IODP Expedition 342: Paleogene Newfoundland Sediment Drifts
Site U1410 Summary

Background and Objectives

Site U1410 (proposed site SENR-23A; 41° 19.6993'N, 49° 10.1847'W) is a mid-depth site (~3400 m; ~2950 m paleodepth at 50 Ma, Tucholke and Vogt, 1979), in the upper mid-depth end of the Expedition 342 Paleogene Newfoundland Sediment Drifts depth transect. The site is positioned to capture a record of sedimentation around 1.5 km shallower than the largely sub-carbonate compensation depth record drilled at IODP Site U1403. The location, well above the average late Paleogene carbonate compensation depth (CCD), should be sensitive to both increases and decreases in carbonate burial, whether these reflect variations in dissolution related to changes in the CCD, changes in carbonate production, or variations in background non-carbonate sedimentation. Our primary scientific objectives for drilling Site U1410 were (1) to obtain an expanded record of lower to middle Eocene drift sedimentation to compare directly to the relatively condensed record at Site U1409 drilled on the edge of the same drift; (2) capture fine-scale variations in carbonate preservation and lysocline shifts in carbonate-rich sediments that are about 400 m deeper than Site U1408; and (3) to evaluate the history of deep water and the carbonate compensation depth on sediment chemistry, grain-size and provenance. Secondary objectives included the possible recovery of specific Paleogene hyperthermals such as the Middle Eocene Climatic Optimum (MECO) for comparison with the record of these events elsewhere, particularly Sites U1404, U1406 and U1408 along the Expedition 342 depth transect.

Principal Results

The vessel arrived at Site U1410 (proposed site SENR-23A) at 1845 h (UTC-2.5h) on 20 July 2012, after a 3.46 nmi transit from Site U1409 in dynamic positioning mode that took 3.5 hours at 1.0 nmi/hr. The plan for Site U1410 called for three holes to a depth of ~250 m drilling depth below seafloor (DSF). Hole U1410A (3387.3 m water depth) was spudded at 2125 h on 20 July. Cores U1410A-1H through 16H were recovered to 151.0 m DSF using non-magnetic core barrels and the FLEXIT core orientation tool. Core U1410A-16H experienced the first partial stroke. The XCB system was deployed for Cores U1410A-17X through 28X to the final depth of 259.8

m DSF. The seafloor was cleared at 0500 h on 22 July, ending Hole U1410A. Overall core recovery for Hole U1410A was 256.88 m for the 259.8 m interval cored (99%). The total time spent on Hole U1410A was 34.25 hours.

The vessel was offset 20 m to the east. Hole U1410B (3398.7 m water depth) was spudded at 0650 h on 22 July. Cores U1410B-1H through 18H were recovered to 153.8 m DSF using non-magnetic core barrels and the FLEXIT core orientation tool. The XCB system was deployed for Cores U1410B-19X through 28X to the final depth of 245.2 m DSF. The seafloor was cleared at 1620 h on 23 July, ending Hole U1410B. The recovery for Hole U1410B was 244.84 m over the 245.2 m cored (100%). The total time spent on Hole U1410B was 35.25 hours.

The vessel was offset 20 m to the south and Hole U1410C (3386.9 m water depth) was spudded at 1825 h on 23 July. Cores U1410C-1H through 16H were recovered to 146.8 m DSF using non-magnetic core barrels. No core orientation was performed on Hole U1410C. The XCB system was deployed for Cores U1410C-17X through 27X to the final depth of 243.8 m DSF. The recovery for Hole U1410C was 238.81 m over the 243.8 m cored (98%). The recovery for Site U1410 was 740.5 m out of 748.8 m cored (98%). The seafloor was cleared and the vessel was secured for transit at 0915 h on 25 July, ending Hole U1410C. The total time spent on Hole U1410C was 41.00 hours.

