Integrated Ocean Drilling Program
Expeditions 303 and 306 Scientific Prospectus Addendum

North Atlantic Climate II

Documenting and monitoring bottom water temperature variations through time: installing a Cork at Site 642, Norwegian-Greenland Sea

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DISCLAIMER

This IODP Scientific Prospectus is based on precruise Science Advisory Structure panel discussions and scientific input from the designated Co-Chief Scientists on behalf of the drilling proponents. During the course of the cruise, actual site operations may indicate to the Co-Chief Scientists and the Operations Superintendent that it would be scientifically or operationally advantageous to amend the plan detailed in this prospectus. It should be understood that any proposed changes to the science deliverables outlined in the plan presented here are contingent upon the approval of the IODP-USIO Science Services, TAMU, Deputy Director of Science Services in consultation with IODP-MI.

ABSTRACT

Integrated Ocean Drilling Program Expeditions 303 and 306 are based on two separate proposals (572-Full3 and 543-Full2/543-ADD) entitled "Ice sheet–ocean atmosphere interactions on millennial timescales during the late Neogene–Quaternary using a paleointensity-assisted chronology (PAC) for the North Atlantic" and "Installation of a CORK in Hole 642E to document and monitor bottom water temperature variations through time," which are described fully in the Expeditions 303/306 *Scientific Prospectus.* This addendum presents the revised operations schedule for Expedition 306 based on the preliminary results and accomplishments from Expedition 303 and other operational refinements. It also describes new proposed sites not identified previously in the Expeditions 303/306 *Scientific Prospectus.*

INTRODUCTION

Integrated Ocean Drilling Program (IODP) Expedition 306 is the second cruise of the North Atlantic Climate study that aims to generate a late Neogene–Quaternary chronostratigraphic template for North Atlantic climate proxies to allow their export and correlation at a sub-Milankovitch scale, by using a paleointensity-assisted chronology (PAC). Expedition 306 also will include installation of a CORK (Circulation Obviation Retrofit Kit) at Ocean Drilling Program (ODP) Site 642 (Vøring Plateau, Norwegian margin) to investigate the feasibility of reconstructing bottom water temperature histories at the decade to centennial timescale by making high-precision temperature-depth measurements. The objectives at Site 642 are summarized in "CORK Installation at ODP Site 642" in the Expeditions 303/306 *Scientific Prospectus*. This addendum also aims to provide guidance to the science party for completing sample requests and initiating scientific collaboration discussions. Please refer to the *Scientific Prospectus* for detailed information regarding scientific objectives, original sites, and other information.

The ultimate objective is to generate a chronostratigraphic template for North Atlantic climate proxies to allow their export and correlation at a sub-Milankovitch scale.

BACKGROUND

Because the weather window for Expedition 303 was challenging, we designed a flexible operations scenario, which required reassessment of the original Expedition 306 operational plan following Expedition 303 drilling. During Expedition 303, seven proposed sites were occupied and more than 4600 m of high quality upper Pliocene–Quaternary sediments were recovered. Proposed sites occupied during Expedition 303 were ORPH-3A and ORPH-2A (Sites U1302/U13033), GAR-2B (Site U1304), LAB-6A, LAB-7A, and LAB-8C (Sites U1305, U1306, and U1307, respectively), and IRD-1A (Site U1308). See the Expedition 303 *Preliminary Report* for additional details (**iodp.tamu.edu/publications/PR/303PR/303PR.html**).

In addition to the sites not drilled during Expedition 303 that are described in the Expedition 303/306 *Scientific Prospectus,* several new sites have been identified to provide additional operational and scientific flexibility. These new sites, approved for drilling prior to Expedition 303 (LAB-8V, LAB-8X, LAB-8Y, and LAB-8Z-alt), are located in the Eirik Drift area along the same seismic line (*Knorr* KN166-14 cruise Line KN166-14 25a) where Sites LAB-8C (Site U1307) and LAB-8A are situated (Fig. **F1**).

They are positioned in series downslope from Site LAB-8C, encompassing LAB-8A. Results from drilling at LAB-8C (Site U1307) on this transect during Expedition 303 established the feasibility of recovering the Pliocene sedimentary section on the Eirik Drift using the advanced piston coring (APC) system. This transect provides a unique opportunity to sample the older (Pliocene–Miocene) stratigraphy to complement the stratigraphic sections sampled at Sites U1305, U1306, and U1307 and, hence, document drift architecture and climate history since the onset of Eirik Drift deposition.

