Lighter filling in Earth's core

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New experiments conducted by a team led by the Carnegie Institution's Dr. Jung-Fu Lin suggest that the core of the Earth may contain more light elements than previously thought. The research is published in the June 24, 2005, issue of *Science*.

"The composition of Earth's core has been the subject of scientific debate for years," commented Lin. "The prevailing consensus is that the outer core is a molten cauldron mostly of iron with some light elements and the inner core is made of solid iron with a little bit of light elements. We can't sample the core directly, so we've made these estimates by reading seismic waves as they travel through the interior and through experimentation and theory," he continued.

As depth increases inside the Earth, so does the pressure and heat. The pressure in the core varies from 1.4 million times the pressure at sea level at the outer edge of the core, to 3.6 million times that pressure at its center. Current models suggest that center conditions are also a scorching 8,000 to 10,000 degrees Fahrenheit (5000 to 6000 K). Materials in this environment become so compressed, dense, and hot that the atoms behave very differently from those under normal conditions. Until now, scientists have deduced the nature of core materials by measuring seismic waves as they pass through the interior and applying a law known as Birch's law, which predicts that sound velocities travel slower through less-dense material and faster through denser materials. The scientists discovered through their experiments on iron, however, that temperature had a significant effect, with a resulting impact on the velocity/density relationship. "We found that when temperature is added

to the experiment, the velocities of the compression waves (the waves that force atoms closer for a moment) and shear waves (when the atoms rub against each other) actually decreased with increasing temperature even though the pressure was moderately high," stated co-author of the study Wolfgang Sturhahn.

The researchers compared their results with seismic-wave measurements of the Earth's interior and determined that there are more light elements contained in the iron there than previously inferred from linear extrapolation at room temperature.

"The law is a first approximation," stated Lin. "It assumes that we only needed to consider the density effect in the interior. Our study demonstrates that we need to deal with the pressure and temperature effects."

Using a diamond-anvil pressure cell, the scientists subjected iron to pressures up to about 720,000 times the atmospheric pressure at sea level, and with laser heating they increased temperatures up to 2,600° F. They witnessed the changes to the iron atoms with the intense X-rays of the nation's premier third-generation synchrotron source, the Advanced Photon Source at Argonne National Laboratory near Chicago. They measured the sound velocity through the compressed, hot iron with a sophisticated technique known as nuclear resonant inelastic X-ray scattering. "The development of this new technique was crucial for our studies, which had to advance far beyond the more common structure investigations to provide us with these unique insights into the planetary interior," commented Sturhahn, who developed the technique and is leading the High Resolution X-ray Scattering group at the Advanced Photon Source.

"For the past 50 years, Birch's law has helped geophysicists to understand dense materials under the extreme conditions in Earth's

interior. Our results show how new technology can bring added understanding of the interior," reflected co-author of the study Ho-kwang (Dave) Mao, the director of the High-Pressure Collaborative Access Team at the Advanced Photon Source.

Source: The Carnegie Institution of Washington