IODP Expedition 366: Mariana Convergent Margin

Site U1493 Summary

Background and Objectives

International Ocean Discovery Program (IODP) Site U1493 (proposed Site MAF-14A) is located at the foot of the southern flank of Asùt Tesoru Seamount (informally called Big Blue Seamount in the Expedition 366 *Scientific Prospectus* and previous publications) at 17°59.17′N, 147°6.01′E, in 3359 m of water. The site lies on multichannel seismic (MCS) reflection profile EW0202 42-44.

Asùt Tesoru Seamount is a serpentinite mud volcano that lies about 72 km from the trench axis, and it is the farthest from the trench of the three seamounts targeted on this expedition. The subducting slab lies approximately 18 km below its base according to interpretation of MCS data (Oakley, et al., 2007). This mud volcano is the largest so far discovered on the Mariana forearc. It is about 50 km in diameter and over 2 km high. It may have been active since the Eocene, because DSDP Leg 60 Site 459 recovered two intervals of sediment immediately above Eocene basement that were comprised of about 50% serpentine (Despraires, 1981).

Drilling at Site U1493 was expected to recover pelagic sediment and some of the oldest serpentinite mud flow materials on the edifice. Also it was hoped that the recovered muds and included rock clasts would provide information regarding the lithology of these early erupted materials. Potentially, serpentinized peridotite clasts and other lithologies may reveal different décollement pressure, temperature, and compositional conditions from those that would be expected from the shallower sites on the edifice. It was also expected that pore fluids might tell a story of possible interaction with seawater after lengthy exposure at the base of the seamount. Such interactions might also have effects on the microbial communities present in the subseafloor environment.

The objectives for Site U1493 were to: 1) core sediments and serpentinite mudflows on the deep southern flank; 2) potentially date discrete mud flows paleontologically, should there be sediment layers between them; 3) determine variability of mudflow composition and thickness; 4) investigate potential systematic variability in degree of serpentinization; 5) examine transport conditions; 6) provide an assessment of pore fluid composition; and 7) collect samples for microbiological analysis.

Operations

The ship arrived at Site U1493 (proposed Site MAF-14A) at 0400 h on 4 January following a 136 nmi, 13 h transit from Site U1492. A reentry cone was set up in the moonpool in preparation for its use at the future Site U1496 (proposed Site MAF-11A) at the summit of Big Blue Seamount, and the drill pipe was lowered through it. Sites U1493 to U1496 (proposed Sites MAF-14A, 13A, 12B, and 11A) form a ~14 km south to north transect from the foot to the summit, and are close enough for transit between them in dynamic positioning (DP) mode, allowing the same drill string to be used without being raised back up to the ship. Owing to the extra unscheduled time taken in casing Hole U1492D, we scaled back the drilling plan for the Big Blue flank sites (Sites U1493, U1494, and U1495) to a single 50 m advanced piston corer (APC)/extended core barrel (XCB) hole at each of these three sites. While taking the first core, the APC core barrel bent in two places. This core recovered 9 cm of mud with microfossils, and we decide to offset a short distance to avoid the hard zone or rock that caused the bent core barrel at this location.

The ship was offset 10 m to the east, and we started Hole U1493B at 1800 h on 4 January. Coring in Hole U1493B penetrated to 32.6 m. An advanced piston corer temperature tool (APCT-3) measurement was made on Core U1493B-5F at 24.5 mbsf, obtaining a satisfactory temperature equilibration curve. Because of slow coring due to difficult APC/XCB drilling conditions, and because we had sufficient samples for lithological, geochemical, and microbiological assessment of the site, we decided to stop after Core U1493B-9X and move 4 nmi upslope to Site U1494. Hole U1493B penetrated 32.6 m and recovered 19.0 m (58%). The transit started at 1615 h on 5 January in DP mode.

