IODP Expedition 342: Paleogene Newfoundland Sediment Drifts
Site U1404 Summary

Background and Objectives

Site U1404 is the second deepest drill site of the Expedition 342 Newfoundland Sediment Drifts depth transect. Principal goals include recovery of a Paleogene record of the position of the North Atlantic carbonate compensation depth, and a more expanded record of sedimentation compared to the condensed, sub-CCD record at Site U1403. A related objective is to discover the types of sediments that contribute to the expanded, acoustically transparent, sediment drift deposits that are so prominent on J Anomaly Ridge.

Principal Results

After a 4.2 nmi transit from Site U1403 (JA-1A), the vessel arrived at Site U1404 at 1455 h (UTC-2.5h) on 19 June 2012. The original plan called for three holes to a depth of ~250 m DSF.

Hole U1404A was spudded at 1030 h on 20 June and the mud line was established at 4753.8 m drilling depth below rig floor (DRF; water depth 4742.3 m), which was 35.4 m below the Precision Depth Recorder (PDR) depth estimate. The discrepancy between the PDR depth and the drill pipe depth might have been attributable to strong currents putting an S-shape into the drill pipe, or the thermal and current layering in the water column, as indicated by the poor quality of the acoustic signal received from the acoustic beacon on the seafloor. Cores U1404A-1H through 32H were taken to 271.0 m (DSF), with a recovery of 257.97 m. Cores U1404A-22H through 32H were partial strokes and the hole was advanced by recovery. The XCB system was deployed for Cores U1404A-33X through 36X to a final depth of 308.8 m DSF, with a recovery of 23.05 m for the 37.8 m interval cored. Overall core recovery for Hole U1404A was 281.02 m for the 308.8 m interval cored (91% recovery).

The vessel was offset 20 m to the east and Hole U1404B was spudded at 2255 h on 22 June. The water depth was determined to be 4747.6 m based on the mudline core recovery. Cores U1404B-1H through 27H were recovered to a total depth of 228.7 m DSF. Cores U1404B-21H through 27H were partial strokes and the hole was advanced by recovery. Eight core liners were either collapsed or broken and three of

those had to be pumped out of the core barrel with a high-pressure pump. Total recovery was 228.04 m (100%).

The vessel was offset 20 m to the south and Hole U1404C was spudded at 1445 h on 24 June. Hole U1404 was drilled to 16 m and then cored to 44.5 m DSF (Cores U1404C-2H through 4H) in an attempt to re-capture a zone that potentially contained gas hydrate based on observations in the previous two holes. The seafloor depth was assumed to be the same as that at Hole U1404B (4759.1 m DRF; 4747.6 m water depth). The total advance was 28.5 m, with 28.98 m of core recovered (102%).

The bit cleared the seafloor at 1945 h on 24 June, ending Hole U1404C. The drill floor was secured and the vessel began moving to Site U1405 in dynamic positioning (DP) mode at 0.9 nmi/hr. The total time spent on Hole U1404C was 6.5 hours. The total time spent on Site U1404 was 5.2 days.

The downhole sedimentary sequence at Site U1404 reveals four lithostratigraphic units. Unit I is ~2 m thick and composed of Pliocene-Pleistocene brown foraminiferal sandy clays and nannofossil ooze with manganese nodules and a cobble-sized dolomitic dropstone, transitioning to Pliocene brown clay with silt. Unit II is a green and greenish-gray carbonate-poor Oligocene to Miocene clay that occurs in a nearly 200 m-thick sequence and contains abundant diatoms, radiolarians and sponge spicules. Unit II is subdivided into an upper Subunit IIa (20-m thick), which is barren of microfossils, and lower Subunit IIb (180-m thick), which contains abundant siliceous microfossils (diatoms, radiolarians, sponge spicules) and a minor abundance of calcareous nannofossils. Unit III is an ~26-m interval of carbonate-rich nannofossil ooze alternating with clay-rich nannofossil ooze and clay that spans the lowermost Oligocene and uppermost Eocene. Unit IV is an ~75-m thick succession of clay and claystone with some intervals containing abundant radiolarians and/or calcareous nannofossils. Lithoclasts are found in the >63 μm size fraction in Site U1404 sediments, particularly in the Miocene and Oligocene sequences, and may represent ice-rafted debris.

