IODP Expedition 349: South China Sea Tectonics
Site U1432 Summary

Background and Objectives

International Ocean Discovery Program (IODP) Site U1432 (proposed site SCS-6A) is located about 60 km south of Ocean Drilling Program (ODP) Site 1148 (Wang, Prell, Blum, et al., 2000; Li et al., 2006; Wang and Li, 2009), just south of the northern continent-ocean boundary. This part of the basin shows the deepest basement and is likely the oldest among the sub-basins based on magnetic anomalies (Taylor and Hayes, 1980, 1983; Pautot et al., 1986; Briais et al., 1993). This site was chosen to recover the oldest oceanic crust and the oldest sedimentary rocks in the East Sub-basin to test the hypothesis that the onset of seafloor spreading in the South China Sea occurred here first around 32 Ma. Magnetic Anomaly 11, the oldest anomaly interpreted by Taylor and Hayes (1980) and Briais et al. (1993), passes near this site, and hence would allow key calibrations between ages estimated from magnetic anomalies and those from biostratigraphy, radiometric dating, and magnetostratigraphy.

The true nature of the continent-ocean transition (COT) and oceanic basement at this site is still speculative; there could be volcanic extrusions associated with early continental breakup and the onset of seafloor spreading, exhumed lower crustal materials from preferential lower crust extension, exhumed mantle materials, or even Mesozoic rocks. Coring at this site was intended to help pinpoint the exact location and tectonic nature of the COT and address key problems in the early tectonic transition from rifting to drifting and associated paleoenvironmental changes, including:

(1) The age of basement (presumably the oldest oceanic crust) near the continent-ocean boundary;

(2) Petrology and geochemistry of basement rocks and their bearings on continental breakup, incipient seafloor spreading, and mantle evolution;

(3) Physical properties of basement rocks and their implications for interpreting sharp magnetic contrasts between different sub-basins; and

(4) Sedimentary, paleoceanographic, and ecosystem responses to the opening of the South China Sea.

Due to operational challenges (see "Operations"), the objectives of sampling basement and basal sediments at Site U1432 were not achieved.

Operations

After a 181 nmi transit from Site U1431 averaging 11.0 kt, the vessel stabilized over Site U1432 at 2337 h (UTC + 8 h) on 31 January 2014. Site U1432 consisted of three holes. The first hole was a planned jet in test to determine the correct casing depth for the 20 inch casing string. The second hole was to consist of a reentry system with three strings of casing to approximately 900 mbsf, followed by coring to ~1930 mbsf. Because of poor weather conditions, an additional hole was piston cored while waiting on suitable weather to continue the reentry installation.

Hole U1432A was successfully jetted to 62.0 mbsf. A reentry system was then successfully installed to 787.1 mbsf on Hole U1432B. The final cement job on the last casing string compromised the reentry system when the drill string became stuck in the casing. The drill string had to be severed, forcing us to abandon Hole U1432B. Hole U1432C was successfully cored to 110.0 mbsf with the advanced piston corer (APC) coring system. Four downhole temperature measurements were taken in Hole U1432C with the advanced piston corer temperature tool (APCT-3). A total of 12 APC cores were collected at this site, recovering 88.74 m of core over 110.0 m of penetration (81% recovery). The total time spent on Site U1432 was 492 h (17.9 days).

Principal Results

Hole U1432C consists of 12 cores (Cores 349-U1432C-1H to -12H) that penetrated to 110.0 mbsf. The lithology is dominated by a sequence of dark greenish gray clay and clay with silt, assigned to lithostratigraphic Unit I. Clay layers are interbedded with very thin-bedded (in centimeter scale) or laminated silty layers. These layers mostly fine upward and have sharp erosive bases. These graded sequences are generally 10–20 cm thick and are interpreted as distal turbidites. A 2.4 m thick unconsolidated sand layer occurs in the middle of the drilled section. The sand and silt layers represent <5% of the total recovered core and can usually be identified using magnetic susceptibility measurements, as they typically exhibit lower values than the clays. Thin volcanic ash layers (0.5–2.0 cm thick) occur occasionally in some cores.

