

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

### **Week 2 Report (9–15 August 2015)**

The second week of IODP Expedition 356 (Indonesian Throughflow) consisted of operations at Sites U1459 and U1460. Site U1459 was completed at 1254 h on 12 August after successful coring to 400 mbsf (early Eocene) and downhole logging. By the end of the week, coring at Site U1460 (proposed site NWS-5A) had begun and finished, completing operations at the southern sites of the expedition's latitudinal transect. Currently, the vessel is underway to the first of four northern sites, Site U1461 (proposed site NWS-4A).

### **Operations**

#### *Hole U1459C*

After piston (APC, HLAPC) and XCB coring in Holes U1459A and U1459B, this week started with RCB drilling in Hole U1459C. After drilling without coring to 205.8 m, the core barrel with a center bit was retrieved; two sections worth of material (2.65 m) were found in the core liner and curated with the drilled interval. RCB coring began and Cores U1459C-2R to 4R were recovered to 219.6 mbsf. The next core barrel was dropped at 1115 h on 9 August, but increasing ship heave made it difficult to keep the bit on bottom for coring. Coring was suspended with the vessel heave increasing to >4 m and the bit was raised up to 212 mbsf while the driller maintained circulation, rotation, and worked the pipe up and down. At 1515 h on 9 August, the drill string torque increased and rotation stopped. After working the stuck pipe for almost an hour with circulation, rotation, and overpull, it came free. The bit was then pulled up to 115.5 mbsf and the driller continued to circulate, rotate, and work the pipe up and down. Heave continued to increase up to ~5.8 m before gradually diminishing. The following day (10 August), the heave reduced to the point where it was possible to pull the empty core barrel back to the surface. A core barrel with a center bit was dropped and the hole was washed back to bottom without difficulty. Coring resumed at 1215 h on 10 August with recovery of Core U1459C-5R. Coring continued for another 3.25 h, when the drill pipe became stuck again. After 1.25 h, it came free and coring resumed; Cores U1459C-6R to 42R were recovered to 400.0 mbsf at ~1730 h on 11 August. This depth was 70 m deeper than what was originally approved before the expedition. This extra penetration was necessary to recover appropriate Paleogene-aged material and permission was obtained during operations at sea. After coring was completed, the hole was prepared for wireline logging. High viscosity mud was circulated to clean the hole of cuttings and then the hole was also displaced with 120 barrels of 11 ppg mud. The end of the pipe was raised to 72.2 mbsf and the drill floor was rigged up for logging.

The triple combo logging tool string was prepared at 2330 h on 11 August. It 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 the logging equipment head-q tension (LEH-QT). The tools were assembled, tested and run in the hole at 0030 h on 12 August. After the tool string exited the drill pipe, the wireline active heave compensator was turned on. The initialization of the unit normally imparts a slight shock to the wireline system, but because of the shallow water and the shortness of the logging string, the fluctuation in the tension of the wireline resulted in the wireline coming off the sheaves of the compensator. The logging tool string was hung off with a T-bar, while the wireline was put back into the sheaves and tested. The wireline compensator software was modified slightly to be less reactive to the high heave conditions and wireline logging resumed. A downlog was performed from just above seafloor to the full hole depth of 389.0 mbsf. The hole was logged up with the triple combo tool string to 278 mbsf. A second uplog was made from 389.0 to ~139 mbsf. A problem with the caliper on the second pass caused the arm to stick at ~10 inch (bit size). Eventually, this was corrected and a third pass was made from ~317 mbsf with a better caliper response. The tools were pulled from the hole and were back on the rig floor at 0445 h on 12 August. The FMS-sonic logging tool string was then 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 0630 h, the tool string was lowered without difficulty through the drill pipe and to ~180 mbsl, just above the seafloor. The logging tools were activated and the hole was logged down to 300 mbsf. After trying unsuccessfully to make it past an apparent bridge, the hole was logged upwards from that depth. The calipers for the FMS tool were opened at 287 mbsf and the hole was logged up to just below the end of the pipe. The tool string was lowered back to the bottom of the hole, where ~8 m of fill had accumulated, so the second pass was made from 292 mbsf up to the just below the end of the pipe. The tool string was pulled back into the drill pipe and log data was collected within the pipe to the seafloor. The tool string was pulled back to the surface and rigged down by 1030 h on 12 August, successfully completing logging operations.

