IODP Expedition 340T: Atlantis Massif Oceanic Core Complex APL
Site 1309 Summary

Background and objectives

The primary scientific objective of IODP Expedition 340T was to investigate hydration of the crust within the domal core of Atlantis Massif, located just west of the spreading axis of the Mid-Atlantic Ridge at 30°N. To accomplish this, the expedition completed the wireline logging of existing Hole U1309D on the Central Dome of Atlantis Massif, focusing on temperature and acoustic velocity measurements, and a zero-offset vertical seismic profile (VSP). The study aimed to provide insight into potential sources of seismic reflectivity in the footwall of this oceanic core complex, which could be attributed to variations in alteration between lithologic units or to narrow fault zones with higher porosity and potentially pore fluids.

All components of the planned logging program at Hole U1309D were successfully conducted during Expedition 340T. The Triple Combo, Sonic, and Magnetic Susceptibility wireline logging runs produced high quality data. The majority of the VSP data are noisy and will require substantial post-processing. However, a few stations in the upper 150 m of the section recorded clear, strong seismic arrivals, thus providing in-situ constraints on average properties across the zone inferred to be most strongly affected by detachment processes at the Central Dome.

Scientific Results

The first tool string deployed in Hole U1309D was the Triple Combo, measuring hole size, density, gamma ray, resistivity and borehole fluid temperature. This was the first time Hole U1309D had been entered since the conclusion of Expedition 305 operations in February 2005, so the borehole fluid had seven years to reach equilibrium with the surrounding rock formation. The dominant trend in the downhole temperature profile is quasi linear increase with depth, with modest deviations focused at two distinct intervals. The maximum temperature recorded in the hole was ~145°C at 1404 mbsf, more than 20°C hotter than the maximum temperature recorded at the end of Expedition 305, when drilling and flushing had

altered conditions considerably. Gamma ray and resistivity data confirmed repeatability of Expedition 305 data.

The Versatile Seismic Imager (VSI), essentially a downhole three-axis geophone accelerometer, was deployed three times as part of the VSP experiment. Vertical seismic profile station coverage at zero offset now extends the full length of the hole, including the uppermost 150 mbsf where fault detachment processes are expected to have left their strongest imprint. Recorded waveforms are noisy; the exact cause is unknown but likely is due to a combination of factors such as sea conditions, wireline tension, and possibly ship-generated noise. First arrivals from 93 out of the total 659 shots, corresponding to 33 of the 55 station depths, were graded as excellent to very good on at least one channel, primarily the vertical component. The good VSP stations for Expedition 340T thus range from 86 to 1360 mbsf extending the Expedition 305 data that covered the interval from 272 to 792 mbsf.

The sonic tool string, including the Dipole Sonic Imager (DSI) and General Purpose Inclinometer Tool (GPIT), was deployed twice in Hole U1309D. A full set of sonic data was obtained, including borehole compressional, shear, and Stoneley wave slowness (the reciprocal of velocity) from 700 to 1384 mbsf, an interval where no velocities were measured at the end of Expedition 305. These data are the first in situ measurements of the velocity of gabbros typical of oceanic lower crust, with compressional velocity (V_p) values higher than 7000 m/s.

The final tool string run in Hole U1309D included the deep-reading sensor of the Magnetic Susceptibility Sonde (MSS). This expedition marked the first sea trial of the deep-reading sensor of the newly rebuilt LDEO MSS, providing a measure of the magnetic susceptibility of the borehole, which depends on the concentration and composition of magnetic minerals in the wallrock. This tool string is temperature-limited, so the logging run sampled only the cooler, upper interval of the hole down to 2419 mbrf (763 mbsf). Magnetic susceptibility was measured on core recovered from Site U1309 during Expeditions 304/305; the MSS log shows similar features, suggesting the measurement is a reliable one, and corresponds well with fine-scale (meter to submeter scale) variations in lithology.

Following the conclusion of logging operations, a short camera survey was carried out in the vicinity of Hole U1309D. The survey was designed as a 5-m expanding spiral centered at Hole U1309D, in order to document the local seafloor environment. Following the survey, the ship navigated back to a distinctive mound-like feature that was imaged a few meters from Hole U1309D during re-entry and again in the camera survey.