

IODP Expedition 356: Indonesian Throughflow

Week 7 Report (13–19 September 2015)

Week 7 of Expedition 356 (Indonesian Throughflow) consisted of coring at Sites U1463 and U1464. Site U1463 was completed and contains a fantastic Plio–Pleistocene record to address the paleoceanographic objectives of the expedition. In addition to the recovery of this record, two holes were successfully logged with all three standard wireline tool strings. At the end of the week, the science party were finalizing their results and writing the Site U1463 reports, and processing the upper 300 m of core recovered at Site U1464.

Operations

We began the week with recovery of Cores U1463B-9H to 30H to 271.2 mbsf. The HLAPC system was then deployed and we recovered Cores U1463B-31F to 33F to 284.4 mbsf, at which depth piston coring refusal was reached. The XCB coring system was deployed and coring continued from Core U1463B-34X through 60X to a final depth of 530.0 mbsf at 0005 h on 15 September. The APC system penetrated 271.2 m and recovered 267.73 m of core, while the HLAPC system recovered 13.30 m from 13.2 m cored. The XCB system cored 245.6 m and recovered 117.97 m of material. Overall, recovery for Hole U1461B was 75%.

At the conclusion of coring, we prepared the hole for logging by circulating high viscosity mud to clean the hole of cuttings and pumping a go-devil through the drill string to open the lockable float valve. The bit was raised up to 358.1 mbsf and the upper part of the hole was displaced with heavy mud. The bit was then pulled up to logging depth (82.1 mbsf) and the first logging tool string, the triple combination, was assembled. The tool string contained the following tools: magnetic susceptibility sonde (MSS), Hostile Environment Natural Gamma Ray Sonde (HNGS), Hostile Environment Litho-Density Tool (HLDT), Enhanced Digital Telemetry Cartridge (EDTC), and logging equipment head-q tension (LEH-QT). The triple combination tool string was deployed at 0710 h on 15 September. After the tool string exited the drill pipe, the active heave compensator was turned on. A downlog was performed from just above seafloor to 454.7 mbsf (~75 m above the bottom of the total depth of coring in this hole) where the tool could not pass an obstruction in the hole. The hole was logged up to ~350 mbsf, run back to the bottom, and a second uplog was made from 454.7 mbsf to 82.1 mbsf (end of the pipe). The tools were back on the rig floor at 0930 h. The next tool string, the Versatile Seismic Imager (VSI), was then readied. A caliper extension was added to the tool because the triple combo caliper suggested a wide borehole diameter (>17 inch). The protected species watch required for using a seismic source was started at 1000 h, and the tool string was deployed at 1130 h and reached 446.7 mbsf where it encountered a bridge. Whales were sighted continuously until 1315 h, but after an hour of observations without any further sightings, the seismic source began a soft ramp-

up and the vertical seismic profile began at 1445 h. One station was completed at 428.7 mbsf, before another whale sighting was reported. At 1500 h, we decided to cancel the vertical seismic profile experiment and the VSI tool string arrived back on the rig floor at 1530 h. After rigging down the VSI, the FMS-sonic tool string was assembled with the following tools: Formation MicroScanner (FMS), Dipole Sonic Imager (DSI), Hostile Environment Natural Gamma Ray Sonde (HNGS), Enhanced Digital Telemetry Cartridge (EDTC) and the logging equipment head-q tension (LEH-QT). At 1705 h, the FMS-sonic was deployed and two passes were made over the total depth of open borehole (445.7–82.1 mbsf). The tool string was pulled back to the surface at 2030 h. At 2200 h on 15 September, all logging tools were disassembled and the logging wireline was secured. The drill string cleared the seafloor at 2230 h, ending Hole U1463B. The total time spent on Hole U1463B was 74.0 h (3.1 d).

