October 18, 2004

IODP EXPEDITION 303: NORTH ATLANTIC CLIMATE I
SITES 1302 AND 1303 SUMMARY

Hole 1302A Latitude: 50° 9.985'N Longitude: 45°38.271'W
Hole 1302B Latitude: 50° 9.995'N, Longitude: 45°38.290'W
Hole 1302C Latitude: 50°10.007'N, Longitude: 45°38.309'W
Hole 1302D Latitude: 50°10.019'N, Longitude: 45°38.324'W
Hole 1302E Latitude: 50°10.030'N, Longitude: 45°38.343'W
Hole 1303A Latitude: 50°12.401'N, Longitude: 45°41.220'W
Hole 1303B Latitude: 50°12.383'N, Longitude: 45°41.197'W
Water depth Site 1302: 3555 mbsl
Water depth Site 1303: 3518 mbsl

The overall objective at Sites 1302 (ORPH3A) and 1303 (ORPH2A) is to explore the record of Laurentide Ice Sheet (LIS) instability at this location close to Orphan Knoll. Piston cores collected at Site 1303 (HU91-045-094P, MD99-2237, MD95-2024) show the presence of numerous detrital layers, some of which are rich in detrital carbonate, in sediments deposited during the last glacial cycle. Isotopic data from planktonic foraminifers indicate that these detrital layers are associated with low-productivity melt-water pulses. The objective at Sites 1302 and 1303 is to document this manifestation of LIS instability both during and prior to the last glacial cycle. The two sites are separated by 5.68 km. The drilling revealed a very similar stratigraphic sequence at the two sites. The MST data could be correlated from site-to-site at fine scale. The rationale for drilling Site 1302 was that the single channel air-gun seismic data indicated a thicker section above mud waves at Site 1302 than at Site 1303 (the site of the piston cores mentioned above). We moved to Site 1303 after encountering a coarse-grained debris flow at about 105 mcd at Site 1302 that caused the cessation of APC penetration. The same debris flow was, however, encountered at Site 1303. The top of the debris flow coincides with a strong reflector in the air-gun seismic data, at about 100 ms two way travel time, which can be traced between the two sites.

Five holes, offset by 30 m from each other, were cored with the APC coring system at Site 1302 with an average recovery of 90.3%. Three holes (Holes 1302A-C) were cored to total depth (maximum of 107.1 mbsf), which was limited by the presence of a debris flow. Holes 1303D and 1302E consisted only of two cores each to capture the intervals at the top of the succession and provide overlap with coring gaps from the previous holes. We cored two APC holes, 30 m apart, at Site 1303. Penetration depth was limited to 93.9 mbsf in Hole 1303A (73.6% recovery) and 85.7 mbsf in Hole 1303B (83.5% recovery) by the debris interval.

An almost complete composite section was constructed at Site 1302 spanning the interval 0-107 mcd. It was not possible to construct a complete composite record at Site 1303. However, the density and magnetic susceptibility records from the Sites 1302 and 1303 are remarkably similar and can be easily correlated. Using a short segment of one core from Site 1303 and the composite record from Site 1302, provides a continuous stratigraphic sequence to ~107 mcd.

The sediments at Sites 1302 and 1303 are dominated by varying mixtures of terrigenous components and biogenic debris (primarily quartz, detrital carbonate, and nannofossils), so that the most common lithologies are clay, silty clay, silty clay with nannofossils, nannofossil silty clay, silty clay nannofossil ooze, and nannofossil ooze with silty clay.

Dropstones are present throughout the cores. Calcium carbonate content ranges from 1 to 47 wt.%. The sediments at Sites 1302 and 1303 have been designated as a single unit due to the gradational interbedding of these lithologies at scales of a few meters or less. This unit has been subdivided into two subunits, however, based on evidence for downslope mass flows at the base of the section. Subunit IA (0-~106 mcd) is composed of undisturbed sediments, whereas Subunit IB (106-132 mcd) contains abundant intraclasts in a matrix of sand-silt-clay, and is interpreted to be debris flow deposits.

Samples from Sites 1302 reveal rich assemblages of calcareous, siliceous and organic-walled microfossils. Coccoliths are abundant and well preserved in most samples, and permit establishment of biostratigraphical schemes that are complemented by a few datums from diatoms and palynological data. According to these schemes, the composite sequence of Site 1302 covers an interval spanning less than 1.16 Ma, and approximately the last 0.95 Ma, whereas the composite sequence of Site 1303 probably corresponds to an interval spanning approximately the last 0.85 Ma. Beyond the biostratigraphical schemes, the micropaleontological assemblages provide insight into paleoclimatological and paleoceanographical conditions. In particular, the relative abundance of the planktonic foraminifer *Neogloboquadrina pachyderma* (sinistral) and some dinocyst assemblages allow identification of glacial and interglacial conditions from some core catcher samples.

The pore water chemistry from Sites 1302 and 1303 is dominated by reactions associated with organic matter degradation, despite the relatively low organic matter content of the sediments (~0.5 wt%). Sulfate concentrations decrease from seawater values to 5.9 mM close to the base of the recovered section indicating that sulfate reduction is almost complete by 109 mcd. Corresponding increases in alkalinity and ammonium downcore are byproducts of organic matter reactions. Alkalinity does not reach concentrations expected for the degree of sulfate reduction. Decrease in calcium (to a minimum of 5.5 mM, a 52% decrease from seawater values) with depth suggests precipitation of carbonate minerals as one possible explanation for the alkalinity profiles. Strontium concentrations remain at seawater values or lower throughout the cored interval indicating that carbonate dissolution and recrystallization are not important processes at these sites.

Overall, sediments of Lithologic Subunit IA from Sites 1302 and 1303 are excellent geomagnetic field recorders as indicated by the fidelity of the shipboard paleomagnetic record. Inclinations vary coherently around that expected for the site latitudes. Declinations show consistent behavior within cores and, when tensor corrected, between cores. Directional geomagnetic excursions appear to be observed in three replicate sections from Holes 1302C, 1303A, and 1303B at ~ 31.40 mcd and are interpreted to represent the Iceland Basin Event at ~ 187 ka. Magnetization intensities are strong and magnetic properties look favorable for shore-based paleointensity studies. Within the debris flow, Lithologic Subunit IB, the paleomagnetic record is not of the same quality. There is some evidence for reversed magnetizations within apparently undisturbed sediment within or below the debris flow, possibly denoting the uppermost Matuyama Chron, but the overall sediment quality in Subunit IB does not allow further interpretation. In addition, it appears that the removal of the drill-string magnetic overprint is greatly facilitated by the nonmagnetic core barrels.

The magnetic susceptibility (MS) records obtained at these sites present a well-defined pattern of glacial–interglacial variability. At both sites, NGR variation is consistent with both MS and density measurements (i.e., low MS and density values correspond to low NGR counts– 20 to 22 cps), which suggests these intervals were characterized by a carbonate-dominated sedimentation. The downcore MST records not only provide a guide to the glacial–interglacial cycles, possibly back to MIS 17, but also provide a millennial scale record

of LIS instability through recognition of Heinrich-like detrital events. Detrital events in the Heinrich Layer 1-6 interval are easily recognized in the MST data at Sites 1302 and 1303, and can be unambiguously correlated to similar records in neighboring piston cores such as MD95-2024 and MD99-2237 that record the last glacial cycle. The sedimentary succession at Sites 1302 and 1303 provides a record of LIS instability back to MIS 17. This record is a proximal analog to the classic Heinrich-layer stratigraphy of the central Atlantic.