IODP Proposal Cover Sheet

944 - Full 2

Mid-Norwegian Continental Margin Magmatism

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Title	The Nature, Cause and Climate Implications of Excess Magmatism During the Northeast Atlantic Continental Breakup
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Area	Vøring and Møre margins

Proponent Information

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Abstract

The NE Atlantic conjugate passive margins are characterized by extensive break-up related magmatic products including extrusive basalt lava flows and volcanogenic sediments, shallow intrusive complexes emplaced within marginal sedimentary basins, and deep magmatic underplating at the base of the crust. The volume of generated magma cannot be explained by passive decompression melting of sub-lithospheric mantle with a normal mantle temperature. Competing geodynamic end-member hypotheses exist for the formation of this excess magmatism: 1) elevated mantle potential temperatures associated with mantle plume processes, 2) enhanced material flux through the melt window during rifting caused by small-scale convection at the base of the lithosphere, and 3) mantle source heterogeneity which may contribute to anomalously high melt production during continental breakup. While we have unsurpassed constraints on crustal structure of the Norwegian-Jan Mayen-Greenland conjugate rifted margins, the relative importance of hypothesized mechanisms responsible for excess magmatic productivity remains unresolved. Voluminous magmatism also coincides with global greenhouse (hot) climate in the early Paleogene and, via various mechanisms (e.g. magmatic volatile release; sill-induced gas generation from organic rich sediments and released to the atmosphere via hydrothermal vents etc.), proposed as a driver of both short-term (Paleocene-Eocene Thermal Maximum) and long-term (early Eocene Climate Optimum) global warming. However, the timing of the magmatism is not sufficiently constrained to test the proposed mechanisms or to evaluate volcanic and gas fluxes. Improved constraints on melting conditions, timing of magmatism, magmatic fluxes in time and space, eruption environment, sedimentary proxy data, and relative timing of climate events are required to resolve these linked controversies. Systematic IODP drilling is the only way to provide these constraints and the proposed drilling effort will provide a quantitatively testable framework for volcanic rifted margin formation and consequences for global climate. New 3D seismic data collected by the hydrocarbon industry during the past decade have provided unique insights into the nature and distribution of both the volcanic and sub-basalt sequences along the margin, enabling the identification of optimal drill sites. To meet our objectives, volcanic and sedimentary sequences are targeted in a series of boreholes along and across the Mid-Norwegian margin. The targeted material is essential in achieving our primary goals: testing the end-member models for the formation of excess magmatism during continental breakup and testing the influence of tectonic and magmatic events on Paleogene global climate.

Scientific Objectives

The primary objectives of drilling the Vøring and Møre volcanic margins sections are:
• To determine the conditions of mantle melting (e.g. mantle sources, temperature, pressure, degree of melting).
• To determine spatial and temporal variations in along axis volcanic fluxes in order to test predictions made by fundamentally different geodynamic models for volcanic rifted margin formation including segmentation.
• To determine variations in the depositional environment (sub-aerial vs sub-marine) of inner and outer lava flows (e.g. seaward dipping reflectors) in order to test correlations between magma genesis and dynamic thermal support during late syn-rift, break-up, and early post-rift oceanic spreading.
• To assess the temporal evolution of the styles of volcanic and magmatic activity in relation to paleoclimate proxies to test the relationship between large-scale volcanism and climate change events.
• To investigate the relative importance environmental consequences of two key processes during the initial opening of the North Atlantic: Direct volcanic degassing and explosive thermogenic release through hydrothermal vent complexes from contact metamorphism.

The proposal will also address two important secondary objectives mainly resulting from recovered sedimentary archives:
• Early Eocene hot-house and fresh water incursions into the Atlantic
• Carbon capture and storage in basalt provinces

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

None

944 - Full 2

Proposed Sites (Total proposed sites: 26; pri: 9; alt: 17; N/S: 0)