The sedimentary sequence at Site U1410 comprises four lithostratigraphic units. Unit I is a ~34 m thick succession of Pleistocene sediments with alternating reddish brown clay, gray to dark brown muddy/clayey foraminiferal ooze with nannofossils, grayish brown foraminiferal sand, and occasional sand- to pebble-sized lithic grains. Unit II is a ~30 m thick succession of clay, clay with nannofossils, and nannofossil clay of late Miocene to Oligocene age. Manganese, present as discrete nodules or disseminated silt- to sand-sized flecks, and disseminated sulfides are common. Sedimentological and biostratigraphic information indicate that Unit II contains multiple hiatal surfaces in addition to the unconformities that define its upper and lower boundaries. Middle to Early Eocene Unit III is the thickest of the four units (ranging from 63 to 68 m thick) and contains greenish gray nannofossil clay and greenish nannofossil clay to clayey nannofossil ooze with distinctive 10-25 cm thick bands of light gray to white nannofossil ooze that occur as a secondary lithology. Lithostratigraphic Unit IV is a 48 m thick sequence of white to pinkish white nannofossil chalk with foraminifers and/or radiolarians of Middle Eocene to Early Eocene age. This unit is subdivided into two generally similar subunits, with the lower subunit containing several chert beds.

Nannofossils, planktic foraminifers and benthic foraminifers are present through most of the Pleistocene to lower Eocene succession. Short barren intervals occur between thin Pleistocene, upper Miocene and lower Miocene/Oligocene sequences. Radiolarians are only present in the uppermost Pleistocene and lower Eocene. Thin Pleistocene, upper Miocene and lower Miocene/Oligocene sequences overlie a middle Eocene through lower Eocene succession. Hiatuses or highly condensed intervals occur between the lower Pleistocene and upper Miocene (7.1 my duration), upper and lower Miocene (7.4 my duration), lower Miocene and upper Oligocene (5.4 my duration), and lower Oligocene and middle Eocene (7.4 my duration). The Oligocene is highly condensed and may also contain significant hiatuses.

Shipboard results reveal two series of normal and reverse magnetozones. The first zone is observed between Cores U1410A-1H and 4H (~0-33 m core depth below seafloor [CSF-A]), between Cores U1410B-1H and 5H (~0-33 m CSF-A), and between Cores U1410C-1H and 4H (~0-32 m CSF-A). The second series is observed between Cores U1410A-8H and 24X (~69-218 m CSF-A), between Cores U1410B-9H and 15H (~69-121 m CSF-A), and between Cores U1410C-8H and 14H (~70-118 m CSF-A). These magnetostratigraphies are straightforward to correlate among all three holes and represent two distinct time intervals. The first interval is from Chron C1n (Brunhes, Modern) through upper Chron C2An.1n (Gauss, ~2.6 Ma); the second interval is from upper Chron C18n.1n (~39.6 Ma) through upper Chron C21r (~47.4 Ma). The lower part of Chron C20n, as well as Chrons C21n and C21r, have not yet been correlated in the XCB recovered intervals in Holes U1410B and U1410C. Finally, the geomagnetic field transitions from C18n.1n to C18n.1r to C18n.2n are recorded in exceptional detail in Hole U1410B, and show remarkably similar behavior as the same transitions recorded at Site U1408.

The magnetochronology and biochronology suggests that average linear sedimentation rates (LSRs) were ~1.5-2.3 cm/ky during the Pleistocene, with higher sedimentation rates during Chron C2 than during Chron C1. Sedimentation rates are 0.2 cm/ky through the Oligocene. Average LSRs varied from 1.30 cm/ky at the beginning of the Middle Eocene to 1.98 cm/ky at the end of the Middle Eocene. Within the Middle Eocene, LSRs peak at 2.63 cm/ky during Chron C20n, one chron younger than the interval of peak LSRs at Site U1409. Finally, biochronology suggests sedimentation rates of 0.6 cm/ky through the lower Eocene.

