New properties of the very deep Earth discovered

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To truly understand some of the movement we see at the Earth's surface, scientists have to probe deep into the interior. A region near the planet's core, about 1,800 miles down called the core-mantle boundary, is particularly intriguing.

Through novel experiments mimicking high-pressures and temperatures there, scientists at Los Alamos National Laboratory (LANL) and the Carnegie Institution's Geophysical Laboratory may have solved a longstanding mystery about why certain seismic waves called shear waves move so sluggishly through clumpy patches (ultralow velocity zones) at these incredible depths.

The team found that when lots of iron is added to the most prevalent mineral in that region, (post-perovskite) shear waves put on the breaks and move in slow motion. Their discovery offers an alternative to the prevailing idea that these regions are partially melted, and it has important implications for understanding how volcanoes, located in places such as Hawaii and Iceland, may originate. The research is published in the April 28, 2006, *Science*.

Seismologists learn about the deep Earth, in part, by observing different seismic waves from earthquakes as they travel through the planet. Shear waves wiggle at right angles to the direction of their movement, but they don't move through liquid at all and are thus useful for understanding aspects of the Earth's composition. The team, including the daughter/father duo Wendy Mao (LANL) and Carnegie's Ho-kwang

(Dave) Mao, used a novel technique to measure the velocity of shear waves in the lab, through the most abundant mineral in that region called post-perosvkite.

"The major mineral in Earth's mantle is iron-magnesium silicate perosvkite," explained Dave Mao. "Post-perosvkite, discovered a couple years ago, is a different phase of the mineral at the core-mantle boundary and scientists have been fascinated by its properties. Understanding the mineral and the intrigue of the ultralow velocity zones led us to these experiments," he continued.

Ultralow velocity zones exist as patches between the solid mantle and liquid core, and are very different from the mantle above and material on the sides. Since shear waves can't propagate through a liquid, a prevailing thought has been that the zone contains some liquid, or melts, which would slow the waves down. Scientists have noticed that the ultralow velocity patches could also give rise to mantle plumes, eventually sparking volcanoes in places like Hawaii and Iceland.

The researchers subjected post-perosvkite, containing 40% iron, to pressures as high as 1.6 million times the pressure at sea level (170 Gigapascals) and 3100 °F (2000K). Although the researchers can add as much as 80% iron in the post-perovskite, only 40% is needed to match the ultralow velocity zones.

"With our new techniques we were able to determine the shear velocity of this material," stated Wendy Mao. "We were amazed that adding iron dramatically slowed the velocities to those that seismologists have observed in the ultralow velocity zones. Iron-rich post-perosvkite, formed by reactions between the mantle and the core, could be what these thin, patchy regions are made of."

In addition to offering an alternative explanation to partial melting of the ultralow velocity zones, the dense material would sink instead of rising with the convection at hot spots. This behavior would explain why these zones are clumped and not uniformly distributed and why the clumps are associated with the hot spots and contribute to the volcanic activity at the surface.

Source: Carnegie Institution