IODP Expedition 363: Western Pacific Warm Pool

Week 3 Report (16–22 October 2016)

Operations

The majority of this week was spent conducting coring operations in three holes at Site U1482.

Transit to Site U1482 (proposed Site WP-12D)

After an uneventful transit, the ship arrived at Site U1482, and we lowered the thrusters and switched to dynamic positioning (DP) control at 1524 h (UTC + 8 h) on 16 October 2016. The 1514 nmi transit from Singapore to Site U1482 was completed in 128.3 h at an average speed of 11.8 kt.

Hole U1482A

Position: 15°3.3227′S, 120°26.1049′E
Water depth: 1467.7 m below sea level (mbsl)
Penetration depth: 490.0 m below seafloor (mbsf)

A seafloor positioning beacon was deployed at 1535 h on 16 October 2016. Initial operations consisted of making up and spacing out the bottom-hole assembly (BHA), which included an advanced piston corer (APC)/extended core barrel (XCB) coring assembly with two stands of drill collars. During deployment of the drill string, the drill pipe was drifted (checked to ensure that the interior was clear) and strapped (measured). The seafloor depth was measured at 1480.4 m below rig floor (mbrf) using the precision depth recorder (PDR). After the drill string appeared to take weight at 1475 mbrf, we decided to shoot the first core from 1472 mbrf. Hole U1482A was spudded at 0035 h on 17 October with Core U1482A-1H recovering 2.98 m of core, establishing a seafloor depth of 1467.7 mbsl. The hole was originally planned as an APC hole to refusal (estimated at 250 mbsf), but we decided to APC to refusal and then XCB to the total depth approved for the site (490 mbsf) to better guide drilling decisions for subsequent holes.

Oriented APC coring with nonmagnetic core barrels continued through Core U1482A-37H to 344.9 mbsf. The advanced piston corer temperature tool (APCT-3) was deployed on Cores 4H (31.4 mbsf), 7H (59.9 mbsf), 10H (88.4 mbsf), and 13H (116.9 mbsf). The APCT-3 obtained good temperature measurements on three of the four deployments (the initial measurement showed movement in the core shoe). After the liners of Cores 31H and 32H partially imploded, followed by a partial stroke and shattered core liner on Core 37H, we switched to the half-length APC (HLAPC) coring system. HLAPC coring continued from Core 38F to 45F (344.9–380.2 mbsf). Partial strokes occurred on Cores 42F, 43F, and 45F. The core liner of Core 45F shattered upon recovery, and so we then switched to the XCB to continue deepening the hole to the maximum approved depth of 490 mbsf. Coring with the XCB was slow, but recovery was excellent. Hole U1482A reached 490 mbsf with Core 58X. The drill string was pulled out of Hole U1482A with the bit clearing the seafloor at 1610 h on 19 October.

Coring in Hole U1482A penetrated 490.0 m and recovered 505.88 m (103%). Total time on the hole was 3.0 d (72.75 h).

Hole U1482B

Position: 15°3.3142′S, 120°26.0988′E
Water depth: 1464.5 mbsl
Penetration depth: 366.6 mbsf

The vessel was offset 20 m at 320° from Hole U1482A, the drill string was spaced out so the bit was at 1472 mbrf, and Hole U1482B was spudded at 1905 h on 19 October. The seafloor was calculated at 1475.4 mbrf (1464.5 mbsl) based on 6.13 m of recovery in the mudline core. Oriented APC coring using nonmagnetic core barrels penetrated to 343.6 mbsf (Cores 1H through 39H). Three intervals were drilled without coring for stratigraphic correlation purposes. After a partial stroke on Core 39H, we drilled ahead 3.0 m before switching to the HLAPC coring system. Cores 41F through 45F penetrated to 366.6 mbsf and the hole was terminated at that depth in order to initiate the next hole at a similar tidal phase to Hole U1482A. The drill string cleared the seafloor at 0000 h on 21 October, ending Hole U1482B.