The drill string was pulled from the hole, the thrusters and hydrophones were pulled and secured, and Site U1459 ended at 1254 h on 12 August. The total time spent on Hole U1459C was 92.25 h.

### *Site U1460*

After an 85 nmi transit (7.9 h), the vessel arrived at Site U1460. The vessel was offset 50 m to the west of the site coordinates and a seafloor positioning beacon was deployed at 1230 h on 12 August. After offsetting the vessel from the beacon, drill floor activities commenced. Given the previous difficulty establishing the mudline and initiating coring at Site U1459 (broken core barrel), we decided to tag the seafloor with the bit to determine depth and hardness. Hole U1460A was spudded at 0115 h on 13 August. Based on the recovery of the mudline core, the seafloor depth was calculated as 214.5 mbsl. Cores U1460A-1F to 65F were recovered to 300.1 mbsf. Core recovery was excellent (300.1 m cored, 291.39 m recovered, 97%). Hole U1460A ended at 0605 h on 14 August. The total time spent on Hole U1460A was 33.25 h.

After offsetting the vessel 20 m north of Hole U1460A, Hole U1460B was spudded at 1920 h on 15 August. Based on the recovery of the mudline, the seafloor depth was calculated as 214.4 mbsl. After establishing the mudline, the advance on each core was by recovery in an attempt to recover gaps in core recovery in Hole U1460A. Cores U1460B-1F to 68F were recovered to 306.6 mbsf with the HLAPC system. Core recovery was excellent with 296.41 m recovered from 306.6 m cored (97%). In situ temperature measurements with the APCT-3 were taken on Cores U1460B-12F, 20F, 28F, 33F, and 36F. Site U1460 ended at 1945 h on 15 August with the vessel prepared for transit to the next site. The total time spent on Hole U1460B was 37.75 h.

## Science Results

This week we report results from Hole U1459C and Site U1460. All reports from Site U1459 have been finalized.

### *Hole U1459C*

The sedimentology group finalized the description of all recovered material from Site U1459. In addition to the previous five units described from Holes U1459A and U1459B, two others were added from Hole U1459C. Unit I is a lithified skeletal packstone to floatstone; Unit II is a unlithified mudstone to packstone with interlayers of skeletal grainstone; Unit III is glauconitized unlithified to partially lithified packstone to grainstone with macrofossils; Unit IV is an unlithified homogeneous packstone with glauconite; Unit V is a dolomitic packstone with quartz, Subunit Va is an unlithified packstone that includes a partially to fully lithified interval, while Subunit Vb is an unlithified packstone with dolomite interbedded with lithified fine quartz sand; Unit VI is lithified beige to light brown/gray to brown dolostone; Unit VII is lithified, chert-rich packstone and microcrystalline dark gray chert.

The core catchers of Hole U1459C contained well-preserved rare to abundant calcareous nannofossils within a matrix of micrite. The upper part of the hole contains typical assemblages of early–late Miocene medium- to large-sized reticulofenestrids. Paleogene strata were identified in Core U1459C-10R (Top *Cyclicargolithus abisectus*, >23.06 Ma). There are few barren intervals in Cores U1459C-12R to 14R and 16R, coincident with high dolomitization. From Core U1459C-17R downward, calcareous nannofossils increased in abundance. The bottom of Hole U1459C was dated to early–middle Eocene.

Due to severe dolomitization, the upper half of Hole U1459C contains only rarely preserved planktonic foraminifera. After Core U1459-20R, identifiable foraminifera are present again, but overall preservation remains (very) poor. The first faunas appearing were identified as Oligocene. Below Core U1459-29R, a well-developed Eocene faunal assemblage is present covering biozones E14-E9 (~38–50 Ma), so that the bottom of Hole U1459C dates to the latest

Early Eocene. Of the 42 cores recovered from Hole U1459C, 28 contained benthic foraminifera. These samples had poor preservation with 2–11 species per sample. Samples below U1459C-19R-CC were dominated by *Cibicides* spp. and *Cibicidoides* spp. and were almost exclusively comprised of epifaunal species.