The stratigraphic splice constructed for Site U1410 is continuous from 0 to ~256 m core composite depth below seafloor (CCSF), with the exception of one append at ~226 m CCSF. Correlation during drilling operations was possible because of clear, correlative signals in magnetic susceptibility. Magnetic susceptibility and natural gamma radiation (NGR) were used for refining the real-time correlation and constructing the splice. All three holes recorded the prominent lithological transition from greenish clay to carbonate-rich sediments, characterized by a step change to lower magnetic susceptibility and NGR at ~220 to 230 m CCSF (across the early-middle Eocene). Core U1410A-23X, showing the transitional physical properties data, shows clear green to white cycles, which are absent from the equivalent cores in Holes U1410B and U1410C. As a result, we append Core U1410A-23X in the splice and add large offsets to Cores U1410B-26X and U1410C-24X (13.3 and 4.8 m, respectively).

Headspace methane concentrations (2.11–6.72 ppmv) were not above atmospheric levels. Interstitial pore water profiles display evidence of compartmentalization with prominent abrupt downhole shifts in magnesium, manganese, and potassium at ~220-230 m CSF-A suggesting that the unrecovered sequence of cherts functions as an aquiclude. Overall, interstitial pore water profiles of potassium, calcium, and magnesium are consistent with those resulting from exchange with and alteration of basaltic basement at depth. Potassium and magnesium concentrations decrease and calcium concentrations increase with depth. The downhole patterns of manganese, iron and sulfate suggest organic matter degradation. Low alkalinity, ammonium and manganese concentrations and high sulfate concentrations suggests that the influence of organic matter respiration within the sediment column at Site U1410 is modest.

The broad downhole peak in boron concentrations at ~30 m CSF-A presumably indicates increased supply from the terrigenous sediment component in lithostratigraphic Unit II.

Carbonate content in the entire sediment column at Site U1409 ranges from 0.7 to 92%. As observed at our other drill sites on the Southeast Newfoundland Ridge (Sites U1407-U1409), the most prominent change is a step increase (46 to 52 wt% CaCO3, ~210 m CSF-A) in calcium carbonate content in sediments around the Early to Middle Eocene boundary (during NP14). This step correlates with shifts in several proxies (e.g., color reflectance, magnetic susceptibility, NGR, TOC and TN values) and marks a transition in time from pelagic chalk sedimentation to clay deposition in the initial stages of sediment drift development. Middle Eocene sediments appear cyclic, with alternating clay-rich beds and white nannofossil ooze layers that have ~30% and 80% carbonate, respectively. TOC values are typically 0.01%–0.57% throughout the sediment column. Organic matter is thermally immature and relatively well preserved with low T_{max} values (380°-420°C). Organic matter throughout the sediment column is a mixture of Type II (algal and microbial) and Type III (land plant/detrital) kerogen.

Bulk density shows a general increase downhole from 1.5 to 2.4 g/cm^3. Grain density is ~2.7 g/cm^3 in Hole U1410A and both water content and porosity show a decreasing trend downhole (from 53% to 21% for water content and from 76% to 43% for porosity). P-wave velocity increases progressively downhole from 1490 to 1960 m/s. Magnetic susceptibility decreases from ~290 to –2 IU with notable steps at 30 and 45 m CSF-A but exhibits uniform (–2 to 20 IU) values below 45 m CSF-A to the bottom of the sediment column. Color reflectance parameters a* and b* gradually increase from –3 to 3 down to 210 m CSF-A. Below 210 m CSF-A, a* and b* increase to 12 and 8, respectively. L* increases downhole from 13 to 91, with steps at 115, 150, and 210 m CSF-A. NGR fluctuates from 21 to 47 cps down to 210 m CSF-A, but then decreases from 27 to ~10 cps from 210 m CSF-A to the bottom of the hole. Color reflectance and NGR reflect calcium carbonate content. Thermal conductivity gradually increases downhole from 0.9 to 1.5 W/(m•K).