Coring in Hole U1482B penetrated 349.1 m and recovered 365.83 m (105%). In addition, five drilled intervals advanced the bit a total of 17.5 m without coring to offset core gaps for stratigraphic correlation. Total time on the hole was 1.3 d (31.75 h).

Hole U1482C

Position: 15°3.3298′S, 120°26.1135′E
Water depth: 1465.2 mbsl
Penetration depth: 447.9 mbsf (as of 0000 h on 23 October 2016)

The vessel was offset 20 m at 140° to Hole U1482A. The drill string was then spaced out so the bit was at 1476 mbrf and Hole U1482C was spudded at 0440 h on 21 October 2016. A seafloor depth of 1476.1 mbrf (1465.2 mbsl) was established based on 9.43 m of recovery in the mudline core. Oriented APC coring using nonmagnetic core barrels continued to 335.4 mbsf (Cores 1H through 37H). Three drilled intervals (12.5 m total) were drilled without coring for stratigraphic correlation. Prior to switching to the XCB coring system, we drilled ahead an additional 4.5 m to offset the core gaps. XCB coring had penetrated to 447.9 mbsf (Core 50X) by the end of the week.

Science Results

The sedimentologists described cores from Holes U1482A (Cores 1H through 58X), U1482B (Cores 1H through 45F), and U1482C (Cores 1H through 15H) using a combination of visual core description, microscopic inspection of smear slides, core imaging, spectral color scanning, and point magnetic susceptibility. The stratigraphy at this site is tentatively divided into three lithologic subunits. The uppermost subunit (Subunit IA) consists mostly of light gray to light greenish gray clay-bearing foraminifer-rich nannofossil ooze, with moderate bioturbation. The boundary between Subunits IA and IB is identified in Core U1482A-13H where sediments reach a maximum in carbonate content and sulfide patches become common. Subunit IB includes the most clay-rich portion of the site. Sediment in this unit is primarily greenish gray clay-rich nannofossil ooze, with sulfide and pyrite present throughout. The interval is moderately bioturbated with visible burrows that include the ichnofossil *Skolithos*. The base of the subunit is in Core U1482A-22H. The sediment in Subunit IC shows strong cyclicity that is visible as approximately meter-scale variations in color that largely reflect changes in carbonate content. Subunit IC sediment is generally light greenish gray clay-rich nannofossil ooze to chalk. Sulfide deposition is common, but decreases towards the bottom of the hole. Smear slide analysis supports the lithologies identified through macroscopic core description and verifies the occurrence of biogenic components, particularly nannofossils and foraminifers, throughout the recovered interval.

The biostratigraphers completed analysis of core catcher samples from Holes U1482A and U1482B, as well as Cores U1482C-1H through 28H. Additional samples from split cores were taken at a rate of approximately three per core in Holes U1482A (nannofossils) and U1482B (foraminifers and nannofossils) to refine the biostratigraphy. Calcareous microfossils are not only diverse but also extremely well preserved throughout most of the succession. To further assess the preservation state of benthic and planktonic foraminifers, we established a protocol using the scanning electron microscope (SEM), which demonstrated that foraminifer tests are not recrystallized throughout the intervals recovered so far, which is very encouraging for future geochemical studies. The excellent preservation may be related to the relatively high clay content.

A preliminary age model based on calcareous nannofossil and planktonic foraminifer biostratigraphy indicates that the succession spans the upper Miocene to Quaternary, with a likely decrease in sedimentation rate from the Miocene into the Pliocene. Stratigraphic complexities in the upper 100 m required careful examination to distinguish intervals of reworking and occasional downhole contamination in core catchers. Below that the calcareous microfossils appear to be well suited for refining biostratigraphic calibrations, conducting evolutionary and taxonomic studies, and studying assemblage variability in relation to global change. Since the targeted age of ~14 Ma was not reached at the approved maximum penetration depth (490 mbsf) for the site, we requested and received permission to core deeper.