The age of the sedimentary sequence recovered in Hole U1432C is <0.91 Ma (Middle–Late Pleistocene) based on planktonic foraminifer and calcareous nannofossil biostratigraphy. Radiolarians are abundant and moderately to poorly preserved in the upper 15 m of the hole, but become progressively rarer and more poorly preserved downhole and comprise a Pleistocene–Holocene assemblage. Nannofossil preservation is moderate to good throughout the hole, with considerable reworking of Pliocene and Miocene species above ~50 mbsf. Preservation of planktonic foraminifers is also moderate to good, with evidence of moderate dissolution as indicated by frequent fragmentation. Planktonic foraminifers are more dominant in sandy intervals that also contain reworked Pliocene species and shallow-water benthic foraminifers.

A total of 16 whole-round samples (5 cm in length) were taken for interstitial water measurements in Hole U1432C. Geochemical analysis shows that sulfate is completely consumed at ~90 mbsf, coincident with maximum methane concentrations between 4650 and 4750 ppmv just below this depth. The absence of higher hydrocarbons suggests that the methane is primarily microbial in origin. Total organic carbon (TOC) in the hole varies from 0.34 to 0.99 wt%, whereas $CaCO_3$ concentrations are generally low (<12%).

Five whole-round samples and five interface samples were collected from Hole U1432C for DNA and lipid analysis. The five whole-round samples were also used to inoculate several types of microbiological media to test whether autotrophic and heterotrophic microbes can be grown. For heterotrophic culture enrichments, glucose, acetate, fumarate, and formate were used as sources of carbon and energy. For autotrophic culture enrichments, sodium bicarbonate and hydrogen were used as sources of carbon and energy, respectively. We also collected and preserved 200 mL of drilling fluid for fluid community tracer analysis. The microbial communities present in these samples will be compared to those present on the inside and outside of the cores to determine whether microbes in the drilling fluid behave as suitable contaminant tracers.

As seen at Site U1431, the natural remanent magnetization (NRM) of samples from Hole U1432C contains a vertical component generated by the drilling process, which is easily removed by 5–10 mT alternating field (AF) demagnetization. A polarity reversal at ~105 mbsf is defined as the Brunhes/Matuyama boundary (0.78 Ma). In the Brunhes Chron, there are two directional anomaly intervals at about 10 mbsf and between 50–70 mbsf, respectively. These anomalies could either represent authentic magnetic

excursions or be caused by post-depositional disturbances. These magnetostratigraphic results, when combined with the biostratigraphy, indicate a higher sedimentation rate (~13.5 cm/k.y.) at Hole U1432C than for the same age interval at Hole U1431D (~5.8 cm/k.y,).

Physical properties measurements made on whole-round core sections were smoothed using a 5-point (10 cm) moving average and combined with discrete sample measurements. The bulk density, *P*-wave velocity, magnetic susceptibility (MS), natural gamma radiation (NGR), thermal conductivity, and shear strength decrease with depth in the top 50 m of Hole U1432C, showing an inverse relationship with porosity. Variations in these records are lower below 50 mbsf. This indicates that the compaction effect dominates the physical properties in the top part of Hole U1432C. The 2.5 m thick sand layer near 50 mbsf is clearly delineated by low NGR, low MS, and higher *P*-wave velocity.

Four advanced piston corer temperature tool (APCT-3) downhole temperature measurements on Cores 349-U1432C-5H, 7H, 9H, and 11H indicate a geothermal gradient of 85°C/km. Combining these temperatures with thermal conductivity measurements made on the sediment cores, the preliminary heat flow value at Hole U1432C is 94 mW/m^2. This geothermal gradient and heat flow is similar to that at Ocean Drilling Program Site 1148, ~60 km to the NNE (Wang, Prell, Blum, et al., 2000).

References

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