IODP Expedition 366: Mariana Convergent Margin

Site U1497 Summary

Background and Objectives

International Ocean Discovery Program (IODP) Site U1497 (proposed Site MAF-9B) is located in the center of a depression at the summit region of Fantangisña Seamount (informally called Celestial Seamount in the Expedition 366 *Scientific Prospectus* and previous publications) at 16°32.25′N, 147°13.26′E, in 2020 m of water. The site lies close to the intersection of multichannel seismic (MCS) reflection profiles EW0202 42-44 and EW0202 67-68.

Fantangisña Seamount is a serpentinite mud volcano located about 62 km from the trench and about 14 km above the subducting Pacific Plate. The seamount lies on the north edge of a prominent forearc block that trends northwestward. The main feature of the summit is a slump down the north flank. Several stages of slumps exist, based on nested headwalls with sharply defined features in the bathymetry at 2000 and 1840 m water depth. It was hypothesized, therefore, that a fluid conduit region may be present just north of the 2000 m depth contour, and may have instigated the most recent slump, similar to the situation at South Chamorro Seamount (Wheat et al., 2008).

However, no active seeps or chimneys were observed during the one *Jason 2* ROV dive on this seamount (J2-038). Instead, much of the caldera floor consists of pelagic sediment, smooth serpentinite muds, serpentinite muds dotted with dark-colored rocks, white-colored layers, a few manganese crusted rocks, sponges, and small serpentintie/rock mounds. The only indication of active serpentinite processes on the seamount is a 40 cm core of serpentinite material, the base of which has lower concentrations of Mg and alkalinity (49.6 and 0.89 mmol/kg, respectively) compared to bottom seawater values (53 and 2.4 mmol/kg, respectively), indicating slow discharge of deep-sourced pore waters.

The primary objective was to define the source fluid composition and core a possible permeable zone that may have transported deep-sourced fluid from depth within the cased/screened borehole structure. Additional objectives included: 1) determine the variability of mudflow and rock clast compositions and thicknesses of discrete units within the summit area; 2) investigate potential systematic variability in degree of serpentinization with depth in the conduit region; 3) examine transport characteristics of the mud/clast material; and 4) collect samples for microbiological analysis. Upon completion of coring, we installed casing in the borehole for a future installation of a borehole monitoring system (CORK-Lite) with an ROV.

Operations

Hole U1497A (16°32.2538'N, 147°13.2641'E, water depth 2020 m)

The 94 nmi transit to Site U1497 (proposed site MAF-9B) took 9 h at 10.4 kt. Site U1497 is located near the summit of Celestial (Fantangisña) Seamount, and is known from previous ROV dives to have more surface boulders and cobbles than the other two seamounts drilled on this expedition. Prior to starting the hole, we surveyed the seafloor with the subsea camera to find preferred coring locations with fewer surface rocks. Hole U1497A began at 1915 h on 13 January and reached 34.2 mbsf using a combination of half-length advanced piston corer (HLAPC) and extended core barrel (XCB) coring. After each HLAPC core we reamed/drilled down to the base of advancement of the previous HLAPC core, during which we recovered additional core material ("ghost" cores, which are defined to come from an interval that had been previously penetrated). Hole U1497A cored 34.2 m and recovered 23.4 m (70%).

Hole U1497B (16°32.2528'N, 147°13.2606'E, water depth 2019 m)

Hole U1497B started at 1530 h on 14 January, reaching 25.1 mbsf and recovering 23.8 m (95%). It was decided to stop the hole at this point because of difficult drilling, and the bit was raised clear of the seafloor at 0005 h on 15 January.

Hole U1497C (16°32.2504'N, 147°13.2500'E, water depth 2019 mbsl)

Hole U1497C started at 1145 h on 15 January with the aim to drill down with a 14.75 inch bit to about 120 mbsf, then deploy screened casing in this pre-drilled hole for future borehole monitoring at this site. However, we stopped this hole at 12 mbsf because of high torque and slow penetration.

Hole U1497D (16°32.2548'N, 147°13.2621'E, water depth 2020 mbsl)

For a second attempt to drill a 14.75 inch hole to 120 m, we started Hole U1497D at a location 5 m north of where Hole U1497B had achieved reasonable penetration. Hole U1497D reached 120 mbsf at a slow but steady average rate of 7 m/h. The formation was firm and the hole appeared to be in good condition, apart from a difficult zone in the upper part of the hole, perhaps related to loose sand and gravel observed in Hole U1497A between 23–26 mbsf. The hole was swept with 50 barrels of high viscosity mud to prepare for installing the screened casing. The reentry cone was deployed by free-fall, then the drill pipe was raised back up to the ship.