Two additional sites were identified along the same seismic line (KN166-14 25a) during the process of assessing options for a revised operations plan for Expedition 306: LAB-8F and LAB-8G (Fig. **F1**). Although these sites are optimally positioned to maximize recovery of progressively older sediments, at the time of this addendum they are awaiting clearance from Denmark/Greenland. When these two sites are approved, they will be elevated from "alternate" to "primary" status.

Drilling results from the LAB-8 transect sites could extend the climate record back into the Miocene at locally enhanced sediment accumulation rates and provide a more-or-less complete record of Eirik Drift sedimentation that can be traced throughout the KN166-14 seismic network. The combination of successful drilling, logging, and the high-quality KN166-14 seismic records would make the Eirik Drift one of the best documented sediment drifts yet drilled and would answer questions about the sedimentary architecture of sediment drifts, the role of the Western Boundary UnderCurrent (WBUC) in North Atlantic Deep Water (NADW) formation, and provide a unique record of Greenland Ice Sheet instability.

OPERATIONS PLAN OVERVIEW AND DRILLING STRATEGY

All primary and alternate sites not drilled during Expedition 303 are shown in Tables **T1** and **T2,** respectively. The coring strategy will remain the same as that for Expedition 303, consisting of APC utilizing the "drillover" technique to maximize penetration in three or more holes at each site to ensure complete and undisturbed recovery of the stratigraphic section (see the Expeditions 303/306 *Scientific Prospectus*). The revised drilling schedule for Expedition 306 will be in the following order upon departure from Ponta Delgada, Azores Islands, Portugal: IRD Belt Sites IRD-3A and IRD-4A, Eirik Drift Sites LAB-8V and LAB-8X, and CORK Site 642 (Fig. **F2**). If proposed Sites LAB-8F and LAB-8G are approved, the preferred order among LAB-8 sites would be LAB8F, LAB8X, and LAB8G (Fig. **F1**). Drilling of the third site in the LAB area will de-

pend on drilling progress, weather, available time, and other factors that may arise during the cruise.

LOGGING/DOWNHOLE MEASUREMENTS PLAN

The current operations plan for Expedition 306 includes downhole logging at the first proposed site, currently IRD-3A (alternatively, if a different site is drilled first then that site will be logged in place of IRD-3A), and at one of the Eirik Drift (LAB) sites. Logging operations at additional sites will take place if time permits.

The two standard IODP tool string configurations will be deployed. The triple combination (triple combo) tool string logs formation resistivity, density, porosity, natural gamma radiation, and borehole diameter and will be run first, followed by the Formation MicroScanner (FMS)-sonic tool string, which provides an oriented 360° resistivity image of the borehole wall, logs of formation acoustic velocity, natural gamma radiation, and borehole diameter. The Lamont-Doherty Earth Observatory (LDEO) high-resolution Multisensor Gamma Tool (MGT) will be deployed on the top of the triple combo tool string and run on a separate pass.

In addition to the standard logging tools, the Inline Checkshot Tool (QSST) or the Well Seismic Tool (WST) might be deployed (subject to clearance and time availability) at one of the Eirik Drift sites to facilitate core-seismic-log integration. The Schlumberger QSST is a single-axis seismic checkshot tool that runs in-line with the triple combo tool string. The QSST consists of a single hydrophone and does not utilize a clamping arm. Seismic coupling is achieved by setting the tool on the hole bottom and allowing the tool to lean against the borehole wall, coupling passively to the formation. The QSST then records the vertically incident signals at the bottom of the hole that are generated by a seismic source on the *JOIDES Resolution* (e.g., generator injector [GI] guns) positioned just below the sea surface. The recorded signals enable a one-way traveltime to be determined from the surface to total depth, providing a check of sonic velocity versus depth for calibration of seismic profiles and correction of sonic logs. The rig time required to run this single-point checkshot survey is negligible, as the QSST may be included during the triple combo logging run.

The WST is used to produce a zero-offset vertical seismic profile and/or checkshots in the borehole. The WST consists of a single geophone that records the full waveform of acoustic waves generated by a seismic source positioned just below the sea surface. The WST is clamped against the borehole wall at regular predetermined intervals

(usually 5–50 m) with a hydraulic arm, and the air gun is typically fired between 5 and 15 times at each station. The recorded waveforms are stacked, and a one-way traveltime is determined for each station, thus providing calibration of the time/depth relationship in the seismic survey. The WST requires a separate logging run, generally after completion of the triple combo and FMS-sonic runs. The WST would provide more detailed data than the QSST.

