IODP Proposal Cover Sheet

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NW Greenland Glaciated Margin

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Title	Cenozoic evolution of the northern Greenland Ice Sheet exposed by transect drilling in northeast Baffin Bay (CENICE)
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Proponent Information

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Abstract

Understanding the long-term history of the Greenland Ice Sheet (GrIS) is key to understanding northern hemisphere glaciation, to elucidating mechanisms underlying amplification of glacial cycles since the late Pliocene and to predicting how the GrIS will respond to modern climate warming. To address current knowledge gaps in the evolution and variability of the GrIS and its role in Earth's climate system, we propose to drill along a transect across the northwest Greenland margin extending from the shelf to Baffin Bay where thick Cenozoic sedimentary successions primarily reflect the evolution of the northern GrIS (NGrIS). The mission strategy is to retrieve a composite stratigraphic succession representing the Late Cenozoic era from Oligocene/early Miocene to Holocene. The proposed drill sites will specifically target high-accumulation-rate deposits associated with contourite drifts and potential interglacial deposits within a trough-mouth-fan system including proximal shelf deposits, all densely covered by excellent quality 2-D and 3-D seismic data. We seek to test if the NGRIS underwent near-complete deglaciations in the Pleistocene and assess recent models for the change in orbital cyclicities through the Mid-Pleistocene transition. Moreover, the proposal will examine a possible linkage between the general decrease in atmospheric CO2 from the Oligocene to the early Miocene and arrival of cold and possibly glacially-dominated environments in northwest Greenland and establish the timing for tectonic margin adjustments inferred from the seismic record. Finally, records will be produced that can test hypothesis that glacial expansion of the NGrIS is linked with intensification of northern hemisphere glaciations (3.3-2.8 Ma) and unravel marine heat transport through the western North Atlantic and Baffin Bay as a potential cause for the Pliocene high Arctic warmth. The detailed information obtained from these paleoclimate archives will be of great value for predictive models addressing how the GrIS may respond to global warming in the near future. The overall aim is to investigate the full range of forcing and feedbacks - oceanic, atmospheric, orbital, tectonic - that influence the GrIS over a range of time scales, as well as conditions prevailing at the time of glacial inception and deglacial to interglacial periods. The scientific objectives of this proposal are of key significance in addressing the challenges "How do ice sheets and sea level respond to a warming climate?" and "How does Earth's climate system respond to elevated levels of atmospheric CO2?" under the Climate and Ocean Change theme of the IODP science plan.

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Scientific Objectives

1. Test the hypothesis that the northern Greenland Ice Sheet (NGrIS) underwent significant deglaciation at intervals within the frequency range of orbital eccentricity (~100-400 ka).
2. Test the hypothesis that the general decrease in pCO2 from the early-middle Oligocene to the early Miocene is linked to cold and possibly glacially-dominated environments in northwest Greenland.
3. Provide information on timing, sedimentary processes and changes in NGrIS erosion related to tectonic adjustments inferred from the seismic record.
4. Test the hypothesis that major glacial expansion of the NGrIS is linked with intensification of NHG (3.3-2.8 Ma).
5. Assess recent models for the change in orbital cycles through the MPT, by analyzing sediment maturity and regolith history.
6. Test the hypothesis that the high Arctic warmth of the early-mid Pliocene is related to heat advection through the western North Atlantic Ocean and Baffin Bay.

Non-standard measurements technology needed to achieve the proposed scientific objectives

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Proposed Sites (Total proposed sites: 18; pri: 7; alt: 11; N/S: 0)