Site Name	Position (Lat, Lon)	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
VMVM-20A (Primary)	64.9630 002.7518	2077	200	0	200	The main site objective is to sample sub-basalt sediments of unknown age on the Kolga High to characterize pre-eruption environment.
VMVM-21A (Alternate)	64.9578 002.7488	2078	200	0	200	The main site objective is to sample sub-basalt sediments of unknown age on the Kolga High to characterize pre-eruption environment.
VMVM-22A (Alternate)	64.9449 002.7889	2017	200	0	200	The main site objective is to sample sub-basalt sediments of unknown age on the Kolga High to characterize pre-eruption environment.
VMVM-23A (Primary)	64.9651 002.7312	2137	25	175	200	The main target of this site is emerget basalts, intra-basalt sediments, and the base-basalt contact for geochemical, volcanological, and geochronological studies.
VMVM-24A (Alternate)	64.9599 002.7282	2145	30	170	200	The main target of this site is emerget basalts, intra-basalt sediments, and the base-basalt contact for geochemical, volcanological, and geochronological studies.
VMVM-25A (Alternate)	64.9515 002.7235	2160	25	175	200	The main target of this site is emerget basalts, intra-basalt sediments, and the base-basalt contact for geochemical, volcanological, and geochronological studies.
VMVM-31A (Primary)	65.3645 003.0563	1707	200	0	200	The primary objective of the site is to drill Paleocene-Eocene sediments for lithological, geochemical and geochronolgical characterization.
VMVM-32A (Alternate)	65.3717 003.0605	1695	200	0	200	The primary objective of the site is to drill Paleocene-Eocene sediments for lithological, geochemical and geochronolgical characterization.
VMVM-33A (Alternate)	65.4065 003.0947	1673	200	0	200	The primary objective of the site is to drill Paleocene-Eocene sediments for lithological, geochemical and geochronolgical characterization.
VMVM-40A (Primary)	65.3584 003.0528	1696	200	0	200	The primary objective for this site is to drill the central part of a hydrothermal vent complex, including the base of the eye structure, to determine the lithology, age, and nature of the vent complexes.
VMVM-41A (Alternate)	65.3762 003.0632	1686	200	0	200	The primary objective for this site is to drill the central part of a hydrothermal vent complex, including the base of the eye structure, to determine the lithology, age, and nature of the vent complexes.
VMVM-42A (Alternate)	65.4086 003.0735	1695	200	0	200	The primary objective for this site is to drill the central part of a hydrothermal vent complex, including the base of the eye structure, to determine the lithology, age, and nature of the vent complexes.
VMVM-50A (Primary)	65.8311 002.0111	2195	800	0	800	The primary objective is to drill hole of 800 m to obtain an extended sedimentary sequence across the Paleocene-Eocene boundary for paleoclimate studies.
VMVM-51A (Alternate)	65.8735 001.9606	2147	800	0	800	The primary objective is to drill hole of 800 m to obtain an extended sedimentary sequence across the Paleocene-Eocene boundary for paleoclimate studies.
VMVM-55A (Alternate)	65.8310 002.0096	2197	200	0	200	The primary objective is to drill hole of 200 m to obtain an extended sedimentary sequence across the Paleocene-Eocene boundary for paleoclimate studies.
VMVM-56A (Alternate)	65.8303 001.9928	2220	200	0	200	The primary objective is to drill hole of 200 m to obtain an extended sedimentary sequence across the Paleocene-Eocene boundary for paleoclimate studies.
VMVM-57A (Alternate)	65.8296 001.9782	2245	200	0	200	The primary objective is to drill hole of 200 m to obtain an extended sedimentary sequence across the Paleocene-Eocene boundary for paleoclimate studies.
VMVM-58A (Alternate)	65.8290 001.9637	2271	200	0	200	The primary objective is to drill hole of 200 m to obtain an extended sedimentary sequence across the Paleocene-Eocene boundary for paleoclimate studies.
VMVM-61A (Primary)	67.3069 003.7396	1200	125	115	240	The primary objective is to sample basalt flows of the subaerial and faulted Landward Flow unit (Sequence 1) to obtain volcanic facies, geochemistry, and geochronology.
VMVM-62A (Alternate)	67.2893 003.6779	1198	115	115	230	The primary objective is to sample basalt flows of the subaerial and faulted Landward Flow unit (Sequence 1) to obtain volcanic facies, geochemistry, and geochronology.
VMVM-07A (Primary)	67.3310 03.6215	1206	220	100	320	The primary objective of the site is to sample basalt flows in the uppermost part of the SDR (Sequence 2) with a pitted surface (likely sub-acqueous), and if possible, reach the Sequence 1 - Sequence 2 boundary, for facies, geochemistry, and geochronology.

Proposed Sites (Continued; total proposed sites: 26; pri: 9; alt: 17; N/S: 0)

Site Name	Position (Lat, Lon)	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
VMVM-71A (Alternate)	67.3386 003.6967	1200	195	105	300	The primary objective of the site is to sample basalt flows in the uppermost part of the SDR (Sequence 2) with a pitted surface (likely sub-acqueous), and if possible, reach the Sequence 1 - Sequence 2 boundary, for facies, geochemistry, and geochronology.
VMVM-80A (Primary)	68.6004 004.6428	2864	210	100	310	The primary objective is to sample volcaniclastic sediments and possibly basalt of the Outer High, to determine volcanic facies and age.
VMVM-81A (Alternate)	68.6266 004.5848	2913	55	145	200	The primary objective is to sample volcaniclastic sediments and possibly basalt of the Outer High, to determine volcanic facies and age.
VMVM-09A (Primary)	68.7605 05.7971	3156	450	100	550	The primary objective is to sample basalt in old oceanic crust associated with the Outer SDR for volcanic facies, geochemistry and geochronology
VMVM-10B (Alternate)	68.8306 004.1306	3237	650	100	750	Alternate site for VMVM-9A. The key objective of the site is to sample old basalt associated with initial age.