Mystery of Earth's Innermost Core Solved

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New studies show that iron, the principal constituent of the innermost parts of the earth's core, becomes unusually 'soft' at the extreme pressures and temperatures that prevail there. The findings, now being published in *Science*, enhance our possibility of understanding the innermost parts of the earth and how earthquakes occur, for example. In a more immediate perspective, scientists will have new tools for developing better materials.

The findings were attained by a team of Swedish and Russian researchers, who used advanced simulations on Swedish supercomputers. This new knowledge explains some of the seismic data-signals from earth tremors-that stations around the world gather and that have puzzled scientists until now.

"These new discoveries about the innermost part of the earth provide an explanation for the low velocity of the seismic waves deep down in the earth. They explain, in turn, why signals from earth tremors look like they do, thereby facilitating the work of seismologists," says Anatoly Belonoshko at the Royal Institute of Technology in Stockholm, who directed the studies.

The innermost core of the earth, which consists of highly compressed iron in a solid state, is known to have an extremely low degree of rigidity in regard to shear-the impact of twisting or other forces. The iron at the center of the earth therefore behaves largely like a fluid, which lacks all resistance to shear, making it easy for shifts to take place in the matter in the earth's core. One consequence is that the seismic waves that move along the surface of the inner core move unexpectedly slowly.

“Besides providing an entirely new potential for understanding a number of mysterious phenomena associated with the low velocity of the movement of these seismic waves, the methods we are using to explain the softness of the earth’s core can also be applied to materials science,” says Anatoly Belonoshko.

This dual nature of iron has been an enigma to researchers for more than 50 years, since iron in laboratory experiments has not evinced any tendency whatsoever to behave like a fluid under high pressure. The reason for this is the much lower temperatures in laboratory experiments compared with the center of the earth.

The solution to the riddle of this ‘soft’ iron lies in the how the iron atoms are arranged and can move under the conditions that prevail in the inner parts of the earth. The conditions can be likened to a solid structure in which the parts, instead of being nailed to each other, are fastened together with rubber bands. This makes it extremely easy for certain parts to shift in relation to each other.

A more scientific description is that the iron at the center of the earth cannot be depicted as an average of single crystalline iron. Instead, it is a so-called polycrystalline material with liquid-like granule edges and masses of defects in the structure. Anatoly Belonoshko, in collaboration with his colleagues Natalia Skorodumova and Anders Rosengren, has been able to show that an external disturbance like shear is rapidly mitigated by a migration of atoms and a gliding of the liquid-like granule edges.

The study shows that traditional methods of mineral physics are valid, despite the unexpected behavior of iron in the earth’s core, and that what is key to an enhanced understanding of the core of the earth is to be able to recreate the conditions there with great accuracy. A challenge for scientists is to further develop a new way to calculate the elastic properties of various materials at high temperatures.

“The methods we use help us understand, and thereby describe and predict, properties of materials at high temperatures. This opens new avenues for the theoretical, and in the long term practical, construction of new materials,” says Anatoly Belonoshko.

The simulations were possible to perform with the help of the most powerful Swedish supercomputers, situated at the Center for Parallel Computers (PDC) at the Royal Institute of Technology in Stockholm and the National Supercomputer Center (NSC) in Linköping.

Source: The Swedish Research Council

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