Times Standard

Not My Fault: Expedition to the Earth's Mantle

Lori Dengler for the Times-Standard
Posted June 10, 2023
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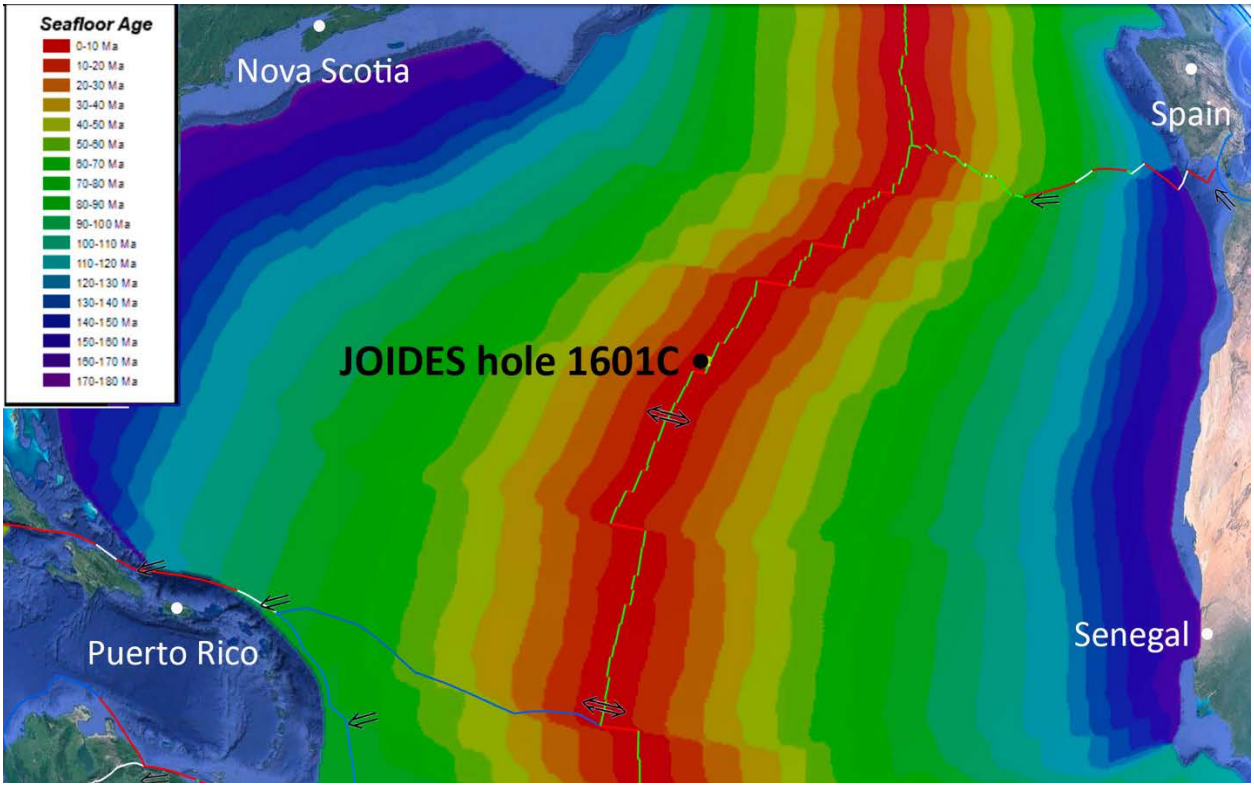
https://www.times-standard.com/2023/06/10/lori-dengler-expedition-has-touched-the-earths-mantle/



Location of Hole 1601C where mantle core has been retrieved from JOIDES Resolution Expedition 399. Colored zones mark oceanic crustal age. The youngest and thinnest crust is near the Mid-Atlantic ridge; the oldest and thickest crust is at the ocean margins.

History was made this month. No, not another indictment, or a candidate throwing a hat into the presidential race. For the first time, a drill has penetrated into the earth's mantle and retrieved samples of this hither before unknown part of the planet.

The mantle comprises a whopping 84% of the earth by volume and two-thirds of the planet's mass. We know about the mantle from indirect means such as gravity measurements and the passage of seismic waves. There are a few places on the planet where geologic processes have thrust chunks of mantle rocks onto the surface. One of those places, the Josephine Ophiolite that straddles the California – Oregon border is quite nearby. But mantle rock on the surface is always contorted and altered by tectonics. Never before have scientists reached below the crust into in-situ mantle and collected samples that have been undisturbed.

The simplified view of the earth is a series of concentric shells. At the center is the inner core. Very dense, it is likely composed mostly of solid iron with a little nickel and a few other elements. The outer core comes next, a liquid version of the inner core; the fluid movement generating our protective magnetic field.

