

## **IODP Expedition 356: Indonesian Throughflow**

### **Week 5 Report (30 August–5 September 2015)**

Week 5 of Expedition 356 (Indonesian Throughflow) began while in transit to Site U1462 (proposed site NWS-3A). This week consisted of operations at Site U1462, including coring in three holes (U1462A, U1462B, and U1462C) as well as downhole logging in one (Hole U1462A). The scientists began analyses of Site U1462. In addition, the downhole logging and stratigraphic correlation groups are finalizing their Site U1461 reports after receiving all of the necessary data.

### **Operations**

After a 61 nmi (5.9 h) transit from Site U1461, we arrived at Site U1462 at 0245 h on 30 August. The vessel was offset 50 m to the northwest (330°) from the site coordinates and a seafloor positioning beacon was deployed at 0340 h. After offsetting the vessel from the acoustic beacon, drill floor activities commenced. The APC/XCB system was assembled and deployed to just above the seafloor. Given the previous difficulty with the Site U1459 mud line core (broken core barrel), we decided to tag the seafloor with the bit. The seafloor was tagged at 95.6 m below rig floor and thought to be soft. Thus, a non-magnetic HLAPC core barrel was dressed with a core liner in preparation for starting Hole U1462A. Unfortunately, the first attempt resulted in a water core and the depth of the bit was moved down three meters. During the second attempt, the core barrel could not be recovered. After trying unsuccessfully to shear off from the core barrel, the coring line was cut at the surface and allowed to fall into the pipe. The top drive was set back and the bottom-hole assembly was pulled back to the surface to investigate the stuck core barrel. It was clear when the bit cleared the rotary table that the core barrel was severely bent, most likely caused by contact with a hard seafloor. Sections of the core barrel were cut and the core barrel was finally removed. The coring line was reheaded, the APC/XCB system was reassembled, and an XCB core barrel was deployed. Hole U1462A was started at 1530 h on 30 August. Cores U1462A-1X to 6X extended from the seafloor to 58.2 mbsf. Because recovery was terrible (0.3 m recovered from 58.2 m cored; 0.7%), the HLAPC system was then deployed in an effort to recover some material. However, Core U1462A-7F recovered only 0.25 m, so the XCB system was redeployed; coring continued with low recovery (<5%) through Core U1462A-32X to 300.9 mbsf. Beginning with Core U1462A-33X, recovery began to improve (46%) and Cores U1462A-34X to 66X penetrated to 621.03 mbsf. Below this depth, we decided to start advancing with half-cores (~4.7 m) in an attempt to further improve recovery; this continued with the recovery of Cores U1462A-67X to 75X to 671.7 mbsf. After Core U1462A-75X, we changed back to full XCB advances and continued through Core U1462A-88X to 796.7 mbsf. After hitting a zone of low recovery (Cores U1462A-87X and 88X; 0.56 m recovered from 19.4 m cored), we changed again to half-core advances that continued to a final depth of

855.0 mbsf. The last core of Hole U1462A (100X) was recovered at 0745 h on 3 September. In total, 320.54 m were recovered from 855.0 m cored (38%).

