IODP Proposal Cover Sheet

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Arctic Atlantic Gateway Climate

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Title	THE OPENING OF THE ARCTIC-ATLANTIC GATEWAY: TECTONIC, OCEANOGRAPHIC AND CLIMATIC DYNAMICS (“AAG-DRILL” – ARCTIC-ATLANTIC GATEWAY DRILLING CAMPAIGN”)
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Keywords	Arctic, Gateway, Cenozoic, Climate, Tectonic
Area	Norwegian-Greenland Sea, NE Greenland Continental Margin, Boreas Basin

Proponent Information

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Abstract

The modern polar cryosphere reflects an extreme climate state with profound temperature gradients towards high-latitudes. It developed in association with stepwise Cenozoic cooling, beginning with ephemeral glaciations and the appearance of sea ice in the late Middle Eocene. The polar ocean gateways played a pivotal role in changing the polar and global climate, along with declining greenhouse gas levels. The opening of the Drake Passage finalized the oceanographic isolation of Antarctica, some 40 Ma ago. The Arctic Ocean was an isolated basin until the early Miocene when rifting and subsequent sea-floor spreading started between Greenland and Svalbard, initiating the opening of the Fram Strait / Arctic-Atlantic Gateway (AAG). Although this gateway is known to be important in Earth's past and modern climate, little is known about its Cenozoic development. Indeed, the opening history and AAG's consecutive widening and deepening must have had a strong impact on circulation and water mass exchange between the Arctic Ocean and the North Atlantic.

To study the AAG's complete history, ocean drilling at four (primary) sites located between 73°N and 78°N are proposed. These sites will provide unprecedented sedimentary records that will unveil (1) the history of shallow-water exchange between the Arctic Ocean and the North Atlantic, and (2) the development of the AAG to a deep-water connection and its influence on the global climate system.
The specific overarching goals of this proposal are to study:

- the influence of distinct tectonic events in the development of the AAG and the formation of deep water passage on the North Atlantic and Arctic paleoceanography, and

- the role of the AAG in the climate transition from the Paleogene greenhouse to the Neogene icehouse for the long-term (~50 Ma) climate history of the northern North Atlantic.

The proposed drilling addresses a number of key questions raised in the IODP Science Plan 2013-2023. It is specifically linked to the Research Theme "Climate and Ocean Change: Reading the Past, Informing the Future".

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Scientific Objectives

This proposal has two major objectives: (1) to understand the tectonic processes leading to the development of the only deep-water connection to the Arctic Ocean and its influence on the Earth's climate, and (2) to understand the role of the gateway region in the circulation and water mass exchange between the Arctic Ocean and North Atlantic.

Scientific drilling is the only approach that can provide answers for the following, so far untested, hypotheses:

1. The initial opening of the AAG in the late Oligocene/early Miocene due to tectonic movements between NE Greenland and Svalbard caused a catastrophic flooding of the Norwegian-Greenland Sea with freshwater from the Arctic Ocean.

2. The deepening and widening of the AAG in the late Miocene caused the re-organization of deep-water circulation and water-mass exchange between the Atlantic, Pacific and Arctic Oceans.

3. The vertical motion in the AAG region triggered further cryospheric evolution in the Northern Hemisphere as evidenced by the presence of sea ice and glacial ice as early as the middle Eocene.

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

none

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Proposed Sites (Total proposed sites: 19; pri: 4; alt: 15; N/S: 0)