The mantle is the largest shell, extending from the top of the outer core, roughly 1800 miles below us, to the base of the crust, an irregular boundary roughly 9 to 25 miles beneath continents and only 3 to 6 miles beneath the sea floor. The crust is the world we live on, providing the soils that nurture plant life and the minerals and materials we rely on for modern life. It makes up less than one percent of the planet.

I've written about drilling and deep earth structure several times in this column. Only four months ago I remarked that no drill hole had punctured the Mohorovičić discontinuity (Moho), the irregular boundary between the granites, basalts and other relatively less dense crustal rocks and the much denser mantle below.

Sampling the mantle has been a holy grail search by geophysicists for more than a half century. There have been a number of attempts to reach the Moho; the first serious attempt in the 1960s was called Project Moho. It only reached a depth of 600 feet into the crust in the Gulf of Mexico before funding was discontinued. The deepest hole ever drilled was in NW Russia. The Kola Superdeep Borehole was an effort by the Soviet Union that began in 1970 and reached a depth of 7.6 miles in 1989. Had it been on the sea floor, it would have easily reached the Moho. But on the continent, it was several miles short.

Now the Moho has been pierced. In April of this year, a group of scientists on board the JOIDES Resolution deep drilling ship began Expedition 399. Called 'Building Blocks of Life', the voyage took them to the Atlantis Massif a section of the seafloor near the Mid-Atlantic ridge roughly midway between Florida and Morocco. This week, the group announced they were able to penetrate nearly three-quarters of a mile into the mantle. The real pay dirt was core after core of mantle rock recovered.

Why was this location chosen? Like many scientific advances, serendipity played a role. Expedition 399 didn't start out to study the mantle. The purpose was to probe the Atlantis Massif, an area close to the Mid-Atlantic ridge where the ocean crust is very young and extensional faulting has brought mantle rock almost to the surface. It is an area rich in hydrothermal vents and complex organic molecules. As the name implies, the research group was studying the origin of life and wanted to examine how microbial communities in this environment originate and are sustained.

Expedition 399 only expected to make a small pinprick into mantle rock. Deep ocean drilling is notoriously complicated. The vessel is constantly tossed by ocean waves and sits nearly thousands of feet above its starting point on the sea floor. The JOIDES Resolution was designed for this difficult task. JOIDES (Joint Oceanographic Institutions for Deep Earth Sampling) is a consortium of oceanographic research institutions and the Resolution, a sophisticated drilling platform/laboratory, has operated as the primary deep drilling research vessel since the 1980s.

The expedition team expected drills to get stuck and core recovery to be problematic. But sometimes a group gets lucky. The drill penetrated easily and kept going deeper. Core retrieval was nearly perfect. What do you do when you are scientists heading a million-dollar project and suddenly you find

opportunity outside of your funded proposal? You change your focus and keep going and going and going. The result – a nearly continuous 4,175 section of the upper mantle.

Retrieving core is only the initial step in what will be decades of research. Geochemists will analyze both mineral and fluid compositions, looking at alteration as seawater interaction increases near the seafloor. They will examine the Moho boundary and the sharpness of the transition between crust and mantle. They will likely find surprises and formulate new questions The three graduate students onboard the Resolution will have no problem completing theses and legions will follow.

The core retrieved from Expedition 399 is only one spot. It won't be able to answer questions of how uniform the upper mantle is or how different the mantle might be beneath continents than beneath the sea floor. Those questions will require sampling other areas, and at present, the outlook for similar drilling expeditions is unlikely.

Expedition 399 may be one of the last JOIDES Resolution ventures. On March 6, the National Science Foundation (NSF) announced the early retirement of the vessel. The last funded expedition will be in 2024, four years earlier than expected. It costs NSF $48 million in annual upkeep, plus an addition $24 million from international partners to keep her afloat and operating. To quote the NSF, "By ending support for the JR now, funds and resources can be directed towards ensuring a sustainable future for the scientific ocean drilling community." Support will be directed towards maintaining less expensive vessels and supporting diversity and other programs.

I hope that the spectacular success of Expedition 399 may sway NSF officials into reconsidering the Resolution's retirement. There are so many other spots on the sea floor that beckon, and the Resolution is the only vessel with the capability to explore them.

Lori Dengler is an emeritus professor of geology at Humboldt State University, an expert in tsunami and earthquake hazards. The opinions expressed are hers and not the Times--Standard's. All Not My Fault columns are archived online at https://kamome.humboldt.edu/taxonomy/term/5 and may be reused for educational purposes. Leave a message at (707) 826-6019 or email Kamome@humboldt.edu for questions and comments about this column. Downloadable copies of the North Coast preparedness magazine "Living on Shaky Ground" are posted at https://rctwg.humboldt.edu/prepare/shaky-ground.

https://joidesresolution.org/record-hole-in-mantle-rock/
https://joidesresolution.org/preliminary-findings-for-expedition-399/

One of those places is quite near us. The Josephine Ophiolite