Earth's getting 'soft' in the middle

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Since we can’t sample the deepest regions of the Earth, scientists watch the velocity of seismic waves as they travel through the planet to determine the composition and density of that material. Now a new study suggests that material in part of the lower mantle has unusual electronic characteristics that make sound propagate more slowly, suggesting that the material there is softer than previously thought.

The results call into question the traditional techniques for understanding this region of the planet. The authors, including Alexander Goncharov from the Carnegie Institution’s Geophysical Laboratory, present their results in the January 25, 2008, issue of *Science*.

The lower mantle extends from about 400 miles to 1800 miles

(660-2900 kilometers) into Earth and sits atop the outer core. Pressures and temperatures are so brutal there that materials are changed into forms that don't exist in rocks at the planet's surface and must be studied under carefully controlled conditions in the laboratory. The pressures range from 230,000 times the atmospheric pressure at sea level (23 GPa), to 1.35 million times sea-level pressure (135 GPa). And the heat is equally extreme—from about 2,800 to 6,700 degrees Fahrenheit (1800K–4000K).

Iron is abundant in the Earth, and is a major component of the minerals ferropericlase and the silicate perovskite in the lower mantle. In previous work, researchers found that the outermost electrons of iron in ferropericlase are forced to pair up under the extreme pressures creating a so-called spin-transition zone within the lower mantle.

“What happens when unpaired electrons—called a high-spin state—are forced to pair up is that they transition to what is called a low-spin state. And when that happens, the conductivity, density, and chemical properties change,” explained Goncharov.

“What's most important for seismology is the acoustic properties—the propagation of sound. We determined the elasticity of ferropericlase through the pressure-induced high-spin to low-spin transition. We did this by measuring the velocity of acoustic waves propagating in different directions in a single crystal of the material and found that over an extended pressure range (from about 395,000 to 590,000 atmospheres) the material became ‘softer’—that is, the waves slowed down more than expected from previous work. Thus, at high temperature corresponding distributions will become very broad, which will result in a wide range of depth having subtly anomalous properties that perhaps extend through most of the lower mantle.”

Source: Carnegie Institution