IODP EXPEDITION 306: NORTH ATLANTIC CLIMATE II
SITE U1313 SUMMARY

Hole U1313A Latitude: 41°0.068'N, Longitude: 32°57.439'W
Hole U1313B Latitude: 41°0.082'N, Longitude: 32°57.438'W
Hole U1313C Latitude: 41°0.081'N, Longitude: 32°57.421'W
Hole U1313D Latitude: 41°0.067'N, Longitude: 32°57.421'W
Water depth: 3412.6 mbsl

IODP Site U1313 constitutes a reoccupation of DSDP Site 607 located at the base of the upper western flank of the Mid-Atlantic Ridge in a water depth of 3426 m, approximately 240 miles northwest of the Azores. Two holes were drilled at this site during DSDP Leg 94 (June-August, 1983) using the Variable Length Piston Coring System (VLHPC) and the Extended Core Barrel System (XCB). Hole 607 penetrated to a total depth of 284.4 m, and Hole 607A to a total depth of 311.3 m. The sediments recovered at Site 607 predominantly consist of calcareous biogenic oozes with variable amounts of fine-grained terrigenous material. Based on magneto- and biostratigraphy, the mean sedimentation rate at DSDP Site 607 is about 5 cm/k.y. for the Pliocene-Pleistocene time interval. Incomplete recovery and the present condition of the existing DSDP cores collected in 1983 do not permit the detailed paleoceanographic studies proposed here. The rationale for reoccupying DSDP Site 607, one of the benchmark sites for long- and short-term paleoclimatic reconstructions of the sub-polar North Atlantic, is to obtain a high-resolution record of ice sheet variability and changes in surface- and deep-water circulation on millennial to sub-millennial timescales.

Four holes (Holes U1313A, U1313B, U1313C, and U1313D) were cored with the Advanced Piston Coring (APC) system and nonmagnetic core barrels to a maximum depth of 308.6 mbsf, 302.4 mbsf, 293.4 mbsf, and 152.0 mbsf, respectively. The average recovery was 103.5%. At Holes U1313A and U1313C, “drill over” technique was required for recovery of the last two and four cores, respectively. After completing coring operations at Hole U1313B, the hole was prepared for logging and the Triple-Combo tool string was deployed (including the GPIT and

MGT tools) to 2.0 m off the bottom of the hole. The entire 300 m sequence was successfully logged.

The Holocene to latest Miocene sedimentary succession at Site U1313 consists primarily of nannofossil ooze with varying amounts of foraminifers and clay- to gravel-sized terrigenous components. Two major lithologic units have been identified. Unit I (0-111.86 mbsf in Hole U1313A, 0-111.28 mbsf in Hole U1313B, 0-112.00 in Hole U1313C, and 0-113.14 mbsf in Hole U1313D) consists of Holocene to upper Pliocene alternating nannofossil ooze, silty clay nannofossil ooze, and nannofossil ooze with clay. Regular occurrences of dropstones in Unit I demonstrate that Northern Hemisphere ice-sheet instability plays a role in the sediment's paleoclimate record during the Pleistocene to late Pliocene. Unit I can be further subdivided into two subunits. Subunit IA exhibits largest amplitude fluctuations in detrital clay and biogenic carbonate and is reflected by distinct color changes and shifts in L*, percent carbonate, gamma ray attenuation, and magnetic susceptibility, whereas Subunit IB is defined by decreased variability in these components. Millimeter- to centimeter-scale pale green color bands are distributed throughout the succession and a horizon of reworked volcanic ash can be correlated across all holes in Subunit IA. Unit II extends to the bottom of each hole (111.86-308.42 mbsf in Hole U1313A, 111.28-302.52 mbsf in Hole U1313B, 112.00-293.33 mbsf in Hole U1313C, and 113.14-153.0 mbsf in Hole U1313D). Unit II is very homogenous and differs mainly from Unit I in its smaller terrigenous component, which decreases gradually downhole from the unit boundary to about 150 mbsf. Unit II consists of upper Pliocene to uppermost Miocene nannofossil ooze and is characterized by high and stable carbonate concentrations. Discrete patches and streaks of pyrite occur throughout this unit and are probably related to local reducing conditions associated with organic matter complexes. Pale green color bands continue to be prevalent in the otherwise nearly white sediment.

