IODP Proposal Cover Sheet

937 - Full 2

Deepening Hole U1309D

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Title	Accessing the Building Blocks of Life: Deepening Hole U1309D, Atlantis Massif, Mid-Atlantic Ridge
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Area	Mid-Atlantic Ridge

Proponent Information

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Abstract

The Atlantis Massif Oceanic Core Complex (OCC) is one of the best studied locations in the ocean crust, the site of four IODP expeditions so far (304, 305, 340T and 357). It is the site of the Lost City Hydrothermal Field (LCHF), venting alkaline fluids rich in hydrogen and methane at 40-90 centigrade. IODP Hole U1309D, located 5km north of the LCHF, is the deepest (1415m) hole so far drilled in young (<2 Ma) ocean crust, sampling a primitive series of gabbroic rocks interpreted in part to be metasomatised peridotite. Gabbroic lithologies in Hole U1309D contrast with serpentinized peridotites sampled near the LCHF by seafloor coring in Exp. 357 and sampling on the south wall of the Massif. The hydrologic regime is also very different at the two locations, with deep permeability required beneath the LCHF, and a low permeability conductive regime evidenced by a linear thermal gradient deeper than 750 mbsf in Hole U1309D.

The principle aim of this proposal is to sample fluids and rocks in a stable regime with temperatures higher than ever sampled before by IODP. We hope to access temperatures above 200 centigrade, where active serpentinization is occurring in olivine-rich rocks, and where the building blocks for life (H2, CH4, and more complex organic compounds) may be created abiotically.

In addition we will drill a short Hole close to the Lost City Hydrothermal Field in order to gain a complete section through a detachment fault zone and address biosphere, structural and alteration objectives not completed in IODP Expedition 357 due to failure to penetrate to depths envisaged.

We will sample fluids in the existing Hole 1309D using newly developed temperature-sensitive sampling tools and leave a clean legacy hole reaching 2100 mbsf and temperatures of 220 C for future logging and fluid sampling once thermal equilibrium has returned. H2, CH4, other organic molecules and cations will be sampled in fluid inclusions to compare with ambient fluids. We hypothesise that concentration gradients in volatile species may exist in the Massif.

We will also study the magmatic evolution of oceanic core complexes including melt-rock reaction processes critical to the assembly and geochemistry of oceanic gabbro bodies and the relationship between plutonic rocks and MORB

Drilling to temperature regimes not previously accessed by IODP will allow the limitations of current technology to be evaluated in preparation for future deep drilling

Scientific Objectives

Our proposed drilling strategy will address a number of objectives in the Earth in Motion, Earth Connection and Biosphere Frontiers themes of the IODP Science Plan.

Objective 1: The life cycle of an oceanic core complex: Links between igneous, metamorphic, structural and fluid flow processes, and testing of geophysical and hydrothermal models. This objective addresses Science Plan Challenge 9: "How are seafloor spreading and mantle melting linked to ocean crustal architecture?" Challenge 10: What are the mechanisms, magnitude and history of chemical exchanges between the ocean crust and seawater" and Challenge 14: How do fluids link subseafloor tectonic, thermal, and biogeochemical processes?

Objective 2: Accessing the chemical kitchen preceding the appearance of life on Earth: formation of organic molecules of prebiotic interest at high and low temperatures in the Atlantis Massif. This objective addresses Science Plan challenge 10 "What are the mechanisms, magnitude, and history of chemical exchanges between
the oceanic crust and seawater?", Challenge 13 “What properties and processes govern the flow and storage of carbon in the subseafloor”; and Challenge 14 “How do fluids link subseafloor tectonic, thermal, and biogeochemical processes?” It will also be of great interest to the Astrobiology Community studying hydrothermal processes on Icy Worlds and Mars

Objective 3: Deep biosphere and limits for life in the Atlantis Massif: controls of lithological substrate, porosity and permeability, temperature, fluid chemistry and reactive gradients on microbiology. This objective concerns Science Plan Challenge 5 "What are the origin, composition, and global significance of deep
subseafloor communities?" and Challenge 6 "What are the limits of life in the subseafloor realm?"

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

Sampling of fluids using downhole logging tools at selected intervals, in particular using shape metal alloy sampling systems currently under development
Preserving selected samples away from atmospheric alteration and potentially at near-ambient temperature above the temperature limits of life

937 - Full 2

Proposed Sites (Total proposed sites: 3; pri: 2; alt: 1; N/S: 0)

Site Name	Position (Lat, Lon)	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
AMDH-01A (Primary)	30.1687 -42.1186	1656	0	660	660	(i) Sample fluids and measure temperature in existing Hole 1309D down to 1414 mbsf (expected temperature 225 centigrade). (ii) Deepen existing Hole U1309D by ~650 m and collect samples for petrology and geochemistry of abiotic organic compounds and H2; (iii) log Hole with flasked tools. (iv) Drill new 80m Hole 20-30 m north of Hole U1309D, for microbiology sampling of porous rocks, fault zones, and correlation with Holes U1309B and D. This Hole is designated "U1309-J" in the text and site form. Note that Hole 1309C with protruding casing needs to be avoided.
AMDH-02A (Primary)	30.1317 -42.1202	825	3	200	203	200mHole with re-entry. Complete section through detachment fault zone in serpentinized peridotite. Sample for deformation, alteration, igneous petrology, microbiology and organic/inorganic geochemistry. Log for temperature and other properties. Legacy Hole for sampling fluids and gases, establishing temperature profile, potential instrumentation
AMDH-03A (Alternate)	30.1389 -42.1455	1275	5	200	205	Drill through detachment fault shear zone; igneous petrology, alteration, deformation fabrics, microbiology, organic geochemistry. potential for post-detachment volcanic rocks. Temperature profile, fluid sampling, potential to provide re-entry system for legacy