Japan Association of Mineralogical Sciences

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MOHOLE TO THE MANTLE (M2M)

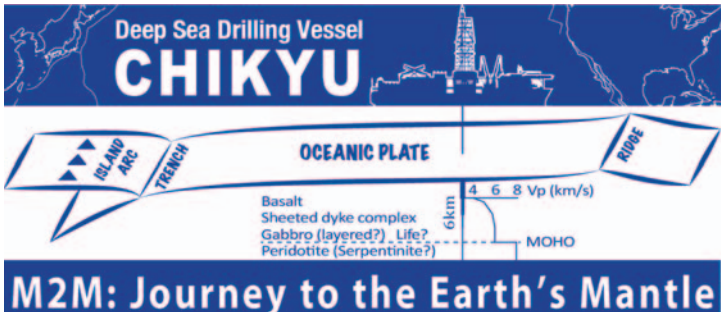
An Ultradeep Drilling Project to the Mantle Led by Japanese Scientists

The M2M proposal, submitted in April 2012 to the Integrated Ocean Drilling Program (IODP) for funding, aims to sample, for the first time, upper-mantle peridotites that resided in the convecting mantle in the near geological past and recently (~20 to 100 My) underwent partial melting at a fast-spreading mid-ocean ridge. This will be achieved by drilling ~500 m into the mantle lithosphere through intact fast-spreading oceanic crust (ca 6 km thick). This first in situ sampling of fresh upper mantle rocks will provide hitherto unattainable information on the chemical and isotopic composition (including fluid mobile substances like K, U, C, S, H_2O, and noble gases), physicochemical conditions (e.g. fO_2, fS), seismic velocities and magnetic signatures, physical properties, deformation and rheology, and scales of chemical and physical heterogeneity of the uppermost mantle. This information is essential to understanding the formation and evolution of the Earth; its internal heat budget; planetary differentiation; and reservoir mixing by mantle convection, mantle melting, and melt focusing and transport at mid-ocean ridges.

To date, exploration of the elusive frontier at the Mohorovičić Discontinuity (Moho) and the enormous mantle domain beneath has been a symbolic, unattainable goal. However, the riser drilling vessel *Chikyu* has made drilling through the oceanic crust and into the upper mantle, ~6 km below the seafloor, technically feasible.

During the drilling, the ultradeep hole (MoHole) will sample fast-spreading oceanic crust and make the first in situ observations of the geological nature of the Moho, the uppermost primary seismic boundary in the Earth and assumed to be the crust–mantle boundary. Fast-spreading oceanic crust is targeted because it exhibits relatively uniform bathymetry and seismic structure and it constitutes the great majority of the crust recycled back into the mantle by subduction during the past 200 My. Sampling a section of the 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 subseafloor biosphere and its functions, and ground-truth remote geophysical observations.

The M2M proposal provides the scientific justification for drilling a >6000 m borehole to the mantle. The rationale has been developed during six workshops since 2006, and the proposal summarizes the scientific state-of-the-art and the current vision for engineering and technology development and operations. M2M directly addresses challenges of the 2013–2023 International Ocean Discovery Program Science Plan of the IODP. A site for mantle drilling has yet to be selected, but three potential target regions (the Cocos Plate off Central America, the Pacific Plate off Southern and Baja California, and the Pacific Plate north of Oafu, Hawaii) await additional site surveys.



The riser drilling vessel *Chikyu*

Drilling into the mantle will be the most ambitious undertaking ever carried out 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. The M2M project is currently at the proposal stage and will cost at least $1 billion. We hope that the Japanese government is committed to covering a significant portion of these costs in collaboration with many other countries.

Further information is available at the MoHole website: www.jp.mohole.org.

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