After offsetting the vessel 20 m south, APC coring at Hole U1463C started at 0435 h on 16 September. Based on the recovery of the mudline core (4.11 m), the seafloor depth was calculated to be 144.8 mbsl. APC coring continued through Core U1463C-31H to 280.7 mbsf; all of these APC cores were oriented. Formation temperature measurements were made with the APCT-3 tool while taking Cores U1463C-4H, 7H, 10H, 13H, 16H, and 20H. We switched to the HLAPC system and Cores U1463C-32F to 61F were recovered to 392.2 mbsf. A total of 280.7 m were cored with the APC system, recovering 285.40 m, and 111.5 m were cored with the HLAPC system with 111.94 m recovered. The overall recovery for Hole U1463C was 101%. Hole U1463C ended at 1640 h on 17 September. The total time spent on Hole U1463C was 42.25 h (1.8 d).

The vessel was offset 20 m west of Hole U1463C, and APC coring at Hole U1463D started at 1740 h on 17 September. Based on the recovery of the mudline core (1.40 m), the seafloor depth was calculated to be 144.5 mbsl. APC coring continued through Core U1463D-32H to 288.4 mbsf. We switched to the HLAPC system and Cores U1463D-33F to 47F were recovered to 352.8 mbsf. The APC system cored 288.4 m and recovered 282.16 m of core. The HLAPC system cored 64.4 m and recovered 64.45 m of core. The overall recovery for Hole U1463D was 98%. The total time spent on Hole U1463D was 25.75 h (1.1 d). After coring was completed, the drill string was pulled back to surface, clearing the seafloor at 1750 h. The seafloor positioning beacon was recovered at 1810 h on 18 September. After securing the rig floor, the thrusters and hydrophones were pulled and secured, ending Site U1463. The total time spent on Site U1463 was 147.0 h (6.1 d).

At 2024 h on 18 September, the vessel was underway to Site U1464 (proposed site NWS-7A). After, a 79 nmi transit (7.4 h) from Site U1463, we arrived at 0348 h on 19 September. The vessel was offset from the site coordinates and a seafloor positioning beacon was deployed at 0430 h. The APC/XCB bottom-hole assembly was assembled and we decided to begin Hole U1464A with the XCB coring system to establish the character of the upper sediments. The seafloor was tagged at 260.0 mbsl and an XCB core barrel was dropped. Hole U1464A was started at 0655 h on 19 September and Cores U1464A-1X and 2X were cut to 19.4 mbsf but did

not recover any core. Since the sediment was deemed appropriate for APC coring, we terminated Hole U1464A at 0845 h, offset 20 m to the east, and started APC coring Hole U1464B at 0915 h on 19 September. Based on the recovery of the mudline core (2.26 m), the seafloor depth was calculated to be 264.3 mbsl. By the end of the week, we had recovered Cores U1464B-1H to 33H to 303.7 mbsf.

