IODP Proposal Cover Sheet

Greenland Ice Sheet

814 - Pre

Title	Assessing the history of the south Greenland Ice Sheet and its interaction with ocean circulation, climate, and sea level
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Abstract:

We propose a multi-phase drilling project (MDP) to investigate the behavior of the south Greenland Ice Sheet (GIS) and its interaction with ocean circulation and climate from its likely Miocene inception through the Quaternary. The impetus for this Integrated Ocean Drilling Program (IODP) pre-proposal directly stems from the conclusions of an IODP workshop that resulted in the development of the DEGREE (DEglaciated GREEnland) Project (Carlson & Stoner, 2012; www.geology.wisc.edu/degree). The workshop highlighted the need to use ocean archives to assess past GIS behavior and linkages with ocean circulation and climate. Prior work demonstrates that both traditional and newly developed sedimentological, biological, geochemical, and magnetic proxies can be extracted from sediment surrounding south Greenland and used to reconstruct south GIS responses to past climate changes, in particular ice losses during interglacial climate intervals and the role of the ocean in both driving and responding to changes in GIS behavior. Results to date are limited by a lack of spatial and temporal coverage and completeness. For this drilling experiment, a coordinated array of sites are needed to cover a broad temporal range (Miocene-Quaternary) and to trace the flow path of erosion products from Greenland (and to a lesser extend Iceland and North America) from source to sink, as well as to understand patterns of oceanic temperature and circulation in relation to GIS behavior. For the south GIS, such a drilling experiment can be accomplished through a network of 'paleoceanographic' sites, without the complexity of ice proximal drilling, where long continuous records of GIS and paleoceanography can be obtained from deep-water locations. Survey data exist for some of these sites, including a series of mud waves on the Eirik Ridge that could be used in an offset Advance Piston Coring (APC) drilling strategy to step back into older Mio-Pliocene sequences deposited at high resolution (> 200 m/Ma) and re-drilling of ODP Sites 646, and 918 and 919 on the SE Greenland margin. Other locations required for this MDP will require additional survey. This MDP experiment could be carried out in three expeditions that are scientifically linked (using similar methodologies, proxies and the same over arching goals) but operationally separate. This proposal is central to the IODP Science Plan theme "Climate and Ocean Change", and in particular IODP Challenge 1, on the response of climate to elevated CO2, and Challenge 2, on the response of ice sheets and sea level to a warming climate.

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Scientific Objectives

1. What are the respective roles of atmospheric and oceanic forcings in controlling the extent of glaciation on south Greenland?
2. Is subsurface oceanic temperature important in predicting the behavior of the south GIS?
3. What is the role of buttressing ice shelves and sea ice?
4. How does freshwater discharged from Greenland influence ocean circulation?

Time intervals to be studied to address these process-oriented questions related to the history of the south GIS and its (in)stability.

1. Establish the climate state during the Miocene before a GIS existed.
2. Establish when valley glaciers coalesced to form the south GIS, hypothesized to occur in the late Neogene.
3. Document the variability of the south GIS (if in existence) during the Pliocene when atmospheric CO2 concentrations were close to present concentrations.
4. Record the advance and retreat of the south GIS during the Quaternary and any potential change during the transition from a 40 to 100 kyr glacial-interglacial world, noting glacial periods when the south GIS reached its maximum extent at the continental shelf break.
5. Estimate GIS retreat during interglaciations, particularly MIS 1, 5e, 7, 11, 19 and 31, maximum extent during MIS 2, 4, 6, 8, 10 and 12, and the timing and pattern of GIS advance and retreat relative to global glacial-interglacial events.
6. Identify whether ice shelves existed over the Labrador Sea during glacial periods, and if so, which glacial periods.

