July 2, 2005

IODP EXPEDITION 308: GULF OF MEXICO HYDROGEOLOGY
SITE U1324 SUMMARY

Hole U1324A Latitude: 28° 4.786'N, Longitude: 89° 8.357'W
Hole U1324B Latitude: 28° 4.785'N, Longitude: 89° 8.344'W
Hole U1324C Latitude: 28° 4.783'N, Longitude: 89° 8.368'W
Water depth: 1056.8 m

Site U1324 is the westernmost site drilled in the Ursa basin by Expedition 308. Of the three sites in the Ursa Basin, Site U1324 has the thickest sediment loading above the permeable Blue Unit. The principal objectives of drilling Site U1324 were to document rock physical properties at the location of maximal overburden in the Ursa Basin, measure in-situ formation temperature and pressure, document geochemical composition of the pore water, and establish a preliminary age model leading to an estimate of sediment accumulation rates at this location. The ultimate goal of drilling the Ursa Basin is to explore fluid flow and fluid pressures in an overpressured basin.

The stratigraphy of Hole U1324A was first divided into two main units based on log responses. These units were subdivided into several subunits based on comparisons with nearby core data from Hole U1324B and variations in the log responses. The main regional seismic reflectors (S10 through S50) can be identified in the logging data as significant variations in velocity, gamma ray, and/or resistivity. The LWD resistivity images show a large degree of deformation especially in logging Unit II. These images show significant folds and variable dips ranging from shallow to relatively steep (>60º). This suggests a significant amount of deformation most likely caused by mass transport events. These events seem to indicate a high degree of slope instability due to the presence of turbidites that have been dislocated, and in some instances, also folded. Tilted beds, folds and faults are dominated by a general east-west strike.

The 612 meter-thick sedimentary succession overlying the Blue Unit at Site U1324 records the evolution of the eastern levee of the Southwest Pass Canyon channel-levee system. Visual observation of the cores supported the subdivision of the lithologies into two lithostratigraphic units. Lithostratigraphic Unit I is composed of clay and mud, and contains three mass flow deposits. Lithostratigraphic Unit II is composed of interbedded silt, sand, and mud, and contains two mass flow deposits. We interpret the boundary between these units as reflecting a fundamental change in the development of the Southwest Pass Canyon channel-levee system. Below the boundary, relatively unconfined deposition of sand, silt, and mud points to a young, developing channel-levee system. Above the boundary, the Southwest Pass Canyon channel was firmly established to the east, and was effective at confining sands and silts to the channel axis. Overspill of mud and clay developed the thick levee assemblage recorded in Lithostratigraphic Unit I. Seismic correlation suggests that acoustically transparent intervals in this succession represent regional mass flow deposits composed of faulted and contorted masses of mud and clay. However, close examination reveals that the mass flow deposits contain levee clay and mud that are only mildly deformed and tilted, and thus were not transported very far from their original position.

Variations in physical properties correlate well with lithostratigraphic units. The interbedded silt, sand, and mud, and mass flow deposits in Lithostratigraphic Unit II are characterized by highly variable bulk density, porosity, and undrained shear strength. Physical properties shows much less scatter in the uniform hemipelagic mud and clay in Lithostratigraphic Unit I.

Bulk density measured by MAD is consistent with those measured by MST and LWD in Lithostratigraphic Unit I. A porosity increase at 40 mbsf correlates with seismic reflector S10. A decrease in resistivity and low thermal conductivity were also observed at that depth. A sharp porosity increase at ~160 mbsf is be related to the silt layer above seismic reflector S30, which may be significantly overpressured. This explanation is supported by the observed decrease in *P*-wave velocity, thermal conductivity, and undrained shear strength at this depth.