The paleomagnetists completed measurement of the magnetization of archive-half sections from Holes U1482A and U1482B on the superconducting rock magnetometer (SRM). After determining that a maximum peak alternating field of 15 mT was required to remove the drill string induced overprint, we made routine measurements of the natural remanent magnetization (NRM) before and after demagnetization at 15 mT. In addition to the SRM measurements on archive-half sections, we also took discrete samples at a rate of approximately one per core over the upper 250 mbsf of Holes U1482A and U1482B. These samples were then demagnetized in greater peak alternating fields (AFs) of 60–80 mT. In the top 50 mbsf of both holes, magnetic behavior is typical of magnetite and the inclination reflects expected values for normal polarity (Brunhes Chron) for the site latitude. After correction of declination using the Icefield MI5 tool, declination is internally consistent between cores for a stable polarity zone; however, absolute values of 150°–180° are higher than would be expected for normal polarity (0°) and suggest that we are experiencing the same orientation problem encountered during Expedition 362.

Between 50 and 90 mbsf, the NRM intensity after 15 mT AF demagnetization begins decreasing and magnetic directions become less well defined. From 90 mbsf to the base of the APC section, intensity stabilizes at relatively low levels that are 5–10 times lower than those in the upper 50 mbsf. HLAPC and XCB cores have higher intensity, but this may be due to a higher pervasive overprint associated with these coring techniques that is not removed by AF demagnetization of 15 mT. Directional data for Holes U1482A and U1482B begin to diverge below ~50 mbsf, making a geomagnetic interpretation of the data difficult. Decreased data quality around 90 mbsf is coincident with an increase in methane concentration, a decrease in interstitial water sulfate concentration, and the appearance of sulfides in the sediment. We propose that the loss of intensity and subsequent decrease in the quality of the paleomagnetic directions results from early sediment diagenesis associated with the reduction of primary remanence carrying iron oxides (e.g., [titano]magnetite, maghemite) to secondary iron sulfides (e.g., pyrite, greigite). This is supported by geochemical data and macroscopic and microscopic (SEM) observations of framboidal pyrite found in the sediments below ~100 mbsf during core description. Data from Hole U1482C will help us to understand the observed differences between Holes U1482A and U1482B, and ongoing rock magnetic tests will be used to confirm the signature of the observed diagenesis in the magnetic record.

Physical property measurements were conducted on samples from Holes U1482A, U1482B, and U1482C to provide basic information for characterizing the cored section using whole-round cores, split cores, and discrete samples. The Special Task Multisensor Logger (STMSL), or "fast track," was used to measure magnetic susceptibility (MS) and gamma ray attenuation (GRA) bulk density at 5 cm resolution for Holes U1482B and U1482C for real-time stratigraphic correlation. After equilibration to room temperature, all core sections from Holes U1482A and U1482B, as well as Cores U1482C-1H through 30H, were measured on the Whole-Round Multisensor Logger (WRMSL), which measured *P*-wave velocity as well as MS and GRA bulk density at 2.5 cm resolution. We stopped measurement of the *P*-wave velocity at approximately Core 20H in each hole when the data became unreliable due to frequent cracks in the core. All cores were also analyzed with the Natural Gamma Radiation Logger (NGRL) to measure the naturally occurring radioactivity in the sediment. By the end of the week, all cores from Holes U1482A and U1482B plus Cores U1482C-1H through 10H had been analyzed. Thermal conductivity was measured on Section 3 (at ~75 cm) for all cores in Hole U1482A, although in some cases a different section was used depending on the quality of the sediment. We stopped using the needle probe method at Core U1482A-53X because the sediment was too hard to penetrate with the needle. From Core U1482A-53X to the bottom of the hole (Core 58X), we measured thermal conductivity after cores were split by placing a puck on a sediment piece from the working half. After the whole-round sections were split, moisture and density (MAD) samples were taken from Hole U1482A, usually in Sections 1, 3, and 5. The Section Half Measurement Gantry (SHMG) was used to measure *P*-wave velocity along all three axes (z, y, x). These measurements were stopped when data quality decreased and became unreliable (at ~40 mbsf [y-axis], ~130 mbsf [z-axis], and ~250 mbsf [x-axis]).