Site U1313 yielded abundant assemblages of calcareous microfossils spanning the late Miocene to Holocene. Biohorizons based on calcareous microfossils closely match ages based on paleomagnetic data for the Pliocene and Pleistocene, and indicate nearly constant sedimentation rates of ~4.1-4.5 cm/k.y. throughout this time interval. The oldest sediments at Site U1313 are tentatively dated at 6.0 Ma based on a nannofossil last occurrence near the base of Holes

U1313A and U1313C, a tentative planktonic foraminifer event at the base of Hole U1313A, and a possible diatom event in Core U1313C-32H. Based on these biohorizons, sedimentation rates within the late Miocene are ~13-14 cm/k.y.

Calcareous nannofossils are well-preserved throughout much of the section, although some dissolution and overgrowth is present within the upper Miocene. Pleistocene sediments contain very minor amounts of reworked nannofossils. Planktonic foraminifers are moderately- to well-preserved and reveal a high faunal diversity including several (sub)tropical species. An incursion of encrusted *Neogloboquadrina atlantica* (dex) occurs in the lower Pleistocene, making this the youngest occurrence of this species in the mid-latitude North Atlantic.

Radiolarians at Site U1313 reveal great variation in abundance, state of preservation, and faunal associations among the four holes. Generally speaking, radiolarians are abundant and well preserved in the upper five to six core catcher samples, while dissolution is severe in the lower part. *Cycladophora davisiana* is found in samples up to 14 cores deeper than its anticipated first occurrence in the North Atlantic at 2.6 Ma. If these occurrences are real and not a result of downhole contamination, then the first occurrence of *C. davisiana* is approximately 5.5 Ma.

A diverse warm-water diatom flora is generally present within the upper 40-70 mbsf during the Pliocene-Pleistocene intervals, containing a mixture of Arctic and Subarctic possibly ice-rafted species. However, diatoms are only abundant in the first two core catchers, and occur only as traces below 50-60 mbsf. When present, warm-water diatoms are generally well preserved, but often fragmented. The diatoms from colder water masses are usually partially dissolved.

The magnetostratigraphy at Site U1313 was constructed on the basis of continuous measurements of the natural remanent magnetization (NRM) after alternating field (AF) demagnetization at a peak field of 20 mT. NRM intensities after 20 mT AF demagnetization are in the range of 10^{-3} to 10^{-4} A/m above 150 mbsf, but fall in the range of 10^{-5} A/m in the lower part of the section. The sediments provide a good record of the Brunhes, Matuyama, and Gauss polarity intervals, down to about 150 mbsf. Below this depth, the inclination signal is noisier but alternating intervals of normal and reversed polarities can still be defined with confidence down

to about 250 mbsf. The magnetostratigraphy is uncertain below this depth, as it varies from one hole to the other, part of which might be due to the stronger drill-string overprint induced by alloy steel core barrels used in the bottom part of Holes U1313A and U1313C instead of non-magnetic core barrels. The magnetostratigraphy is consistent with the biostratigraphy from the top down to about 220 mbsf. In the underlying sediment, however, the link to the biostratigraphy is not straightforward.

The four holes cored at Site U1313 provided ample sediment for constructing one complete spliced stratigraphic section and a second nearly complete section. Correlation between holes was excellent in the upper 168.5 mcd because of pronounced variations in nearly all physical properties measured. In particular, the lightness (L*) from color reflectance measurements mimic variations in the global benthic oxygen isotope stack and a preliminary age model was constructed by matching sharp L* variations with glacial and interglacial terminations. Between-hole correlation was more difficult below 168.5 mcd (~151 mbsf) because the sediments are fairly homogenous calcareous nannofossil ooze.

