IODP Expedition 363: Western Pacific Warm Pool

Site U1490 Summary

Background and Objectives

International Ocean Discovery Program (IODP) Site U1490 (WP-02A) is located on the northern edge of the Eauripik Rise at 5°48.95′N, 142°39.27′E in 2341 m water depth. The site is situated on seismic reflection profile RR1313 WP2-1, approximately 3.6 km east of the intersection with seismic reflection profile RR1313 WP2-6. The seismic profile shows a continuous succession of hemipelagic, carbonate-rich sediment with basement at ~450 m below seafloor. At Site U1490, horizontally bedded layers continue down to approximately 0.07 s two-way traveltime (TWT) below the seafloor, where reflector geometry shows a dramatic change in depositional process. From ~3.26 to ~3.60 s TWT, there is an apparently uninterrupted accumulation of current-controlled mud waves, with the exception of a possible break at 3.27 s. Other multichannel seismic (MCS) lines in the survey grid surrounding Site U1490 show these features as well. They are about 1 km in wavelength, oriented SW–NE (perpendicular to seismic reflection profile RR1313 WP2-1) with 15–18 m maximum amplitude that gradually decreases upsection, possibly reflecting a several million-year record of current-controlled bedforms.

Site U1490 is located ~431 km north of Site 1488 at the northern end of the Eauripik Rise, where it terminates in a tectonically complex region that includes the Sorol Fault, Sorol Trough, and Caroline Ridge (Hegarty and Weissel, 1988). The roughly N–S trending Eauripik Rise is a wide aseismic ridge (~1000 m elevation above the surrounding seafloor) which separates the East and West Caroline Basins of the Caroline microplate. It was formed by a series of NE-trending spreading centers and represents the youngest spreading of the Caroline microplate (Hamilton et al., 1979). The extinct spreading center is characterized by a broad crest at ~2500 m water depth with gently sloping sides. Marine magnetic anomalies C13–C9 at the southern part of Eauripik Rise where Site U1488 is located trend roughly E–W and indicate seafloor spreading from 36 to 27 Ma. The magnetic anomalies are progressively younger northward along the rise (Hamilton, 1979), suggesting that basement underlying Site U1490 is younger than that beneath Sites U1488 and U1489 to the south (Hamilton, 1979). This explains the lower sediment thickness above basement at Site U1490 (~400 m) than at Site U1488 (~700 m).

Site U1490 is located ~6° north of the equator and thus is suitable for reconstructing the hydrographic history of the northern part of the WPWP. The comparatively low sedimentation rate at this site will be used along with the record from Site U1488 to reconstruct the evolution of the WPWP since the late Miocene. At a depth of ~2300 mbsl, the site is bathed by modified Upper Circumpolar Deepwater and hence may be used to monitor past changes in this water mass.

Operations

After a 242 nmi transit from Site U1489, the vessel stabilized over Site U1490 (WP-02A) at 0000 h (all times are local ship time; UTC + 10 h) on 1 December 2016. The original operations planned called for two advanced piston corer (APC) holes to 250 m below seafloor (mbsf), and a third APC hole to 150 mbsf. With approximately two days of contingency remaining, we opted to deepen Hole U1490A to extended core barrel (XCB) refusal (382.8 mbsf), core Hole U1490B to half-length advanced piston corer (HLAPC) refusal (292.9 mbsf), and then use the remaining time to core as deeply as possible in Hole U1490C (170.0 mbsf).

Hole U1490A was cored to 251.2 mbsf (Cores 363-U1490A-1H through 27H) with the APC using orientation and nonmagnetic hardware. Downhole formation temperature measurements using the Advanced Piston Corer Temperature Tool (APCT-3) were taken on Cores 4H (32.7 mbsf), 7H (61.2 mbsf), 10H (89.7 mbsf), 13H (118.2 mbsf), and 16H (146.7 mbsf), with some movement detected on two of the runs (4H and 10H). Cores 25H through 27H experienced excessive overpull and required drillovers to extract them from the formation, indicating APC refusal. We switched to the HLAPC and continued coring to 270.0 mbsf (Cores 28F through 31F), where excessive overpull and a drillover indicated HLAPC refusal. We then XCB cored to 376.7 mbsf (Cores 32X through 42X). While cutting Core 43X, the rate of penetration slowed dramatically, so we retrieved the core after only a 5.6 m advance. The XCB showed extensive wear and a small amount of chert was recovered in the bottom of the core. Core 44X advanced only 0.5 m over 45 minutes, so we terminated coring. No core was recovered and the XCB cutting shoe had lost all of its carbide teeth. We collected 367.35 m of core over 382.8 m of coring (96% recovery) in Hole U1490A.

Hole U1490B was APC cored using orientation and nonmagnetic hardware to 228.0 mbsf (Cores 363-U1490B-1H through 25H). Core 25H required a drillover to extract it from the formation, and the core liner had to be pumped out of the core barrel. We switched to the HLAPC coring system and continued to core to 262.9 mbsf (Cores 26F through 33F). We terminated coring in Hole U1490B when Core 33F required a drillover. We retrieved 267.60 m of core over 258.9 m of coring (103% recovery) in Hole U1490B.