Stratigraphic correlation among Holes U1482A, U1482B, and U1482C is ongoing and will continue until reaching 490 mbsf in Hole U1482C, the total depth of Hole U1482A. To do the correlations, we used WRMSL data from the previously drilled hole(s) and quickly collected STMSL data on each core immediately after it was recovered to use for near real-time correlation. It typically took 20–30 min after the core was recovered and on the catwalk to curate, label, and run the sections through the STMSL. Because of the shallow water depth and consequently rapid coring rate, we were not always able to provide instructions to the drillers quickly enough to prevent some stratigraphic gaps, particularly during coring of Hole U1482B. Thus, as we drilled Hole U1482C, we asked the drillers to wait for our instructions before proceeding so that we could ensure recovery of material across gaps in previous holes. Hole U1482B included six drilled intervals (U1482B-61, 191, 221, 261, and 401). After Hole U1482B was terminated at 366.6 mbsf, we had a complete stratigraphic sequence in all but three intervals. For Hole U1482C, coring proceeded slowly over the top ~50 mbsf to ensure recovery over core gaps in the first two holes. Four drilled intervals (U1482C-61, 181, 241, and 381) helped to avoid alignment of core gaps deeper in the hole. We also chose to switch directly from APC to XCB, as correlation with 4.7 m HLAPC cores had proved difficult. Recovery has been excellent with the XCB (~100%), so even though there may be some core gaps in the section cored with the XCB (below ~350 mbsf), these should be minimal. In addition to guiding drilling to recover a complete stratigraphic sequence, we have also used the correlation process to identify three intervals of deformation or discontinuous sedimentary features, which are also apparent in the macroscopic core description and biostratigraphy.

Interstitial water (IW), headspace gas, and solid phase samples were collected primarily from Hole U1482A and analyzed for their chemistry. Interstitial water chemistry indicates a relatively strong degree of early sediment diagenesis. The downhole IW SO_4^{2-} profile indicates complete reduction of sulfate and a transition to methanogenesis by 140 mbsf. A transition at this depth is supported by changes in IW [Ba^{2+}], [PO_4^{3+}], and alkalinity. Profiles of [Mg^{2+}] and [Ca^{2+}] also suggest dolomitization, which is observed as authigenic dolomite in Subunit IB, and possibly active uptake of Mg^{2+} through clay mineral exchange, particularly below ~300 mbsf. These hypotheses will be tested by ongoing X-ray diffraction (XRD) analyses. Headspace gas measurements show a rapid methane increase starting at ~130 mbsf that levels off from 200 to 380 mbsf, followed by a gradual decline. High ratios of methane to ethane and propane indicate a dominantly biogenic (rather than thermogenic) source for the gases. Calcium carbonate content ranges from 22% to >80%, with generally higher percentages in the lower part of the stratigraphic section (Subunit IC).

Education and Outreach

The education and outreach officer conducted ten ship-to-shore events, including two in French and one partly in Mandarin. These events reached schools in Morocco, the United States, Australia, and India, with very positive feedback received following the events. Scheduling of upcoming events is ongoing, and we have developed a photo album and other visual aids that can be shown during the live events to help students understand concepts. We have continued to work on additional activities for the ship-to-shore event with Scitech in Perth. These have been tested and also now include worksheets for the students. We have also posted two blogs on the *JOIDES Resolution* website (http://joidesresolution.org), "Who starts analyzing the core first?" and "How far could we get without the engineers?" as well as photos on Twitter (https://twitter.com/TheJR) and Facebook (https://www.facebook.com/joidesresolution).

Technical Support and HSE Activities

The following technical support activities took place during Week 3.

Laboratory Activities

- Routine processing of cores and support for laboratories and scientists.

HSE Activities

- An abandon ship and fire drill were conducted on 19 October.
- The safety eyewash and showers were tested.