IODP Proposal Cover Sheet

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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

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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, higher hydrocarbons) 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 225 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

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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. Predicted drilling conditions of up to 225 C will test the limitations of current technology.

EARTH IN MOTION: Testing the hypotheses that methane and hydrogen generated abiotically in gabbroic and olivine-rich rocks at elevated temperatures contribute to high levels of these gases in hydrothermal fluids, and that abiotic synthesis of higher hydrocarbons can occur above the temperature limits of life. Ground-breaking sampling of borehole fluids at temperatures up to 225 C (Challenges 13 and 14)

EARTH CONNECTIONS: Sampling a complete section through an oceanic detachment fault in serpentinized peridotite. Addressing relationships between gabbro chemistry and MORB in a major gabbroic section. Addressing the problem of melt supply pathways and plutonic assembly in a large gabbroic body where extensive melt-rock reaction has been shown to convert mantle rocks into olivine-rich troctolites. Quantifying rock-fluid exchanges for cations, gases (H2, CH4, N2), and volatile elements (eg. B, Li) in a detachment fault zone, and in a zone of limited flow within gabbro (Challenges 9 and 10)

BIOSPHERE FRONTIERS: Quantifying and characterising subsurface biota in serpentinite and other lithologies at depths of 16-100 mbsf, in an environment rich in CH4 and H2, and close to a major low temperature vent field, but where cell counts so far observed are low compared to other environments and may be limited by environmental factors other than temperature. (Challenges 5 and 6)

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 at near-ambient temperature above the temperature limits of life

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Proposed Sites (Total proposed sites: 4; pri: 2; alt: 2; 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	800	800	Deepen existing Hole U1309D by 800 to 1000m; log Hole including fluid sampling
AMDH-02A (Primary)	30.1317 -42.1202	825	3	100	103	100m Hole 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	100	105	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
AMDH-04A (Alternate)	30.1879 -42.1303	1740	5	100	105	Hole to the north of Site U1309 (AMDH-01A), where geophysics predicts serpentinite rather than gabbro. Hole will sample the detachment fault. Important intrusive relationships may be recovered. Sample for petrology, alteration, deformation, microbiology, geochemistry et. Log for temperature and other properties