# Earth's iron core is surprisingly weak, researchers say

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The massive ball of iron sitting at the center of Earth is not quite as "rock-solid" as has been thought, say two Stanford mineral physicists. By conducting experiments that simulate the immense pressures deep in the planet's interior, the researchers determined that iron in Earth's inner core is only about 40 percent as strong as previous studies estimated.

This is the first time scientists have been able to experimentally measure the effect of such intense pressure – as high as 3 million times the pressure Earth's atmosphere exerts at sea level – in a laboratory. A paper presenting the results of their study is available online in *Nature Geoscience*.

"The strength of iron under these extreme pressures is startlingly weak," said Arianna Gleason, a postdoctoral researcher in the department of Geological and Environmental Sciences, and lead author of the paper. Wendy Mao, an assistant professor in the department, is the co-author.

"This strength measurement can help us understand how the core deforms over long time scales, which influences how we think about Earth's evolution and planetary evolution in general," Gleason said.

Until now, almost all of what is known about Earth's inner core came from studies tracking seismic waves as they travel from the surface of the planet through the interior. Those studies have shown that the travel time through the inner core isn't the same in every direction, indicating that the inner core itself is not uniform. Over time and subjected to great pressure, the core has developed a sort of fabric as grains of iron elongate and align lengthwise in parallel formations.

The ease and speed with which iron grains in the inner core can deform and align would have influenced the evolution of the early Earth and development of the geomagnetic field. The field is generated by the circulation of liquid iron in the outer core around the solid inner core and shields Earth from the full intensity of solar radiation. Without the geomagnetic field, life – at least as we know it – would not be possible on Earth.

"The development of the inner core would certainly have some effect on the geomagnetic field, but just what effect and the magnitude of the effect, we can't say," said Mao. "That is very speculative."

Gleason and Mao conducted their experiments using a diamond anvil cell – a device that can exert immense pressure on tiny samples clenched between two diamonds. They subjected minute amounts of pure iron to pressures between 200 and 300 gigapascals (equivalent to the pressure of 2 million to 3 million Earth atmospheres). Previous experimental studies were conducted in the range of only 10 gigapascals.

"We really pushed the limit here in terms of experimental conditions," Gleason said. "Pioneering advancements in pressure-generation techniques and improvements in detector sensitivity, for example, used at large X-ray synchrotron facilities, such as Argonne National Lab, have allowed us to make these new measurements."

In addition to intense pressures, the inner core also has extreme temperatures. The boundary between the inner and outer core has temperatures comparable to the surface of the sun. Simultaneously simulating both the pressure and temperature at the inner core isn't yet possible in the laboratory, though Gleason and Mao are working on that for future studies. (For this study, Gleason mathematically extrapolated from their pressure data to factor in the effect of temperature.)

Gleason and Mao expect their findings will help other researchers set more realistic variables for conducting their own experiments.

"People modeling the inner core haven't had many experimental constraints, because it's so difficult to make measurements under those conditions," Mao said. "There really weren't constraints on how strong the core was, so this is really a fundamental new constraint."

**More information:** www.nature.com/ngeo/journal/va … t/full/ngeo1808.html

Provided by Stanford University

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