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IODP Proposal Cover Sheet

758-Full2

☐ New ☒ Revised ☐ Addendum

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Title:	**Serpentinization and life: Biogeochemical and tectono-magmatic processes in young mafic and ultramafic seafloor**		
Proponent(s):	Gretchen Früh-Green, Muriel Andreani, John Baross, Stefano Bernasconi, Chiara Boschi, William Brazelton, Mathilde Cannat, Michael Cheadle, Adélie Delacour, Javier Escartin, Marguerite Godard, Philippe Gouze, Nils Holm, Benoit Ildefonse, Magnus Ivarsson, Barbara John, Deborah Kelley, Susan Lang, Marvin Lilley, Christopher MacLeod, Andrew McCaig, Benedicte Menez, Antony Morris, Matthew Schrenk, Roger Searle		
Keywords: *(5 or less)*	Serpentinization, H_2-based deep biosphere, ultramafic-hosted hydrothermal systems, carbon sequestration, detachment faults	Area:	North Atlantic (MAR 30°N)

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Permission to post abstract on IODP Web site: X Yes

Abstract: (*400 words or less)*

We address two exciting discoveries in mid-ocean ridge research: off-axis, serpentinite-hosted hydrothermal activity, exemplified by the Lost City Hydrothermal Field (LCHF); and the significance of tectono-magmatic processes in forming and exposing heterogeneous mafic and variably serpentinized ultramafic lithosphere that are key components of slow and ultraslow spreading ridges. Serpentinization is a fundamental process that controls rheology and geophysical properties of the oceanic lithosphere and has major consequences for heat flux, geochemical cycles and microbial activity in a wide variety of environments. However, we currently have no constraints on the nature and distribution of microbial communities in ultramafic subsurface environments. Our proposed drilling focuses on: (1) exploring the extent and activity of the subsurface biosphere in young ultramafic and mafic seafloor; (2) assessing how abiotic and biotic processes change with aging of the lithosphere and with variations in rock type; (3) quantifying the role of serpentinization in driving hydrothermal systems, and in sustaining microbiological communities, and in the sequestration of carbon in ultramafic rocks; and (4) characterizing tectono-magmatic processes that lead to lithospheric heterogeneities and the evolution of hydrothermal activity associated with detachment faulting. We propose an MSP expedition to core a series of shallow (50-100m) holes across the Atlantis Massif oceanic core complex (30°N, Mid-Atlantic Ridge), where detachment faulting exposes both mafic and ultramafic lithologies on the seafloor. We aim to recover in-situ sequences of sediments, hydrothermal deposits/veins, and basement rocks that comprise a broad zone of detachment faulting across: a spreading-parallel (E-W) profile along the southern wall and at varying distances from the LCHF; and a ridge-parallel (N-S) profile into the center of the massif, where the dominant rock compositions changes from ultramafic to mafic. Drilling the E-W profile will allow us to evaluate how microbial communities evolve with variations in hydrothermal activity and with age of emplacement on the seafloor. We aim to compare microbial activity and diversity in areas of diffuse H_2-rich fluid flow and carbonate precipitation with communities in areas away from the active hydrothermal system and with variable substrates and crustal ages. By quantifying the extent and evolution of carbonate precipitation we will evaluate the potential for natural CO_2 sequestration in serpentinizing peridotites. Drilling the N-S profile will allow us to evaluate how faulting and lithospheric heterogeneities influence hydrothermal alteration and the nature of the deep biosphere in varying lithologies; and to assess the role of the differing rheologies of gabbros and serpentinized ultramafic rocks in localizing detachment faults.

758-Full2

Scientific Objectives: (*250 words or less*)

Highest priority is to drill a spreading-parallel profile across the southern wall of the Atlantis Massif. Sites AM-01A (AM-11A as alternate) and AM-06A target the upflow region associated with the LCHF. Sites AM-02A and AM-03A in the E will sample the biosphere in deeper parts of denuded mantle sequences that are younger with respect to time exposed on the seafloor, and may record the highest thermal gradients. Sites AM04A and AM05 will sample the "shallowest" and more brittle sections of denuded mantle and those closest to the breakaway, but possibly with the most diverse microbial communities reflecting a more protracted history of alteration. We aim to constrain: (1) the nature and distribution of microbial communities supported by H_2- and CH_4-rich fluids and how these vary with age and substrates; (2) the consequences of serpentinization for global (bio)geochemical cycles and carbon fixation; and (3) the links between denudation and hydrothermal circulation and the role of detachment faults in channeling hydrothermal fluids and ultimate formation of mid-ocean ridge vent fields.

Sites AM-01A and AM-06A through AM-10A will investigate axis-parallel variations in lithologies, alteration, and microbial activity away from the focus of fluid discharge and in ~1.16 to 1.31 Ma lithosphere. This profile will allow us to evaluate (1) changes in ecosystems as the basement changes from ultramafic to mafic; the length scale of lithological and hydrothermal variability and the implications for microbial activity; and (2) the rheological role of competent gabbros and weaker serpentinized ultramafic rocks in localizing deformation.

Please describe below any non-standard measurements technology needed to achieve the proposed scientific objectives.

MSP Expedition using a seabed rock drill equipped with a wire line coring system or a geotechnical vessel with diamond coring capabilities.

Proposed Sites:

Site Name	Position		Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
				Sed	Bsm	Total	
AM-01A	30°7.55'N	42°7.15'W	800	1-3	50-100	100	*Upflow region*: Recover sediments, hydrothermal deposits, fault surface & talc schist/serpentinite basement for petrological, chemical & microbiological analysis. Log if possible.
AM-06A	30°7.95'N	42°7.20'W	870	1-3	50-100	100	
AM-11A (alt. for AM-01A)	30°7.63'N	42°7.10'W	750	1-3	50-100	100	
AM-02A	30°7.50'N	42°5.75'W	1140	0.5-3	50-100	100	*Variations with age*: Recover sediments, fault surface & talc schist/ serpentinite basement for petrological, chemical & microbiological analysis.
AM-03A	30°7.67'N	42°3.91'W	1590	0.5-3	50-100	100	
AM-04A	30°7.44'N	42°9.20'W	1400	1-3	50-100	100	
AM-05A	30°7.86'N	42°10.82'W	1450	1-3	50-100	100	
AM-07A	30°8.47'N	42°8.21'W	1150	1-3	50-100	100	*Axis-parallel variations*: Recover sediments, fault surface & mafic basement for petrological, chemical & microbiological analysis.
AM-08A	30°9.60'N	42°8.10'W	1510	1-3	50-100	100	
AM-09A (U1309D)	30°9.84'N	42°7.28'W	1570	1-3	30-50	50	
AM-10A	30°11.43'N	42°7.04'W	1770	1-3	50-100	100	