IODP Proposal Cover Sheet

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Reykjanes Mantle Convection

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Title	Mantle Dynamics, Paleoceanography and Climate Evolution in the North Atlantic Ocean
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Area	Iceland Basin

Proponent Information

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Abstract

The intersection between the Mid-Atlantic Ridge and Iceland hotspot provides us with a natural laboratory where the composition and dynamics of Earth's upper mantle can be observed. Plume-ridge interaction drives variations in the melting regime, resulting in a range of crustal types including a series of V-shaped ridges and troughs south of Iceland. Time-dependent mantle upwelling beneath Iceland dynamically supports regional bathymetry, leading to changes in the height of oceanic gateways which control the strength of deep-water flow over geologic timescales. We propose a drilling program that contains three objectives: (1) to test contrasting hypotheses for the formation of V-shaped ridges; (2) to understand temporal changes in ocean circulation, and explore connections with plume activity; (3) to reconstruct the evolving chemistry of hydrothermal fluids with increasing crustal age, varying sediment thickness and crustal architecture. This drilling program will recover basaltic samples from crust that is blanketed by thick sediments and is thus inaccessible with dredging. Major, trace and isotope geochemistry of basalts will allow us to observe spatial and temporal variations in mantle melting processes. We will test the hypothesis that the Iceland plume thermally pulses on two timescales (5-10 Ma, and ~30 Ma), leading to fundamental changes in crustal architecture. This idea will be tested against alternative hypotheses involving propagating rifts and buoyant mantle upwelling. Millennial-scale paleoclimate records are contained within rapidly accumulated sediments of contourite drifts in this region. The accumulation rate of these sediments is a proxy for current strength, which is moderated by dynamic support of oceanic gateways such as the Greenland-Scotland Ridge. These sediments also provide constraints for climatic events including Pliocene warmth, the onset of Northern Hemisphere Glaciation and abrupt Late Pleistocene climate change. Our combined approach will explore relationships between deep Earth processes, ocean circulation and climate. Our objectives can only be addressed by recovering sedimentary and basaltic cores, and we plan to penetrate 200 m into igneous basement at five sites east of Reykjanes Ridge. Four sites intersect V-shaped ridges/troughs pairs, one of which coincides with Bjorn Drift. A fifth site is located over 32.4 Ma oceanic crust devoid of V-shaped features, chosen to intersect Oligo-Miocene sediments of Gardar Drift. Sediments and basalts recovered during this program will provide a major advance in our understanding of mantle dynamics, and of the coupled nature of Earth's deep and surfical domains.

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Scientific Objectives

Objective 1: Crustal Accretion and Mantle Plume Behavior
We will use the composition of drilled basalts to understand crustal formation south of Iceland at two temporal scales. On 5-10 Ma timescales we will test three hypotheses for V-shaped ridge formation: 1) thermal pulsing; 2) propagating rifts; and 3) buoyant mantle upwelling. These models predict differing depths, temperatures and degrees of melting between V-shaped ridges and troughs, expected to be reflected in basalt composition. On 30-40 Ma timescales, we aim to test the controls on crustal architecture by comparing basalts from smooth and fractured seafloor types, which are thought to arise from different melting regimes relating to plume activity.

Objective 2: Ocean Circulation and Sedimentation
We plan to quantify how oceanic circulation in the North Atlantic Ocean has varied since Oligocene times. These observations will allow us to test the hypothesis that deep-water flow in the North Atlantic Ocean has been moderated by transient activity of the Iceland mantle plume. This program will extend the high-resolution climate record into late Pliocene times. Thus, we aim to evaluate both the millennial- and million-year scale variability in Neogene climate during important intervals when temperatures were warmer than today.

Objective 3: Time-Dependent Hydrothermal Alteration of Oceanic Crust
We will investigate the nature, extent, timing and duration of hydrothermal alteration within the upper Reykjanes Ridge flank. Drilling will enable us to quantify the timing and extent of hydrothermal fluid-rock exchange, to assess the hydrothermal contributions from a rapidly sedimented slow-spreading ridge flank to global geochemical budgets.

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

None

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Proposed Sites (Total proposed sites: 12; pri: 5; alt: 7; N/S: 0)

Site Name	Position (Lat, Lon)	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
REYK-13A (Primary)	60.2281 -28.5004	1520	210	200	410	Sample ~200 m of basalt at V-shaped trough 1. Primary site.
REYK-11A (Primary)	60.2000 -28.0000	1415	340	200	540	Sample ~200 m of basalt at V-shaped ridge 2a. Primary site.
REYK-6A (Primary)	60.1251 -26.7016	1871	705	200	905	Obtain continuous stratigraphic section through Bjorn Drift, then sample ~200 m of basaltic crust at V-shaped trough 2b. Primary site.
REYK-4A (Primary)	60.0992 -26.4436	2110	185	200	385	Sample ~200 m of basalt at V-shaped ridge 3. Primary site.
REYK-2A (Primary)	59.8506 -23.2664	2206	970	200	1170	Obtain continuous stratigraphic section through Gardar Drift, then sample ~200 m of basaltic rocks from the rough crustal domain. Primary site.
REYK-7A (Alternate)	60.1507 -27.1698	1735	330	200	530	Sample ~200 m of basalt at V-shaped ridge 2b. Alternate site.
REYK-9A (Alternate)	60.1702 -27.5310	1701	310	200	510	Sample ~200 m of basalt at V-shaped trough 2a. Alternate site.
REYK-1A (Alternate)	59.8496 -23.2473	2209	955	200	1155	Obtain continuous stratigraphic section through Gardar Drift, then sample ~200 m of basaltic rocks from the fractured crustal domain. Alternate site.
REYK-3A (Alternate)	60.0989 -26.4404	2110	205	200	405	Sample ~200 m of basalt at V-shaped ridge 3. Alternate site.
REYK-5A (Alternate)	60.1264 -26.7516	1894	675	200	875	Obtain continuous stratigraphic section through Bjorn Drift, then sample ~200 m of basaltic crust at V-shaped trough 2b. Alternate site.
REYK-8A (Alternate)	60.1491 -27.1370	1695	320	200	520	Sample ~200 m of basalt at V-shaped ridge 2b. Alternate site.
REYK-10A (Alternate)	60.1667 -27.4726	1689	155	200	355	Sample ~200 m of basalt at V-shaped trough 2a. Alternate site.