IODP Proposal Cover Sheet

851 - Full

Cenozoic Western North Atlantic Transect

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Title	Cenozoic Evolution of the North Atlantic from Greenhouse to Icehouse—the Western North Atlantic Latitudinal and Paleobathymetric Transect (WNAT)
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Abstract

We propose the Western North Atlantic latitudinal (33°N to 53°N) and paleobathymetric (~2500-4500 m) Transect (WNAT) of 4 primary sites to evaluate the role of the North Atlantic in global climate change. We will reconstruct the Cenozoic evolution of North Atlantic surface (subtropical and subpolar gyres), thermocline, and deep water (Northern Component Water [NCW]) circulation. We hypothesize that the Gulf Stream-North Atlantic Current (GS-NAC) and NCW played the key role in interhemispheric heat transfer and warmth in some intervals (e.g., middle Miocene to early Pliocene), but contributed negligibly during others (e.g., the middle Eocene cooling). We particularly are interested in evaluating the role of North Atlantic driven circulation in decoupling the glacial histories of Antarctica (at the Eocene/Oligocene Transition; EOT ~34 Ma) and northern hemisphere glaciation (NHG~ 2.7 Ma). The transect will also evaluate how the Miocene closure of both the Tethys and Central American Seaways affected circulation, how changing tectonics and greenhouse gas levels affected the initiation and development of NCW, and how changes in deep circulation in the North Atlantic have affected the global carbon cycle. We target Eocene to Miocene sections at all sites at Milankovitch resolution; Plio-Pleistocene sections will also be sampled at all sites and Paleocene at WNAT-1. Sea surface and thermocline changes will be evaluated across the GS-NAC to the subpolar gyre through time. Benthic foraminiferal isotopic and assemblage records will monitor Antarctic-derived bottom waters versus NCW and seismic stratigraphic record calibrated to the core and grain size will document variations in NCW flow. Stable isotopes, Mg/Ca, and organic paleothermometers will be used to reconstruct hydrographic changes in surface and thermocline temperature/salinity as means of relating climate variations to water mass exchange/ circulation, and sources. The sites are located on the western edge of the Mid-Atlantic Ridge above the level of turbidite deposition and will avoid erosional intervals found under high current regimes along the North American margin. Past drilling shows that excellent magnetochronology can be accessed from WNAT sediments to develop robust age models and important ties with biostratigraphy. Coupled with drilling at the Newfoundland margin, it should be possible to determine both the timing and strength of GS-NAC flow and NCW production through time. An ancillary objective is to better intercalibrate the paleomagnetic time scale, biostratigraphy, and regional North Atlantic climate events. Drill sites will be used to continue reconnaissance of pore water geochemistry and deep biosphere microbial diversity.

Scientific Objectives

We will document Cenozoic North Atlantic paleoceanography, focusing on the late Eocene-Miocene, on a latitudinal (33°- 53°N) and paleobathymetric (~2500-4500m) transect with orbital-scale resolution. We will reconstruct surface, thermocline, and deep-water changes to evaluate the overarching hypothesis that variations in GS-NAC and NCW were prime contributors to the divergent Cenozoic glacial histories of southern and northern hemispheres, emphasizing these hypotheses:

1) Since 34 Ma, the North Atlantic exerted a strong effect on global climate through GS-NAC and NCW, responding to changes in northern sill depth, Arctic passageways, and climatic feedbacks.
2) NCW and attendant GS-NAC flux had varying effects on global climate, but played major role in the change from a unipolar Icehouse at 34 Ma to bipolar one at 2.7 Ma.
3) A modern vertical density, nutrient, and O_2 structure began to develop in the Oligocene due to North Atlantic cooling and increased NCW.
4) The depth of the CCD in the Atlantic reflects primarily ventilation rates related to NCW supply.
5) Variations in NCW production have contributed to orbital-scale climate through their influence on heat transfer and carbon storage over the past 34 Myr, with increasing influence in the Pleistocene.

In summary, we posit that the North Atlantic had progressively greater influence on global climate with the closing of low latitude and opening of high-latitude passageways. We address all 4 challenges of the Climate and Ocean Change theme of the science plan, particularly the response to elevated CO_2 (Challenge 1) and ocean resiliency to chemical perturbations (Challenge 4).

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

None

Proposed Sites (Total proposed sites: 10; pri: 4; alt: 6; N/S: 0)