Hole U1490C was cored with the APC using orientation and nonmagnetic hardware to 170 mbsf (Cores 363-U1490C-1H through 20H). Coring was terminated when a ground fault was detected in the top drive motor that could not be repaired within the amount of time remaining for coring operations (~18 h). The drill bit was pulled clear of the seafloor at 1017 h on 5 December and retrieved to the rig floor. The vessel was secured for transit and we departed for Guam at 0542 h on 6 December, ending operations at Site U1490. A total of 125.75 h (5.2 d) was spent on Site U1490. We collected 69 APC cores, recovering 662.07 m of core over 641.2 m of coring (103% recovery) and 11 HLAPC cores, retrieving 53.7 m of core over 51.7 m of recovery. We also collected 13 XCB cores, recovering 87.42 m of core over 112.8 m of coring (76% recovery).

Principal Results

We recovered an ~380 m sequence of upper Oligocene to recent sediments that contain the following components: 1) calcareous microfossils (mainly nannofossils and foraminifers); 2) siliceous microfossils (radiolarians, diatoms, and sponge spicules); 3) clay minerals; and 4) volcanic ash. The sediment is assigned to one unit, divided into three subunits, based primarily on variations in biosilica, clay minerals, and ash downhole. Subunit IA (~185 m thick) includes a sequence of upper Miocene to recent foraminifer-rich nannofossil ooze with variable, but generally low amounts of clay. Coarser, decimeter-thick layers dominated by foraminifer ooze are also present. In Subunit IB (late early to early late Miocene, ~78 m thick) clay minerals become a significant component of the sediment and their abundance increases downhole. The primary lithology in Subunit IB is clay-rich foraminifer–nannofossil ooze. Biosilica (mainly sponge spicules and radiolarians) is also one of the sediment constituents of this subunit. Subunit IC is ~124 m thick and was deposited during the late Oligocene to the middle Miocene. The uppermost ~10 m are composed of greenish radiolarian-rich nannofossil ooze, whereas the remainder of the subunit is radiolarian-rich chalk. Discrete, dark gray to black partially indurated layers and nodules, and indurated rock fragments (cherts) are exclusively found in this subunit. The number, thickness, and degree of induration of these layers increases downhole. Siliceous particles, either volcanic glass and/or biosilica (radiolarians, sponge spicules, and diatoms), are the dominant lithologic component of these layers, although calcareous components are also occasionally present.

Calcareous nannofossils and planktonic foraminifers are present throughout the ~380 m sequence recovered at Site U1490. Planktonic foraminifer preservation is very good to good for most of the succession, although it decreases to moderate to poor in the chalk of Subunit IC, whereas calcareous nannofossil preservation is moderate through most of the succession. Benthic foraminifers indicate a deepwater environment, and the planktonic to benthic ratio is <99:1 throughout the succession. The assemblages are similar to those from other Eauripik Rise sites (U1488, U1489). The most common species are *Laevidenatlina* spp., *Plaunlina wuellerstorfi*, and *Oridorsalis umbonatus*.

Calcareous nannofossil and planktonic foraminifer biostratigraphy indicate that the recovered succession spans the uppermost Oligocene to recent. A series of paleomagnetic reversals identified in the lower and middle Miocene interval correlate well with the biostratigraphic datums. There is no evidence of hiatuses but the top ~40 m of the site is complicated because of upward reworking of calcareous nannofossil and planktonic foraminifer marker species. The age at the base of the succession is constrained to ~24 Ma based on extrapolation through Oliogcene/Miocene boundary biohorizons and the appearance of common *Cyclicargolithus abisectus* (~24 Ma) at the base of the hole. The Oligocene/Miocene boundary is placed at ~340 mbsf based on the presence of *Sphenolithus delphix*. The Miocene/Pliocene boundary is located at ~90 mbsf between the biohorizon bases *Ceratolithus cristatus* and *C. armatus*, and the Pliocene/Pleistocene boundary is approximated by the biohorizon top *Discoaster surculus* at

~35 mbsf. The sedimentation rate appears to be near constant for long periods, separated by four inflection points at 3.60 Ma, 5.33 Ma, 9.11 Ma, and 22.25 Ma, the last three of which correspond to marked changes in lithology. Average sedimentation rates are ~4.7 cm/ky in the latest Oligocene, ~0.88 cm/ky in the early and middle Miocene, 1.57 cm/ky in the late Miocene, 2.9 cm/ky in the early Pliocene, and 1.4 cm/ky in the late Pliocene and Pleistocene.

