NEWS RELEASE
Ocean Drilling Program

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ODP Leg 140

Ocean Drilling Program drills

ocean crust's deepest hole

JOIDES Resolution, drill ship for the Ocean Drilling Program, (ODP), has deepened a hole in the eastern Pacific to 2 kilometers, making it the deepest hole ever drilled into ocean crust.

Hole 504B represents at this time the only hole in the world in which scientists have the chance to observe the transition between the layers that compose ocean crust. This transition represents a region of rapid changes in the physics and chemistry of Earth, changes scientists say are critical to understanding how ocean crust forms and interacts with the overlying ocean.

To reach the 2-kilometer barrier, ODP invested in 1991 two cruises, 100 days at sea and 36 scientists representing 11 countries. The ship drilled in water depths of more than 3,400 meters and deployed more than 5 kilometers (3 miles) of drill string. The feat culminated more than 12 years of off-again, on-again drilling at the site.

One of ODP's primary goals is to better understand the structure, tectonics, mineralogy and chemical alterations in ocean crust. Drilling deep into the crust allows scientists to observe firsthand how ocean crust evolves. To learn more about the nature of oceanic basement, scientists have previously studied ophiolite complexes, which are fossil sections of ancient ocean crust uplifted onto land. They have also relied on geophysical surveys and have sampled rocks or cores retrieved from the ocean floor. Geoscientists recognized early that the rocks sampled at spreading centers were similar to certain components of ophiolite complexes. Through their observations, they conceived models of ocean crust based on the stratigraphy of the ophiolite complex and on geophysical data.

The ophiolite model proposes an upper stratum, Layer 1, of deep-sea sediments that covers pillow basalts, Layers 2A and 2B. These upper sections grade down into a dike complex, Layer 2C, which then grades into a sequence of gabbros and ultramafic rocks. Layer 2 -- sometimes called the volcanic layer -- averages 2 kilometers in thickness but can vary greatly.

Beneath Layer 2, the rocks' density increases sharply and seismic waves travel at higher speeds. Scientists believe that gabbros and ultramafic rocks make up Layer 3, which they also surmise to be a uniform thickness averaging 4.5 kilometers. The gabbros represent the slowly cooled remains of extinct magma chambers, great pools of molten rock beneath the mid-ocean ridges. Injections of the magmas produce the sheeted dikes of Layer 2C.

ODP and its predecessor program, the Deep Sea Drilling Project, have deepened the hole seven times. Over the years, they have lost coring bits and other drilling equipment down the hole.

On each succeeding visit, poor drilling conditions, high temperatures, cave ins and the difficulty in clearing the large amount of junk at the bottom of the hole left further drilling at Hole 504B in serious doubt.

In a last-ditch effort to salvage the hole, ODP this year sponsored two cruises. The first deepened the hole by 60 meters, but left with a drill bit and part of the drill pipe at the bottom. The crew also lost a fishing tool -- a device used to "fish" out dropped tools -- down the hole.

In October the ship was able to successfully retrieve the broken tool and a long section of the broken drill pipe.

Over the next 26 days, drilling at little more than 15 meters a day, the hole was steadily deepened to the 2-kilometer depth. To date, Hole 504B extends through 274.5 meters of sediment and 1,725.9 meters into basement, which includes 571.5 meters of pillow lavas and minor flows, underlain by a 209-meter transition zone of mixed pillow lavas, thin flows and dikes, and 845.4 meters of sheeted dikes.

This cruise drilled well into this transition between Layers 2 and 3. Scientists onboard observed significant changes in the mineralogy of the rock, increases in rock density and variations in other physical properties at the bottom of the hole.

As ODP drilled deeper, they found the mineralogy and chemistry of the dikes in deep sections to be nearly identical to the overlying pillow basalt lavas and dikes drilled earlier. The rocks' composition indicates a partial melting from a depleted mantle source.

The characteristics found in the chilled dike margins. however, indicate that we are approaching Layer 3. When the magma shoots up through the dike formation, it quickly forms a glassy rind next to the cooler rocks already laid down. At the 2-kilometer depth, the chilled margins were of fine-grained basalt rather than brittle, glassy material found in the upper layers. Furthermore, the average grain size of the dikes was coarser. The basaltic chill margins and coarse grain size indicate slower crystallization and cooling, a characteristic found in ophiolite suites near the boundary between Layer 2C and the magma chamber.

Seawater and rock interaction alter to some extent the oceanic basement rocks. The exchange produces distinctly different alteration zones with increasing depth. As they drilled deeper, ODP discovered that the dike section in Hole 504B has suffered high-temperature alteration, indicating that temperature increases with depth. These mineralogical changes are again consistent with the changes that take place toward the base of the sheeted dike section in many ophiolites.

Furthermore, many of the lavas drilled contained fragments of gabbros that clearly have been carried from depth, where they had been broken off the walls of the conduit. Scientists believe these fragments also indicate that a magma chamber once existed beneath the bottom of the hole.

Scientists also discovered a dramatic drop in the concentration of zinc in the rocks at the bottom of the hole. Zinc is a significant metal in the black-smoker, massive-sulfide metal deposits discovered in recent years at mid-ocean ridges.

Scientists have debated the source of zinc and the other metals in the deposits, including small amounts of gold and silver. The source of at least some of the zinc is now apparent. Cold seawater sinks into the crust below the seafloor, where it leaches the zinc from the rocks. Heated by geothermal energy, the metal-rich fluid returns up through the crust to deposit the zinc at hot springs bubbling at the seafloor. Further drilling, then, may find the source of other metals deposited at the hot springs.

