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Mission Moho: Rationale for drilling deep through the ocean crust into the upper mantle

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Sampling a complete section of the ocean crust to 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 unresolved due to the absence of in-situ samples and measurements. The geological nature of the Mohorovičić discontinuity itself remains poorly constrained.

"Mission Moho" is a proposal that was submitted to IODP in April 2007, with the ambition to drill completely through intact oceanic crust formed at a fast spreading rate, across the Moho and into the uppermost mantle. Although, eventually, no long-term mission was approved by IODP, the scientific objectives related to deep drilling in the ocean crust remain essential to our understanding of the Earth. These objectives are to :

- 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 understand mantle melt migration,
- 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,
- Calibrate regional seismic measurements against recovered cores and borehole measurements, and understand the origin of marine magnetic anomalies,
- Establish the limits of life in the ocean lithosphere.

The "MoHole" was planned as the final stage of Mission Moho, which requires non-riser and riser drilling, geophysical site surveys and the development of new technology including the construction of a +4000 m riser. Initial expeditions would use existing drilling capabilities to sample shallow and deep targets in increasingly hostile conditions in ocean crust formed at both fast and slow spreading rates, allowing us to deliver major short-term science returns while we develop the equipment, technology and experience to tackle a full crustal penetration.

The first, short-term milestone is to return in IODP Hole 1256D, into intact crust formed during a period of superfast spreading (> 200 mm/yr) on the East Pacific rise 15 million years ago, and drill as deeply as possible with non-riser technology. The first gabbroic rocks below the sheeted dikes were encountered at the end of IODP expedition 312 at 1407 meters below seafloor. They mark the interface between the axial melt lens and the base of the hydrothermal system. Future deepening to a minimum of a few hundred meters should recover cumulate gabbros that will further constraint accretion mechanisms of the lower, igneous crust.