Science Results

Lithostratigraphy

Coring operations at Site U1463 were completed. Four holes (Holes U1463A, U1463B, U1463C, and U1463D) were cored and described. The unit boundary definitions and the report for Site U1463 are currently in progress. The lithostratigraphy of Site U1463 is currently divided into four units, defined by visual core description and smear slide observations, and assisted by XRD and petrographic thin-section analyses. The lithology of Unit I (9.7–13.98 mbsf (Hole U1463A); 0–11.71 mbsf (Hole U1463B); 0–13.65 mbsf (Hole U1463C); 0–15.4 mbsf (Hole U1463D)) is primarily unlithified, creamy gray to light greenish gray wackestone and mudstone, with abundant peloids. Macrofossils are abundant and diverse, and include bivalves, gastropods, bryozoa, serpulids, echinoderms, pteropods, scaphopods, and small benthic foraminifera. Bioturbation is moderate but only occurs intermittently and there are a few contact surfaces (e.g., gradational, bioturbated, and erosive). The bottom boundary of Unit I is defined by the disappearance of peloids. Unit II (13.98–18.29 mbsf (Hole U1463A); 11.71–12.4 mbsf (Hole U1463B); 15.81–112.11 mbsf (Hole U1463C); 15.4–114.3 mbsf (Hole U1463D)) is characterized by alterations between wackestone and mudstone with occasional packstone layers. Lithological changes are also expressed as subtle color variations ranging from light creamy gray to olive gray. Isolated macrofossils occur in darker, coarse-grained wackestone and packstone intervals and include a diverse range of mollusks (gastropods, bivalves, and scaphopods), echinoderms, serpulids, and bryozoans. Bioturbation is slight in this unit, and only some sedimentary and diagenetic features (gradational to sharp contacts, and rare concretions) were noted. Unit III (112.4–388.64 mbsf (Hole U1463B)) is divided into two subunits, IIIa (112.4–299.25 mbsf) and IIIb (299.25–386.94 mbsf), based on a sharp increase in quartz content observed in smear slides. Visual core description for this unit indicates subtle changes in both color and bioturbation, in an otherwise uniform moderately to heavily bioturbated mudstone with rare wackestone. Sedimentary features include rare wavy, sharp, scoured, and gradational contacts, and sporadically preserved parallel lamination. Fossils include common small benthic foraminifers and bivalve fragments present throughout Unit III; less common constituents include fragments of gastropods, bryozoans, echinoderm spines, crustaceans, scaphopods, barnacles, and worm tubes. Occasional concretions (celestite) occur lower in Subunit IIIa (~150–250 mbsf), with disseminated pyrite grains and nodules becoming common in Subunit IIIb. The exact position of the Unit II/III boundary in Holes U1463C and U1463D is still in discussion.

Units IV and V were only recovered in Hole U1463B. The upper boundary of Unit IV (388.64–428.2 mbsf) is defined by the first occurrence of grainstone with abundant macrofossils (mainly bivalve fragments). The unit is further characterized by an increased dolomite content as observed in both smear slides and XRD analyses. Unit V (428.2–525.25 mbsf) is creamy gray to light brown dolostone with sand-sized grains of pyrite and/or glauconite occurring in patches and as scattered grains throughout the matrix. Gypsum/anhydrite nodules, dissolution features, and fine vein structures characterize the dolostone. Both bioturbation and macrofossils are locally common, and bioclasts consist mainly of bivalves and occasional bryozoans and foraminifers.

In addition, coring at Site U1464 started this week, and the lithological description of recovered cores from Hole U1464B is currently in progress.

Biostratigraphy and Micropaleontology

The biostratigraphy and micropaleontology team processed core catcher (CC) samples from Site U1463 at 20 m intervals with occasional higher frequency sampling in horizons of interest. Calcareous nannofossils recovered at Site U1463 represent a complete stratigraphic succession from the early Pleistocene to late Miocene. Barren intervals were present from 429.28 mbsf to the bottom of Hole U1463B (525.25 mbsf). A total 73 smear slides were examined from Holes U1463B (42 samples) and U1463C (31 samples) and show that calcareous nannofossils are few to abundant in Pleistocene samples, common to dominant in Pliocene samples, and few to abundant in late Miocene samples. They are well to moderately preserved throughout the cored interval. The Pliocene–Pleistocene boundary is placed between 238.89–265.63 mbsf based on the presence of *Discoaster sucrculus* (Top at 2.49 Ma). Early Pliocene–late Miocene marker species were rarely found (e.g., *Amaurolithus* spp. and *Ceratolithus* spp.); therefore, the Miocene–Pliocene boundary, which falls within Biozone NN12, was difficult to constrain. However, it is tentatively placed between 327.62 mbsf (>4.2 Ma) and 386 mbsf (<5.59 Ma). Specimens of *Reticulofenestra rotaria* were present above the barren intervals, indicating a maximum age of 6.91 Ma at 429.28 mbsf.

