IODP Expedition 363: Western Pacific Warm Pool

Site U1487 Summary

Background and Objectives

International Ocean Discovery Program (IODP) Site U1487 (WP-14A) is located ~190 km west–southwest of Manus Island at 2°20.00′S, 144°49.17′E in 874 m of water. The site is situated on seismic reflection profile RR1313 WP6-5, ~1.4 km southwest of the cross-point with profile RR1313 WP6-3a. The seismic profile shows a continuous succession of hemipelagic sediment with acoustic basement estimated at ~185 m below seafloor (mbsf).

The tectonic setting of Sites U1486 and U1487 (as for that of the northern Papua New Guinea [PNG] sites) was shaped by the oblique northward movement of the Australian plate as it rapidly converged with the Pacific plate. This collision resulted in a complex plate boundary zone that includes volcanic arcs, but also resulted in the formation and rotation of microplates within this zone, as well as lithospheric rupture that formed small oceanic basins (Baldwin et al., 2012). The Bismarck Sea, on the northeastern side of PNG, forms a back-arc basin with respect to the New Britain arc and is divided into the North Bismarck (NBS) and South Bismarck (SBS) microplates, separated by the active Bismarck Sea left-lateral transform fault and spreading segments (Taylor, 1979). Site U1487 is located on the North Bismarck microplate. To the north, the NBS microplate is bordered by the Manus Trench, which defines the boundary between it and the Pacific plate. Within this complex tectonic regime, the southwestern side of Manus Basin is considered one of the more stable regions. Magnetic anomalies in the Bismarck Sea indicate rapid asymmetric spreading since 3.5 Ma (Taylor, 1979). The continuous collision between the Australian and Pacific plates caused the SBS microplate to rotate rapidly clockwise (~9°/My), whereas the NBS microplate is rotating slowly anticlockwise (0.3°–1.25°/My) (Baldwin et al., 2012). Asymmetric rotation of the North and South Bismarck Basins likely changed the position of New Britain and adjacent islands relative to PNG. Ocean Drilling Program Leg 193 focused on the eastern part of the Manus Basin, exploring the tectonic, volcanic, and seafloor hydrothermal system activity in this convergent plate margin setting.

Site U1487 is upslope from Site U1486 and was expected to show the same sediment composition but with reduced sedimentation rate due to its shallower position. As a companion to Site U1486, Site U1487 was also targeted because of its potential to provide an excellent Pleistocene paleoceanographic record to examine orbital-scale climate variability at high resolution through the Pleistocene. It is also ideally located to monitor the contribution from the New Guinea Coastal Current and Undercurrent, which is the southern branch of the westward, cross-equatorial flowing South Equatorial Current, and constitutes the main southern Pacific contribution to the Indonesian Throughflow. At a water depth of ~880 m below sea level (mbsl), the sediment is bathed by modified Antarctic Intermediate Water originating from the Southern Ocean, and thus will allow for the reconstruction of past variability of this water mass.

Operations

After a 13.3 nmi transit from Site U1486, the vessel stabilized over Site U1487 (WP-14A) at 1145 h (all times are local ship time; UTC + 10 h) on 17 November 2016. Site U1487 was an alternate site added to the operations during the expedition. We planned two holes using the advanced piston corer (APC) to ~175 m below seafloor (mbsf), with a third hole to cover stratigraphic gaps if required. We ultimately cored two holes: Hole U1487A cored to 144.2 mbsf and Hole U1487B to 144.3 mbsf.

Hole U1486A was cored with the APC coring system using orientation and nonmagnetic hardware to 144.2 mbsf (Cores 363-U1487A-1H through 16H). Downhole formation temperature measurements using the Advanced Piston Corer Temperature Tool (APCT-3) were taken on Cores 4H (34.9 mbsf), 7H (63.4 mbsf), 10H (91.9 mbsf), and 13H (120.4 mbsf), obtaining good results on all four deployments. We terminated coring after Cores 14H and 16H recorded partial strokes and Core 15H had to be drilled over due to excessive overpull when attempting to retrieve it. Cores 14H through 16H included unconsolidated sand. We collected 146.43 m of sediment over 144.2 m of coring (102% recovery) in Hole U1487A.

Hole U1487A was then cored to 125.5 mbsf (Cores 363-U1487B-1H through 14H) with the APC using orientation and nonmagnetic hardware. We then switched to the half-length advanced piston corer (HLAPC) to core the interval where we encountered unconsolidated sand in Hole U1487A. We cored to 144.3 mbsf (Cores U1487B-15F through 18F) with the HLAPC, where we terminated the hole. We collected 148.73 m of core over 144.3 m of coring (103% recovery) in Hole U1487B. Operations at Site U1487 ended at 2215 h on 18 November 2016. Total time spent at Site U1487 was 34.5 h (1.4 d).