Principal Results

Sediments recovered at Site U1493 include pelagic clays and highly consolidated serpentinite mud flows. At the top of the sequence, 0.8 m of reddish oxidized vitric silty-clay represents deposition since the underlying serpentinite mudflow at this location. Similar to the other sites on the flank of Asùt Tesoru Seamount (Sites U1494 and U1495), there is a common progression of serpentinite color with depth. Down to 12 mbsf in Hole U1493B, the serpentinite mud and clasts have a pale brown color characteristic of oxidation. Below, the serpentinites are pale greenish to 13 mbsf, changing to light to dark blue-grey serpentinites that are occasionally more clast rich down to the base of the recovered section at 31.0 mbsf.

The most common clasts in the shallow parts of the cores are ultramafic breccias cemented by carbonate and altered ultramafics. Below, two types of serpentinized ultramafic rocks are present: massive serpentinites with pseudomorphic textures and highly variable serpentinization degree (from 30% to 100% serpentinization); and foliated serpentinites made of thinly recrystallized serpentine blades or lamellae (antigorite?) with interpenetrating textures. The ultramafic protoliths are harzburgite and dunite. Rock deformation is marked by the crystallization of orientated veins made of thin recrystallized talc-like phases and/or chlorite associated with magnetite. Mafic igneous rocks also occur rarely among the smaller clasts.

Pore fluid geochemistry reflects mixtures of seawater and a serpentinite pore fluid that was originally emplaced or trapped when the serpentine muds erupted. The original emplaced pore fluids likely evolved with time (e.g., through continued water-rock reactions and/or microbial activity and diffusion). Pore fluid pH values are only moderately higher than seawater in Hole U1493B. Concentrations of K, Ca, and Sr are elevated, whereas B shows a depletion pattern that may reflect boron uptake into the serpentines at lower pH. Sulfate is depleted relative to seawater, possibly resulting from microbial sulfate reduction. Na/Cl ratios for these sites are higher than seawater (0.86), and increase with depth, likely reflecting continuing serpentinization (e.g., Mottl et al., 2004; Hulme et al., 2010). These signatures are similar to those observed for the Yinazao Seamount flank Site U1491, and it may be possible to define pore fluid chemistries that are typical of flank sites on serpentinite seamounts, both near and far from the trench.

The physical property data show that there is a rapid increase in consolidation with depth, far greater than observed in other seafloor sediments (Bekins and Dreiss, 1992). Porosity decreases from 60% to 30% in just 20 m at Site U1493. In the serpenite muds, bulk density is 2.2–2.3 g/cm^3, *P*-wave velocity is ~1900 m/s, porosity is ~30%, and thermal conductivity is ~2 W/m·K. Such high values (in comparison to siliciclastic or pelagic sediments, or deposits at Site U1496 at the summit of this mud volcano) imply that consolidation of the material is unlikely to be only related to compaction. Low-temperature diagenetic processes (e.g., ongoing serpentinization) or gravitational destabilization and sliding along the flanks (Oakley et al., 2007) may be important in explaining the differences with the younger deposits at the summit of this mud volcano.

At Hole U1493B, a single formation temperature measurement (APCT-3) was made at 24.5 mbsf. It yielded a medium-quality temperature equilibration curve, from which a formation temperature of 2.51°C and a bottom water temperature of 1.76°C were derived. The resulting geothermal gradient of 32°C/km and heat flow of 49 mW/m^2 compares to values of 25 and 30 mW/m^2 obtained at DSDP Holes 458A and 459B (Uyeda and Horai, 1982), each located ~25 km away.

Paleomagnetic measurements of section halves and discrete samples from the flank holes were affected by coring disturbance and a pervasive vertical overprint, likely imparted from the drill string, and no clear normal or reversed polarity could be obtained from shipboard measurements.

Sampling efforts for postcruise microbiological analysis focused on representative sequences of both near surface and deeper whole-round cores with evidence of transitions across gradients of microbiologically affecting compounds and gases, e.g., hydrogen, methane, hydrogen sulfide, and sulfate.

References

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