May 15, 2005

IODP EXPEDITION 307: SITE U1317 SUMMARY
MODERN CARBONATE MOUNDS: PORCUPINE DRILLING

U1317A	51°22.848'N	11°43.108'W	815.1 mbsl
U1317B	51°22.840'N	11°43.092'W	798.0 mbsl
U1317C	51°22.830'N	11°43.076'W	791.7 mbsl
U1317D	51°22.832'N	11°43.092'W	794.0 mbsl
U1317E	51°22.799'N	11°43.058'W	781.1 mbsl

Site U1317 (proposal Site PORC-3A) is located on the northwest shoulder of the Challenger Mound (51º 22.8 N, 11º 43.1W, in 781 to 815 m water depth). Scientific drilling of the Challenger Mound was the central objective of Expedition 307. Specific objectives of drilling Site U1317 were:

- To establish whether the mound base is on a carbonate hardground of microbial origin and whether past geofluid migration events acted as a prime trigger for mound genesis.
- To describe stratigraphic, lithologic and diagenetic characteristics for establishing the principal deposional model of deep-water carbonate mounds including timing of key mound-building phases.
- To define the relationship, if any, between the mound-developing event and global oceanographic events, which might have formed erosional surfaces displayed on high-resolution seismic profiles
- To analyze geochemical and microbiological profiles that define the sequence of microbial communities and geomicrobial reaction throughout the drilled sections.

Sediments from the on-mound Site U1316 can be divided into two units; the Pleistocene coral-bearing unit (Unit 1) and the Neogene siltstone (Unit 2). Unit 1 consists mainly of coral floatstone, rudstone, wackestone, and packstone, and repeats cyclic color change between light gray and dark green. Carbonate contents of the sediment relate to the color. Lighter color sediment tends to be more calcareous and commonly exhibits lithification textures. The corals were mostly identified as *Lophelia pertusa*. The thickness of the unit increases to the middle of the mound. It is 130 m at the most flankward location of Hole U1317A, and thickens to 155 m at Hole U1317E, which is the locality closest to the mound summit. This coral mound unit rests on Unit 2 with a sharp erosional boundary that appears identical to the boundary between Units 2 and 3 of Site 1316. Unit 2, 124 m in thickness (Hole U1317D), consists of glauconitic and partly sandy siltstone. It is lithologically correlated with Unit 3 at Site U1316.

The early Pleistocene age of small *Gephyrocapsa* Zone (0.96-1.22 Ma) is assigned for the upper part of Unit 1 (0-73.0 mbsf: Hole U1316A) by abundance of this genus. The nannofossils from the lower part of Unit 1 (73.0-130.0 mbsf) correspond to the early Pleistocene *Calcidiscus macintyre* Zone (1.59-1.95 Ma). The age of Unit 2 ranges from early Pliocene to Miocene, as indicated by both nannofossils and planktonic foraminfers. Interval of the hiatus between Unit 1 and 2 was estimated more than 1.65 m.y.

Whole-round cores were measured for magnetization after 0, 10, and 15 mT demagnetization steps. Whole rounds were used because (a) two of the holes would not be opened during the expedition (b) twice as much sediment (compared to the archive half) would give a better signal in these weakly magnetic carbonate-rich sediments, (c) the sediment would be undisturbed by splitting, and (d) the possible presence of ephemeral magnetic minerals such as greigite. Demagnetization tests were run to ensure that only the overprint was removed by bulk demagnetization at 15 mT. Lithostratigraphic Unit 1, the mound sediments, had somewhat scattered inclinations, but coherent changes in polarity could be observed in Hole 1317B, 0-62 mbsf is predominantly normal polarity, and interpreted as the Brunhes chron (0-0.78 Ma), and two predominantly reversed intervals occur from 62-82 and 96-105 mbsf that are tentatively interpreted as part of the Matuyama chron.

The two lithostratigraphic units at this site have distinctive and contrasting physical properties. Unit 1, the mound facies, has generally low values of natural gamma radiation and magnetic susceptibility that are caused by the high carbonate content. Some cyclically recurring intervals are characterized by relatively higher in natural gamma radiation and magnetic susceptibility, density and P-wave velocity, indicating a higher clay content. These intervals could be traced from Hole 1317A upslope through Holes 1317B, D, C, and E. These intervals coincide with floatstones. The corresponding seismic facies is acoustically transparent, despite the layering observed in the cores, which could be because of the high coral content scattering the seismic waves, or because the internal layers identified in the physical property measurements are not laterally consistent enough to give internal reflectors inside the mound facies. The lower boundary of Unit 1, the mound base, is characterized by an increase in density, gamma radiation and magnetic susceptibility. Lithological Unit 2 is characterized by very low susceptibility values and eight peaks of high density, P-wave, magnetic susceptibility, and gamma radiation that coincide with more lithified layers and sandier layers. These layers can be correlated with the high amplitude sigmoidal reflectors observed in the seismic profiles.

Triple Combo, FMS sonic downhole logs, and a zero-offset VSP were between 80 and 245 mbsf in Hole U1317D. The density, resistivity, and acoustic velocity logs show a steady downhole increase due to compaction, interrupted by 1-5-m-thick intervals of higher values, indicating the presence of more lithified layers similarly to Hole U1316C. The PEF values for these layers indicate they are carbonate-rich. These lithified layers are the cause of the high amplitude sigmoidal reflectors observed in the seismic profiles. Interval velocities were calculated from the checkshot survey: they confirm the values of the acoustic velocity logs, but show that the physical property measurements made on the cores significantly underestimate the in-situ velocity.

The striking lack of any clear evidence for a microbial role in the build up of Challenger Mound, either active or historical, dominated the first impression of the geochemistry and microbiogical results. We did not find significant quantities of gas in the mound or in the sub-basal mound sediments. There was no evidence for the formation of a carbonate crust where the mound growth should have begun. Overall indices of microbial activity and abundance in the mound were low. In short, Challenger Mound is not a model for microbial origin of Phanerozoic carbonate mounds. Rather it is the subtle intertwining of carbonate diagenesis and microbial sulfate reduction that provide the highlights of the chemical and microbiolgical investigations on the mound site. Sulfate, ammonium and alkalinity profiles reflect zones of microbially mediated organic mineralization. The concave-down profile for sulfate between 10 and 50 mbsf, concurrent with the convex-up curvature for alkalinity indicates active sulfate reduction. Magnesium also shows a loss; this is clearly shown in the decreased Mg/Ca ratio at these depths. With the slight increase in Sr, we propose that aragonite dissolution to release Sr to the interstitial pore fluids is occurring. Concurrently, dolomite precipitates and removes Mg. Mineralization of organic matter via sulfate reduction (organoclastic) may be driving this process by (1) producing CO_2 that enhances aragonite weathering and by (2) increasing the overall dissolved inorganic carbon concentration. Interestingly, this dolomite formation must be occurring in a sulfate-rich zone. Deeper in the methane zone below 150 mbsf there is also evidence for dolomite formation. A broad transition of methane and sulfate between 150 and 200 mbsf defines the zone of anaerobic oxidation of methane coupled to sulfate reduction (methylotrophic).