Comment: Magnetization of the Oceanic Crust

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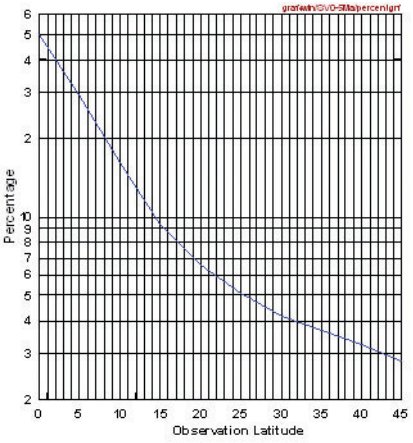
In the March 2007 issue of *Scientific Drilling* there is a report of the "Mission Moho" meeting. Mission Moho is being proposed to the Integrated Ocean Drilling Program to investigate the formation and evolution of oceanic lithosphere. Deep drilling has been one of the main objectives of the drilling program ever since the first phase (Deep Sea Drilling Project) started in 1968. Shortly afterwards, a committee was formed to look at scientific objectives of deeper penetration into the oceanic crust. Part of the rationale for deeper penetration was to understand how the oceanic crust is magnetized and how this magnetization contributes to the formation of sea floor spreading magnetic anomalies. More recently the COMPLEX Meeting (May 1999, Vancouver, Canada http://www.odplegacy.org/PDF/Admin/Long_Range/COMPLEX.pdf) had a section on "How do marine magnetic anomalies relate to crustal architecture, cooling, and alteration". It is pointed out that "To fully understand the depth distribution of magnetization requires drilling of an intact crustal section". The CONCORD report (July 1997: Tokyo, Japan, http://www.odplegacy.org/PDF/Admin/Long_Range/CONCORD.pdf) on Ocean Riser Drilling posed the question "What role do the lower crust and upper mantle play in the origin of marine magnetic anomalies?" The Initial Science Plan (http://www.odplegacy.org/PDF/Admin/Long_Range/IODP_ISP.pdf) for IODP "Initiative: 21st Century Mohole" states that "…the source of marine magnetic anomalies will be much better understood when a complete section of the lower oceanic crust is available for analysis". These suggestions seem to have been forgotten by the "Mission Moho" group. The only place that crustal magnetization is discussed is in one phrase: "better understand the origin of magnetic anomalies". No mention was made of the desirability of drilling at higher latitudes in order to unscramble the magnetic signal. The main site for drilling lies at 6.5°N (but was probably formed closer to the equator). I have recently compiled a data set of paleomagnetic observations over the past 5 Ma in which Virtual Geomagnetic Poles from all latitudes were used. From this data set it is possible to determine, as a function of observation latitude,



how frequently a field direction with positive inclination occurs when the core field is reversed (see figure). For a recording latitude of 6.5° fully 25% of the samples of positive inclination will have been produced by the secular variation during a time that the main field is of reversed polarity. Inclination is the only way of determining a sample's magnetic polarity in the absence of horizontal orientation, and an error rate of 25% renders the data relatively useless. It will be very difficult to unscramble the magnetization values gathered at such a place so as to be able to determine the external magnetic signature of the crustal rocks. Even at a recording latitude of 25° the probability is still 5% of confusing reversed with normal polarity. The IODP scientific advice structure should give serious consideration to choosing drilling sites at higher latitudes, preferably greater than 25°. Alternatively, they should ensure that a proven method of horizontal orientation of cores is available by the time "Mission Moho" starts.

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Response to: Magnetization of the Oceanic Crust

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We fully share Dr Harrison's concerns about the difficulty in deciphering the magnetic signal at low latitudes, such as the location of ODP/IODP Site 1256D , and we thank him for bringing everyone's attention to the critical need for a method to provide azimuthal orientation. Although this topic was not discussed in the workshop report published in the March 2007 issue of *Scientific Drilling*, it was extensively discussed at the Mission Moho Workshop. We would like to take this opportunity to emphasize the following points, which were also articulated in the Mission Moho proposal that was submitted to IODP in April 2007 :

- Although Site 1256D is the site for current deep drilling in the upper crust, it will not necessarily be the deep crustal, MoHole site. The latter has yet to be chosen. Site selection for deep drilling in the fast-spread ocean crust faces a few major trade-offs, dominated by water depth vs temperature at Moho, and also magnetic geometry vs weather window. Sites under consideration near San Diego and near Valparaiso would satisfy Dr Harrison's concerns.

- Site 1256D, the "6.5 °N main site" mentioned by Dr Harrison is favored for the near future for reasons including gaining engineering experience in deep gabbro holes and for better predicting the thermal structure, which will be useful even if we eventually choose a site at a higher latitude.

- We cannot emphasize enough the importance, for the future of scientific drilling in the ocean crust, to be able to reorient cores in a geographic reference frame. A Hard Rock Core Orientation (HRCO) system would be the ideal solution, and further development and implementation requires community support.

- Measuring the downhole magnetic field with logging tools does meet some of the objectives that Dr Harrison suggests in choosing a site far from the equator. Remanent magnetic data from samples collected over nearly 40 years of drilling still do not provide an unambiguous solution to the dominant source for lineated magnetic anomalies. This is partly related to the prominent effect of drilling induced remanence, and every effort to reduce this effect should be encouraged. While much can be learned from the magnetization of drillcore samples, detailed magnetic logging is arguably the best way to establish the relative contributions of the various parts of the crust to the magnetic anomalies. A reliable gyro-oriented tool should be designed, developed, and regularly used in IODP to achieve this goal.

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