A total of 30 APC cores were recovered at this site, collecting 276.34 m of sediment over 269.7 m of coring (103% recovery). We also collected 4 HLAPC cores, retrieving 18.82 m of sediment over 18.8 m of coring (100% recovery).

Principal Results

Sediments at Site U1487 are composed of ~144 m of upper Pliocene to recent volcanogenic, authigenic, and biogenic sediments, with a similar sequence to that seen at Site U1486, which is located 25 km west–southwest. We assign the recovered succession to one lithologic unit divided into three subunits based on visual observation of core sections and smear slides, mineralogical analysis by X-ray diffraction, and physical property data, with the subunits distinguished based on the amount of volcanogenic material in the sediment. Subunit IA (late Pleistocene to recent) spans the upper ~21 m and is composed primarily of biogenic (foraminifer and nannofossil) sediments mixed with clay minerals with rare ash layers. The dominant lithology is nannofossil-rich foraminifer ooze, whereas the sediments at Site U1486 are finer grained and consist mostly of foraminifer-rich nannofossil ooze. Trace amounts of siliceous components (radiolarians, diatoms, and silicoflagellates) are also present. Pteropods are also found in the uppermost part of the section. The base of Subunit IA is placed at the second downhole tephra layer, which marks an increase in the proportion of volcanic particles in the sediment. Subunit IB (late Pleistocene) extends from the base of Subunit IA to ~86 mbsf. Biogenic sediments (predominantly foraminifers) are still the main sedimentary component of this subunit but volcanogenic sediments are more abundant than in Subunit IA. The main lithology is nannofossil-bearing to nannofossil-rich ash-rich foraminifer ooze. Siliceous microfossils are also still present in trace amounts. Tephra layers are typically brown to black in color and composed primarily of glass shards, indicative of explosive volcanism. Black tephra layers become more common towards the base of the subunit. As at Site U1486, the base of Subunit IB is marked by a prominent volcanic ash layer that corresponds with a shift to higher values in magnetic susceptibility (MS). Subunit IC (late Pliocene to early Pleistocene) marks the transition from dominantly biogenic to dominantly volcanogenic sediments. The principal lithology is ash, with varying proportions of nannofossils, foraminifers, and clay. The volcanogenic component in Subunit IC is primarily composed of microscoria, rather than glass, and were likely sourced from less explosive eruptions.

The sedimentary sequence recovered at Site U1487 exhibits many similarities to that recovered at Site U1486. Both sites span the past ~2.7 Ma and exhibit a reduction in volcanogenic input through time. Despite the overall similarity between the two sites, we note four important differences in the sedimentology of Site U1487 relative to Site U1486. These include: (1) an overall coarser grain size (foraminifer ooze versus nannofossil ooze), (2) lower sedimentation rates, (3) more intense bioturbation and reworking, and (4) thicker tephra layers with relatively large microscoria fragments.

The sediment succession at Site U1487 contains calcareous nannofossil, planktonic foraminifers, and benthic foraminifers throughout. Microfossil preservation is excellent to very good. Benthic foraminifers indicate a relatively deepwater bathyal sedimentary environment with a planktonic/benthic ratio typically 99:1 throughout the succession.

Biostratigraphic and magnetostratigraphic horizons are generally in good agreement. The oldest sediments recovered belong to calcareous nannofossil Zone NN16 and planktonic foraminifer Zone PL5 (late Pliocene) and are estimated to be 2.7 Ma based on extrapolation of the age-depth trend. From the base of the hole to ~2 Ma, sedimentation rates averaged ~15 cm/ky, mainly because of the very high rate of volcanic ash deposition early in the site's history. Sedimentation rates slowed significantly in the Pleistocene, averaging ~3.5 cm/ky.