The planktonic foraminifer abundance and preservation at Site U1463 was the best among all investigated sites so far during Expedition 356 with very good to moderate preservation encountered in the entire Plio–Pleistocene with abundant to common planktonic foraminifer between 7.78 mbsf (Sample U1463B-1H-CC) and 378.9 mbsf (Sample U1463B-44X-CC). Biostratigraphic marker species were identified to locate the Mid-Pleistocene boundary (Top *Globorotalia tosaensis*) at 0.61 Ma (46 mbsf), the Plio–Pleistocene boundary below the Top of *Globorotalia limbata* (2.39 Ma) in Section U1463C-24H-CC (220.54 mbsf), *Dentoglobigerina altispira* (3.47 Ma) in Section U1463B-29H-CC (265.87 mbsf) for the Mid-Pliocene, and *Sphaeroidinellopsis kochi* (Top 4.53 Ma) in Section U1463C-46X-CC (334.71 mbsf) for the Early Pliocene. Similar to the calcareous nannofossils, an extended barren interval occurs from 429.26–525.25 mbsf.

At Site U1463, 49 samples were examined this week for benthic foraminifera. Preservation is generally moderate to good with only the lowest section of the cores (>390 m) showing poor preservation. The preservation at this site has been exceptional in comparison with other sites from Expedition 356 and yielded a wide array of foraminiferal species. The layer of poor preservation is coincident with sediment coarsening and a shallower water assemblage that has likely been transported downslope. The number of species per sample ranges from one to 43 with an average of 23. The samples remain largely dominated by *Cibicides* spp. and *Cibicidoides* spp. and dominant species within isolated phases include *Bolivina* spp., *Brizalina semilineata*, *Lenticulina* spp., *Uvigerina* spp., *Siphogenerina raphana*, *Reophax* spp., and other large foraminiferal species including *Neoeponides margaritifer*, *Rotalinoides gaimardii*, and *Pseudorotalia indopacifica*.

Geochemistry

Geochemical analyses on the squeeze cake and interstitial water samples from Holes U1463A and U1463B, including total organic and inorganic carbon content, total nitrogen, and major and minor element content, were completed. Headspace gases also were monitored throughout the entire cored interval. No headspace or interstitial water samples were collected in Holes U1463C or U1463D because these holes recovered a section that had already been sampled. Similar to previous sites from Expedition 356, elevated salinity characterizes Site U1463 with values ranging from 35 to 111, and subsequently elevated sodium and chloride concentrations. The site is also characterized by high percentages of calcium carbonate (mean value of ~77.5%), low total organic carbon (mean value of 0.7%), and low total nitrogen (mean value of 0.031%). The U1463 site report is in progress.

Additionally, we are working on the headspace and interstitial water samples from Hole U1464B. So far, the pore water salinity values show an increase from 35 at the top to 101 at ~250 mbsf. Extremely low methane contents (<4 ppmv) were observed, and no higher hydrocarbon compounds were detected.

Paleomagnetism

Paleomagnetic investigations focused on natural remanent magnetization (NRM) and alternating field (AF) demagnetization measurements from Site U1463. Archive-half core sections were measured on the superconducting rock magnetometer (SRM), before and after AF demagnetization. The AF demagnetization was performed at various steps in Hole U1463C, based the response of different intervals observed in the archive-half core sections from Hole U1463B. Observed intensity values ranged from 10^{-5} to 10^{-2} A/m (upper 350 m), and from 10^{-4} to 10^{-1} A/m (350–530 mbsf). The results indicated that the AF cleaning up to 20 mT revealed very steep, negative inclination values that were observed until ~290 mbsf, from which the AF demagnetization pattern indicated only a slightly changing in inclination values from NRM to 20 mT. This may suggest the presence of a higher coercivity phase, which dominates the remanent magnetism at depth (350–530 mbsf). Isothermal remanent magnetization (IRM)

acquisition curves for three discrete samples indicated that the SIRM was reached at ~100–200 mT. However, one of the samples exceeded the limits of the shipboard analysis for SIRM, indicating the presence of high coercivity magnetic phases.