Apart from their general trends, most pore water chemical constituents show a notable change between ~80 and 110 mbsf (i.e., at the transition of lithologic Units I to II). Alkalinity and Sr^{2+} increase downhole while the Li^{+} decreases. The highest dissolved silica content of ~563 µM is measured at 39.3 mbsf. SO_4^{2-} concentration exhibits a slight downhole decrease from ~26 to 24 µM whereas the NH_4^{+} shows an opposite trend (126-418 µM with a high value of 615 µM at 47.8 mbsf). Ba^{2+} shows a more or less uniform concentration (~3.2 µM) throughout the profile.

Carbonate concentrations in the sediments of Hole U1313A range from 31.5 to 96.7 wt% (average of 80.5 wt%). Relatively uniform and high values (>90 wt%) are observed below ~120 mbsf (Unit II) whereas the top ~120 mbsf (Unit I) is characterized by distinct and strong variations (30-90 wt%). Maximum amplitude with up to 60 wt% difference in $CaCO_3$ occurs in the uppermost 40 mbsf whereas the amplitude of variation is reduced to 40-50 wt% from 40 to 120 mbsf. Similar general features of the $CaCO_3$ variability were observed at DSDP Site 607. Total organic carbon varies between 0 and 0.65 wt% with the lowest values (<0.1 wt%) below

170 mbsf but higher and more variable values (0.1-0.65 wt%) above. Total nitrogen is low and relatively constant throughout the hole (0.1-0.15 wt%).

Preliminary results from a limited number of samples (10) show that solvent extractable organic matter at Site U1313 consists primarily of odd-numbered C_{25}-C_{35} *n*-alkanes and long chain C_{37}-C_{40} alkenones. Variations in proportions of these compound classes reflect a change in the organic matter composition with respect to terrigenous and marine sources. Alkenone derived sea-surface temperatures show variability from ~13 to 19°C in Pleistocene whereas temperatures of ~20 and 22°C are obtained for the upper Pliocene and the latest Miocene, respectively.

Physical properties measured at Site U1313 include magnetic susceptibility (by MST and MSCL), GRAPE, PWL, and NGR using the MST. In addition, the porosity and density were measured on discrete samples by MAD. Finally, P-wave velocities were measured in the x-direction using the PWS. The results show a large variability of all physical properties in the upper ~120-140 m, which is probably related to the variation of clay content in the upper part. Below 140 mbsf, the variability in physical properties is small, as a result of the very high carbonate content of >95%.

The successful deployment of the Triple Combo tool string in Hole U1313B provided complete coverage of the 300 m section and provided very good physical property and lithologic information for density, porosity, natural gamma-ray, resistivity and photoelectric effect. Corresponding core physical property measurements were very consistent with in-situ downhole data. Of special note is the dramatically consistent linear correlation of downhole natural gamma-ray (upper 225 mbsf) with the benthic oxygen isotope record over the last 5.4 Ma. The consistency of downhole data with both core data and age models will allow the mapping of the spliced core record to actual depth resulting in more accurate sedimentation rate calculations as well as more detailed age/depth models.

Site U1313 (especially in combination with similar records from other Expeditions 303/306 Sites) will document the evolution of the complex surface-temperature phasing over time, addressing questions such as whether the patterns are a peculiarity of the last glaciation, whether they were present in the 41-k.y. world, and whether they appeared at the onset of Northern Hemisphere glaciation. By placing the surface temperature signals into a chronological

framework based on a combination of oxygen isotopic stratigraphy, detrital carbonate-bearing IRD (Heinrich-type) events and geomagnetic paleointensity, we expect to obtain an optimal reconstruction of the phasing of the temperature records and its relationship to ice sheet instability and changes in deep-water circulation.