IODP Expedition 342: Paleogene Newfoundland Sediment Drifts
Site U1411 Summary

Background and Objectives

Site U1411 (proposed site SENR-11A; 41° 37.1'N, 49° 00'W) is a mid-depth site (~3300 m; ~2850 m paleodepth at 50 Ma, Tucholke and Vogt, 1979), in the upper end of the Expedition 342 Paleogene Newfoundland Sediment Drifts depth transect. The site is positioned to capture a record of sedimentation around 1.65 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, 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 U1411 were as follows: (1) to obtain an expanded record of the upper half of a Miocene(?) to lower Eocene(?) sediment drift to compare directly to the timing and nature of drift development at the Site U1407-U1408 drift and the Site U1409-U1410 drift; (2) capture fine-scale variations in carbonate preservation and lysocline shifts in Miocene-Eocene carbonate-rich sediments that are about 550 m shallower than the Site U1406 Oligocene-Miocene section; and (3) to evaluate the history of deep water and the carbonate compensation depth on sediment chemistry, grain-size and provenance. Secondary objectives include the possible recovery of the Oligocene-Miocene and Eocene-Oligocene boundaries for comparison with the record of these events elsewhere, particularly Sites U1404-U1406 along the Expedition 342 depth transect.

Principal Results

The vessel arrived at Site U1411 (proposed site SENR-11A) at 1115 h (UTC-2.5 h) on 25 July 2012 after a 19.0 nmi transit from Site U1410, which took 2.0 hours at 9.5 nmi/h. The plan for Site U1411 called for three holes to a depth of ~250 m drilling depth below seafloor (DSF).

Hole U1411A was spudded at 2320 h on 25 July. The first core for Hole U1411A, Core U1411A-1H, with a length of 9.87 m failed to capture the mudline and the hole

was terminated. The seafloor was cleared at 2320 h on 25 July, ending Hole U1411A. Recovery for Hole U1411A was 9.87 m for the 9.5 m interval recovered (104%). The total time spent on Hole U1411A was 12.0 hours. The vessel was offset 20 m to the east and Hole U1411B (3298.8 m water depth) was spudded at 0035 h on 26 July. Cores U1411B-1H through 20H were recovered to 177.4 m using non-magnetic core barrels and the FLEXIT core orientation tool. The XCB system was deployed for Cores U1411B-21X through 28X to a final depth of 254.2 m DSF. The seafloor was cleared at 1310 h on 27 July, ending Hole U1411B. The recovery for Hole U1411B was 233.94 m over the 254.2 m cored (92%). The total time spent on Hole U1411B was 38.00 hours.

The vessel was offset 20 m to the south. Hole U1411C (3300.5 m water depth) was spudded at 1505 h on 27 July. Cores U1411C-1H through 2H were recovered to 9.2 m DSF. After recovering Core U1411C-2H, the hole was drilled without coring from 9.2 to 100 m DSF in order to save operational time for deeper objectives. After the drilling advance, APC coring continued with Cores U1411C-4H through 9H (100-152.2 m DSF). All APC cores were oriented with the FLEXIT core orientation tool and were recovered using the non-magnetic core barrels. The XCB system was deployed for Cores U1411C-10X through 17X to a final depth of 223.9 m DSF. After Core U1411C-17X, a medical emergency arose and it was decided to terminate operations and transit to St. John's, Newfoundland. The seafloor was cleared and the vessel was secured for transit at 0500 h on 29 July, ending Hole U1411C. The recovery for Hole U1411C was 118.62 m over the 133.1 m cored (89%). The total time spent on Hole U1411C was 39.75 hours.

Overall recovery for Site U1411 was 91%. The total time spent on Site U1411 was 89.75 hours or 3.7 days.

At Site U1411, we recovered a 254.5 m thick sedimentary succession of deep-sea, pelagic sediments of Pleistocene to Late Eocene age highlighted by an expanded record of the Eocene-Oligocene Transition. The sedimentary sequence at Site U1411 comprises three lithostratigraphic units. Unit I is a 13 m thick succession of Pleistocene sediments of alternating gray and reddish brown clayey foraminiferal ooze, gray silty sand with foraminifers, and brown to grayish brown silty clay with

foraminifers. Dropstones and sand-sized lithic grains are prominent in Unit I. Unit II is a 198 m thick succession of silty clay, clay with nannofossils and silty nannofossil clay of Early Miocene to Late Eocene age. Nannofossil ooze is also present in Unit II, but is only present in the interval immediately after the Eocene-Oligocene boundary. Small blebs of quartz silt on core surfaces, interpreted as ice-rafted siltstone clasts, are very common in the Miocene and Oligocene sediments of Unit II. Nannofossil ooze occurs just above the Eocene-Oligocene boundary, possibly representing the widespread 'carbonate overshoot' observed at other Expedition 342 sites. Unit III is 42 m thick and composed of greenish gray and dark greenish gray nannofossil clay with foraminifers, clayey nannofossil chalk with foraminifers, clayey foraminiferal chalk. Laminated intervals, some of which are highly concentrated in foraminifers, are common in Unit III, and provide evidence for significant reworking and winnowing by currents associated with drift formation.

