IODP Proposal Cover Sheet

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North Iceland Rift Propagation

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Title	Rift propagation north of Iceland: A case of asymmetric plume dynamics?
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Abstract

The overarching mission of this proposal is to improve the understanding of bi-modal compositions recorded globally in mantle plumes. Drilling is required in order to obtain crustal samples for determining mantle characteristics essential for constraining geodynamic modeling and the hypothesized origin of mantle plumes from Large Low Shear Velocity Provinces (LLSVP) at the core-mantle boundary. Crust generated by a plume-ridge centered system offers unique opportunities for tracing plume compositions in both time and space, which significantly can improve numerical modeling of plume dynamics. The interaction of the Iceland Plume with the spreading system in the Northeast Atlantic has been active since continental breakup (~55 Ma). However, generating a distinct south-north asymmetry in crustal thickness inconsistent with an axi-symmetric plume. Intriguingly, present-day compositional trends mirror this crustal asymmetry, showing a distinct shift from enriched compositions in the south and in Iceland to depleted compositions north of Iceland. Crustal accretion north of Iceland experienced phases of rift propagation correlated with a northward retreat (~50-25 Ma) of spreading along the Ægir Ridge, the formation of the Kolbeinsey Ridge (~25 Ma), and transform faulting north of Iceland (~10 Ma). This development may suggest two end-member hypotheses: (i) present-day crustal asymmetry reflects an intrinsic bilateral plume structure that persisted during variable lithospheric settings and eventually were dynamically separated; or (ii) current tectonic setting favors melting processes focusing depleted mantle towards the north. The difference between these two hypotheses ultimately relates to degree of mixing between plume components and to plume dynamics. A transect of drill-sites, constraining the age and compositional characteristics of the crust generated during the different tectonic stages, will test these hypotheses by modeling of the different scenarios established by new data. The proposed drilling transect will also address a key tectonic objective not explored before by ocean drilling: Rift propagation within paired and overlapping rifts. This process tore off a continental sliver from Greenland that now forms the Jan Mayen microcontinent in the middle of the Northeast Atlantic ocean, a globally important topic (e.g., “Mauritia” and the Réunion plume) that is hypothesized to even apply to parts of the Icelandic lithosphere. Our primary objectives are key to IODP theme ‘Earth Connections’ of the IODP Science Plan. Our secondary objectives focus on the transition into the ice-house world during the Oligocene and variability in sea-surface temperature and ice-cover during the Plio-Pleistocene, and will contribute to theme ‘Climate and Ocean Change’.

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Scientific Objectives

The scientific objective is an overarching mission to improve the understanding of the origin, nature and dynamics of deep-seated mantle plumes hypothesized to be rooted in the Large Low Shear Velocity Province (LLSVP) located below Africa at the core-mantle boundary, and by this contribute to the understanding of the compositional structure of the LLSVP.

The scientific strategy for making contributions to this broad topic hinges on three primary objectives:

• Establish the temporal evolution of the mantle sourcing the formation of the Iceland Plateau from 50 Ma to 20 Ma, bench-mark this against the mantle compositions observed today along the spreading south of, in and north of Iceland

• Constrain the tectonic evolution of the paired extensional system operating north of the Iceland plume between 50 – 25 Ma and rifting off a continental sliver from the Greenland Margin. Thus, to examine the interaction between mantle plume and continental lithospheric mantle recorded in crustal compositions, and therefore assist model constrains for formation of microcontinents including their potential presence within south-east Iceland.

• Establish temporal and spatial changes in mantle composition and temperature to perform geodynamic modelling that commensurates with the history of the tectonic evolution established by drilling and the broader regional setting.

Secondary objectives include:

• Sampling of the sub-Arctic Oligocene record of transition into the ice-house world within an important conduit for Atlantic-Arctic oceanic exchange.

• Plio-Pleistocene evolution in sea-surface temperature and ice-cover in a region prone to record these, and a locus of deep-water formation representing the Northern edge of the Atlantic Meridional Overturning Circulation.