Physical Properties

Physical properties measurements were carried out on the Whole-Round Multisensor Logger (WRMSL), natural gamma ray (NGR) sensor, and discrete samples of cores from Site U1463. Magnetic susceptibility (MS) shows variability on a 10–20 m scale throughout the cored interval (0–530 mbsf), with a sharp increase in amplitude around 270 mbsf. The variability in MS is consistent between different holes and between the WRMSL and the Section Half Multisensor Logger (SHMSL). The 10–20 m scale variability was also observed in NGR and WRMSL *P*-wave velocity data. To assess the variability in *P*-wave velocity, we carried out three discrete *P*-wave measurements per section between Cores U1463C-1H and 9H and Cores U1463D-23H and 33F. These measurements confirmed the variability in *P*-wave velocity at this scale. However, discrete *P*-wave velocity measurements on XCB cores from Hole U1463B show an increasing trend from 300–390 mbsf. Over the same depth interval, discrete *P*-wave measurements on APC cores from Hole U1463C showed relatively constant velocities around 1900 m/s, a discrepancy that is being pursued further. NGR measurements revealed similar trends and variations in all holes. Porosity decreased gradually from 64% to 40% at 250 mbsf. Below 370 mbsf, porosity was scattered and ranged from 13% to 43%. At the end of the week, the Site U1463 Report was in preparation and physical properties measurements were ongoing at Site U1464.

Downhole Logging

In the middle of the week, the processed downhole logs from Hole U1462C were received and the analysis of these results was begun. Around the same time, successful logging operations in Hole U1463B were carried out with the triple combination and FMS-sonic tool strings. The triple combination tool string was deployed with sources; therefore bulk density and porosity data were collected from Hole U1463B. The downhole logs were sent to shore for processing and the processed logs were received at the end of the week. The Site U1462 and U1463 reports are currently in preparation.

Stratigraphic Correlation

Triple APC coring was completed in Holes U1463B, U1463C, and U1463D for the upper ~270 m with the HLAPC system employed for Holes U1463C and U1463D below this depth to ~390 and 350 mbsf, respectively. We provided coring guidance for the mudline cores of Holes U1463C and U1463D to ensure the tidal variation and the offset for correlation was correct. Several cores were cored short (e.g., Cores U1463C-9H and 12H) to cover recovery gaps and aid in the creation of the stratigraphic splice. Holes U1463B, U1463C, and U1463D were correlated using MS data measured on the Special Task Multisensor Logger (STMSL) and refined with

NGR data. The correlation is still being refined, but the generation of a splice will be possible and provided to the science party shortly. The Site U1463 report is being finalized.

In addition to activities at Site U1463, we provided coring guidance for Site U1464 using our stratigraphic position based on MS (STMSL) and comparing it with the seismic reflection profiles of the site. We expect that either a splice will be possible from this site or, at the very least, a more continuous stratigraphy can be provided to the science party to aid in sampling.

Education and Outreach

This week we conducted eight outreach events, including Pound Middle School (7th grade, Lincoln, NE, USA), and the University of Hannover (Hannover, Germany). In addition, there were two events where the scientists presented their shipboard science and life to their friends and families. We continued to engage with social media, post blogs, and work on individual projects. Finally, the Reddit “Ask Me Anything” broadcast was successfully completed.

Technical Support and HSE Activities

Technical staff primary activities included archiving and processing of cores from Holes U1463B, U1463C, U1463D, and the first cores from Hole U1464B, which brought the total core recovered this expedition to ~4800 m. In general, the technical staff is continuing to support core flow through the laboratories and laboratory maintenance. The Underway Geophysics Laboratory supported two seismic source deployments for vertical seismic profiles, of which one was completely successful and one had to be terminated due to the presence of marine mammals. Miscellaneous tasks include the updated inventory on tagged equipment.

HSE Activities

- Safety showers and eyewash stations were tested.