Nannofossils, planktic foraminifers and benthic foraminifers are present through most of the Pleistocene to upper Eocene succession. A short barren interval occurs between the Pleistocene and lower Miocene-Eocene sequence. Radiolarians are only present in the uppermost Pleistocene. A relatively thin Pleistocene sequence overlies a lower Miocene to mid-Oligocene succession with relatively poor carbonate microfossil preservation, followed by an expanded lower Oligocene through upper Eocene succession with excellent preservation of calcareous microfossils. Average linear sedimentation rates across the Eocene-Oligocene boundary transition are up to ~5 cm/ky.

Shipboard results reveal two series of normal and reverse magnetozones. The first zone is observed in Core U1411B-2H (~1-11 m core depth below seafloor [CSF-A]), and in Cores U1411C-1H through 2H (~0-7 m CSF-A). The second series is observed between Cores U1411B-4H and 20H (~20-177 m CSF-A), and part of it is observed between Cores U1411C-7H and 8H (~127-143 m CSF-A). These magnetostratigraphies can be correlated between both holes and represent two distinct time intervals. The first interval is from Chron C1n (Brunhes, Modern) through upper Chron C1r.3r (~1.2 Ma); the second interval is from lower Chron C8n.2n (~25.9 Ma) through upper Chron C15n (~35.0 Ma). There are at least four significant conclusions that can be drawn from this shipboard magnetostratigraphy. First, Site U1411 contains

a nearly complete and expanded Oligocene record, with average linear sedimentation rates (LSRs) of 1.53 cm/ky and peak LSRs of 3.22 cm/ky. Second, the C11r/C12n and C12n/C12r boundaries are not clearly identified in the shipboard paleomagnetic data, suggesting a hiatus of at least ~0.5 m.y. in the lower Oligocene; this interval also corresponds to a 10 m-broad zone of depressed NGR values, a sharp lithostratigraphic contact in Section U1411B-10H-5, and a hiatus inferred from nannofossil and foraminifer biostratigraphic datums. Third, the Eocene-Oligocene transition is highly expanded, with average LSRs of 2.63 cm/ky and peak LSRs of 5.02 cm/ky. The Chron C13n/C13r boundary (33.705 Ma) is recognized in Section U1411B-17H-1 at ~144.15 m CSF-A and in Sections U1411C-8H-5 and 6 at ~142.50 m CSF-A. Finally, shipboard paleomagnetic data indicate at least three cryptochrons within Chron C13r. The second and longest of these cryptochrons occurs in the same stratigraphic interval as the first downhole appearance of the Eocene marker foraminifer *Hantkenina alabamensis*.

The stratigraphic splice constructed for Site U1411 is composed of a series of stratigraphically continuous intervals from 0 to ~20 m, ~100 to 128 m, ~128 to 178 m, ~207 to 226 m, and ~226 to 236 m core composite depth below seafloor (CCSF). Core U1411A did not recover a mudline, so Hole U1411A was ended after the first core. Hole U1411B spans the thickest sediment column recovered at this site, with a maximum depth of ~269 m CCSF, whereas Hole U1411C has a maximum depth of ~236 m CCSF. The large number of appended intervals in the splice is due to a drilling advance without coring from ~20-100 m CCSF in Hole U1411C. As a result, only Hole U1411B recovered this interval. Correlation during drilling for the interval from ~100 to 236 m CCSF was possible based on magnetic susceptibility and GRA bulk density data, though magnetic susceptibility was low from ~100 to 148 m CCSF. Magnetic susceptibility was used for refining the real-time correlation and constructing the splice. The longest continuous intervals in the splice are from ~100 to 128 m CCSF and ~128 to 178 m CCSF; the former covers the Eocene-Oligocene boundary. The appended cores from ~178 to 269 m CCSF are a function of poor XCB recovery in both Holes U1411B and U1411C.

Methane was the only hydrocarbon detected in the headspace samples from Hole U1411B. Methane increases very slightly downhole, with values between 2.11 and

4.12 ppmv. Pore fluid constituents at Hole U1411B are consistent with consumption of organic matter under oxic to suboxic conditions. However sulfate concentrations remain high throughout the sequence indicating that pore fluid diagenesis does not proceed to sulfate reduction. 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 concentrations may be responding to adsorption onto clay particles. As with other sites where the Eocene/Oligocene transition was recovered (Sites U1404 and U1406), carbonate content shows an increase across the transition followed by a decrease in carbonate contents within the lower Oligocene. Total organic carbon ranges from 0.01 to 0.50 wt%, with many samples falling below detection limits. TN values generally fall below 0.1 wt%, with slightly lower values at the bottom of Hole U1411B.

Bulk density globally increases downhole from 1.5 to 1.95 g/cm^3 but an abrupt step down to ~1.5 g/cm^3 occurs at the transition between lithostratigraphic Units I and II between Pleistocene and Miocene sediments. Grain density averages 2.75 g/cm^3, and water content and porosity exhibit a decreasing trend downhole (from 55% to 25% and from 80% to 45%, respectively) as expected for sediment compaction. P-wave velocity increases progressively downhole from 1500 to 1700 m/s. Magnetic susceptibility drops from ~160 to 30 IU at 18 m CSF-A and remains constant downhole other than a small increase at ~140 m CSF-A. Color reflectance parameters a* and b* follow similar trends throughout the hole but in lithostratigraphic Units II and III some superimposed peaks appear in b*. NGR and L* show a major peak at ~140 m CSF-A that correlate with the major variation in calcium carbonate content. Almost all physical properties show a shift or a peak in their values at ~140 m CSF-A associated with the post Eocene-Oligocene (E-O) pulse of carbonate deposition.