In preparation for downhole logging, we circulated the hole with high viscosity mud to clean out the cuttings and a go-devil was pumped through the drill string to open the lockable float valve. The bit was raised to 299.8 mbsf and the upper section of the hole was displaced with heavy mud. The bit was raised up to 82.1 mbsf and the rig floor was set up for downhole logging. We began assembling the triple combo logging tool string at 1400 h on 3 September. The tool string contained the following tools: magnetic susceptibility sonde (MSS), Hostile Environment Natural Gamma Ray Sonde (HNGS; caliper only, no source), Hostile Environment Litho-Density Tool (HLDT), Enhanced Digital Telemetry Cartridge (EDTC), and logging equipment head-q tension (LEH-QT). The tools were deployed at 1520 h on 3 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 ~800 mbsf (~55 m above the bottom of the hole). Log data were collected with the triple combo tool string to 692 mbsf and then run back to bottom; a second uplog was made from 799 mbsf up to the bit (82.1 mbsf). The caliper reading indicated the hole size ranged from 14 inch near the bottom of the hole up to ~17 inch at the top. The tools arrived back on the rig floor at 1900 h and then were disassembled. 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 2050 h, the tool string was lowered to just above the seafloor. The logging tools were activated and the hole was logged down to 797 mbsf. The hole was logged up to just below the end of pipe (82.1 mbsf). A second pass was made over the total length of open hole. The tool string was pulled back into the drill pipe and logging continued to the seafloor. The tool string arrived back on the rig floor at 0200 h on 4 September. After rigging down the FMS-sonic tool string, we assembled and tested the Versatile Seismic Imager (VSI) tool string in preparation to conduct a vertical seismic profile. A caliper extension was added to the tool due to the large diameter of portions of the hole. The tool string was deployed at 0445 h. We then waited for daylight so that the protected species watch could begin. Over the next 3.5 h, humpback whales were sighted continuously and at 1120 h, we canceled the VSP experiment. The tool string arrived on the rig floor at 1150 h. At 1245 h, all logging tools were disassembled and the logging wireline was secured. The total time spent on Hole U1462A was 130.5 h (5.4 d).

The vessel was offset 20 m in a direction of 060° from Hole U1462A, and XCB coring in Hole U1462B was started at 1425 h on 4 September. Coring with full advance (9.7 m) continued for the first two cores, but half advance intervals were then used to recover Cores U1462B-3X to 9X to 52.3 mbsf. Core recovery was very low with only 1.99 m recovered from the 52.4 m cored (4%). After coring was completed at 1955 h on 4 September, the bit was pulled out of the hole at 2040 h and the bit was back on the rig floor at 2255 h on 4 September. The total time spent on Hole U1462B was 9.75 h (0.4 d).

We then offset the vessel again and prepared for RCB coring in Hole U1462C. The bit was deployed to just above the seafloor before the upper guide horn was removed and the moonpool doors opened for deploying the subsea camera system for a short visual survey of the seafloor surrounding the site. Unfortunately, the camera system stopped working shortly after it was deployed. The camera and frame were pulled back to the surface and repaired (a connector had leaked). We decided to abandon the survey and start RCB coring. A center bit was deployed and drilling without coring in Hole U1462C started at 0400 h on 5 September. After drilling to 33.0 mbsf, the center bit was pulled and RCB coring began with half-length advances. We recovered Cores U1462C-2R to 44R to 242.0 mbsf. After dropping the next core barrel, the drill string became stuck and the end of week 5 was spent freeing the drill string and conditioning the hole so that coring could resume.

## Science Results

### *Lithostratigraphy*

In the first part of the week, the final version of the Site U1461 report was completed.

The rest of the week involved describing cores from Site U1462. Preliminary lithostratigraphy assigned four units to the material recovered for Hole U1462A; correlations to Hole U1462B and Hole U1462C are currently in progress. Unit I (0–291.22 mbsf) is characterized by very poor recovery (~3%–4%). Visual core description is thus mainly based on core catcher material and short (<30 cm) intervals of core recovered. The sediments of Unit I are partially to fully lithified packstones and grainstones with sand-sized to coarse sand-sized grains. Some sedimentary features occur, such as sharp and gradational contacts, slight to moderate bioturbation, and parallel laminations. Macrofossils are common in Unit I and include mollusks, barnacles, solitary corals, echinoderms, bryozoans, and serpulids. Notably, Core U1462A-16X (136–139.75 mbsf) yielded comparatively high (~45%) recovery consisting of ooid packstone. The same interval was also encountered in Hole U1462C (Cores 22R and 23R; 129.59–140.40 mbsf) with similarly good recovery. All material recovered from the upper 291.22 m of Hole U1462A and the corresponding intervals recovered from Hole U1462B and Hole U1462C reflect neritic facies. Unit II (300.90–777.30 mbsf) is composed of lithified, olive gray to (dark) greenish gray packstone. Overall, the sediment is uniform in appearance with noted variabilities in grain size, bioturbation intensity, and siliciclastic content. Bioturbation and sedimentary features suggesting transport increase in the lower part of the unit (635.50–777.3 mbsf). The subdivision of Unit II is currently in progress, pending smear slide and thin section data from Hole U1462C. Unit III (777.30–843.65 mbsf) is defined by the visual appearance of medium to coarse sand-sized siliciclastic (i.e. quartz) grains within the sediment. The increase in coarse siliciclastic content coincides with a sharp decrease in core recovery. The lithology of Unit III consists of packstone and wackestone with quartz, moderate bioturbation, and frequent intraclasts. Macrofossils are present and include fragments of bivalves, bryozoa, and echinoderms. Lenses and layers rich in