Table T1. Proposed primary site operations for Expedition 306.

Site	Location (lat/long)	Water depth (mbsl)	Operations description	Transit (days)	Drilling (days)	Logging (days)
Ponta Delgada			Sea Voyage from Ponta Delgada to IRD-3A: 416 nmi @ 10.0 kt	1.7		
IRD-3A (International)	41°0.068′N, 32°57.438′W	3426	3X APC to 300 mbsf. Drillover stuck core barrels. Tensor orientation on all APC cores.		6.4	
			Displace hole with mud; log with triple combo and FMS-sonic (2 passes each).			0.8
			Transit from IRD3A to IRD-4A: 454 nmi @ 10.0 kt	1.9		
IRD-4A (International)	42°50.205′N 23°05.252′W	3542	3XAPC to 300 mbsf. Drillover stuck core barrels. Tensor orientation on all APC cores.		6.8	
			Transit from IRD-4A to LAB-8V: 1287 nmi @ 10.0 kt	5.4		
LAB-8V (Greenland)	58°29.513′N 46°25.751′W	2647	3XAPC to 300 mbsf. Drillover stuck core barrels to extend depth of APC. Tensor orientation on all APC cores.		5.5	
			Transit from LAB-8V to LAB-8X: 1.3 nmi @ 10.0 kt	0.1		
LAB-8X (Greenland)	58°27.602′N 46°29.714′W	2778	3XAPC to 300 mbsf. Drillover stuck core barrels to extend depth of APC. Tensor orientation on all APC cores.		5.9	
			Displace hole with mud; log with triple combo and FMS-sonic (2 passes each).			0.8
			Transit from LAB-8X to Site 642: 1297 nmi @ 10.0 kt	5.5		
Site 642 (Norway)	67°13.20′N 02°55.80′W	1288	Install reentry cone with 1 casing string and CORK thermistor.		4.8	
Dublin			Sea Voyage from Site 642 to Dublin, Ireland: 910 nmi @ 10.0 kt	3.8		
			Subtotal:	18.4	29.4	1.6
			Total operating days:	49.4		

Notes: APC = advanced piston coring. FMS = Formation MicroScanner.

Table T2. Proposed alternate drilling sites for Expedition 306.

Site	Location (lat/long)	Water depth (mbsl)	Operations description	Transit (days)	Drilling (days)	Logging (days)
GAR-1B (International)	56°21.882′N 27°53.310′W	2821	3X APC to 200 mbsf. Drillover stuck core barrels. Tensor orientation on all APC cores.		6.0	
LAB-3A (Greenland)	58°02.17′N 48°27.57′W	3350	3X APC to 300 mbsf. Drillover stuck core barrels. Tensor orientation on all APC cores.		6.4	
LAB-8A (Greenland)	58°28.525′N 46°27.823′W	2714	3X APC to 300 mbsf. Drillover stuck core barrels. to extend APC depth. Tensor orientation on all APC cores.		5.9	
LAB-8B (Greenland)	58°33.227′N 46°18.04′W	2556	3X APC to 300 mbsf. Drillover stuck core barrels. to extend APC depth. Tensor orientation on all APC cores.		5.5	
LAB-8F (Greenland)	58°30.112′N 46°24.507′W	2612	3X APC to 300 mbsf. Drillover stuck core barrels. to extend APC depth. Tensor orientation on all APC cores.		5.5	
LAB-8G (Greenland)	58°26.074′N 46°32.847′W	2852	3X APC to 300 mbsf. Drillover stuck core barrels. to extend APC depth. Tensor orientation on all APC cores.		6.0	
LAB-8Y (Greenland)	58°26.743′N 46°31.484′W	2830	3X APC to 300 mbsf. Drillover stuck core barrels. to extend APC depth. Tensor orientation on all APC cores.		5.9	
LAB-8Z-alt (Greenland)	58°23.119′N 46°39.137′W	2941	3X APC to 300 mbsf. Drillover stuck core barrels. to extend APC depth. Tensor orientation on all APC cores.		6.0	

Note: APC = advanced piston coring.

Figure F1. Eirik Drift proposed sites.