The rig crew assembled the 106 m long casing string, including three joints of 10.75 inch casing, three joints of screened casing, and three further joints of 10.75 inch casing. The regular casing joints underneath the screened section provided space for cement to seal the bottom of the casing to prevent the formation from entering. The mud motor and underreamer assembly was lowered through the casing string, and the running tool on the drill pipe was attached to the hanger at the

top of the casing. The bit and underreamer extended ~4 m below the base of the casing. The whole assembly was lowered to the seafloor and Hole U1497D was reentered at 2310 h on 17 January. At 1230 H on 18 January, the casing had been successfully installed to 107 mbsf in Hole U1497D. During the installation, it took ~5 h to pass below a difficult zone at ~40 m. Then at ~70 mbsf, the casing prereleased from the running tool, falling ~15 m further down the hole (a similar prerelease happened at Hole U1492D, earlier in the expedition), but we were able to continue washing and reaming down to the target depth. The hole was swept with high viscosity mud and the drill pipe and underreamer assembly was raised back up to the ship.

The cementing bottom-hole assembly reentered Hole U1497D and was lowered down to 105 mbsf, where five barrels of 14 ppg cement were pumped down to seal the bottom of the casing at that depth. The drill pipe was raised above the seafloor and the drill pipe was flushed to remove any residual cement. The bit was at the rig floor at 1540 h on 19 January and the ship prepared for transit. The positioning beacon would not release from the seafloor, but we planned to return to Hole U1497D to check the location of the cement plug later in the expedition and to try to retrieve the beacon using a grapple hook.

We returned to reoccupy Hole U1497D at 2045 h on 22 January after a 95 nmi, 9 h transit. Hole U1497D was reentered at 0325 h on 23 January, and the drill pipe was lowered to 24 mbsf, in the middle of the top joint of screened casing, where the water-sampling temperature probe (WSTP) was deployed to sample borehole fluids and take temperature measurements. The drill pipe was lowered further to check the location of the cement plug, now that it had time to harden. The top of cement was tagged at 103 mbsf, about 4 m above the base of the casing, thus the cement plug is well positioned to stop the formation entering into the casing. The ROV landing platform was deployed by free-fall. On the expedition's previous visit to Site U1497, the beacon failed to release, so this time we fished it manually using a grappling hook that had been attached to the subsea camera frame for this purpose. This concluded operations at Site U1497.

Principal Results

Serpentinite mud deposits at the summit of Fantangisña Seamount appear to be more consolidated and viscous than at the summit of Asùt Tesoru Seamount (Site U1496), which may reflect less present-day fluid upwelling at the summit of Fantangisña. Moreover, zones of reddish oxidized serpentinite muds in both cored holes under the uppermost intervals of dark bluish-gray muds suggests significant periods of time in the past during which the surface was exposed at the seafloor. Ultramafic lithic clasts in the serpentinite muds below the oxidized zones were generally highly serpentinized, indicating long residence times in high pH fluids.

Pore water methane and other hydrocarbon concentrations were not detected in high concentrations at Site U1497. Interestingly, methane contamination in background atmospheric samples was not observed, suggesting that the source of atmosphere contamination that was

detected while analyzing samples from Yinazao and Asùt Tesoru Seamounts likely resulted from degassing of sediments. The 14 pore water samples from Site U1497 show distinct trends of major and trace element abundances with depth. Concentrations of potassium, sodium, boron, lithium, and magnesium in interstitial waters decrease downhole from seawater concentrations. In contrast, concentrations of calcium and strontium and pH increase from seawater values. Systematic variations in pore water profiles are consistent with the upwelling of a deep-sourced fluid. The fluid from the WSTP sampler, collected 3.25 d after circulation ceased, is a mixture of this deep-sourced fluid and bottom seawater, indicating fluid discharge into and out of the borehole and laying the foundation for future experiments and observations with a borehole monitoring system (CORK-Lite) to be installed postcruise.

Samples were collected for shore-based microbiological samples. To assess possible artifacts from drilling operations, tracers were pumped into the drill string prior to and during core recovery. Tracer analyses indicate that most of the whole-round samples for microbiology are suitable for continued shore-based analyses.

Compared to the summits of Yinazao and Asùt Tesoru Seamounts, the serpentinite muds at the summit of Fantangisña Seamount have higher bulk density (2.0–2.3 g/cm^3), higher *P*-wave velocities (1750–1900 m/s), higher thermal conductivities (1.3–1.8 W/m·K), and lower porosities (38%–44%). These values are similar to those obtained on the flanks of Asùt Tesoru Seamount (Sites U1493–U1495). No clear physical properties trend with depth was identified within these serpentinite mud units.

Downhole measurements included a single formation temperature measurement (APCT-3) in Hole U1497B and a water sample and temperature measurement (WSTP) taken inside the cased borehole in Hole U1497D. Data for the single downhole temperature estimate and minimum seafloor temperature yielded a gradient of 12°C/km and an estimated heat flow of 17 mW/m^2.

References

Wheat, C. G., P. Fryer, A. T. Fisher, S. Hulme, H. Jannasch, M. J. Mottl, and K. Becker (2008), Borehole observations of fluid flow from South Chamorro Seamount, an active serpentinite mud volcano in the Mariana forearc, *Earth Planet. Sci. Lett.,* 267, 401–409, doi:10.1016/j.epsl.2007.11.057