Most of Earth's carbon may be hidden in the planet's inner core, new model suggests

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Clouds over Australia are shown. Credit: NASA

As much as two-thirds of Earth's carbon may be hidden in the inner core, making it the planet's largest carbon reservoir, according to a new model that even its backers acknowledge is "provocative and speculative."

In a paper scheduled for online publication in the *Proceedings of the National Academy of Sciences* this week, University of Michigan researchers and their colleagues suggest that iron carbide, Fe7C3, provides a good match for the density and sound velocities of Earth's inner core under the relevant conditions.

The model, if correct, could help resolve observations that have troubled researchers for decades, according to authors of the *PNAS* paper.

The first author is Bin Chen, who did much of the work at the University of Michigan before taking a faculty position at the University of Hawaii at Manoa. The principal investigator of the project, Jie Li, is an associate professor in U-M's Department of Earth and Environmental Sciences.

"The model of a carbide inner core is compatible with existing cosmochemical, geochemical and petrological constraints, but this provocative and speculative hypothesis still requires further testing," Li said. "Should it hold up to various tests, the model would imply that as much as two-thirds of the planet's carbon is hidden in its center sphere, making it the largest reservoir of carbon on Earth."

It is now widely accepted that Earth's inner core consists of crystalline iron alloyed with a small amount of nickel and some lighter elements. However, seismic waves called S waves travel through the inner core at about half the speed expected for most iron-rich alloys under relevant pressures.

Some researchers have attributed the S-wave velocities to the presence of liquid, calling into question the solidity of the inner core. In recent years, the presence of various light elements—including sulfur, carbon, silicon, oxygen and hydrogen—has been proposed to account for the density deficit of Earth's core.

Iron carbide has recently emerged as a leading candidate component of the inner core. In the *PNAS* paper, the researchers conclude that the presence of iron carbide could explain the anomalously slow S waves, thus eliminating the need to invoke partial melting.

"This model challenges the conventional view that the Earth is highly depleted in carbon, and therefore bears on our understanding of Earth's accretion and early differentiation," the *PNAS* authors wrote.

In their study, the researchers used a variety of experimental techniques to obtain sound velocities for iron carbide up to core pressures. In addition, they detected the anomalous effect of spin transition of iron on sound velocities.

They used diamond-anvil cell techniques in combination with a suite of advanced synchrotron methods including nuclear resonant inelastic X-ray scattering, synchrotron Mössbauser spectroscopy and X-ray emission spectroscopy.

More information: Hidden carbon in Earth's inner core revealed by shear softening in dense Fe7C3 , *PNAS*, www.pnas.org/cgi/doi/10.1073/pnas.1411154111

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