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

Proposed Sites

Site Name	Position (Lon, Lat)	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
REYK-2A	-29.15, 60.1167	1072	300	0	300	This site is part of a depth transect that will record the evolution of subsurface water mass properties, in particular temperature, which may impact the GIS directly or indirectly through the melting of ice shelves.
REYK-1A	-29.4667, 60.1667	899	300	0	300	This site is part of a depth transect that will record the evolution of subsurface water mass properties, in particular temperature, which may impact the GIS directly or indirectly through the melting of ice shelves.
SEGN-1A	-32.56, 63.5	2500	700	0	700	Sites in this region will document southeast GIS retreat and record water mass and ice rafting changes into and out of Denmark Straits. At present no survey data exist.
SGLD-1A	-43.06, 59.5	1000	300	0	300	High resolution records of the Glacial retreat, not surveyed at present.
SWG-1A	-53.8997, 62.6498	455	300	0	300	Sites in this region will document southwest GIS retreat and record water mass and ice rafting changes into and out of Baffin Bay. At present no survey data exist,but piston coring indicate that planktonic 18O stratigraphies are possible and MIS 5

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-	-	-	-	-	-	sediment were recovered down to 15 m
LABM-1A	-56.133, 55.6167	2063	300	0	300	This site could be part of a depth transect if suitable sediments are available that would record the evolution of subsurface water mass properties, in particular temperature, which may impact the GIS directly or indirectly through the melting of ice shelves. This site should also provide evidence for ice shelf if they existed and which are hypothesized as an important part of the Laurentide Greenland ice sheet system.
FLEM-3A	-46.62, 47.63	2107	300	0	300	
FLEM-2A	-46.63, 48.33	1355	300	0	300	This site is part of a depth transect that will record the evolution of subsurface water mass properties, in particular subsurface temperature, which may impact the GIS directly or indirectly through the melting of ice shelves.
FLEM-1A	-45.96, 48.17	990	300	0	300	This site is part of a depth transect that will record the evolution of subsurface water mass properties, in particular subsurface temperature, which may impact the GIS directly or indirectly through the melting of ice shelves
SEGS-3A	-38.6389, 63.0928	1868	600	0	600	To access the older part of the East Greenland record, including the possible initiation of the GIS at relatively shallow depths.
SEGS-2A	-36.3587, 62.3352	2600	300	0	300	To establish, for the last few Myrs (Late Neogene - Quaternary), the intercalibration of geomagnetic paleointensity, isotope stratigraphies, and regional environmental stratigraphies with tracers of GIS extent and oceanic conditions from a SE Greenland location that captures expanded interglacial periods. Such a template is a requirement for understanding the relative phasing of atmospheric, cryospheric and oceanic changes that are central to the understanding of the sensitivity of the GIS to future warming
SEGS-1A	-37.4603, 62.67	2086	700	0	700	To establish at high resolution, for the last few Myrs (Late Neogene - Quaternary), the intercalibration of geomagnetic paleointensity, isotope stratigraphies, and regional environmental stratigraphies with tracers of GIS extent and oceanic conditions from a SE Greenland location. Such a template is a requirement for understanding the relative phasing of atmospheric, cryospheric and oceanic changes that are central to the understanding of the sensitivity of the GIS to future warming.

EIRK-3A	-46.301, 58.5538	2556	300	0	300	Would sample an expanded Pliocene–Quaternary sediment package at relatively shallow water depths providing complementary information to Site 1306, 1305 and facilitate the interpretation of EIRIK-2A and Site 1307.
EIRK-2A	-46.4637, 58.4754	2650	300	0	300	Will drill mudwaves scheduled for but not drilled because of weather during Exp 306. The mudwaves represent an opportunity to access the older part of the record through APC drilling, not known to be available anywhere else off south Greenland. This drilling would build upon results from Site 1307 that extended back 3.5 Ma (Channell et al., 2006). The results will also provide important information on the sedimentary architecture of the mudwaves and, hence, on sedimentary evolution of the Eirik Drift.
EIRK-1A	-48.369, 58.2093	3450	700	0	700	Re-drilling at ODP Site 646 to develop a continuous Eirik Drift record back to the Miocene. Two holes were drilled at ODP Site 646, with Site 646B extending back 9 Ma at 766 mbsf, while Hole 646A was APC to 103.5 mbsf (~1.3 Ma). Drilled prior to the development of modern composite sections, complete recovery of the late Miocene–Holocene record was further exacerbated by incomplete recovery (646A APC 89%, 646B APC 74%, XCB 48%), drilling disturbance, and poor weather conditions. Re-drilling Site 646 will build upon and substantially extend the record recovered at Site 1305.