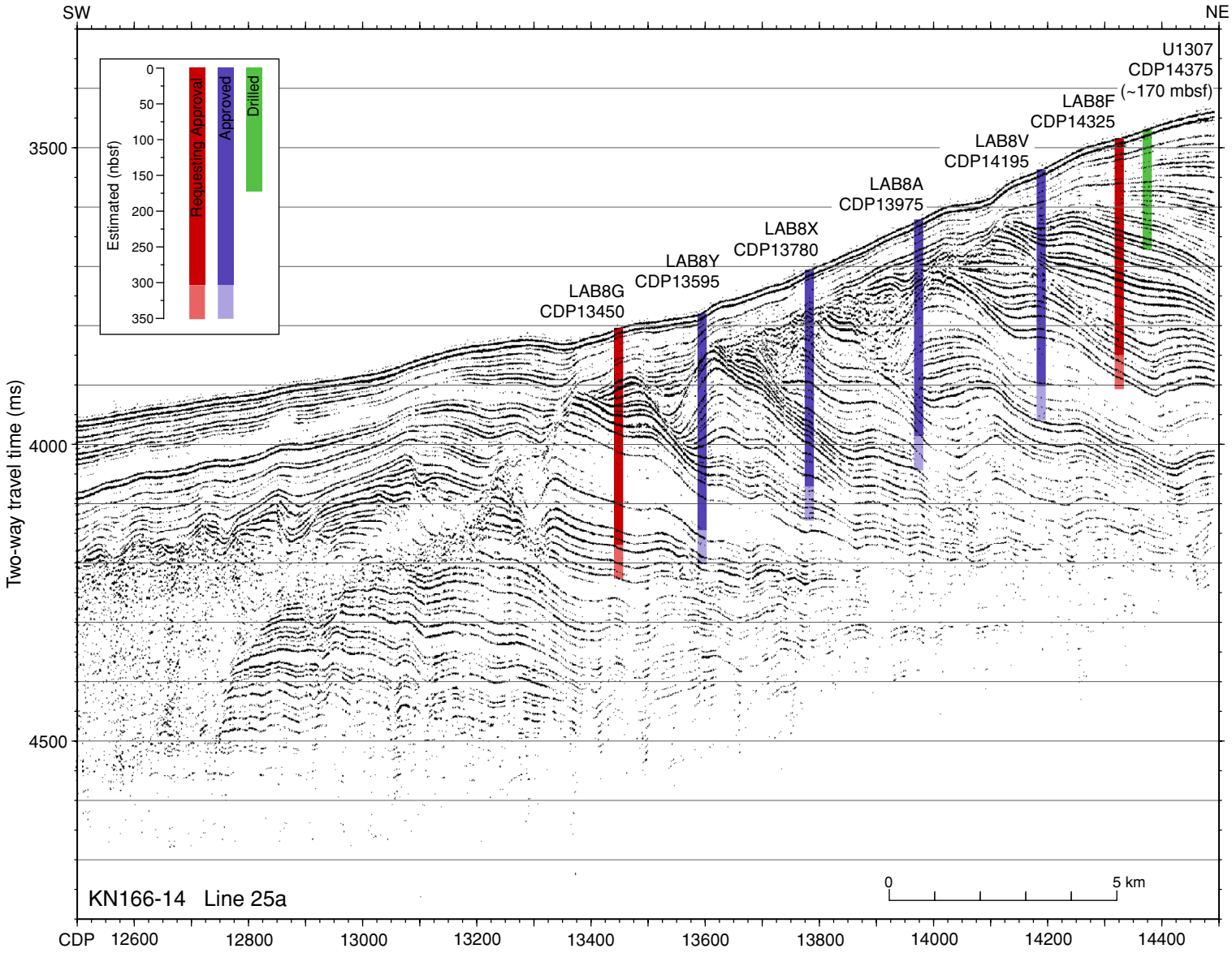