Site Name	Position (Lat, Lon)	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
MB-01C (Primary)	73.0001 -63.0065	1809	473	0	473	Recover a high-resolution paleoceanographic record of a early/middle-late Pleistocene sediment drift system corresponding to the most recent part of the trough-mouth-fan history (scientific objectives 1 and 5). Site MB-1C is targeting expanded intervals of units 9, 10 and 11 and overlaps stratigraphically with the strata drilled at site MB-2C. Site was moved from 1B position to avoid amplitude anomaly at target depth. MB-1C is located 3.9 km from nearest crossing line to provide optimal coverage of units 9, 10 and 11.
MB-20A (Alternate)	72.9118 -63.0642	1928	464	0	464	Recover a high-resolution paleoceanographic record of a middle-late Pleistocene sediment drift system corresponding to the most recent part of the trough-mouth-fan history (scientific objectives 1 and 5). Site MB-20A targets expanded intervals of units 9, 10 and 11 and overlaps stratigraphically with the strata drilled at site MB-2C. The site is located ~1.2 km NW of nearest crossing line to avoid strong reflections at target depth (e.g. channel sands).
MB-02C (Primary)	73.1150 -63.7904	1957	537	0	537	Recover a high-resolution paleoceanographic record of a early/middle-late Pleistocene sediment drift system corresponding to the most recent part of the trough-mouth-fan history (scientific objectives 1 and 5). Site MB-2C targets an expanded interval of unit 8 and overlaps stratigraphically with the strata drilled at site MB-1C. The site is located ~1 km off the nearest crossline to obtain optimal stratigraphic coverage of unit 8 (beween horizons 7-8) and avoid amplitude anomaly at the base of this unit.
MB-22A (Alternate)	73.1388 -63.6402	1850	611	0	611	Recover a high-resolution paleoceanographic record of a early/middle-late Pleistocene sediment drift system corresponding to the most recent part of the trough-mouth-fan history (scientific objectives 1 and 5). Site MB-22A targets an expanded interval of unit 8 and overlaps stratigraphically with the strata drilled at site MB-1C.The site is located ~1 km off the nearest crossline to obtain optimal stratigraphic coverage of unit 8 (beween horizons 7-8) and avoid drilling into strong reflections (e.g. channel sands).
MB-21A (Alternate)	73.6439 -64.8251	1954	751	0	751	Recover a high-resolution paleoceanographic record of a early/middle-late Pleistocene sediment drift system corresponding to the most recent part of the trough-mouth-fan history (scientific objectives 1 and 5). Site MB-2C targets an expanded interval of unit 8 and overlaps stratigraphically with the strata drilled at site MB-1C. Moreover, the site has potential for recovering stratified sediments of units 5-7. The site is located 3.8 km off nearest crossing line to optimize stratigraphic coverage and avoid intervals of slope re-deposition (e.g slumps). Requires drilling through ~150 m of younger fan/slope sediments.
MB-08A (Primary)	73.4870 -62.2682	497	370	0	370	Recover deglacial and interglacial intervals of potentially early-middle Pleistocene age within top-set strata of the trough-mouth fan. High priority for scientific objectives 1 and 5. Site MB-8A penetrates a package of flat-lying, semi-continuous reflections that onlap glacial unconformities of units 6, 7, 8 and 9 (target depth is a positive reflection above horizon 6). The site is ~1 km offset from the nearest crossline to optimize recovery of the identified onlapping reflections.
MB-03B (Alternate)	73.5032 -62.4861	498	375	0	375	Recover deglacial and interglacial intervals of potentially early-middle Pleistocene age within top-set strata of the trough-mouth fan. High priority for scientific objectives 1 and 5. Site MB-3B penetrates a package of flat-lying, semi-continuous reflections that onlap glacial unconformities of units 6, 7, 8 and 9 (TD = top unit 6). The site is placed ~2.7 km off the nearest crossline to optimize recovery of onlapping reflections.
MB-04B (Primary)	73.8711 -62.0342	630	340	0	340	Recover deglacial and interglacial intervals of potentially early Pleistocene age within top-set strata of the trough-mouth fan (scientific objectives 1 and 5). MB-4B penetrates a package of flat-lying, semi-continuous reflections that onlap a major glacial unconformity (horizon 3). Depth target is a positive-phase horizon within an upper slope front segment of unit 3. MB-4B is offset ~2.5 km from nearest crossline to achieve optimal stratigraphic overage of units 3-4. The site is a primary location due to well-defined onlapping reflections reachable within ~300 mbsf.

Proposed Sites (Continued; total proposed sites: 18; pri: 7; alt: 11; N/S: 0)