Site Name	Position (Lat, Lon)	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
FR-03A (Primary)	73.3562 -14.3341	2409	1300	20	1320	Recovery of a complete sediment sequence from Eocene to Quaternary and the top of the oceanic basement. This site will address hypotheses 1 (Initial opening of the AAG), 2 (Deepening and widening of the AAG), and 3 (Cryospheric evolution of the Northern Hemisphere), allowing the reconstruction of the complete transition from the isolated Arctic Ocean to the modern gateway and the relation of uplift and glaciations in East Greenland. The recovery of basement/magmatic rocks will allow to test the current plate-kinematic models.
FR-07A (Primary)	76.5909 -1.3729	2991	800	0	800	Recovery of a complete middle/late Miocene to Quaternary section which will allow to address hypothesis 2, the deepening and widening of the AAG (Primary Site). Recovered drift deposits will enable high-resolution paleoceanographic studies on ocean circulation, sea-ice cover, deep-water formation and continental ice sheets.
FR-08A (Primary)	77.2158 1.0756	3205	1000	20	1020	Recovery of a complete middle/late Miocene to Quaternary section which will allow to address hypothesis 2, the deepening and widening of the AAG. Recovery and dating of basement rocks will allow testing the current plate kinematic model (hypothesis 1).
FR-04A (Primary)	75.2967 -11.3048	1589	1300	0	1300	Recovery of a complete sediment sequence from Late Oligocene to Quaternary. This site will address hypotheses 2 (Deepening and widening of the AAG) and 3 (Cryospheric evolution of the Northern Hemisphere), allowing the reconstruction of the complete transition from the isolated Arctic Ocean to the modern gateway in combination with Sites FR-05A and FR-06A, and the relation of uplift and glaciations in East Greenland.
FR-05A (Alternate)	75.2487 -11.0376	2078	1000	0	1000	Recovery of a complete sediment sequence from Early Oligocene to Early Miocene. This site will address hypotheses 1 (Initial opening of the AAG) and 2 (Deepening and widening of the AAG), allowing the reconstruction of the complete transition from the isolated Arctic Ocean to the modern gateway in combination with Sites FR-04A and FR-06A.
FR-06A (Alternate)	75.2197 -10.8764	1412	1200	0	1200	Recovery of a complete sediment sequence from Late Eocene to Oligocene. This site will address hypotheses 1 (Initial opening of the AAG), allowing the reconstruction of the complete transition from the isolated Arctic Ocean to the modern gateway in combination with Sites FR-04A and FR-05A.
FR-09A (Alternate)	77.1737 1.3165	3195	1000	20	1020	Recovery of a complete middle/late Miocene to Quaternary section which will allow to address hypothesis 2, the deepening and widening of the AAG. Recovery and dating of basement rocks will allow testing the current plate kinematic model (hypothesis 1).
FR-10A (Alternate)	77.1173 1.6345	3187	400	20	420	Recovery and dating of basement rocks will allow testing the current plate kinematic model (hypothesis 1).
FR-02A (Alternate)	77.2243 1.0292	3206	900	0	900	Recovery of a complete middle/late Miocene to Quaternary section which will allow to address hypotheses 2, the deepening and widening of the AAG.
FR-11A (Alternate)	76.4472 -0.6448	3091	800	0	800	Recovery of a complete middle/late Miocene to Quaternary section which will allow to address hypothesis 2, the deepening and widening of the AAG (Primary Site). Recovered drift deposits will enable high-resolution paleoceanographic studies on ocean circulation, sea-ice cover, deep-water formation and continental ice sheets.
FR-12A (Alternate)	76.9056 -2.1056	3058	800	0	800	Recovery of a complete middle/late Miocene to Quaternary section which will allow to address hypothesis 2, the deepening and widening of the AAG (Primary Site). Recovered drift deposits will enable high-resolution paleoceanographic studies on ocean circulation, sea-ice cover, deep-water formation and continental ice sheets.
FR-13A (Alternate)	76.9377 -2.3151	3012	800	0	800	Recovery of a complete middle/late Miocene to Quaternary section which will allow to address hypothesis 2, the deepening and widening of the AAG (Primary Site). Recovered drift deposits will enable high-resolution paleoceanographic studies on ocean circulation, sea-ice cover, deep-water formation and continental ice sheets.
FR-14A (Alternate)	76.4906 -0.0024	3171	800	0	800	Recovery of a complete middle/late Miocene to Quaternary section which will allow to address hypothesis 2, the deepening and widening of the AAG (Primary Site). Recovered drift deposits will enable high-resolution paleoceanographic studies on ocean circulation, sea-ice cover, deep-water formation and continental ice sheets.

Proposed Sites (Continued; total proposed sites: 19; pri: 4; alt: 15; N/S: 0)

Site Name	Position (Lat, Lon)	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
FR-15A (Alternate)	73.4006 -14.1015	2468	1300	20	1320	Recovery of a complete sediment sequence from Eocene to Quaternary and the top of the oceanic basement. This site will address hypotheses 1 (Initial opening of the AAG), 2 (Deepening and widening of the AAG), and 3 (Cryospheric evolution of the Northern Hemisphere), allowing the reconstruction of the complete transition from the isolated Arctic Ocean to the modern gateway and the relation of uplift and glaciations in East Greenland. The recovery of basement/magmatic rocks will allow to test the current plate-kinematic models.
FR-16A (Alternate)	73.2257 -14.2778	2464	1300	20	1320	Recovery of a complete sediment sequence from Eocene to Quaternary and the top of the oceanic basement. This site will address hypotheses 1 (Initial opening of the AAG), 2 (Deepening and widening of the AAG), and 3 (Cryospheric evolution of the Northern Hemisphere), allowing the reconstruction of the complete transition from the isolated Arctic Ocean to the modern gateway and the relation of uplift and glaciations in East Greenland. The recovery of basement/magmatic rocks will allow to test the current plate-kinematic models.
FR-17A (Alternate)	73.1662 -14.2056	2484	1300	20	1320	Recovery of a complete sediment sequence from Eocene to Quaternary and the top of the oceanic basement. This site will address hypotheses 1 (Initial opening of the AAG), 2 (Deepening and widening of the AAG), and 3 (Cryospheric evolution of the Northern Hemisphere), allowing the reconstruction of the complete transition from the isolated Arctic Ocean to the modern gateway and the relation of uplift and glaciations in East Greenland. The recovery of basement/magmatic rocks will allow to test the current plate-kinematic models.
FR-18A (Alternate)	73.2394 -13.7612	2561	1300	20	1320	Recovery of a complete sediment sequence from Eocene to Quaternary and the top of the oceanic basement. This site will address hypotheses 1 (Initial opening of the AAG), 2 (Deepening and widening of the AAG), and 3 (Cryospheric evolution of the Northern Hemisphere), allowing the reconstruction of the complete transition from the isolated Arctic Ocean to the modern gateway and the relation of uplift and glaciations in East Greenland. The recovery of basement/magmatic rocks will allow to test the current plate-kinematic models.
FR-19A (Alternate)	73.4605 -14.3375	2347	1300	20	1320	Recovery of a complete sediment sequence from Eocene to Quaternary and the top of the oceanic basement. This site will address hypotheses 1 (Initial opening of the AAG), 2 (Deepening and widening of the AAG), and 3 (Cryospheric evolution of the Northern Hemisphere), allowing the reconstruction of the complete transition from the isolated Arctic Ocean to the modern gateway and the relation of uplift and glaciations in East Greenland. The recovery of basement/magmatic rocks will allow to test the current plate-kinematic models.
FR-20A (Alternate)	74.7940 -8.5566	3288	1100	20	1120	Recovery of a complete sediment sequence from Eocene to Quaternary and the top of the oceanic basement. This site will address hypotheses 1 (Initial opening of the AAG), allowing the reconstruction of the complete transition from the isolated Arctic Ocean to the modern gateway.