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OOZING MAGMA OF OCEAN RIDGE TELLS ABOUT MANTLE BELOW

An article in Nature Magazine this week reports new information about the movement of the upper mantle immediately underneath the Earth's crust.

Plate tectonics is the surface manifestation of this movement. The plate including India is crashing into Asia, pushing up toward the Himalayan Mountains. The recent large earthquake in India is part of this movement.

By analyzing the magma that oozes up from a long crack in the Earth's crust under the Indian Ocean, the researchers studied the movement of the mantle, according Frank Spera, professor of geological sciences at the University of California, Santa Barbara, and co-author of the paper.

The scientists analyzed properties of rocks dredged from 5,800 kilometers along the Southeast Indian Ridge. Samples from 6 different voyages, including both American and French expeditions, were included.

This project represents the first time that scientists have related the geochemical variability of the Earth's mantle to its movement, or geophysics -- on an intermediate length scale of approximately 400 kilometers below the crust. The connection of geochemistry to geophysics is a difficult bridge to cross, according to Spera.

By using chemical tracers, principally the isotope composition of helium, the researchers discovered that small scale convection occurs in the upper 400 kilometers of the Earth's mantle. The upper mantle moves in small rotating gyres, with a three-dimensional helical flow. Fault lines sometimes correlate with these secondary flows.

It has already been established that larger gyres on the scale of 2700 kilometers occur at a deeper level in the mantle. The mantle is the area between the Earth's core and its crust.

Ocean ridges are excellent areas for the study of the mantle because the Earth's crust is thinner there than it is on the continents. The oceanic crust is created by spreading centers where magma comes up in sheets through ridges and then separates laterally. The magma wells up and then spreads apart. About 30 cubic kilometers of magma per year oozes up under all the Earth's oceans, according to Spera.

The researchers are developing a detailed map of the composition of the Earth's upper mantle, using chemical tracers as a key. "You have to look at the surface to build a picture of what the mantle looks like underneath," said Spera.

"We are looking at the internal evolution of the Earth. We want to know how the Earth is behaving thermally and chemically over time. It's like tracking the atmosphere, we are looking at the 'weather' of the mantle. We can send down seismic waves, but that yields only crude information. This method allows us to look at smaller scale circulation in the upper mantle."

Spera explained that the Earth is ultimately cooling and will eventually be inert, like the moon, solid to the core. But for billions of years into future the Earth's internal mantle will continue to move in circulation around the core, as it has for billions of years. The heat inside the Earth comes from its primordial heat and from radioactive decay. Heat loss occurs through mantle convection.

Spera went on to explain that the chemical evolution of the Earth is inextricably bound to the style of convection or circulation of the Earth's mantle.

The researchers call this spatial geochemistry. By analyzing the composition of magmas and how their composition varies across the Earth, their location in latitude and longitude, researchers get more information about the mantle.

"It's like mixing ice cream in chocolate and vanilla swirls," he said. "We look at the concentration of the vanilla and the chocolate and the way they become unrelated defines something about the movement in the mantle."

The other authors are D.W. Graham and D.M. Christie of the College of Oceanic and Atmospheric Sciences at Oregon State University, and J.E. Lupton of the National Oceanic And Atmospheric Administration (NOAA) at the Hatfield Marine Science Center. Funders were NOAA, the National Science Foundation and the Department of Energy.

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