which dominates the sediment layers. The low NGR value in Unit IV corresponds to the basalts. The MS values in the basalts range from 10–90 × 10^{-5} SI, which is much lower than typical for basalt. This is at least partly due to the poor

recovery and the relatively low volume of basalt pieces in the core liner. The high grain densities in the claystone of Units II and III suggest the presence of heavy minerals, such as hematite. The porosity measured on discrete samples increases from 40% to 60% with depth, which may be correlated to the lithification and composition of the claystone.

References

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