large benthic foraminifers are a common feature throughout Unit III. Unit IV (843.65–849.50 mbsf) is tentatively defined by a sharp lithological change from quartz-rich limestone to quartz-rich dolomite in Section U1462A-98X-3, based on preliminary smear slide and thin section data. Visual core description shows no clear lithological change until Core U1462A-99X, where large anhydrite nodules are encountered. Black metal-oxide staining was frequently noted within the lower part of this unit. Work is continuing to further define these lithostratigraphic units.

### *Biostratigraphy and Micropaleontology*

The biostratigraphy team processed core catcher (CC) samples from Site U1462 at 20 m intervals, completing Holes U1462A and U1462B, and commencing Hole U1462C. Calcareous nannofossils recovered at Site U1462 represent a complete stratigraphic succession from the early Pliocene to late Miocene. In Hole U1462A, 64 smear slides were analyzed. Samples from the Pleistocene section contain rare to abundant nannofossils with poor to good preservation, and the Miocene–Pliocene sections contain rare to dominant nannofossils with moderate to good preservation; however, nannofossils are absent from 844.8–855 mbsf. In addition, seven smear slides were analyzed from Hole U1462B, revealing calcareous nannofossils that are rare to common with poor and moderate preservation, and some barren intervals. The bottom of Hole U1462B (47.8 mbsf) was dated to early Pleistocene age (>0.44 Ma). The top of biozone NN16, which includes the Pliocene–Pleistocene boundary, is marked by the presence of *D. surculus* (2.49 Ma) between Samples U1462A-57X-CC and 55X-CC (539.97–515.92 mbsf). Oligocene reworking (e.g., *Reticulofenestra bisecta* and *Cyclicargolithus floridanus*) was found in Samples U1462A-61X-CC to 95X-CC (581.1–827.56 mbsf), and marker specimens of the early Pliocene–late Miocene were rare; therefore, the Miocene/Pliocene boundary is difficult to place. However, the presence of *D. quinquerasmus* from Sample U1462A-93X-CC (818.28 mbsf) downhole suggests late Miocene age (>5.59 Ma). In Hole U1462C, 20 smear slides were analyzed with rare to few nannofossils exhibiting poor to moderate preservation. Medium *Gephyrocapsa* spp. (>4 µm) is still present in Sample U1462C-42R-CC (227.43 mbsf), indicating a maximum age of 1.73 Ma.

Forty-five samples have been examined from Hole U1462A, seven from Hole U1462B, and 15 from Hole U1462C for planktonic foraminifera. Preservation ranged from moderate to (very) poor with frequently barren intervals in the Pleistocene. The poor preservation in Hole U1462A (Cores U1462A-6X to 28X; 48.5–252.4 mbsf) was accompanied by less than four species per sample, with the exception of Sample U1462A-1X-CC which contained 14 species. Poor preservation and barren samples were also encountered for most of Hole U1462B and Hole U1462C to 227 mbsf. Relatively improved preservation was observed from ~271.87 mbsf in Hole U1462A, but yielded few markers. The Pleistocene marker species *Globorotalia tosaensis* (Top 0.61 Ma) and *G. truncatulinoides* (Base biozone Pt1a; 1.93 Ma) only co-occur in Sample U1462A-39X-CC (368.71 mbsf) giving an apparent base for *G. truncatulinoides*. The very rare occurrence of these two species in shallower intervals is probably due to their habitat depth. The

