IODP Proposal Cover Sheet

890 - Full

Walvis Ridge Hotspot

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Title	Drilling Walvis Ridge, Southeast Atlantic Ocean, to Test Models of Ridge-Hotspot Interaction, Isotopic Zonation, and the Hotspot Reference Frame
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Area	South Atlantic

Proponent Information

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Abstract

Walvis Ridge (WR) is a long-lived hotspot trail that began with a ~132 Ma continental flood basalt at the opening of the South Atlantic Ocean. It stretches ~3300 km to the active volcanoes Tristan and Gough, and is paired with the Rio Grande Rise (RGR) oceanic plateau. Because of its duration and volcanic expression it is the most influential of Atlantic hotspots and is thought to have a deep mantle plume source, which can be projected to the edge of the African large low shear wave velocity province (LLSVP), a hypothesized plume generation zone. The hotspot displays long-lived (~70 Ma) isotopic zonation, a characteristic thought to originate at the LLSVP edge, and may be the first known triple-zoned plume. After erupting as a narrow ridge with a small range of isotopic ratios for ~60 Myr, it split into three seamount chains with distinct isotopic ratios at 60-70 Ma and has remained zoned since. The hotspot interacted with the Mid-Atlantic Ridge (MAR) for most of its early history, producing both the WR and RGR near the MAR before moving beneath the African plate at about the same time it became zoned. Valdivia Bank, a WR plateau paired with the main RGR, represents the maximum hotspot output and may have formed with RGR around a microplate. These complexities are a challenge for simple plume models and raise questions about the geodynamic implications of this hotspot trail. We propose to core at six locations on WR to recover successions of basaltic lava flows along the older portion of the ridge (~60, ~85, ~110 Ma) to test hypotheses about mantle plume zonation, hotspot drift, and WR formation. Samples will show the evolution of the geochemical and isotopic signature as the plume became zoned, giving important clues about changes in the composition of the plume source and testing the hypothesis that the plume base drifted across the LLSVP edge. Isotopic dating will show the progression of volcanism both at individual sites and along the ridge, testing whether the WR formed as a strictly age-progressive hotspot track, and whether Valdivia Bank formed as a plume pulse or extended volcanism around a microplate. Cored samples can test the hypothesis that Valdivia Bank and RGR are continental fragments. Paleomagnetic data from the WR will trace paleolatitude changes of the hotspot, testing whether hotspot drift or true polar wander (or both) better explain changes in paleolatitude.

Scientific Objectives

This project seeks to understand the origin and geodynamic significance of the Walvis Ridge. Primary questions are whether the chain split and isotopic zonation are consistent with magma sourced at the LLSVP edge and what are implications for the plume generation zone? - whether the chain is strictly age-progressive, or whether there were plume pulses, microplates, or continental fragments involved? - and what do expected large shifts in paleolatitude tell about the fixity and geodynamics of the hotspot? The project will use the JOIDES Resolution to core basaltic lava flows from six sites, with the goal of obtaining 50-100 m of lava flows at 4 sites (VB-1B, VB-4B, GT-1B, CT-3A) and ~250 m at two deep-penetration sites (FR-1B, TT-1A). Basalt samples will be analyzed to document the geochemical and isotopic evolution of Walvis Ridge, especially the division into three distinct isotopic zones after ~60-70 Ma. Sites TT-1A, CT-3A, and GT-1B form a transect across ridges that define the isotopic zones and may represent divisions of the plume generation zone at the edge of the LLSVP. High-precision geochronology from igneous samples at all sites, but especially VB-1B and VB-4B, will test models of ridge-hotspot interaction, including a microplate model, and examine the duration of volcanism at individual sites and further document the age progression. Paleomagnetic measurements on igneous samples will constrain paleolatitude changes of seamounts along Walvis Ridge, allowing more rigorous testing of models of hotspot motion and true polar wander.

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

none

Proposed Sites (Total proposed sites: 16; pri: 6; alt: 10; N/S: 0)

Site Name	Position (Lat, Lon)	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
CT-1A (Alternate)	-32.4875 -0.1466	1953	486	100	586	Coring of seamount basalts for measurement of age, geochemistry, isotopic chemistry, and paleolatitude. Determination of "Center Track" seamount geochemical signature and age.
CT-2A (Alternate)	-32.6080 0.0056	1588	659	100	759	Core basaltic basement rocks for geochemical and isotopic characterization, age, and paleolatitude measurement. Determine geochemical signature and age of "Center Track" guyots.
CT-3A (Primary)	-32.6489 0.0570	1796	399	100	499	Core basaltic basement rocks for measurements of geochemistry, isotopic chemistry, age, and paleolatitude. Characterize "Center Track" seamounts.
FR-1B (Primary)	-21.8661 6.5906	3258	171	250	421	Core basaltic rocks for geochemical, isotopic, age, and paleomagnetic measurements. Determine age and paleolatitude of Frio Ridge.
FR-2B (Alternate)	-21.7073 6.7620	3008	443	220	663	Core basalt for geochemical, isotopic, age, and paleomagnetic measurements. Determine age and paleolatitude of Frio Ridge.
GT-1B (Primary)	-31.3169 2.7966	1526	175	100	275	Core basaltic rocks for measurements of geochemistry, isotopic chemistry, age, and paleolatitude. Determine geochemical and isotopic signature of Gough Track seamounts.
GT-2A (Alternate)	-31.1823 2.5501	1981	201	100	301	Core basaltic rocks for geochemistry, isotopic chemistry, age, and paleolatitude measurements. Determine geochemical and isotopic signature of Gough Track.
GT-3A (Alternate)	-31.2900 2.7474	1486	327	100	427	Core basaltic rocks for geochemistry, isotopic chemistry, age, and paleomagnetic measurements. Determine geochemical and isotopic signature of Gough Track seamounts.
VB-1B (Primary)	-23.4176 4.9078	2831	122	100	222	Core basaltic rocks for geochemical, isotopic, geochronology, and paleomagnetic study. Determine nature of Valdivia Bank crust.
VB-2B (Alternate)	-23.2812 5.0573	2818	126	100	226	Core basaltic rocks for geochemical, isotopic, age, and paleomagnetic study. Determine nature of Valdivia Bank.
VB-3B (Alternate)	-24.6027 4.6676	4050	193	100	293	Core basaltic rocks for geochemistry, isotopic chemistry, age, and paleomagnetic measurements. Determine age, nature, and history of Valdivia Bank.
VB-4B (Primary)	-24.5848 4.6609	3959	299	100	399	Core basaltic rocks for geochemical, isotopic, age, and paleomagnetic measurements. Determine age, nature, and history of Valdivia Bank.
VB-5A (Alternate)	-23.3719 4.9579	2809	165	100	265	Core basaltic rocks for geochemical, isotopic, age, and paleomagnetic study. Determine origin and history of Valdivia Bank.
VB-6A (Alternate)	-23.1767 5.1703	2610	452	100	552	Core basaltic rocks for geochemical, isotopic, age, and paleomagnetic measurements. Determine age, nature, and history of Valdivia Bank.
TT-1A (Primary)	-30.3808 1.0894	1864	172	250	422	Core basaltic rocks for geochemical, isotopic, age, and paleomagnetic measurements. Document the signature of the Tristan track.
TT-2A (Alternate)	-30.2467 0.8392	2356	389	250	639	Core basaltic rocks for geochemical, isotopic, age, and paleomagnetic measurements. Document geochemical and isotopic signature of Tristan track seamounts.