Researchers discover unexpected properties of materials in lowermost mantle

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Materials deep inside Earth have unexpected atomic properties that might force earth scientists to revise their models of Earth's internal processes, a team of researchers has discovered.

The researchers recreated in the lab the materials, crushing pressures and infernal temperatures they believe exist in the lowermost mantle, nearly 2,900 kilometers (1,800 miles) below Earth's surface. They report in the journal *Nature Geoscience* the materials exhibit rare and unexpected atomic properties that might influence how heat is transferred within Earth's mantle, how columns of hot rock called superplumes form, and how the magnetic field and heat generated in Earth's core travel to the planet's surface.

The planetary building blocks magnesium, silicon, oxygen and iron are the most abundant minerals in the lowermost mantle. A team of scientists led by Jung-Fu Lin at The University of Texas at Austin's Jackson School of Geosciences synthesized materials from these building blocks in a diamond anvil cell, a device containing two interlocking diamond pieces that squeeze the sample like a vice. They subjected the sample to more than 1.3 million times standard atmospheric pressure. Shining a laser through the transparent diamonds, they then heated the sample to almost 3,000 degrees Celsius (5,400 degrees Fahrenheit) for several days.

The scientists used the nation's most powerful source of X-rays, a facility at Argonne National Laboratory called a synchrotron light source, to reveal the sample's electronic and atomic structure. They determined the high pressures had caused some of the electrons in the sample's iron, which normally repel each other, to "pair up" or become bound to each other. Earlier experiments by Lin and others had found evidence for areas in the lower mantle in which electrons were either mostly paired up or were mostly unpaired. This was the first evidence of a broad region in the subsurface with what scientists describe as "intermediate-spin state," or partially paired iron electrons.

"We were surprised to find partially paired electrons," said Lin. "That doesn't normally occur in other geological materials that we know about."

The degree of electron pairing, also known as electronic spin state, can affect how well the materials conduct heat and electricity. Lin said modelers who make computer simulations of mantle dynamics will now have to go back and try to determine how this intermediate-spin state might affect the way heat is transferred within Earth, how superplumes form, how convection occurs in the mantle and how Earth's magnetic field might radiate from the core.

The electronic spin state can also affect the speed of seismic waves traveling through material in the deep mantle. As a result, seismic images of the lowermost mantle—collected when earthquake vibrations travel through and reflect off of material in the subsurface—may have to be reinterpreted.

Nature Geoscience will publish the paper, "Intermediate-Spin Ferrous Iron in Lowermost Mantle Post-Perovskite and Perovskite," in its October 2008 edition and online Sept. 14.

Source: University of Texas at Austin