Beyond the Moho: Plans for a complete penetration of *in situ* ocean crust into the upper mantle

DAMON A.H. TEAGLE[1] ON BEHALF OF THE MISSION MOHO PROPONENTS[2] AND THE ODP LEG 206[3] AND IODP EXPEDITION 309/312 SCIENCE PARTIES[4]

[1]National Oceanography Centre, Univ. Southampton, SO14 3ZH, UK (dat@noc.soton.ac.uk)
[2]http://www.iodp.org/ocean-lithosphere/#7
[3]http://www-odp.tamu.edu/publications/206_IR/front.htm
[4]http://iodp.tamu.edu/publications/exp309_312/30912title.htm

Sampling the upper mantle was the original inspiration for scientific ocean drilling and remains an unfulfilled ambition of Earth scientists. Fundamental questions about the composition, structure, and evolution of the ocean lithosphere, and 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 Mohorovicic Discontinuity itself remains poorly understood.

"Mission Moho" is a proposal with the ultimate goal to drill completely through intact oceanic crust formed at a fast spreading rate, across the Moho and into the uppermost mantle. The "MoHole" will be the final stage of a multi-cruise campaign requiring non-riser and riser drilling, detailed geophysical survey and technological development, including the construction of a +4000 m riser. The initial cruises will harness existing ocean drilling capabilities to sample shallow and deep targets in increasingly hostile conditions in ocean crust formed at both fast and slow spreading rates.

A major step on the "Road to the MoHole" was made with the drilling of Hole 1256D into intact crust formed during a period superfast spreading (>200 mm/yr) on the East Pacific Rise 15-million years ago. This is the first complete penetration of upper oceanic basement through lavas, dikes and into the uppermost gabbros [1, 2]. The first gabbroic rocks were encountered at 1407 m below seafloor. Below this lies a ~100 m complex zone of fractionated gabbros intruded into contact metamorphosed dikes. The first gabbros were recovered from within the depth range predicted by extrapolating the inverse relationship between spreading rate and the depth to low velocity zones, thought to be axial melt lenses, at modern ocean ridge crests (e.g., [3]). Hole 1256D is open to its full depth and future deepening in the next phase of IODP should recover cumulate gabbros that will settle long-standing debates on the mechanisms of accretion of the lower oceanic crust.

References

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Reconstructing the Mg/Ca and Sr/Ca history of seawater from ocean ridge-flank hydrothermal carbonate veins

DAMON A.H. TEAGLE[1], ROSALIND M. COGGON[2], CHRIS SMITH-DUQUE[1], JEFFREY ALT[2] AND MATTHEW COOPER[1]

[1]National Oceanography Centre, Univ. Southampton, SO14-3ZH, UK (dat@noc.soton.ac.uk, csd2@noc.soton.ac.uk, mjco@noc.soton.ac.uk)
[2]Geological Sciences, University of Michigan, Ann Arbor, MI48109, USA (coggon@umich.edu, jalt@umich.edu)

Calcium carbonate veins formed from low temperature (<100 °C) ridge flank hydrothermal fluids are common in the upper oceanic crust. Carbonate veins from the Juan de Fuca Ridge (<3.6 Ma) record the compositional evolution of seawater-derived hydrothermal fluids as they are heated and react with the basaltic basement. δ^{18}O-calculated fluid temperatures correlate with the proportion of basalt-derived ^{87}Sr. The Sr/Ca and Mg/Ca of the basement fluids, calculated from carbonate trace element analyses combined with suitable partition coefficients, are also temperature dependent [1].

The precipitation of carbonate veins from fluids with a basaltic Sr component precludes the use of the seawater Sr-isotope curve to date individual carbonate veins. However, the Sr-isotopic compositions of suites of carbonate veins in older sections of ocean crust also correlate with temperature and record the chemical evolution of basement fluids from seawater. The age of a suite of carbonate veins can therefore be estimated from the seawater ^{87}Sr/^{86}Sr curve, by determining the ^{87}Sr/^{86}Sr of contemporaneous seawater from the vein ^{87}Sr/^{86}Sr - temperature trend. Similar to modern carbonate veins, suites of ancient carbonate veins record decreasing basement fluid Mg/Ca and Sr/Ca with increasing temperature, due to fluid-rock interaction. Extrapolation of these trends back to seawater temperatures allows the determination of past ocean Mg/Ca and Sr/Ca.

The fidelity of a particular suite of ocean basement carbonate veins for determining past ocean chemistry depends on the thermal and hydrological history of the site, the duration of fluid circulation and carbonate precipitation, and the variation of ocean chemistry during this period. Analyses of veins from ODP Sites 801 (170 Ma), 1179 (129 Ma), 417 (110 Ma), and 1224 (46 Ma) indicate that ocean Sr/Ca and Mg/Ca were significantly lower than present from the Middle Jurassic to Late Eocene. This approach provides independent corroboration of past seawater chemistry estimates based on foraminifera and sedimentary calcite chemistry.

References

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