# IODP Expedition 366: Mariana Convergent Margin

## Site U1491 Summary

### Background and Objectives

International Ocean Discovery Program (IODP) Site U1491 (proposed Site MAF-16A) is located on the lower northwest flank of Yinazao Seamount (informally called Blue Moon Seamount in previous publications and the Expedition 366 *Scientific Prospectus*) on the Mariana forearc, at 15°47.12′N, 147°8.49′E, in 4511 m of water. The site lies on multichannel seismic (MCS) reflection profile EW0202 71-72.

Yinazao Seamount is a serpentinite mud volcano that lies on the eastern edge of a forearc graben about 55 km from the Mariana Trench axis. Of the three mud volcanoes being cored during the expedition, it is the closest to the trench, and the subducting slab lies approximately 13 km below its base (Oakley, 2008). Like the many other serpentinite mud volcanoes that populate the southern half of the Mariana forearc (the area between the trench and the volcanic arc), Yinazao Seamount is situated along a zone of weakness in the overriding plate's lithosphere. The fault trend that controlled the growth of the edifice has a NE–SW trend.

The plan for drilling at Site U1491 was to penetrate the lower northwest slope of the mud volcano. On the basis of bathymetry and side-scan data, it appeared that this region of the seamount was least deformed by slumping. The eastern and southeastern sectors of the seamount's flanks are disrupted by general downslope movement toward the trench. This deformation is likely caused by seismic activity in the forearc lithosphere and on the décollement beneath the region around Yinazao Seamount. A cluster of earthquakes in 1990 and 1991 was followed by particularly active seismicity lasting at least until 2002 (Engdahl et al., 1998; Fryer, 2012).

MCS profile 71-72 shows shallow reflectors at this site dipping slightly southeastward, consistent with interpretations by Oakley et al., (2007) that the serpentinite mud volcanoes essentially sag under their own weight and extend their distal edges over time. Drilling at Site U1491 on the lower northeast flank was expected to recover older serpentinite mud flow materials than at the summit.

The plan was to core two 50 m deep boreholes separated by 200 m and a third borehole that was up to 250 m deep, forming a transect down flank. This transect was chosen to: 1) intersect mudflows on the midflank; 2) potentially date discrete mud flows paleontologically, should there be sediment layers between them; 3) determine variability of mudflow thickness; 4) investigate potential systematic variability in degree of serpentinization (possible lower degrees at initiation of mud volcanism—e.g., conduit "throat clearing"); 5) examine transport conditions; and 6) provide a measure for the scale of potential flow characteristics.

## Operations

After completing operations to remove part of the CORK body at Site 1200C, the ship transited 137 nmi to Site U1491 in 14.5 h at an average speed of 9.8 kt, arriving in the area of Site U1491 at 1050 h on 15 December.

A precision depth recorder (PDR) seafloor depth measurement was taken once the ship was settled in over the site coordinates; it was, surprisingly, 222 m shallower than the prospectus water depth. Initially, the discrepancy was thought to be an artifact from being on the steep-sided flank (approximate 10° slope) of the mud volcano; however, it was ultimately confirmed that the operations summary being used had an erroneous position coordinate. The plan showed a latitude of 15°42.12′N when it should have been 15°47.12′N, a 5 nmi error. With the drill string at a depth of 1855 mbrf, we could continue tripping the drill string while moving in dynamic positioning (DP) mode to the corrected location coordinates. A new PDR seafloor depth measurement at the corrected drill site was 4442 mbsl, still different from the corrected prospectus depth of 4500 mbsl, because of the slope geometry: the PDR 3.5 kHz reflection first arrival came from upslope rather than from directly under the ship. To be certain about the seafloor depth, it was decided to tag seafloor with the core bit. At 0645 h on 16 December the bit took weight at 4494 mbsl, starting Hole U1491A. During the tagging process, sediment entered the bit and bottom-hole assembly (BHA), and was then collected with the advanced piston corer (APC) core barrel from inside the BHA without the core barrel being fired. The core barrel was recovered at 0800 h with 1.3 m of recovery including three distinct mudlines, likely resulting from ship heave causing the BHA to hop and tag the seafloor three or more times.

