IODP Expedition 342: Paleogene Newfoundland Sediment Drifts
Site U1406 Summary

Background and Objectives

Site U1406 (proposed site JA-6A ; 40° 21.0' N, 51° 39.0'W; 3814 m water depth) was at ~3300 m paleodepth at 50 Ma (Tucholke and Vogt, 1979) and is in the mid-range of the Expedition 342 Paleogene Newfoundland Sediment Drifts depth transect. The site is positioned to capture a record of sedimentation more than 1.1 km shallower than the largely sub-carbonate compensation depth record drilled at IODP Site U1403. Our primary scientific objectives for drilling Site U1406 were (1) to reconstruct the mid-depth CCD in a primarily carbonate-dominated record, (2) to obtain records of the Oligocene-Miocene and Eocene Oligocene transition events in carbonate-rich sediments that host abundant foraminifers suitable to the construction of geochemical climate records, (3) to evaluate the history of deep water and possible northern hemisphere glaciation on sediment chemistry, grain-size and provenance, and (4) to evaluate biological evolution during Paleogene climate transitions.

Principal Results

The vessel arrived at Site U1406 after a 14.9 nmi transit from Site U1405, which was made in dynamic positioning mode at a speed of 1.4 nmi/hr, with the drill pipe suspended below the vessel. The vessel stabilized over Site U1406 at 1435 h (UTC-2.5h) on 30 June 2012. The plan for Site U1406 called for three holes to a depth of ~250 m drilling depth below seafloor (DSF). Cores U1406A-1H through 25H were retrieved from the seafloor to 217.7 m DSF. The first partial stroke was recorded when shooting for Core U1406A-16H, and the APC system was advanced by recovery for this and subsequent cores. The XCB system was deployed for Cores U1406A-26X through 34X to a total depth of 283.3 m DSF. Overall core recovery for Hole U1406A was 267.30 m for the 283.3 m interval cored (94%).

The vessel was offset 20 m to the east and Cores U1406B-1H through 22H were retrieved to 188.8 m DSF. The XCB system was deployed for Cores U1406B-23X through 30X to a total depth of 253.6 m DSF. The recovery for Hole U1406B was

241.34 m over the 253.6 m cored (95%). The vessel was offset 20 m to the south and Cores U1406C-1H through18H were recovered to 161.4 m DSF. The XCB system was deployed to the final depth at 241.4 m DSF. Two intervals were drilled without coring, one of 3 m and one of 2 m.

After clearing the seafloor the drill string was tripped to the surface. The BHA was set back in the derrick with the exception of the lower seal bore drill collar plus subs. The Schlumberger logging tools were then rigged up for a pass through check on the lower portion of the BHA. The drill floor was secured at 1600 h on 6 July, ending Hole U1406C. The acoustic positioning beacon was recovered and the vessel began the move to Site U1405 to recover the beacon left behind there. The total time spent on Site U1406 was 145.5 hours or 6.1 days.

At Site U1406 we recovered a sedimentary succession of deep-sea pelagic sediments of Pleistocene to Middle Eocene age, with four lithostratigraphic units. Unit I is ~2 m thick and composed of Pleistocene brown foraminiferal sand and nannofossil ooze with manganese nodules. Unit II changes from brown to green Miocene and Oligocene nannofossil ooze that occurs in a ~180 m-thick sequence and contains abundant diatoms and/or, radiolarians in some intervals. Unit III is an ~40 m interval of carbonate-rich nannofossil ooze alternating with clay-rich nannofossil ooze and clay that spans the lowermost Oligocene, late Eocene and middle Eocene. Unit IV marks the transition from reduced to oxidized sediments, largely nannofossil oozes, that are middle Eocene to Paleocene in age. Sand-sized lithoclasts are found in the >63 μm size fraction of Site U1406 sediments, particularly in the Miocene and Oligocene sequences, and may represent ice-rafted or current-transported sediments.

The uppermost brown foraminifer sandy clay and nannofossil ooze (Cores U1406A-1H to 2H; 0-2.25 m CSF-A) contain nannofossils and planktic foraminifers that indicate Pleistocene ages (nannofossil zones NN18 to 19). Below 2.25 m CSF-A, nannofossils, planktic foraminifers, and radiolarians provide a well-defined biostratigraphy indicating upper lower Miocene to middle Eocene sediments. Siliceous microfossils are more poorly preserved than at Sites U1404 and U1405 in sediments of Early Miocene and Late Oligocene age, and diatoms are consistently rare or absent. Radiolarians are present in the lower Miocene-upper Oligocene and in

the middle Eocene-upper Paleocene but are absent from the ~110 m thick interval (~130-240 m CSF-A) spanning the Oligocene-Eocene boundary transition. Nannofossils are present and show good preservation continuously across the E/O boundary interval and through the upper to middle Eocene section. A major unconformity at ~255 m CSF-A is inferred to span the entire lower Eocene and uppermost Paleocene, including the PETM. Below this unconformity, a complete succession of uppermost to middle Paleocene microfossil zones is identified. Benthic foraminifers are generally rare (the "present" category) but increase in abundance in upper Eocene to upper Oligocene sediments (~110-220 m CSF-A). Benthic foraminifer preservation is generally good to very good.

