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IODP Proposal Cover Sheet

805-MDP

☒ **New** ☐ **Revised** ☐ **Addendum**

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Please check if this is Mission proposal ☐

Title:	MoHole to Mantle (M2M)		
Proponent(s):	Susumu Umino, Benoît Ildefonse, Peter B. Kelemen, Shuichi Kodaira, Katsuyoshi Michibayashi, Tomoaki Moroshita, Damon A.H. Teagle, and the MoHole proponents (full list inserted after the reference list)		
Keywords: *(5 or less)*	Mantle, Moho, oceanic lithosphere, oceanic crust, Mid-Ocean Ridge processes, hydrothermal cooling, carbon cycle, ultradeep drilling	Area:	Central/East Pacific

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Permission to post abstract on IODP Web site: ■ Yes ☐ No

Abstract: (*400 words or less)*

The M2M project will sample for the first time upper mantle peridotites that in the near geological past resided in the convecting mantle, and recently (~20 to 100 Myrs) underwent partial melting at a fast-spreading mid-ocean ridge. This will be achieved by drilling through intact fast-spread oceanic crust, and ~500m into the mantle lithosphere. This first in-situ sampling of fresh upper mantle rocks will provide hitherto unattainable information on the chemical and isotopic composition (including fluid mobile elements K, U, C, S, H2O, noble gases), physico-chemical conditions (e.g., fO2, fS), seismic velocities and magnetic signatures, physical properties deformation and rheology, and the scales of chemical and physical heterogeneity of the uppermost mantle. This information is essential to understand the formation and evolution of Earth, its internal heat budget, planetary differentiation and reservoir mixing by mantle convection, mantle melting, and melt focusing and transport at mid-ocean ridges.

On the descent to the mantle, the ultradeep hole (MoHole) will sample fast spreading ocean crust, and make the first in situ observations of the geological nature of the Mohorovičić Discontinuity (Moho), the uppermost primary seismic boundary in the Earth, assumed to be the crust-mantle boundary. Fast spreading ocean crust is targeted because it exhibits relatively uniform bathymetry and seismic structure, and is the great majority of crust recycled back into the mantle by subduction during the past 200 Myrs. Sampling a section of intact oceanic crust will test models of magmatic accretion at mid-ocean ridges, quantify the geometry and vigor of hydrothermal cooling and geochemical exchanges with the oceans, identify the limits of life in the sub-seafloor biosphere and its functions, and ground-truth remote geophysical observations.

This proposal provides the scientific justification for drilling a >6000 m borehole to the mantle. The rationale has been developed by six workshops since 2006, and summarizes the scientific state-of-the-art, and the current vision for engineering and technology development, and operations. M2M directly addresses Challenges 6, 8, 9 and 10 of the 2013-2023 IODP Science Plan. A site for mantle drilling has yet to be selected, but three potential target regions await additional site surveys.

Drilling into the mantle will be the most ambitious undertaking ever achieved by the geoscience community and must engage the full spectrum of scientific expertise. Observations of pristine upper mantle will transform our understanding of the evolution of our planet and challenge the fundamental paradigms that are the foundations of Earth science.

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Scientific Objectives: (*250 words or less*)

The M2M project echoes long-term goals of Earth scientists since the late 1950's, to understand the oceanic lithosphere. With a MoHole, we will address first-order questions about the composition and structure of the Earth's convecting mantle, the geological nature of the Moho, the formation and evolution of oceanic crust, and the deep limits of life. Specific objectives of M2M are to:

• Determine the in-situ composition, structure and physical properties of the uppermost mantle, and the physics and chemistry of mantle melting and melt migration processes,

• Determine the scales of physical and chemical heterogeneity of the uppermost mantle,

• Determine the geological meaning of the Moho in fast-spread lithosphere,

• Determine the bulk composition of the ocean crust to establish the relationship between lavas at the seafloor and the melts that separated from their mantle sources,

• Determine the mode of magmatic accretion at fast spreading ridges,

• Understand the extent and intensity of hydrothermal exchange between ocean crust and seawater, and estimate the chemical flux returned to the mantle by subduction,

• Determine the contribution of the lower ocean crust and upper mantle to global geochemical cycles, including carbon and water,

• Establish the limits, and controlling factors of life in the ocean lithosphere.

• Calibrate regional seismic measurements against core samples and borehole experiments, including long-term geophysical and microbiological monitoring,

• Understand the origin of marine magnetic anomalies and quantify the contribution of lower crustal rocks to the magnetic signature of the ocean crust.

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

Continuous mud circulation (water depth > 3500 m); coring, logging, and fluid/gas sampling in a high temperature (≥ 200°C) environment; specialized drill bits for abrasive, hard, hot rocks; specialized drill string with high tensile strength; low weight, special drilling mud for use at high temperature; new casing and cementing materials and strategies; …

Proposed Sites:

Site Name	Position	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
Cocos Plate	6.7-8.7°N 89.5-91.9°W	3400-3650	250-300	>6000	>6000	
Off Southern/Baja California	20-33°N 120-127°W	Mostly 4000-4500	80-130	>6000	>6000	**MoHole site is yet to be determined, and other options may be considered**
NE Hawaiian Arch	22.9-23.9°N 154.5-155.8°W	4050-4500	~200	>6000	>6000	