The biochronology for Site 1404 consists of a lower Miocene (~19 Ma) to middle Eocene (~43 Ma) succession with a thin (~2.5 m) Pliocene-Pleistocene cover. These

abyssal, carbonate-poor, green clays are challenging to date biostratigraphically as none of the microfossil groups are continuously present and the calcareous fossils are frequently poorly preserved or absent. Planktic foraminifers are generally absent except in the lower Miocene. Radiolarians occur more consistently from lower Miocene to middle Eocene although they are absent in the cores spanning the Eocene-Oligocene transition. When combined with the early to middle Eocene radiolarian succession at Site 1403, these assemblages will help to refine radiolarian biostratigraphy in the North Atlantic. Abundant diatoms suggest high productivity in the lower Miocene, supported by the occurrence of well-preserved benthic foraminifer assemblages that indicate high organic matter flux and/or oxygen consumption at the seafloor. Recovery of an Oligocene/Eocene boundary interval that appears to be stratigraphically complete with variable but consistent carbonate, and good preservation of calcareous nannofossils and benthic foraminifera. A succession of nannofossil events that characterizes this interval globally, including the extinction of the multiradiate discoasters and the Clausicoccus acme, is also recorded.

Geochronologic analyses suggest continuous lower Miocene-upper Oligocene and upper-middle Eocene intervals with comparatively high sedimentation rates (7.0 and 1.4 cm/ky, respectively) and an Oligocene to Oligocene-Eocene transition with a lower sedimentation rate (1.0 to 0.5 cm/ky). A ~2 my hiatus is inferred in the lower Oligocene (~34-32 Ma).

Methane concentrations in headspace gas samples were 1.75–28.8 ppmv. In the upper 212 m, the concentration of methane did not exceed 4.24 ppmv. Below 212 m (Core U1404A-25H), there was a concomitant increase in methane and ethane concentrations to ~28.8 and ~1.79 ppmv, respectively. Hole U1404C was drilled and sampled to determine the presence of gas hydrates whose presence was suggested by effervescent sediment, expelled section caps, bulging core liners, a drop in bulk density and the presence of massive pyrite in one core. However, methane concentrations in headspace samples (range = 1.82–2.99 ppmv) were not above atmospheric levels, no other hydrocarbon traces were detected, and uniform chlorinity profiles from rhizon samples do not suggest the presence of methane hydrates. Overall, downhole profiles of porewater components reflect the following processes: 1) organic matter degradation; 2) diffusion-related gradients produced from deep

sources and sinks for chemical constituents; 3) sorption of ions onto clay minerals; and 4) secular variability in seawater chemistry over the depositional age of the sediments. Downhole analysis of sediment geochemistry shows that most sediments are nearly carbonate free (<5 wt%) in the surficial 200 m core depth below seafloor (CSF-A). However, there are prominent increases in carbonate content to >10 wt% around 60, 75, 90, and 170 m CSF-A. Between 200 and 300 m CSF-A, we observed four distinctive increases in $CaCO_3$: 200-206 m CSF-A; 208-213 m CSF-A; 239-245 m CSF-A; and 265-279 m CSF-A, with two less distinct events between 213-226 m CSF-A. The maximum carbonate content recorded is 57% at depth 202.75 m CSF-A, coincident with the Eocene-Oligocene (E/O) boundary transition. Calculated TOC values are typically low (~0.2) with highest values (>1%) in the interval 50-170 m CSF-A.

Sediment physical properties show an increasing trend in bulk density toward 1.8 g/cm^3 in the carbonate-rich sections (below ~200 m CSF-A). Grain density averages 2.7 g/cm^3 in Hole U1404A. Porosity is generally high in the radiolarian-rich sediments (80%) and decreases in the carbonate-rich sediments (~40%). Magnetic susceptibility measurements decrease from 100 to 2 instrument units (IU) between the top of the sediment column and ~20 m CSF-A and remain low until the carbonate content increases near the Eocene/Oligocene boundary (~204 m CSF-A). P-wave velocity increases progressively downhole and shows a small step increase to ~1630 m/s in the carbonate-rich unit (lithologic Unit III). NGR measurements vary between 20 to 55 cps and also increase downhole. A significant peak in NGR is seen at 200 m CSF-A, which corresponds to the E/O transition. Color reflectance follows the same trend as magnetic susceptibility with a distinctive drop at ~15 m CSF-A and a significant increase below the E/O transition.

Real-time stratigraphic correlation at Site U1404 was difficult because of a lack of strong signals in the physical property data. The greenish-grey Miocene to late Oligocene sediments spanning ~20-230 m composite core depth below seafloor (CCSF) had extremely low magnetic susceptibility (below 15 IU), i.e., near the detection limit of the instrument, so only GRA bulk density data were available for real-time correlation. GRA density data contained slightly more structure than magnetic susceptibility but few clear features existed on which to base drilling

adjustments. A sudden increase in magnetic susceptibility at ~238 m CCSF corresponded to the interval immediately preceding the Eocene/Oligocene transition. The primary goal of stratigraphic correlation was to cover the coring gap between Cores U1404A-23H to 24H, interpreted as the E/O transition. Initial correlation suggested that Hole U1404B had not bridged this gap, suggesting a third hole might be necessary. Further consideration of Hole U1404B data, including whole round multisensor logger data and lithological interpretation of split cores suggested that the coring gap was, in fact, covered by Core U1404B-24H.