Paleomagnetic results from Site U1406 reveal a series of normal and reverse magnetozones between ~10 and 204 m CSF-A. Magnetozones can be straightforwardly correlated between all three holes, especially below ~66 m CSF-A. We used nannofossil, radiolarian, and foraminifer biostratigraphic datums to correlate the Hole U1406A magnetostratigraphy to chron boundaries C5Dn/C5Dr.1r (17.533 Ma) through C5Dr.2r/C5En (18.056 Ma), C6n/C6r (19.722 Ma) through C6An.1n/C6An.1r (20.213 Ma), C6AAr.3r/C6Bn.1n (21.767 Ma) through C7An/C7Ar (24.984 Ma), C8r/C9n (26.420 Ma), and C10r/C11n.1n (29.183 Ma) through C13r/C15n (34.999 Ma) on the geomagnetic polarity timescale (GPTS). Hiatuses at Site U1406 are generally coeval with those recognized at Site U1405, where at least three hiatuses were identified to occur during rapid deposition of the Middle Miocene drift deposits. We estimate the age of these hiatuses to range from 0.25 to ~3 Ma. The lower Miocene to middle Eocene succession appears to be stratigraphically complete, at the resolution of shipboard biostratigraphy and magnetostratigraphy, but a significant hiatus occurs between the middle Eocene and uppermost Paleocene. Sedimentation rates are relatively consistent around ~3 cm/ky for the lower Miocene to upper middle Eocene, but are lower (around 0.5 cm/ky) through the lower middle Eocene and the Paleocene.

The shipboard splice for Site U1406 is stratigraphically continuous for most of the sediment column, with only four appended cores in the interval covered by all three holes (~0-240 m CSF-A). The splice is mainly based on natural gamma radiation (NGR), but magnetic susceptibility was also useful below ~200 m CSF-A, where

values exceed 20 instrument units. In particular, our splice indicates a stratigraphically continuous record across the Eocene-Oligocene transition between ~215 to 230 m core composite depth below seafloor (CCSF), including cores from all three holes. Distinct color changes in the upper sediment column at Site U1406 aided real time stratigraphic correlation between holes, allowing initial offset of coring gaps. From ~25 to 200 m CSF-A, magnetic susceptibility is below the detection limit and GRA bulk density shows an overall increase but few prominent features. Changing from APC to XCB drilling resulted in poor recovery in Holes U1406A and U1406B around 200 m CSF-A. By switching to XCB coring earlier in Hole U1406C, most of this missing interval was successfully recovered.

Gradients in calcium concentrations, strontium concentrations, and strontium/calcium ratios of pore water suggest that the upper 70 m CSF-A reflects a mature diffusion profile from deep basaltic exchange reactions. Between 70 and 180 m CSF-A, carbonate dissolution contributes to the shape of the pore fluid profiles, indicated by a switch from decreasing to uniform strontium/calcium ratios at 70 m CSF-A. In lithostratigraphic Unit IV, decreasing pore-water alkalinity and calcium concentrations are consistent with precipitation of authigenic carbonate from pore fluids. Carbonate overgrowths on benthic foraminifers in the sediments of middle Eocene and Paleocene age in lithostratigraphic Unit IV (see Biostratigraphy) are consistent with this interpretation.

The sediment column at Site U1406 is generally carbonate-rich (21-92 wt% $CaCO_3$) with low total organic carbon content (0.01 to 0.5 wt% TOC), and low headspace gas contents. A prominent increase in carbonate content occurs around 190-200 m CSF-A associated with the Eocene/Oligocene transition, as defined by biostratigraphy and magnetostratigraphy. However, peak values (92 wt% $CaCO_3$) occur lower in the sediment column at Site U1406 in Middle to Upper Eocene strata.

Sediment bulk density at Site U1406 increases downhole from 1.4 to 1.9 g/cm^3. Grain density averages 2.7 g/cm^3 and both porosity and water content show a decreasing trend downhole (from 50% to 80% and from 25% to 60%, respectively), with the lowest values occurring in carbonate-rich sediments (below ~170 m CSF-A). Magnetic susceptibility averages 9 instrument units throughout all holes but

significant peaks occur at ~182, 205, and 235 m CSF-A. P-wave velocity increases progressively downhole from 1500 to 1800 m/s reflecting increased compaction and lithification. Significant peaks in NGR, reflectance and magnetic susceptibility are observed associated with the Eocene/ Oligocene transition.