Site Name	Position (Lat, Lon)	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
MB-09A (Alternate)	73.9650 -61.4959	580	270	0	270	Recover deglacial and interglacial intervals of potentially early Pleistocene age within top-set strata of the trough-mouth fan (scientific objectives 1 and 5). The site targets strata that onlap horizon 1 (top of oldest prograding unit). Site MB-09A is alternate to MB-4B due to reduced imaging quality of reflection onlaps and stratigraphic coverage. The site is located ~1 km offset from nearest crossing line to achieve optimal penetration of onlapping deposits.
MB-05B (Primary)	74.2116 -61.3397	704	520	0	520	(1) Capture a thin wedge of progradational deposits that may correspond to the earliest shelf-based glaciations in NW Greenland; (2) Recover Neogene contourite drift sediments of likely Pliocene age that can elucidate paleoceanographic conditions prior to the major basinward expansion of the Greenland Ice Sheet (scientific objectives 3, 4 and 6). MB-5B targets the stratigraphically younger interval of the drift deposit that overlaps with the section drilled at site MB-6C. The site is located within the ANU-3D cube. Selected as primary site due to most optimal recovery of the youngest sediments.
MB-13A (Alternate)	74.2118 -61.3958	707	540	0	540	(1) Capture a thin wedge of progradational deposits that may correspond to the earliest shelf-based glaciations in NW Greenland; (2) Recover Neogene contourite drift sediments of likely Pliocene age that can elucidate paleoceanographic conditions prior to the major basinward expansion of the Greenland Ice Sheet (scientific objectives 3, 4 and 6). Site MB-13A (alternate for 5B) targets the stratigraphically younger interval of the drift deposit that overlaps with the section drilled at site MB-6C. The site is located within the ANU-3D cube.
MB-14A (Alternate)	74.2109 -61.2704	663	510	0	510	(1) Capture a thin wedge of progradational deposits that may correspond to the earliest shelf-based glaciations in NW Greenland; (2) Recover Neogene contourite drift sediments of likely Pliocene age that can elucidate paleoceanographic conditions prior to the major basinward expansion of the Greenland Ice Sheet (scientific objectives 3, 4 and 6). Site MB-14A (alternate for 5B) targets the stratigraphically younger interval of the drift deposit that overlaps with the section drilled at site MB-6C. The site is located within the ANU-3D cube.
MB-06C (Primary)	74.1254 -60.9510	609	620	0	620	Recover Neogene contourite drift sediments of likely Pliocene age that can elucidate paleoceanographic conditions prior to the major basinward expansion of the Greenland Ice Sheet (scientific objectives 3, 4 and 6). Site MB-6C overlaps stratigraphically with the lowermost section drilled at site MB-5B (and alternates 13A and 14A). The main target is an expanded section of the drift deposit that may contain a high-resolution early Pliocene record. TD is placed 30 ms below a prominent reflection draping over a slide scar. MB-6C is located within the ANU-3D cube.
MB-15A (Alternate)	74.1217 -60.9909	605	625	0	625	Recover Neogene contourite drift sediments of likely Pliocene age that can elucidate paleoceanographic conditions prior to the major basinward expansion of the Greenland Ice Sheet (scientific objectives 3, 4 and 6). Site MB-15A overlaps stratigraphically with the lowermost section drilled at site MB-5B (and alternates 13A and 14A). The main target is an expanded section of the drift deposit that may contain a high-resolution early Pliocene record. TD is placed 30 ms below a prominent reflection draping over a slide scar. High priority for scientific objectives 3, 4 and 6. MB-15A is located within the ANU-3D cube.
MB-07A (Primary)	74.5136 -60.6792	737	1173	0	1173	Recover an upper Miocene interval and continue coring through the Middle Miocene horizon (d1) with TD at horizon d2 of possible Oligocene age. The scope is to elucidate past ocean and terrestrial climates in NE Baffin Bay/Greenland and the onset of ephemeral glaciation in NW Greenland (scientific objectives 2 and 3). Located within PITU-3D high-res cube. Site 7A is selected as the primary site on the basis of a better stratigraphic coverage in the topmost section.
MB-11A (Alternate)	74.4283 -60.4086	747	1170	0	1170	Recover an upper Miocene interval and continue coring through the Middle Miocene horizon (d1) with TD at horizon d2 of possible Oligocene age. The scope is to elucidate past ocean and terrestrial climates in NE Baffin Bay/Greenland and the onset of ephemeral glaciation in NW Greenland (scientific objectives 2 and 3). Located within PITU-3D high-res cube.
MB-12A (Alternate)	74.4597 -60.5049	739	1145	0	1145	Recover an upper Miocene interval and continue coring through the Middle Miocene horizon (d1) with TD at horizon d2 of possible Oligocene age. The scope is to elucidate past ocean and terrestrial climates in NE Baffin Bay/Greenland and the onset of ephemeral glaciation in NW Greenland (scientific objectives 2 and 3). Alternate site for 7A. Located within PITU-3D high-res cube.

Proposed Sites (Continued; total proposed sites: 18; pri: 7; alt: 11; N/S: 0)

Site Name	Position (Lat, Lon)	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
MB-10A (Alternate)	74.4584 -61.1792	698	1206	0	1206	Recover an upper Miocene interval and continue coring through the Middle Miocene horizon (d1) with TD at horizon d2 of possible Oligocene age. The scope is to elucidate past ocean and terrestrial climates in NE Baffin Bay/Greenland and the onset of ephemeral glaciation in NW Greenland (scientific objectives 2 and 3). MB-10A is located on the edge of the PITU-3D seismic data. Alternate position to site MB-07A.