

IODP Proposal Cover Sheet

814 - Full

Greenland Ice Sheet

Received for: 2018-04-02

Title	Assessing the history of the south Greenland Ice Sheet and its interaction with ocean circulation, climate, and sea level		
Proponents	Joseph Stoner, Sean Gulick, Robert Hatfield, Alan Mix, Ian Bailey, Tove Nielsen, Anders Carlson, Gregory Mountain, Gabriele Uenzelmann-Neben, Antoon Kuijpers, Claude Hillaire-Marcel, Anne de Vernal, Anne Jennings, Paul Knutz, James Wright, Erin McClymont, Guillaume St-Onge, Maureen Walczak, Brendan Reilly		
Keywords	Greenland, Pliocene, Climate, Ocean-circulation, CO2	Area	Labrador Sea & Irminger Basin

Proponent Information

Proponent	Joseph Stoner
Affiliation	Oregon State University
Country	United States

Permission is granted to post the coversheet/site table on www.iodp.org

Abstract

We propose to investigate the behavior of the south Greenland Ice Sheet (sGIS) and its interaction with ocean circulation and climate from the late-Miocene through the Quaternary to assess its stability in light of future change. The impetus for this International Ocean Discovery Program (IODP) proposal directly stems from the conclusions of an USSSP/NSF/PAGES funded IODP workshop (Carlson and Stoner, 2012; http://usoceandiscovery.org/wp-content/uploads/2016/05/Workshop_Report_Greenland.pdf) and a more recent NSF workshop (Briner et al., 2017; <http://www.glyfac.buffalo.edu/Faculty/briner/greenlandworkshop/>). These community efforts highlighted the need to obtain new Mio-Pleistocene proxy records in the vicinity of Greenland that are capable of providing observational constraints and climatic boundary conditions for past behavior under higher atmospheric CO₂ regimes informing on thresholds for future GIS change. These records are only obtainable through ocean drilling. Prior work demonstrates that both traditional and newly developed sedimentological, biological, geochemical, and magnetic proxies can be extracted from marine sediments surrounding southern Greenland to reconstruct sGIS responses. These methods are particularly adept at tracking ice loss and in understanding the role of the ocean in both driving and responding to changes in GIS behavior, however they are currently limited by a lack of spatial coverage and temporal completeness. For this drilling experiment, a coordinated array of sites over a broad temporal range (Miocene-Quaternary) is proposed to trace erosional products from Greenland from source to sink and to understand patterns of oceanic temperature and circulation that may affect sGIS behavior. For the sGIS, this can be accomplished through a network of 'paleoceanographic' sites, without the complexity of ice-proximal drilling, where long, continuous records of sGIS change and paleoceanographic conditions can be obtained and dated from deep-water locations. Survey data exist for 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 shallowly buried older Pliocene sequences deposited at high resolution (> 200 m/Ma), a Davis Strait Drift Complex that may archive Pliocene-age shelf edge glaciations and provide a unique west Greenland perspective on deglaciation, and through re-drilling of ODP Sites 646 and 919 provide a complete spatial picture of the history of the sGIS since the late-Miocene. This proposal is central to the IODP Science Plan theme "Climate and Ocean Change", and in particular addresses IODP Challenges 1 and 2.

Scientific Objectives

1. Establish the Mio-Pleistocene history of the south Greenland Ice Sheet (sGIS), including its presence/absence and glacial-interglacial variability.
2. Document the response of the sGIS to longer period, globally significant changes to constrain whether the sGIS may have had different sensitivities.
3. Determine the timing of west Greenland shelf edge glaciations.
4. Reconstruct the history of the Deep Western Boundary Current (DWBC) as a component of AMOC and its relationship to regional paleoceanographic conditions and sGIS history from the late Miocene through the Plio-Pleistocene.
5. Extend observations of geomagnetic relative paleointensity (RPI) into the Pliocene

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

Proposed Sites (Total proposed sites: 14; pri: 7; alt: 7; N/S: 0)