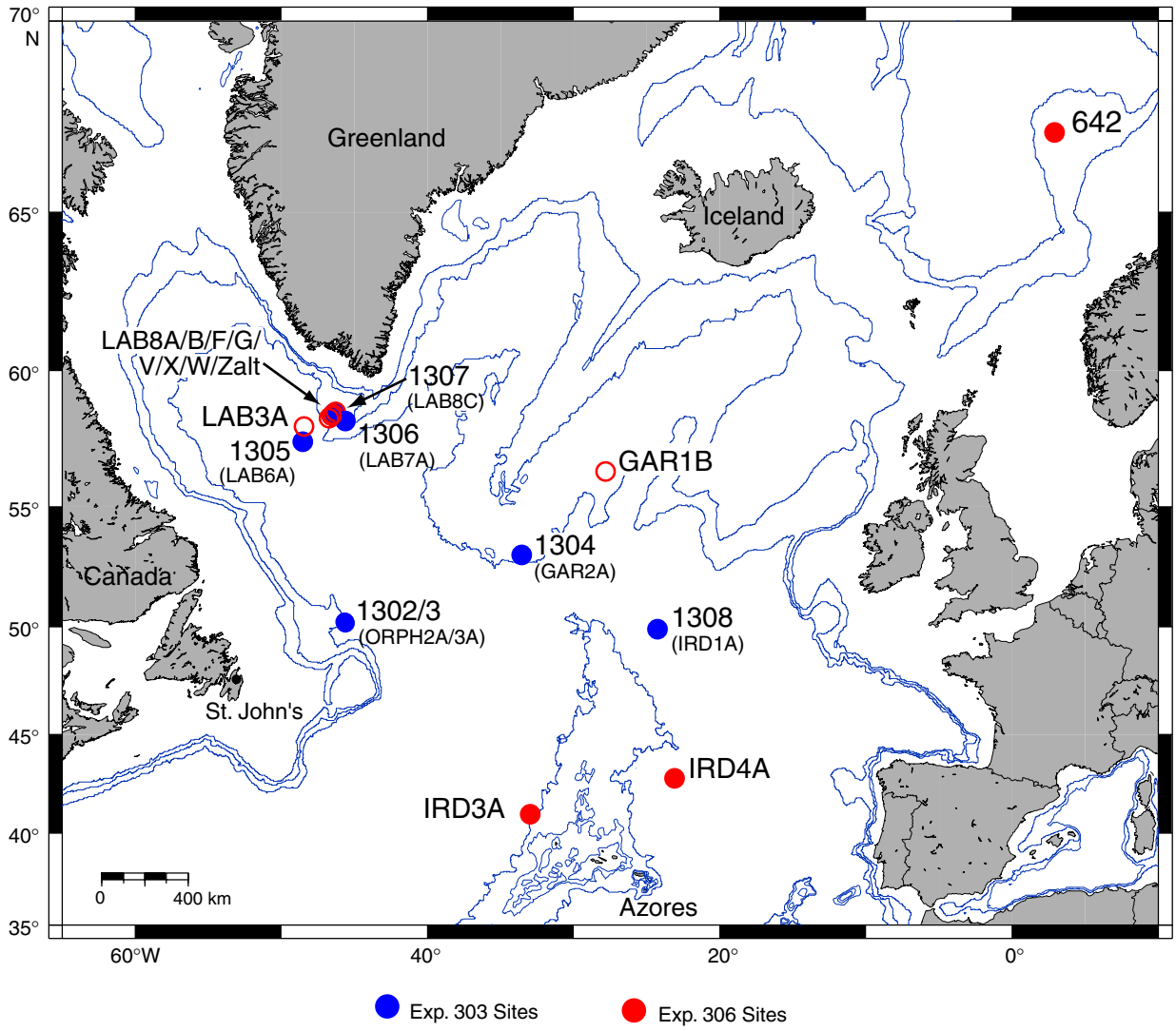