Headspace gases were monitored in each core. Only very low concentrations of methane were detected. Most samples have <2 ppm methane and undetectable ethane. All geochemical analyses on the squeeze-cake and interstitial water samples including total organic and inorganic carbon content, total nitrogen, and major and minor element content were completed from Hole U1459B. Due to the character of the materials (chert and other lithified sediment) recovered in Hole U1459C, no geochemical analyses were performed except for carbonate and headspace gas measurements, which were made when feasible.

Lithified sediments in Hole U1459C were not measured on the superconducting rock magnetometer due to frequent voids and unoriented pieces, and no discrete samples were taken. Preliminary magnetostratigraphy is ongoing.

Physical property measurements were conducted using the Whole-Round Multisensor Logger (WRMSL), natural gamma ray (NGR) sensor, and discrete sampling. Core recovery from Hole U1459C was low (12%), so the collected physical property data are probably not representative of the drilled formations. Nevertheless, interesting results were obtained from discrete samples (moisture and density [MAD] and *P*-wave velocity). For example, high *P*-wave velocities (6257 m/s) were obtained from lithified rocks, including cherts and dolomitic cobbles.

Downhole logging was successful in Hole U1459C in which the both the triple combo and the FMS-sonic tool strings were deployed. Out of safety concerns, the triple combo string was deployed downhole with a reduced configuration (without the porosity, density, and resistivity tools). Inspection of the pre-processed logs indicated that both good gamma ray and magnetic susceptibility logs were obtained. These two logs were passed on to the stratigraphic correlation team. The FMS-sonic tool was not able to pass below ~300 mbsf, but the unprocessed field data indicate that good data was collected. All of the preprocessed logs were transferred to shore for processing.

Hole U1459C had extremely low recovery and so no correlation was possible with Holes U1459B and U1459C. Hole U1459C gamma log data will be used to generate a continuous record of Site U1459. Although the sediment recovery was low, Hole U1459C lithologic changes could be correlated with regional reflectors. Additionally, correlation of Hole U1459B core NGR data to the gamma logs of the nearest industry well in similar water depths (Wittecarra-1) suggested that the precruise approved penetration depth of 330 m at Site U1459 was within the reach of the Paleogene. We therefore sought, and received, approval to extend the total depth at this site by 70 m. The cores from Hole U1459C reached early Eocene sediments, indicating the other nearby but updip industry well (Houtman-1) is actually a better stratigraphic analogue for the Paleogene.

## Site U1460

Two holes were cored at Site U1460: Hole U1460A (300.1 m) and Hole U1460B (306.6 m). Core recovery in both of these holes was very good (97%). The lithology is dominated by carbonate, and preliminary results suggest that Hole U1460A consists of only one lithostratigraphic unit. It is dominated by unlithified to partially lithified skeletal packstones, wackestones, and mudstone. The bioclastic assemblage is dominated by benthic and planktic foraminifera, bivalves, echinoderms, and bryozoan. Sponge spicules are common below 47.05 m and are abundant from 56.01 to 113.91 mbsf. Dolomite occurs only sporadically above 150.01 mbsf, but is present (up to 15%) below this depth. Two thin (10–20 cm), lithified layers at 44.79 and 174.63 mbsf punctuate the otherwise relatively homogeneous sedimentary succession. Both layers are marked by authigenic mineralization and were interpreted as hardgrounds. The uppermost hardground was also identified at a similar depth in Hole U1460B and likely can be used for correlation between both holes. Work is continuing to further characterize the lithostratigraphic units and to integrate lithologic data from Hole U1460B.

Calcareous nannofossils were abundant and continuously present throughout Hole U1460A with good preservation, covering the late Pleistocene (<0.29 Ma) to the late Pliocene (>3.54 Ma). The sequence of nannofossil marker species suggests that sedimentation has been continuous at this site. Reworked specimens of older age (e.g. *D. brouweri*) in late Pleistocene samples were identified, however these are generally rare.