upper part of biozone PL5 (early Pleistocene; 2.39 Ma) is marked by the top of *G. limbata* in Sample U1462A-53X-CC (498.82 mbsf), while the top of PL4 (3.46 Ma) is marked by the top of *Dentoglobigerina altispira* in Sample U1462A-57X-CC (539.97 mbsf). Core U1462A-95X (827.46 mbsf) contained heavily glauconitized specimens with only a few identifiable planktonic foraminifers. Samples were barren of planktonic foraminifers downhole from Core U1462A-98X (844.12 mbsf) due to heavy cementation and Core U1462A-99X (844.8 mbsf) was completely dolomitized.

To date, 47 samples have been examined from Hole U1462A, seven samples from Hole U1462B, and 16 from Hole U1462C for benthic foraminifera. Preservation is generally poor, however there are frequent horizons where it increases to moderate or good. These include Sample U1462A-13X-CC (107 mbsf) and from Samples U1462A-51X-CC to 53X-CC (476.65–498.82 mbsf). Poor preservation is largely due to abrasion and encrustation by calcite, iron, and micrite. The number of species per sample across these three holes ranges from 6–36 with an average of 15. The assemblages remain largely dominated by *Cibicides* spp. and *Cibicidoides* spp. with the addition of several phases where dominant species include larger benthic foraminifer (LBF) species, particularly *Amphistegina lessonii* and *Opderculina* spp., smaller infaunal species including *Bolivina* spp. and *Uvigerina* spp., and lenses of other large foraminifera (non-LBF) including *Neoeponides margaritifer* and *Pseudorotalia* spp.

### *Geochemistry*

At Site U1462, headspace gases monitored in Hole U1462A were present only in low concentrations with a maximum methane value of 82 ppmv detected. Geochemical analyses on the squeeze cake and interstitial water samples from Hole U1462A, including total organic and inorganic carbon content, total nitrogen, and major and minor element content were performed. Due to the low core recovery in the upper 300 m of Hole U1462A, it was not possible to take pore water samples in this interval, nor were measurements for total organic and inorganic carbon or total nitrogen made. Like previous Expedition 356 sites, elevated salinity characterizes Site U1462 with values ~101 at 300 mbsf, and these generally increase with depth. Associated major and minor elements trends are consistent with this. A maximum salinity value of 153 is found at approximately 817 mbsf, the highest observed thus far on this expedition. The site is also characterized by high percentages of calcium carbonate (mean value of ~82.5%) and low total organic carbon (mean value of 0.03%) and total nitrogen (mean value of 0.7%).

### *Paleomagnetism*

Twenty-four discrete samples were taken for analyses from Hole U1462A. Bulk magnetic susceptibility was measured on each sample, and results ranged from ~7–48 × 10<sup>-6</sup> SI units, with the exception of Sample U1462A-16X-2, 30–32 cm, which indicated a predominant diamagnetic response. Isothermal remanent magnetization acquisition (IRM) and backfield IRM acquisition measurements were carried out on samples from Sections U1462A-43X-1, U1462A-54X-1, U1462A-85X-2, and U1462A-93X-1. Results indicated SIRM values range from ~400–700 mT,

and coercivity of remanence values range from 46–60 mT. Alternating field stepwise demagnetization curves indicated a less stable pattern for samples from the top of Hole U1462A. The majority of samples lost 70%–80% of their natural remanent magnetization after the 10–20 mT steps. Using principal component analysis, it was possible to observe negative magnetic inclination values suggestive of normal polarity (e.g., ~350 mbsf) and reversed polarity (Sample U1462A-43X-1, 49–51 cm; ~410 mbsf), but a more complete magnetostratigraphic interpretation is still in progress.