Paleomagnetic investigations at Site U1487 involved measurement of the natural remanent magnetization (NRM) of archive half sections from Holes U1487A and U1487B before and after demagnetization in a peak alternating field (AF) of 15 mT. Corrected declination is largely coherent between cores; however, absolute values in all holes cluster around 180° for normal polarity and 0° for reversed polarity suggesting that the issues of the baseline offset experienced at the majority of sites during Expedition 363 and on previous expeditions (e.g., Stow et al., 2013) affected these measurements. Relatively soft ferrimagnetic minerals are concentrated in the top ~24 mbsf; increased magnetic concentration and coercivity with depth likely reflect the increased deposition of mafic-rich volcanogenic ash and tephra. We identify six 180° shifts in declination at Site U1487; the deepest of these is the Gauss/Matuyama boundary (2.582 Ma) at ~134 mbsf. Continued normal polarity below this depth in both holes implies that the recovered sediment is younger than 3.032 Ma as we do not observe the upper boundary of the Kaena reversed subchron (C2An.1n). The magnetostratigraphy is in good agreement with both the calcareous nannofossil and planktonic foraminifer datums.

All physical property data at Site U1487 exhibit excellent reproducibility between holes and show typical trends consistent with increased downhole volcanogenic input. As with Site U1486, the data collected for Site U1487 show variations that correlate well with the three lithologic subunits defined for the site. These subunits are most easily recognized in the MS data, which are very low in the upper 22 mbsf (~20–50 × 10^{-5} SI), corresponding to lithologic Subunit IA that consists of nannofossil-rich foraminifer ooze with variable amounts of clay and rare ash. Over the same interval, gamma ray attenuation (GRA) bulk density values increase from 1.4 to 1.6 g/cm^3, albeit with low variability. Between 22 and 86 mbsf (Subunit IB), the average MS value increases to ~75–100 × 10^{-5} SI, with a concomitant increase in variability. GRA bulk density values also increase to 1.6 g/cm^3. Within Subunit IB, distinct peaks in MS, GRA, and *P*-wave occur coincident with darker, volcanogenic-rich layers, superimposed on a background lithology of nannofossil-rich foraminifer ooze with variable amounts of clay. The highest values of natural gamma radiation (NGR) occur (~20 counts/s) in the upper ~86 mbsf (Subunits IA and IB) of Site U1487, reflecting the higher biogenic content of these subunits relative to Subunit IC. NGR variability in the upper 86 m probably reflects changes in the amount of biogenic material. Below 86 mbsf (Subunit IC), average MS increases to ~200 × 10^{-5} SI and the distinct peaks in MS, GRA, and *P*-wave occur more frequently, reflecting the dominance of volcanogenic material in the deepest part of the hole.

We constructed a continuous splice for Site U1487 from 0 to 136.0 m core composite depth below seafloor (CCSF) using both Holes U1487A and U1487B. We used Whole-Round Multisensor Logger (WRMSL) MS data aided occasionally by NGR and GRA bulk density to correlate between the holes. Since Hole U1487A was sampled for interstitial water (IW) shipboard measurements, our general approach was to use Hole U1487B as the backbone of the splice and to use short segments from Hole U1487A to cover gaps in recovery encountered in Hole U1487B. There is considerable coarse sand below 136.0 m CCSF and the WRMSL data did not correlate well between the holes due to drilling disturbance, including possible flow-in that occurred while retrieving the cores from the bottom of the drill hole. For this reason, the splice has gaps and uncertain tie points from 136.0 m to the bottom of the site at 156.0 m CCSF.

Site U1487 was sampled at standard shipboard resolution for IW chemistry, with a total of 18 whole-round samples and 1 mudline sample analyzed. Despite the relative proximity of Sites U1487 and U1486, the IW profiles at Site U1487 display distinct differences from those at Site U1486. Low phosphate and ammonium concentrations (<1.5 µM and 0.2 mM, respectively) and relatively high sulfate concentration (>24 mM) downhole suggest lower organic matter (OM) content at Site U1487. Concentration of methane also remains low throughout the hole. Small downhole IW gradients are observed in several elements (potassium, lithium, and boron) and likely reflect clay mineral authigenesis. However, the majority of the IW profiles at Site U1487 display little to no variation with depth and appear to be influenced by advection and/or diffusion of crustal fluids. For example, Ca^{2+} and Mg^{2+} concentrations both change by >15 mM from the mudline to ~5 mbsf, but vary by <1 mM below that depth. Higher permeability expected from the generally coarser sediment grain size and presence of several faults near Site U1487 that penetrate from the basement through the majority of the sediment column may help facilitate fluid migration.

$CaCO_3$ content shows a monotonic decreasing trend with depth, with $CaCO_3$ content from >60 wt% in the upper 20 mbsf to <10 wt% in the bottom 15 m of the recovered sequence. Comparison of $CaCO_3$ content with GRA bulk density data suggests that this trend can be explained by two-component mixing between biogenic carbonate (dominant in the upper portions of the hole) and volcanogenic sediments (dominant in the lower portion of the hole).

References

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