Preliminary biostratigraphic data from nannofossils and planktonic foraminifer assemblages as well as magnetostratigraphy indicate that the sediment sequence recovered at Site U1324 was essentially deposited over the last 60 kyr, more specifically during marine oxygen isotope stages (MIS) 1 to 4. Sedimentation rates varied between 5 to over 10 m/kyr for Lithostratigraphic Unit I in the interval above 365 mbsf of Hole U1324B, with possible sedimentation rate peaks of 12 m/kyr or more in the intervals of mass flow. Between 365 and 608 mbsf, in Lithostratigraphic Unit II, sedimentation rates appear to have been faster, perhaps in excess of 25 m/kyr. However, the low microfossil abundance and the relative young age of the sediments renders precise dating of this interval difficult, thus these results are tentative. Distinctive cyclic patterns were observed in the distribution of nannoplankton and foraminifers, indicating periodic influx of sediments from the Mississippi River associated with turbidity currents in the Ursa Basin. The infauna-dominated benthic foraminifer assemblages also suggest a prevalence of low-oxygenated “stress” environments due to rapid sediment loading in the basin during the last glacial period.

Variation in interstitial water chemistry at Site U1324 is largest at shallow depths (<100 mbsf). Below this depth, only very limited changes are observed. Pronounced pore-water chemical changes are particularly important from sub-seafloor to the S10 seismic reflector (~35 mbsf). Li, B, and Sr reach their maxima within this depth range, and Mn reaches its minimum at ~35-40 mbsf. H_4SiO_4 and Fe reach their maxima between ~20 and 25 mbsf. Between 40 mbsf and 160 mbsf, salinity, Li, B, and Sr decrease; Ba, Fe, and NH_4 increase; Cl, Mn, and H_4SiO_4 are constant. The extremely high ammonium contents (up to 6820 µM) in pore-water are consistent with more reducing conditions at this site compared with the sites drilled in the Brazos-Trinity Basin. The general downhole increase in ammonium likely reflects enhanced organic degradation at greater depths. The vertical profile, especially the surficial maximum and minimum in dissolved Fe and Mn, are consistent with the hierarchy of redox reactions often observed in deep-marine sediments.The high Fe contents at shallow depths might reflect enhanced Fe reduction and/or greater availability of detrital Fe oxides/oxyhydroxides, or simply Fe-rich clays. The pore-water chemistry at sub-seafloor is probably dominated by dissolution processes rather than by organic-matter degradation, which enhances alkalinity, Ca, Mg, Sr, B and Li concentrations at ~35 mbsf. The causes for the very acidic (pH<7.0) nature of the pore-water found above 200 mbsf at Site U1324 are unclear and need further investigation.

Methane concentration increases dramatically in the middle section of Lithostratigraphic Unit I (160 mbsf) but remains low in the rest of the hole. The predominant hydrocarbon found in Hole U1324B was methane, and the C_1/C_2 ratios were high, suggesting a biogenic origin for the methane. Therefore we interpret the methane found at Site U1324 as resulting from *in-situ* microbial activities, or alternatively as having migrating from lateral locations. The microbial cell count at Site U1324 was low with a maximum cell density of 2.0 x 10^5 cells / ml at 2.8 mbsf. This is an extremely low and unexpected value considering the location and high sedimentation rate of this site. At this time, the predominance of clay-rich sediment at Site U1324 preventing fluid migration is the only reason thought to explain the low abundance of microbial communities.

In-situ measurements made with the T2P and the DVTP-P probes documented fluid overpressure and a low thermal gradient at Site U1324. Successful fluid pressure measurements at 117, 300, 405, and 608 mbsf yielded values for λ^* between 0.2 and 0.6 (λ^* is the ratio of overpressure to hydrostatic effective stress). Eighteen temperature measurements constrain a geothermal gradient of 19^0 C/km. The elevated fluid pressure and suppressed thermal gradient are indicative of a rapidly deposited sedimentary package. These data are critical to understanding fluid flow and mechanical behavior at Site U1324 and for testing the flow focusing hypothesis in the Ursa Region.

All of the objectives set for Site U1324 are considered fulfilled. The principal result is that we acquired a good dataset of formation pressures and temperatures for this site. Once compared to a similar dataset obtained at Site U1322, this will allow us to test the model of overpressure on which the strategy of Expedition 308 was based. However, the fact that pore water pressure in Holes U1324B and U1324C lie between the lithostatic and hydrostatic pressure gradient is already a demonstration that the Ursa basin is overpressured. Moreover, results from lithostratigraphy and biostratigraphy have constrained unusually high sedimentation rates, and the timing of mass flow deposition at this location. The data and observation made at Site U1324 are critical for log-seismic integration, and for the understanding of geological processes leading to overpressure in the Ursa Basin.