### *Physical Properties*

Physical properties measurements were carried out using the Whole-Round Multisensor Logger (WRMSL), natural gamma ray (NGR) sensor, and discrete sampling on cores from Site U1462. In the upper 300 m of Holes U1462A and U1462C and in all of Hole U1462B, core recovery was very low; therefore, we only ran Cores U1462A-14X and 16X through the WRMSL and the NGR sensor. Nevertheless, material from all cores in this interval was sampled for discrete measurements. Below 300 m in Hole U1462A, core recovery increased significantly and cores were run through the WRMSL and NGR sensor (at 10 cm spatial resolution). One or two samples per core were taken for discrete moisture and density (MAD) measurements. These measurements show that porosity decreases from about 45% at 300 mbsf to 25% at the bottom of Hole U1462A (849.67 mbsf). Discrete *P*-wave measurements were taken at a rate of at least one per core. In Hole U1462A, sonic velocities were very variable (between 2000–5000 m/s) in the upper 300 mbsf, showed a gradual increase with depth between 300–840 mbsf (from 2000 to 2800 m/s), and then rapidly increased between 840–850 mbsf (from 2800 up to 5000 m/s). Thermal conductivity was measured using either the needle probe or mini-puck methods. The values increased with depth from about 1.3 W/(m·K) at 300 mbsf to 2.4 W/(m·K) at the bottom of Hole U1462A. Currently, physical properties measurements are ongoing from Hole U1462C.

### *Downhole Logging*

The processed logs from Hole U1461D were received back on the ship on 2 September and the analysis of the results is in its beginning stages. Additionally, downhole logging was performed in Hole U1462A. Successful runs were performed with the triple combination and FMS-sonic tool strings. However, the triple combination tool string was deployed without sources, so no bulk density or porosity data were obtained. All of the Hole U1462A log data have been sent to shore for processing.

### *Stratigraphic Correlation*

As coring at Site 1461 was completed, we finalized a splice for Holes U1461A, U1462B, and U1462C that encompasses the upper ~285 m. We also performed correlation on the deeper sections of Holes U1461B and U1461D, but gaps in recovery preclude the production of a continuous stratigraphy from coring data alone. However, the wireline gamma logs obtained via

downhole logging are aiding correlation of Holes U1461B and U1461D, and a deeper, hanging splice may be possible.

At Site 1462, low recovery in the upper ~300 m in Hole U1462A resulted in the decision to core to ~50 m in Hole U1462B, before RCB coring deeply in Hole U1462C. Initial coring results were plotted against the Hole U1462A unprocessed wireline gamma log data to guide coring in the deeper sections of Hole U1462C (below 300 mbsf) and to limit coring gaps as much as possible between the two holes, particularly for those sections with moderate to good recovery in Hole U1462A (e.g., Cores U1462A-33X to 43X, 56X to 86X, and 94X to 98X).

### **Education and Outreach**

This week the education and outreach team conducted four school broadcasts: Marine Science Magnet High School (11<sup>th</sup> grade, Groton, CT, USA), Dalyellup College (7<sup>th</sup>, Bunbury, Western Australia), Jarjum Learning Centre (preschool, Lismore, Australia) and Wilkerson Intermediate School (6<sup>th</sup> grade, Spring, TX, USA). Engagement with social media, blog posting, and work on individual projects are ongoing. A Reddit “Ask me Anything” is currently being finalized.

### **Technical Support and HSE Activities**

Technical staff primary activities included initial archiving of cores from Holes U1462A, U1462B, and U1462C, supporting core flow through the laboratories, and laboratory maintenance. In the Underway Geophysics Laboratory, the technical staff prepared the seismic source and coordinated the associated protected species watch for the attempted vertical seismic profile; however, this had to be abandoned after repeated whale sightings.

#### *HSE Activities*

- Safety showers and eyewash stations were tested.
- A fire and boat drill was conducted on 5 September.