Site Name	Position (Lat, Lon)	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
DAVIS-01A (Primary)	64.467571 -55.3704	945	650	0	650	Drilling at DAVIS-01A targets the 5 Glacigenic Debris Flows (GDFs) imaged in the Davis Strait Drift Complex (Nielsen and Kuijpers, 2013). The emplacement of these GDFs is thought to relate to periods when ice on Greenland reached the paleo-shelf edge. The aim is to drill to the base of the first GDF, hypothesized to be ~4.5 Ma (Nielsen and Kuijpers, 2013) to establish the timing and initiation of shelf edge glaciations in SW Greenland.
DAVIS-02A (Primary)	64.388107 -56.34335	760	400	0	400	This site is free from the Glacigenic Debris Flows (GDFs) present in DAVIS-01A. The continuous sediment sequence from DAVIS-02A will provide Plio-Pleistocene paleoceanography and paleoclimatology from the Davis Strait Drift Complex. Continuous reflectors can be traced from beneath GDF 1 and from between all 5 GDFs in DAVIS-01A to DAVIS-02A meaning that this site can also provide a framework to interpret the DAVIS-01A record.
EIRIK-01A (Primary)	58.20953 -48.36912	3460	550	0	550	Re-drilling at ODP Site 646 to develop a continuous Eirik Drift record of the south Greenland ice-sheet and regional paleoceanography back to the late-Miocene. Two holes were drilled at Site 646; Hole 646B (766 mbsf; ~8.6Ma) and Hole 646A (103.5 mbsf; ~1.3 Ma). Drilled prior to the development of modern composite sections, a complete section was hampered by incomplete recovery (646A APC 89%, 646B APC 74%, XCB 48%), drilling disturbance, and poor weather conditions. EIRIK-01A will build upon, and substantially extend, the record recovered at Site U1305 and provide a framework to interpret all other cores from the Eirik Ridge.
EIRIK-02A (Primary)	58.55189 -46.3047	2556	300	0	300	Develop a continuous (~90m/Myr) paleoceanographic, paleoclimatic, and south Greenland ice sheet evolution record since the Plio-Pleistocene boundary. EIRIK-02A has approximately 2x the sedimentation rate of nearby Site U1307 and is one of three primary sites that make up the Eirik Ridge transect. Combined, these sites will generate a composite high-resolution APC record back into the early-Pliocene. Site EIRIK-02A targets the uppermost sediment section of this transect and it is anticipated that EIRIK-02A will form the 0-2.5 Ma portion of the composite record.
EIRIK-03A (Primary)	58.50194 -46.4083	2590	300	0	300	Develop a continuous high-resolution paleoceanographic, paleoclimatic, and south Greenland ice sheet evolution record in the mid-late Pliocene. EIRIK-03A is close to site U1307 and is one of three primary sites that make up the Eirik Ridge transect. Combined, these sites will generate a composite high-resolution APC record back into the early-Pliocene. Site EIRIK-03A will have a condensed Pleistocene section relative to EIRIK-02A but has an expanded mid-late Pliocene section with sedimentation rates potentially in excess of 200m/Myrs. It is anticipated that EIRIK-03A will form the 2.5-3.5 Ma portion of the composite record.
EIRIK-04A (Primary)	58.47751 -46.4592	2647	300	0	300	Develop a continuous high-resolution paleoceanographic, paleoclimatic, and south Greenland ice sheet evolution record in the mid-late Pliocene. EIRIK-04A is one of three primary sites that make up the Eirik Ridge transect. Combined, these sites will generate a composite high-resolution APC record back into the early-Pliocene. Site EIRIK-04A will have a condensed late-Pleistocene section and potentially a hiatus to the late Pliocene but has an expanded early-mid Pliocene section with sedimentation rates potentially in excess of 200m/Myrs. It is anticipated that EIRIK-04A will form the 3.5-4.5 Ma portion of the composite record.
SEGRN-01A (Primary)	62.67000 -37.46018	2087	500	0	500	Redrilling ODP Site 919 to provide a continuous (~160m/Myr) paleoceanographic, paleoclimatic, and south Greenland ice sheet evolution record from southeast Greenland margin perspective since the Late Pliocene (~3Ma). Records from this site capture millennial-scale variability in bottom currents, ice-sheets, and the geomagnetic field. Site 919 consists of 2 holes with recovery; 919A 0-93.5 mbsf, 919B 90-147 mbsf (~0.95 Ma). APC recovery in 919A and 919B exceeded 100% but the record is discontinuous as these are essentially single holes with almost no overlap. This redrill will fully capture the exceptional potential of this site and extend it into the late Pliocene.