Paleomagnetic investigations at Site U1490 involved measurement of the natural remanent magnetization (NRM) of archive-half sections from Holes U1490A, U1490B, and U1490C before and after demagnetization in a peak alternating field (AF) of 15 mT. We measured the entire sediment succession in Hole U1490A but ceased measurement between ~36 and 161.5 mbsf in Hole U1490B and below ~31 mbsf in Hole U1490C as data quality decreased and became increasingly uninterpretable. Corrected declination is largely coherent between cores; however, absolute values in Holes U1490A and U1490B cluster around 270° for periods of normal polarity and around 90° for reversed polarity. For Hole U1490C no baseline offset is observed and corrected declination during intervals of normal polarity cluster around 0°/360° and 180° for reverse polarity. In the upper ~16 mbsf, Whole-Round Multisensor Logger (WRMSL) magnetic susceptibility (MS) data, mass corrected MS (χ), and saturation remanent magnetization (SIRM) values suggest moderately low (ferri)magnetic mineral concentration in the uppermost sediments deposited at Site U1490. Between ~16 and 175 mbsf, average MS data decrease to negative values, associated with the diamagnetic properties of carbonate that dominate the sediment and an almost complete absence of ferrimagnetic minerals. Below ~168 mbsf, discrete MS data and SIRM begin to steadily increase associated with greater proportions of clay and ash in the sediment. We identify fifty distinct ~180° shifts in declination at Holes U1490A, U1490B, and U1490C. We observe five reversals in the youngest part of the succession, including the Brunhes/Matuyama boundary at ~8 mbsf. Below ~170 mbsf we observe 45 geomagnetic reversals with an almost complete record from the upper boundary of C4An (8.771 Ma; ~171 mbsf) to the upper boundary of C6n (18.748 Ma; ~263 mbsf) in Hole U1490B.

All the physical properties measurements are generally reproducible among the three holes at Site U1490. Gamma ray attenuation (GRA) and discrete sample bulk density generally agree well in terms of long-term trends and short-term variability. The upper 3 mbsf are characterized by the transition away from the mudline, with a rapid increase in GRA bulk density and decrease in natural gamma radiation (NGR). GRA bulk density linearly increases from ~1.6 g/cm^3 at the top of the hole to ~1.9 g/cm^3 at 230 mbsf, related to increased compaction at depth. The MS is extremely low between 20 and 180 mbsf, with average values around -0.8 × 10^{-5} SI, corresponding to light-colored sediment with high carbonate content (nannofossil ooze). MS increases to ~7 × 10^{-5} SI, and *P*-wave velocity increases from ~1500 to ~1700 m/s at ~180 mbsf, coincident with increased clay content in Subunit IB. Between 230 and 270 mbsf, a second transition is visible in all of the physical properties, with the GRA bulk density decreasing from ~1.9 to ~1.7 g/cm^3, which coincides with the highest peaks in MS, with values up to 20 × 10^{-5} SI. A broad MS maximum with values up to ~330 × 10^{-5} SI is concurrent with the first major peak

of ~8 counts/s in NGR at ~255 mbsf, which coincides with an indurated ash layer. Below 270 mbsf (Subunit IC), we observe a general increase in the short-term variability of all physical properties with values ranging from 1.5 to 1.9 g/cm^3 for GRA bulk density, an increase in average MS to ~10×10^{-5} SI, with peaks frequently reaching ~$200–300 \times 10^{-5}$ SI, NGR peaks frequently reaching ~4 counts/s and occasionally reaching ~15 counts/s in the volcanogenic-rich dark layers, and *P*-wave increasing from ~1540 to ~1960 m/s. This large variability is also observed in the dry density, grain density, porosity, and thermal conductivity. This interval is associated with the presence of black layers consisting of silica mixed with volcanogenic material, which become more indurated downhole.

Stratigraphic correlation between holes at Site U1490 primarily used Section Half Multisensor Logger (SHMSL) color reflectance data, mainly redness (a*) and luminosity (l*), as well as WRMSL MS data. In addition, we also used WRMSL GRA bulk density and NGR data. We constructed a splice for the entire site using all three holes. The splice is continuous and well constrained from 0 to 295.95 m core composite depth below seafloor (CCSF), with the exception of one gap at 258.01 m CCSF. There are also a few tentative tie points that should be verified during postcruise research.

A total of 36 interstitial water (IW) samples and one mudline sample were collected from Hole U1490A for geochemical analyses, spanning a depth range from 0 to 326 mbsf. Sampling for IW chemistry was halted below 326 mbsf due to biscuiting and subpar recovery of core. The IW geochemistry indicates relatively weak remineralization of organic matter throughout the sediment column resulting from low total organic carbon (TOC) content ranging from 0.0 to 1.0 wt% and averaging only 0.2 wt%. Low dissolved Fe and Mn concentrations in the shallowest sediments at the site suggest minimal suboxic remineralization of organic matter, and significant sulfate (>21 mM) is present at depth. High carbonate content (~94 wt%) in the upper 230 mbsf is associated with a Sr IW profile indicating a moderate degree of carbonate recrystallization and/or dissolution. Major cation and anion concentration profiles are dominated by upward diffusion from a deeper fluid source with a geochemical signature characteristic of basalt- and/or volcanogenic sediment-seawater interaction. Marked depletion of Na^+ and enrichment of Ca^+ at this site suggest a unique deep fluid source and possible compositional variability of underlying basalt along the Eauripik Rise. Lower and more variable carbonate content below 230 mbsf coincides with clay- and radiolarian-rich intervals and the presence of frequent ash layers.

References

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