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

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Proposed Sites (Total proposed sites: 13; pri: 6; alt: 7; N/S: 0)

Site Name	Position (Lat, Lon)	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
IPII-01B (Primary)	67.61727028 -8.75158581	1583	837	100	937	The IPR-II axial rift target is the objective that intersected IPR-I to SDRs and plateau basalt equivalent sections. Primary sampling for the igneous section for geochronological, geochemical, and volcanological studies. Secondary sampling for sediments for paleo-environment and subsidance history.
IPIII-03A (Primary)	67.57133108 -10.68247975	1777	485	100	585	This site targets the rift valley flood basalts of IRP-III phase at the northern extent of the Jan Mayen Trough volcanic zone. Primary objectives are the sampling for geochemical and geochronological studies and volcanological interpretations. The sediment cover would tie into the the paleo-environment and subsidance history for the northernmot end of the Jan Mayen Trough.
IPIII-01A (Primary)	67.798970 -9.848865	1766	719	100	819	This site targets the rift valley flood basalts of IRP-III phase within a clear separation area between the last two visible SRC blocks of the JMMC within the Jan Mayen Trough volcanic zone. The igneous section is the primary target for geochronological, geochemical, and volcanological studies.
IPIV-02A (Primary)	69.464838 -9.858744	2170	394	100	494	Target flood basalts of rifting stage IPR-IV that overlays the TPU unconformity and IPR-III flood basalts of the Jan Mayen Trough to the east of the proposed site. Sampling is aimed for geochemical and geochronological studies and volcanological interpretations to compare these to the Kolbeinsey Ridge samples and potential influence of the distal Iceland plume. The paleo-environmental and subsidance history study would require sediment sampling and bistratigraphic analysis.
PKR-02A (Primary)	69.27684435 -10.6849484	1708	829	100	929	Targeting the imidiate transition from IPR-IV rifting stage into spreading along the Proto-Kolbeinsey Ridge along the outer western magmatic margin of the Jan Mayne Basin. Sampling the igneous section for difference in plume influence vs. mid-oceanic ridge basalts by detailed geochemical, age and petrographic analysis.
KR-01A (Primary)	69.2497 -12.6983	1811	647	100	747	Kolbeinsey Ridge controle site. Sampling the igneous section for mid-oceanic ridge basalts by detailed geochemical, age and petrographic analysis.
IPIV-01A (Alternate)	67.586210 -12.253577	1766	339	100	439	Target flood basalts of rifting stage IPR-IV that overlays the TPU unconformity and IPR-III flood basalts of the Jan Mayen Trough to the east of the proposed site. Sampling is aimed for geochemical and geochronological studies and volcanological interpretations to compare these to the Kolbeinsey Ridge samples and potential influence of the proximal Iceland plume.
SRCT-01A (Alternate)	68.149742 -8.472475	1534	430	0	430	Target the unconformity between deformed and non-deformed sediments within SRC syncline. Testing termination of transpressive faulting within the SRC of the JMMC and the complete rift propagation to the Kolbeinsey Ridge by detailed sediment biostratigraphic dating and paleo-environment analysis.
IPIII-02A (Alternate)	68.649419 -8.189013	2037	487	100	587	This site targets the rift valley flood basalts of IRP-III phase at the northern extent of the Jan Mayen Trough volcanic zone. Primary objectives are the sampling for geochemical and geochronological studies and volcanological interpretations. The sediment cover would tie into the the paleo-environment and subsidance history for the northernmot end of the Jan Mayen Trough.
IPI-01A (Alternate)	67.055214 -8.307984	1295	426	100	526	Target the southeastern IPR-I igneous margin of extensive and progressively younger lava plateaus covering the SDRs and plateau basalt equivalent. Sample igneous section for geochronological, geochemical, and volcanological studies. Reoccupation of Site 350 of DSDP Leg 38, that drilled 3 cores into basement by loosing 1 core and 43% recovery for the remaining 2 cores.
PKR-01B (Alternate)	69.684462 -10.410205	1899	532	100	632	Target the immediate transition from IPR-IV rifting stage into spreading along the Kolbeinsey Ridge along the outer western magmatic margin of the Jan Mayne Basin. Sampling the igneous section for difference in plume influence vs. mip-oceanic ridge basalts by detailed geochemical, age and petrographic analysis.

Proposed Sites (Continued; total proposed sites: 13; pri: 6; alt: 7; N/S: 0)

Site Name	Position (Lat, Lon)	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
IPII-01A (Alternate)	67.620958 -8.770894	1530	0	0	0	The IPR-II axial rift target is the objective that intersected IPR-I to SDRs and plateau basalt equivalent sections. Primary sampling for the igneous section for geochronological, geochemical, and volcanological studies. Secondary sampling for sediments for paleo-environment and subsidance history. Site was moved to IPII-01B.
PKR-01A (Alternate)	69.684629 -10.397698	1852	0	0	0	Target the immediate transition from IPR-IV rifting stage into spreading along the Kolbeinsey Ridge along the outer western magmatic margin of the Jan Mayne Basin. Sampling the igneous section for difference in plume influence vs. mip-oceanic ridge basalts by detailed geochemical, age and petrographic analysis. Site was moved to PKR-01B.