Site Name	Position (Lat, Lon)	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
WNAT-01A (Primary)	33.8394 -49.2402	4826	625	0	625	(1) Continuous Milankovitch resolving sediment section from Late Cretaceous to Recent from the Sargasso Sea (2) Surface water properties of the Sargasso Sea for the Cenozoic (SST, SSS, nutrients) (3) Deep water provenance and water mass properties in the western Atlantic Basin for the Cenozoic (4) CCD change over the Cenozoic and relationship to changes in Atlantic Ocean connections (5) Collect magnetochronology and biostratigraphy to construct an age model for sedimentation
WNAT-02A (Primary)	38.2732 -38.3909	3815	546	0	546	(1) Continuous Milankovitch resolving sediment section from Eocene to Recent from the southern edge of the GS-NAC (2) Monitor surface water properties of the northern gyre and GS-NAC from the middle Eocene to present. (3) Monitor deep water properties and provenance to determine how Eocene intervals of NCW were formed. (4) Evaluate carbonate burial at an intermediate water depth, Eocene to Holocene,
WNAT-04A (Primary)	43.7213 -37.5705	3945	620	0	620	WNAT-04A is on 55 Ma crust but there is insufficient time to drill to basement. Nevertheless drilling here will penetrate the Eocene/ Oligocene boundary and from Eocene to Holocene: (1) Monitor penetration of GS-NAC into the subarctic gyre region. (2) Monitor water properties of regional bottom water (3) Identify changes in paleoproduction and plankton community (4) Use magnetochronology and biostratigraphy to construct an age model for sedimentation (5) Identify and date transition from coherent seismic horizons to incoherent reflections
WNAT-06A (Primary)	53.0147 -41.8091	3579	620	0	620	WNAT-06A, sited on 37 Ma crust, will drill a section to cross the Eocene/Oligocene transition. Objectives are, from Eocene to Holocene: (1) Monitor change in surface water properties of the subarctic Atlantic gyre (2) Monitor water properties of regional bottom water (3) Identify changes in paleoproduction and plankton community (4) Use magnetochronology and biostratigraphy to construct an age model for sedimentation (4) Identify and date transition from coherent seismic horizons to incoherent reflections
WNAT-03A (Alternate)	41.4655 -36.7441	4193	636	0	636	WNAT-03A is on 52 Ma crust; Objectives are, from Eocene to Recent: (1) Monitor changes in surface water properties along the northern GS-NAC and southern Atlantic subpolar gyre. (2) Monitor water properties of regional bottom water (3) Identify changes in paleoproduction and plankton community (4) Monitor changes in carbonate preservation/CCD (5) Use magnetochronology and biostratigraphy to construct an age model for sedimentation (6) Identify and date transition from coherent seismic horizons to incoherent reflections
WNAT-11A (Alternate)	33.8944 -49.2399	4893	611	0	611	(1) Continuous Milankovitch resolving sediment section from Late Cretaceous to Recent from the Sargasso Sea (2) Surface water properties of the Sargasso Sea for the Cenozoic (SST, SSS, nutrients) (3) Deep water provenance and water mass properties in the western Atlantic Basin for the Cenozoic (4) CCD change over the Cenozoic and relationship to changes in Atlantic Ocean connections (5) Collect magnetochronology and biostratigraphy to construct an age model for sedimentation

Proposed Sites (Continued; total proposed sites: 10; pri: 4; alt: 6; N/S: 0)

Site Name	Position (Lat, Lon)	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
WNAT-12A (Alternate)	33.8389 -49.3066	4911	626	0	626	(1) Continuous Milankovitch resolving sediment section from Late Cretaceous to Recent from the Sargasso Sea (2) Surface water properties of the Sargasso Sea for the Cenozoic (SST, SSS, nutrients) (3) Deep water provenance and water mass properties in the western Atlantic Basin for the Cenozoic (4) CCD change over the Cenozoic and relationship to changes in Atlantic Ocean connections (5) Collect magnetochronology and biostratigraphy to construct an age model for sedimentation
WNAT-21A (Alternate)	38.1979 -38.3940	3705	540	0	540	Alternate Site for WNAT-02A. Objectives are: (1) Continuous Milankovitch resolving sediment section from Eocene to Recent from the Southern GS-NAC (2) Surface water properties for the Cenozoic (SST, SSS, nutrients) (3) Deep water provenance and water mass properties in the western Atlantic Basin for the Cenozoic (4) CCD change over the Cenozoic and relationship to changes in Atlantic Ocean connections (5) Collect magnetochronology and biostratigraphy to construct an age model for sedimentation
WNAT-41A (Alternate)	43.7210 -37.3329	3961	620	0	620	WNAT-41A has a thick young section.Drilling to 620 m will likely not get to the EOT. For Oligocene to Recent: (1) Monitor penetration of GS-NAC into the subarctic gyre region. (2) Monitor water properties of regional bottom water (3) Identify changes in paleoproduction and plankton community (4) Use magnetochronology and biostratigraphy to construct an age model for sedimentation (5) Identify and date transition from coherent seismic horizons to incoherent reflections
WNAT-61A (Alternate)	53.2819 -41.4757	3379	620	0	620	WNAT-61A, sited on 37 Ma crust, is an alternate to WNAT-06A, with a thick Neogene section. Likely base of hole at 620 m is early Miocene: (1) Monitor change in surface water properties of the subarctic Atlantic gyre (2) Monitor water properties of regional bottom water (3) Identify changes in paleoproduction and plankton community (4) Use magnetochronology and biostratigraphy to construct an age model for sedimentation (4) Identify and date transition from coherent seismic horizons to incoherent reflections