Site U1460 contains abundant planktonic foraminifera with poor to moderate preservation throughout Hole U1460A and the bottom of Hole U1460B. The middle Pleistocene, defined as biozone Pt1a (0.61–1.93 Ma), can be identified between Cores U1460A-19F and U1460A-57F. Below this (Core U1460A-60F) a clear Pliocene faunal assemblage occurs (biozones PL4–PL2). This dates the bottom of Site U1460 to ~4 Ma. The samples also reveal good to moderate preservation of benthic foraminifera with a large number of dominant species including *Uvigerina peregrina*, *Siphogenerina raphana*, *Cibicides* spp., *Cibicidoides* spp., and *Textularia* spp.

At Site U1460, headspace gases were monitored in each core from Hole U1460A. Thus far, only very low concentrations of methane (2–10 ppmv) and ethane (below 2 ppmv) have been detected. Samples for interstitial water composition (including pH, alkalinity, salinity, and major and minor element content) were taken every two cores from Hole U1460A. The pH values of interstitial water samples range from 7.1 to 7.8. Alkalinity ranges from 3.4 to 8.8 mM. Salinity at the top is 35 and increases with depth, reaching 61 in Core U1460A-62F. The squeeze cake and interstitial water samples are in various stages of preparation for other geochemical analyses, including total organic and inorganic carbon content, total nitrogen, and major and minor element content.

Paleomagnetic studies focused on natural remanent magnetization (NRM) measurements of the archive-half sections and discrete samples from the working-half sections from Site U1460. The

NRM was measured every 10 cm for archive-half sections using the 2G superconducting rock magnetometer (SRM). NRM was measured after stepwise alternating field (AF) demagnetization at NRM to 30 mT (10 mT steps). AF demagnetization and acquisition curves of isothermal remanent magnetization (IRM) of discrete samples contributed to rock magnetic investigations. Discrete samples were subjected to AF demagnetization in progressive steps of 10 mT up to a peak field of 80 mT. Before IRM acquisition, the samples were demagnetized by applying a 180 mT field. Then IRM was applied using the impulse magnetizer, in different steps, up to a peak field of 1200 mT. IRM acquisition behavior was analyzed by means of cumulative log-Gaussian curve fittings for two selected discrete samples from Hole U1460A. Results indicated the occurrence of multidomain (MD) magnetite grain size distribution, and a high coercivity magnetic component that cannot be unequivocally identified through preliminary studies.

Physical property measurements followed the same measuring and sampling strategy as at Site U1459. However, we increased the resolution of the NGR by a factor of two (10 cm). This decision was motivated by the fact that the NGR data proved extremely useful for correlation purposes at Site U1459. Also, thermal conductivity measurements down to the base of Holes U1460A and U1460B were collected to complement the downhole temperature measurements taken in Hole U1460B with the APCT-3. Physical properties measurements of Holes U1460A and U1460B were still ongoing at the end of the week.

Site U1460 did not experience the same issues with thick hardgrounds near the surface that were experienced at Site U1459, so coring, core recovery, and correlation were more straightforward. Real-time monitoring of Hole U1460B cores using STMSL MS and GRA data allowed core depth adjustments to ensure the gaps in the cores between the two holes did not converge. Correlations will be supplemented by the NGR data once data collection is completed.

## **Education and Outreach**

The onboard education/outreach team created five blog posts and is regularly updating additional posts on social media (Facebook [<https://www.facebook.com/joidesresolution>], Instagram [[http://instagram.com/joides\\_resolution](http://instagram.com/joides_resolution)], and Twitter [<https://twitter.com/TheJR>]). Various GoPro time-lapse videos are being produced along with a series of conversational interviews with scientists. The education/outreach team also participated in activities in the Paleontology and Paleomagnetic Laboratories as well as helping out with sampling the cores.

## **Technical Support and HSE Activities**

The second week involved the technical staff handling core from Hole U1459C and Site U1460, as well as conducting laboratory maintenance.

### *Laboratories*

- Core Laboratory
  - Processing cores.
  - Site U1458 personal samples taken as time allowed.
  - Site U1459 personal samples taken as part of core flow.
- Thin Section Laboratory
  - Producing thin sections.

### *Miscellaneous*

- A new component for DESClogik “principal\_lithology\_rank” is being worked on by developers to accommodate carbonate sedimentology descriptions.

### *HSE Activities*

- Safety showers and eyewash stations were tested on 15 August.
- A fire and boat drill was conducted on 12 August.