The success of Ocean Drilling Program in reaching the 2-kilometer depth barrier sets the stage for final penetration into the deepest layer of the ocean crust. The changes in alteration mineralogy, the increasing average grain size and the absence of glassy chilled dike margins in the newly drilled section of Hole 504B may indicate that ODP has reached the lower part of the sheeted dike section. Only additional drilling of the hole will determine how close scientific ocean drilling is to penetrating the boundary between the dikes and gabbros.

The scientific importance of drilling into this layer is paramount to understanding the evolution of the ocean crust and basaltic magmas. To date, rocks from this layer collected from the seafloor largely consist of debris dredged from from great deep-sea faults where the ocean crust has been broken and dismembered.

"It has become clear that earth scientists will never fully understand the processes controlling the evolution of the ocean crust from buckets of gravel from the seafloor. Drilling Layer 3 will finally allow us to directly study the processes by which lavas evolve, crystallize and erupt deep within the ocean crust," said Dr. Jörg Erzinger, co-chief scientist for the cruise.

"The last decade has seen a revolution in theories about the formation of ocean crust. Drilling into the lower ocean crust will provide the best test of these new theories and revolutionize our understanding of marine geology and geophysics," Dr. Henry Dick, co-chief scientist, said.

Dick is from Woods Hole Oceanographic Institution, and Erzinger is from the University of Giessen, Federal Republic of Germany. Dr. Laura Stokking of Texas A&M University was staff scientist.

"This cruise has become a benchmark in our program's seven years of drilling," said Dr. Philip D. Rabinowitz, director.

"What we can learn from this one site can either confirm what has been theory or open up new ways of thinking about the dynamics of Earth's system," Rabinowitz said.

JOIDES Resolution, registered as *SEDCO/BP 471*, is the research vessel for the ODP, which is funded by the United States National Science Foundation, Canada and Australia, the European Science Foundation Consortium for the Ocean Drilling Program, Federal Republic of Germany, France, Japan, United Kingdom and the U.S.S.R.

The 470-foot-long drill ship's derrick towers 200 feet above the waterline. Seven levels of laboratories provide facilities for on board examination of sediment and hard-rock cores. Laboratories contain space and equipment for studies in chemical, gas and physical properties, paleontology, petrology, paleomagnetics and sedimentology. Marine geophysics research is conducted while the ship is under way.

Texas A&M University, as science operator, operates and staffs the drill ship and retrieves cores from strategic sites around the world. The science operator also ensures that adequate scientific analyses are performed on the cores. To do this, Texas A&M maintains shipboard scientific labs and provides logistical and technical support for shipboard scientific teams. On shore, in the Texas A&M University Research Park, the science operator manages post-cruise activities, curates the cores and publishes the scientific results.

Lamont-Doherty Geological Observatory of Columbia University is responsible for downhole logging.

Joint Oceanographic Institutions for Deep Earth Sampling (JOIDES), an international group of scientists, provides scientific planning and program advice. Joint Oceanographic Institutions (JOI Inc.), a nonprofit consortium of 10 major U.S. oceanographic institutions, manages the program.

Note: JOIDES Institutions are: University of California at San Diego; Columbia University; University of Hawaii; University of Miami; Oregon State University; University of Rhode Island; Texas A&M University; University of Texas at Austin; University of Washington; and Woods Hole Oceanographic Institution.

Canada and Australia Consortium for the ODP; European Science Foundation Consortium for the ODP: Belgium, Denmark, Finland, Iceland, Italy, Greece, the Netherlands, Norway, Spain, Sweden, Switzerland and Turkey; Federal Republic of Germany; France; Japan; the United Kingdom and the U.S.S.R.

The following scientists participated on Leg 140: Henry Dick, co-chief scientist, Woods Hole Oceanographic Institution, Woods Hole, Mass.; Jörg A. Erzinger, co-chief scientist, Institut für Geowissenschaften und Lithosphærenforschung, Universität Giessen, Federal Republic of Germany; Laura Stokking, staff scientist, Ocean Drilling Program, Texas A&M University, College Station; Pierre Agrinier, Université Paris, France; Simon Allerton, University of Oxford, U. K.; Jeffrey C. Alt, University of Michigan, Ann Arbor; Lars O. Boldreel, Geological Survey of Denmark, Copenhagen; Martin R. Fisk, Oregon State University, Corvallis; Peter K.H. Harvey, University of Leicester, U. K.; Gerardo J. Iturrino, University of Miami, Fla.; Kevin T.M. Johnson, University of Tokyo, Japan; Deborah S. Kelley, Woods Hole Oceanographic Institution, Woods Hole, Mass.; Pavel K. Kepezhinskas, Academy of Sciences, Moscow, U.S.S.R.; Christine Laverne, Laboratoire de Petrologie Magnatique, Marseilles, France; Fred Marton, Northwestern University, Evanston, Ill.; Andrew W. McNeill, University of Tasmania, Hobart; Howard R. Naslund, State University of New York, Binghamton; Janet Pariso, University of Washington, Seattle, Wash; Nokolai N. Pertsev, Academy of Sciences, Moscow, U.S.S.R.; Philippe Pezard, Institut Mediterranean de Technologie, Marseille, France, Eva S. Schandl, Univrsity of Toronto, Canada; Joel W. Sparks, Stanford University, Calif.; Paola Tartarotti, Dipartimento de Geologia, Padova, Italy; Susumu Umino, Shizuoka University, Japan; David A. Vanko, Georgia State University, Atlanta; Evelyn Zuleger, Justus-Liebig-Universität, Giessen, FRG.