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Scientists Delve Into Secrets of the Ocean's Crust, Achieve Scientific 'First'

Answers to important questions about the formation of the Earth's crust may be close at hand as a result of recent findings by an international team of scientists. The researchers have, for the first time, recovered black rocks known as gabbros from intact ocean crust, according to an article in the April 20 on-line publication Science Express, the Internet edition of the journal Science.

First author Douglas S. Wilson, an associate research geophysicist with the Marine Science Institute at the University of California, Santa Barbara, chose the location for drilling into the ocean crust. He is co-chief scientist, among five, and was involved with three expeditions. Wilson originated the idea for these missions through study of the ocean crust's magnetic properties. The site of the drilling was approximately 800 kilometers west of Costa Rica and the vessel used was the JOIDES Resolution; the project was managed by the Integrated Ocean Drilling Program

Geophysical theories have projected that oceanic magma chambers freeze to form the coarse-grained, black rocks known as gabbros, commonly used for facing stones on buildings and kitchen countertops. Although gabbros have been sampled elsewhere in the oceans, where faulting and tectonic movement have brought them closer to the seafloor, this is the first time that gabbros have been recovered from intact ocean crust.

"Finding the right place to drill was probably key to our success," said Wilson. His research identified a 15-million-year-old region of the Pacific Ocean that formed when the East Pacific Rise was spreading at a rate of more than 200 millimeters per year, much faster than any mid-ocean ridge on Earth today.

"We planned to exploit a partially tested geophysical observation that magma chambers should be closest to the Earth's surface in crust formed at the fastest spreading rate," said Wilson. "If that theory was indeed correct, then we should only need to drill a relatively shallow hole, compared to anywhere else on the planet, to reach gabbros." Wilson and his colleagues were proven correct.

"To learn about normal ocean crust we needed to go to a normal ocean location," Wilson explained. "This particular place has a normal spread where we could sample an entire sequence where the crust hasn't been broken up by earthquake faulting."

Wilson added that drilling this deep hole in the eastern Pacific was a rare opportunity to calibrate remote geophysical measurements (such as seismic travel time or magnetic field) with direct observations of real rocks. The team drilled through the volcanic rock that forms the Earth's crust to reach a fossil magma chamber lying 1.4 kilometers beneath the seafloor.

After three years of research and three trips to the site in question, the borehole that rendered the magma chamber is more than 1,500 meters deep and took nearly six months at sea to drill. Twenty-five hardened steel and tungsten carbide drill bits were used before the scientists' work was complete. The rocks directly above the frozen magma chamber were extremely hard because they had been baked by the underlying magmas, much like tempered steel.

"By sampling a complete section of the upper oceanic crust, we've accomplished a major goal scientists have pursued for over 40 years, since the days of Project MoHole," said Damon Teagle of the National Oceanography Centre at Britain's University of Southampton, who is co-chief scientist of the expedition. He said that this achievement will ultimately help science answer the important question of how new ocean crust is formed. The formation of ocean crust is a key process in the cycle of plate tectonics and constantly "repaves" the surface of the Earth, builds mountains, and leads to earthquakes and volcanoes. Project MoHole, begun in the 1950s, endeavored to drill all the way through the ocean crust and into the Earth's mantle.

Co-chief scientist Jeff Alt, of the University of Michigan, observed that having this sample from the deep fossil magma chamber allows the scientists to compare its composition to the overlying lavas. This will help explain whether ocean crust, which is about six to seven kilometers thick, formed from one high-level magma chamber -- or from a series of stacked magma lenses. "The size and geometry of the melt lens affects not only the composition and thermal structure of the ocean crust, but also the vigor of hydrothermal circulation of seawater through the crust." Alt explained that such systems lead to spectacular black-smoker vents -- modern analogs of ancient copper deposits and oases in the deep ocean that support exotic life.

The Integrated Ocean Drilling Program (IODP) is an international marine research effort dedicated to advancing scientific understanding of the Earth, the deep biosphere, climate change, and Earth processes by monitoring and sampling sub-seafloor environments. IODP scientists already plan to return to the site of the unearthed magma chamber and explore deeper, in hopes of finding more secrets hidden deep within the ocean's crust. IODP is supported by two lead agencies, the U.S. National Science Foundation and Japan's Ministry of Education, Culture, Sports, Science, and Technology. U.S.-sponsored drilling operations are conducted by the JOI Alliance, made up of the Joint Oceanographic Institutions, Texas A & M University Research Foundation, and Lamont-Doherty Earth Observatory of Columbia University.

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