Part of Earth's mantle shown to be conductive under high pressure and temperatures

January 20 2012, by Bob Yirka

(PhysOrg.com) -- Scientists studying the rotation of the Earth have long known that our planet doesn't have a perfect spin. Most believe this is due to the different types of materials that make up the core, mantle and crust, which all have different rates of spin causing inherent friction. Most models researchers have developed however agree that in order for the planet to wobble the way it does, the mantle would have to respond to the magnetic tug of the core. The problem with this though, is that the mantle is made mostly of rock, not metal, which means it's not supposed to be conductive.

New research by a Kenji Ohta and his colleagues at Osaka University in Japan indicates they've found a possible explanation. As they describe in their paper published in *Physical Review Letters*, it appears that Wustite (FeO), believed to be one of the components that make up the Earth's mantle, can be made to conduct electricity at high pressure and high temperatures.

This new work by the team builds on findings from the 1980's that showed that FeO becomes more conductive when exposed to shock waves. To find out if other conditions might cause the same outcome, the team placed a sample of FeO in a diamond anvil and heated it using a laser. As the experiment proceeded, they also measured the conductivity of the FeO sample.

After heating the sample to 1600°C and applying 70 gigapascals of pressure, the team found the sample became as conductive as an average metal. They also noted it did so without any changes occurring to its structure.

To find out if the same conductive properties would occur under more harsh conditions, comparable to those found inside the Earth, the team turned up the temperature to 2200°C while ratcheting up the pressure to 1.4 million atmospheres and found the same results. Such measurements suggest, the team theorizes, that the same conductive properties would likely hold under even more extreme conditions such as those found near the boundary between the mantle and the core.

To better understand why FeO becomes conductive under high pressure and heat, the team did density and electrical conductivity tests as they relate to temperature and pressure and now believe that the metallization is related to spin crossover.

More information: Experimental and Theoretical Evidence for Pressure-Induced Metallization in FeO with Rocksalt-Type Structure, *Phys. Rev. Lett.* 108, 026403 (2012)
DOI:10.1103/PhysRevLett.108.026403

Abstract
Electrical conductivity of FeO was measured up to 141 GPa and 2480 K in a laser-heated diamond-anvil cell. The results show that rock-salt (B1) type structured FeO metallizes at around 70 GPa and 1900 K without any structural phase transition. We computed fully self-consistently the electronic structure and the electrical conductivity of B1 FeO as a function of pressure and temperature, and found that although insulating as expected at ambient condition, B1 FeO metallizes at high temperatures, consistent with experiments. The observed metallization is related to spin crossover.

via [Physics Synopsis]