At 1015 h, Hole U1491B was started at a seafloor depth of 4492 mbrf. Oriented APC coring continued using the advance by recovery method, penetrating to 19.4 mbsf and recovering 19.0 m of core (98%). Coring was halted due to the continued presence of coarse gravel. All cores were incomplete strokes. Formation temperature measurements using the advanced piston corer temperature tool (APCT-3) were attempted at 13.2 and 19.4 mbsf. The drill string was pulled out of the hole, clearing the seafloor at 2325 h.

Hole U1491C is located 200 m NW (downslope) of Hole U1491B, and coring started at 0025 h at a seafloor depth of 4519 mbsl. The first two cores were oriented APC cores; then, because of incomplete stroke we switched to the half-length APC (HLAPC) and advanced by recovery for Cores U1491C-3F to 8F. At no time did the barrel fully stroke, and recovery varied from 1 to 4.7 m, prompting a switch to extended core barrel (XCB) coring. XCB Core U1491C-9X required 70 min of rotating time to cut the core as well as substantial effort to clean out 5 m of coarse gravel fill on bottom prior to cutting the core. Core U1491C-9X contained only 0.27 m recovery, due to a jammed piece of core in the XCB cutting shoe. A second XCB core barrel was deployed and the bit was advanced to 43.9 mbsf when the driller noticed a loss of torque and pump pressure. Two unsuccessful attempts were made to recover the core barrel; however, the overshot did not engage the pulling neck on the barrel. Upon recovery of the sinker bar string the overshot was found to have all shear pins intact; however, the core line was damaged on both runs. Recognizing that something was wrong with the drill assembly (and fearing a BHA failure) the drill string was recovered back to the ship. When the drill string was pulled back to the ship, we found that the BHA had failed and that the following were lost in the hole: the bit, a non-magnetic drill collar, an APC/XCB outer core barrel assembly, and an XCB core barrel assembly. At 0000 h on 18 December, the ship started the 9 km transit to Site U1492 in DP mode.

**Principal Results**

The sediment units at Site U1491 are interpreted to represent debris flows originating from various upslope source deposits interbedded with serpentinite mud flows that have source vents also upslope. The top 5–8 m at Site U1491 consist of brown mixed pelagic muds containing clays, microfossils, and volcaniclastic material. Beneath the pelagic sediments are sequences of normally-graded carbonate-dominant breccia-conglomerate units, serpentinite-dominant turbidite units, and serpentinite muds containing clasts of serpentinized ultramafic rock and occasionally carbonate (coral?). Generally these distinct lithological units have well-defined contact interfaces, indicating that the deposits result from sporadically energetic downslope debris and turbidite flows, as well as from downslope flows of serpentinite mud. Geochemical analysis of pore fluids at Site U1491 shows only slight variation in values from those of shallow sediments in contact with seawater, except for boron and strontium, which are both slightly enriched relative to seawater and tend to increase downhole.

Physical property measurements clearly distinguish the top pelagic deposits from the underlying units, with the pelagic units having lower density, higher natural gamma radiation, and lower magnetic susceptibility than the underlying materials. The physical properties of the serpentinite mud at Site U1491 are consistent with those measured on other seamounts of the Mariana trench during previous expeditions (Conical Seamount, Leg 125, Fryer et al., 1992; South Chamorro seamount, Leg 195, Salisbury et al, 2002). The high values of magnetic susceptibility of up to $10^{-2}$ SI highlight the presence of magnetite in serpentinite mud, classically associated to the process of serpentinization of ultramafic rocks (e.g. Bonnemains et al., 2016), and variability in magnetic susceptibility reflects heterogeneities in mud and in the type and concentration of the hard-rock clasts. A compaction effect is suggested by the overall increasing trend in GRA bulk density with depth, but because the cored material at Site U1491 is only shallowly buried, other dewatering processes are probably involved. Two downhole temperature measurements were of moderate quality, and together with the seafloor temperature indicate a thermal gradient of about 30°C/km at this site, which serves as a background for comparison with the summit sites where active fluid flow is anticipated to be present.

**References**

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