Figure F2. Location of drilling sites for Expeditions 303 and 306. Solid circles indicate primary sites; open circles indicate alternate sites.



SITE SUMMARIES

Addendum Site LAB-8V

Proposed site:	LAB-8V
Priority:	Primary
Position:	58°29.513′N, 46°25.751′W
Water depth (m):	2647
Target drilling depth (mbsf):	300
Approved maximum penetration (mbsf):	350
Survey coverage:	BGR-2 (SP 4000), KN166-14 Line 25a CDP 14195
Objectives:	Establish, for the last few m.y. (late Neogene–Quaternary), the intercalibration of geomagnetic paleointensity, isotope stratigraphies, and regional environmental stratigraphies and in so doing develop a millennial-scale stratigraphic template. Such a template is a requirement for understanding the relative phasing of atmospheric, cryospheric, and oceanic changes that are central to our understanding of the mechanisms of global climate change on orbital to millennial timescales.
Drilling program:	1-2-3 APC. Triple APC to refusal with drillover.
Logging program:	TBD
Nature of rock anticipated:	Silty clay

SITE SUMMARIES (CONTINUED)

Addendum Site LAB-8X

Proposed site:	LAB-8X
Priority:	Primary
Position:	58°27.602′N, 46°29.714′W
Water depth (m):	2778
Target drilling depth (mbsf):	300
Approved maximum penetration (mbsf):	350
Survey coverage:	BGR-2 (SP 4000), KN166-14 Line 25a CDP 13780
Objectives:	Establish, for the last few m.y. (late Neogene–Quaternary), the intercalibration of geomagnetic paleointensity, isotope stratigraphies, and regional environmental stratigraphies and in so doing develop a millennial-scale stratigraphic template. Such a template is a requirement for understanding the relative phasing of atmospheric, cryospheric, and oceanic changes that are central to our understanding of the mechanisms of global climate change on orbital to millennial timescales.
Drilling program:	1-2-3 APC. Triple APC to refusal with drillover.
Logging program:	Triple combo, FMS-sonic
Nature of rock anticipated:	Silty clay

SITE SUMMARIES (CONTINUED)

Addendum Site LAB-8Y

Proposed site:	LAB-8Y
Priority:	Alternate
Position:	58°26.743′N, 46°31.484′W
Water depth (m):	2830
Target drilling depth (mbsf):	300
Approved maximum penetration (mbsf):	350
Survey coverage:	BGR-2 (SP 4000), KN166-14 Line 25a CDP 13595
Objectives:	Establish, for the last few m.y. (late Neogene–Quaternary), the intercalibration of geomagnetic paleointensity, isotope stratigraphies, and regional environmental stratigraphies and in so doing develop a millennial-scale stratigraphic template. Such a template is a requirement for understanding the relative phasing of atmospheric, cryospheric, and oceanic changes that are central to our understanding of the mechanisms of global climate change on orbital to millennial timescales.
Drilling program:	1-2-3 APC with drillover
Logging program:	TBD
Nature of rock anticipated:	Silty clay

SITE SUMMARIES (CONTINUED)

Addendum Site LAB-8Z-alt

Proposed site:	LAB-8Z-alt
Priority:	Alternate
Position:	58°23.119′N, 46°39.137′W
Water depth (m):	2941
Target drilling depth (mbsf):	300
Approved maximum penetration (mbsf):	300
Survey coverage:	BGR-2 (SP 4000), KN166-14 Line 25a CDP 12800
Objectives:	Establish, for the last few m.y. (late Neogene–Quaternary), the intercalibration of geomagnetic paleointensity, isotope stratigraphies, and regional environmental stratigraphies and in so doing develop a millennial-scale stratigraphic template. Such a template is a requirement for understanding the relative phasing of atmospheric, cryospheric, and oceanic changes that are central to our understanding of the mechanisms of global climate change on orbital to millennial timescales.
Drilling program:	1-2-3 APC with drillover
Logging program:	TBD
Nature of rock anticipated:	Silty clay

SITE SUMMARIES (CONTINUED)

Addendum Site LAB-8F

Proposed site:	LAB-8F (pending clearance)
Priority:	Alternate
Position:	58°30.112′N, 46°26.507′W
Water depth (m):	2612
Target drilling depth (mbsf):	300
Approved maximum penetration (mbsf):	350
Survey coverage:	BGR-2 (SP 4000), KN166-14 Line 25a CDP 14325
Objectives:	Establish, for the last few m.y. (late Neogene–Quaternary), the intercalibration of geomagnetic paleointensity, isotope stratigraphies, and regional environmental stratigraphies and in so doing develop a millennial-scale stratigraphic template. Such a template is a requirement for understanding the relative phasing of atmospheric, cryospheric, and oceanic changes that are central to our understanding of the mechanisms of global climate change on orbital to millennial timescales.
Drilling program:	1-2-3 APC with drillover
Logging program:	TBD
Nature of rock anticipated:	Silty clay

SITE SUMMARIES (CONTINUED)

Addendum Site LAB-8G

Proposed site:	LAB-8G (pending clearance)
Priority:	Alternate
Position:	58°26.074′N, 46°32.847′W
Water depth (m):	2852
Target drilling depth (mbsf):	300
Approved maximum penetration (mbsf):	350
Survey coverage:	BGR-2 (SP 4000), KN166-14 Line 25a CDP 13450
Objectives:	Establish, for the last few m.y. (late Neogene–Quaternary), the intercalibration of geomagnetic paleointensity, isotope stratigraphies, and regional environmental stratigraphies and in so doing develop a millennial-scale stratigraphic template. Such a template is a requirement for understanding the relative phasing of atmospheric, cryospheric, and oceanic changes that are central to our understanding of the mechanisms of global climate change on orbital to millennial timescales.
Drilling program:	1-2-3 APC with drillover
Logging program:	TBD
Nature of rock anticipated:	Silty clay