# Drilling deep through the ocean crust into the upper mantle

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The mid-ocean ridges and the new oceanic lithosphere that they create are the principal pathway for thermal exchange and physical/chemical interactions between the earth's interior, the hydrosphere, and the biosphere. Hence the ocean lithosphere records the inventory of global thermal, chemical and associated biological fluxes. Drilling an ultra-deep hole in an intact portion of oceanic lithosphere, though the crust, to the Mohorovičić discontinuity, and into the uppermost mantle is a long-standing goal of scientific ocean drilling; it remains critical to answer many fundamental questions about the dynamics of the global Earth. Drilling such a deep hole requires as early as feasible geophysical site surveys of targeted sites, and the development of new technologies, including drilling capabilities to achieve +6000 m of penetration in +4000 m water depth. The future scientific ocean drilling program should allow this type of activity to occur jointly with scientific planning activities.

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Sampling a complete section of the ocean crust, from the ocean floor to the uppermost mantle through the seismic Mohorovičić discontinuity (the 'Moho'), was the original inspiration for scientific ocean drilling, and remains the main goal of the 21st Century Mohole Initiative in the IODP Science Plan. Fundamental questions about the composition, structure, and geophysical characteristics of the ocean lithosphere, and about the magnitude of chemical exchanges between the mantle, crust and oceans remain unanswered due to the absence of in-situ samples and measurements. The geological nature of the Moho itself remains poorly constrained.

The "Mission Moho" proposal submitted to IODP in April 2007, sets the ambitious goal to drill completely through intact oceanic crust, across the Moho and into the uppermost mantle, in lithosphere formed at a fast spreading rate. Although, no long-term mission has been adopted by IODP, the scientific objectives related to deep drilling in the ocean crust remain essential to our understanding of the Earth. Our current knowledge if in-situ ocean crust remains limited; much will be learned on the way to the mantle. The journey and the destination are equally important.

Fundamental scientific goals include:

- Determine the bulk composition of the oceanic crust to establish the chemical links between erupted lavas and primary mantle melts, understand the extent and intensity of seawater hydrothermal exchange with the lithosphere, and estimate the chemical fluxes returned to the mantle by subduction,
- Test competing hypotheses of the ocean crust accretion at fast spreading mid-ocean ridges, and quantify the linkages and feedbacks between magma intrusion, hydrothermal circulation and tectonic activity,
- Determine the geological meaning of the Moho in different oceanic settings,
- Determine the in situ composition, structure and physical properties of the uppermost mantle (and its variability), and understand mantle melt migration,
- Calibrate regional seismic measurements against recovered cores and borehole measurements, and understand the origin of marine magnetic anomalies,
- Establish the depth limit of deep biosphere and hydrological/geobiological processes in the lithosphere.

The "MoHole" was planned as the final stage of Mission Moho. At the recent InterRIDGE-IODP Workshop "Melting, Magma, Fluids, Life" (July, 2009), scientists re-iterated their enthusiasm and support for an ultra-deep hole in intact oceanic crust and into the uppermost mantle. This project would provide major inspiration for the next generation of scientists and engineers. The challenge is formidable, and requires as soon as feasible careful site selection, geophysical site survey, and the development of cutting edge technology including drilling capability to achieve +6000m of penetration in +4000m water depth. The next drilling program needs a mechanism to enable the

community to move forward with planning, design and implementation in order to complete one of the major goals of scientific ocean drilling.

The scientific rationale for deep drilling a complete section of intact ocean lithosphere has been developed and discussed in a number of planning documents since Project MoHole at the end of the 50's. First order scientific questions and key hypotheses to be tested are articulated in details in these documents, which in the past decade include:

- COMPLEX, 1999 conference report :
  http://www.iodp.org/index.php?option=com_docman&task=doc_download&gid=808
- "Opportunities in Geochemistry for Post-2003 Ocean Drilling", 2000 workshop report :
  http://www.iodp.org/iodp_journals/2_Mission_Moho_Workshop_SD4.pdf
- ODP Architecture of the lithopshere PPG, summary report, 2003 :
  http://www.iodp.org/index.php?option=com_docman&task=doc_download&gid=783
- Mission Moho, 2006 Workshop Report :
  http://www.iodp.org/index.php?option=com_docman&task=doc_download&gid=1309
- "Mission Moho: Formation and Evolution of Oceanic Lithosphere", EOS, 2006 :
  http://www.iodp.org/index.php?option=com_docman&task=doc_download&gid=1302
- "Mission Moho Workshop: Drilling Through the Oceanic Crust to the Mantle", Scientific Drilling, 2007 :
  http://www.iodp.org/iodp_journals/2_Mission_Moho_Workshop_SD4.pdf
- MissionMoho IODP proposal, 2007 :
  http://www.gm.univ-montp2.fr/spip/IMG/pdf/MissionMohoProposal_April07_LowRes.pdf
- Melting, Magma, Fluids and Life, 2009 workshop report :
  available at http://www.interridge.org/WG/DeepEarthSampling/workshop2009