Proposed Sites (Continued; total proposed sites: 14; pri: 7; alt: 7; N/S: 0)

Site Name	Position (Lat, Lon)	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
EIRIK-05A (Alternate)	58.48485 -46.4438	2627	200	0	200	Develop a continuous high-resolution paleoceanographic, paleoclimatic, and south Greenland ice sheet evolution record in the mid-late Pliocene. EIRIK-05A is an alternate site on the Eirik Ridge Transect. It is positioned to ensure overlap between EIRIK-03A and EIRIK-04A should shipboard analysis suggest that there is a gap between the two records. Combined these sites will generate a composite high-resolution APC record back into the early-Pliocene. Site EIRIK-05A will have a condensed late-Pleistocene section and potentially a hiatus to the late-Pliocene but has an expanded mid-Pliocene section with sedimentation rates potentially in excess of 200m/Myrs.
EIRIK-06A (Alternate)	58.46042 -46.4944	2778	300	0	300	Develop a continuous high-resolution paleoceanographic, paleoclimatic, and south Greenland ice sheet evolution record in the mid-late Pliocene. EIRIK-06A is an alternate site on the Eirik Ridge Transect. It is positioned to recover the early-Pliocene portion of the record and will extend the composite section below primary Site EIRIK-04A. Combined, these sites will generate a composite high-resolution APC record back into the early-Pliocene. Site EIRIK-06A will have a condensed late-Pleistocene section and potentially a hiatus to the mid-early Pliocene but has an expanded early-Pliocene section with sedimentation rates potentially in excess of 400m/Myrs.
EIRIK-07A (Alternate)	58.44542 -46.5254	2830	300	0	300	Develop a continuous high-resolution paleoceanographic, paleoclimatic, and south Greenland ice sheet evolution record in the mid-late Pliocene. EIRIK-07A is an alternate site on the Eirik Ridge Transect. It is positioned to recover the early-Pliocene portion of the record and will extend the composite section below primary Site EIRIK-04A. Combined, these sites will generate a composite high-resolution APC record back into the early-Pliocene. Site EIRIK-07A will have a condensed late-Pleistocene section and potentially a hiatus to the mid-early Pliocene but has an expanded early-Pliocene section with sedimentation rates potentially in excess of 400m/Myrs.
EIRIK-08A (Alternate)	58.43412 -46.5484	2852	300	0	300	Develop a continuous high-resolution paleoceanographic, paleoclimatic, and south Greenland ice sheet evolution record in the mid-late Pliocene. EIRIK-08A is an alternate site on the Eirik Ridge Transect. It is positioned to recover the early-Pliocene portion of the record and will extend the composite section below primary Site EIRIK-04A. Combined these sites will generate a composite high-resolution APC record back into the early-Pliocene. Site EIRIK-08A will have a condensed late-Pleistocene section and potentially a hiatus to the early-Pliocene but has an expanded early-Pliocene section with sedimentation rates potentially in excess of 400m/Myrs.
EIRIK-09A (Alternate)	58.03615 -48.4595	3350	350	0	350	EIRIK-09A is an alternate site to EIRIK-01A, positioned between ODP Site 646 and IODP Site U1305. The site will have slightly higher interglacial sedimentation rates than EIRIK-01A but overall lower sedimentation rate than U1305 allowing a record to be constructed into the mid-Pliocene (~4Ma). It will be used to reconstruct regional paleoceanography, paleoclimatology, and GIS evolution complementing the records from EIRIK-01A and IODP Site U1305.
SEGRN-02A (Alternate)	63.09282 -38.63893	1868	350	0	350	Alternate to SEGRN-1A. Redrill of ODP Site 918 that has slightly higher Pliocene sedimentation rates (~200m/Myr) than SEGRN-01A. 918 consisted of four holes but the well recovered holes (918B and 918C) are only late-Pleistocene in age. A condensed Pleistocene section (and/or potential hiatus) allows access to Pliocene age sediments at a relatively shallow depth to permit construction of paleoceanography, paleoclimatology, and GIS evolution records from the south east Greenland margin since the Mid-Pliocene (~4Ma).
GLOR-01A (Alternate)	53.33127 -45.26195	3862	350	0	350	Site GLOR-1A is positioned as a redrill of ODP Site 647. Sediments in the top ~110m extend through the Pleistocene before a hiatus provides relatively shallow access to the early Oligocene. The uppermost sediments will provide a regional view on the paleoclimatic and paleoceanographic conditions distal to the influence of the Greenland ice-sheet. The deeper record provides a rare opportunity to APC the Oligocene at relatively high resolution (36 m/Myr). Only one hole was rotary drilled through this interval on Leg 105 (647A) with recovery rates of 62%.