Iron carbonates in Earth's mantle help form diamonds

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Under the peculiar conditions present deep in the Earth's mantle, iron carbonates can play a role in forming diamonds, an international team of researchers have found.

Diamonds extracted from depths of some 700 km. bear inclusions that contain carbonates, providing direct evidence that carbonates exist at such depths. However, their range of stability, crystal structures and the thermodynamic conditions of the decarbonation process are not well understood.

The scientists – hailing from Russia, France, Germany, Italy and the United States – investigated these carbonates by simulating the peculiar conditions that characterize the Earth's deep mantle, including:

- Extremely high pressure (equivalent to more than one million times the pressure present in Earth's atmosphere), and
- Extremely high temperatures (typically ranging between 2,000° and 2,500° Celsius).

Obviously, most chemical compounds that are stable on the Earth's surface cannot exist under such extreme conditions.

However, the scientists found some outliers. Specifically, their research revealed that under these conditions, carbonate molecules can exist, and can reorganize so that the carbon carries an extra oxygen atom, forming a tetrahedral shape.

The team detected for the first time two novel compounds, including a so-called "tetracarbonate" that has the potential to survive deep in the Earth's lower mantle.

The results of their work indicate that one of the new crystal structures is uncommonly stable and retains its structure under the conditions present in the earth's mantle, to depths of 2,500 km – close to where the mantle meets the earth's core.

Through the process of self oxidation, carbonates can remain preserved deep in the Earth's mantle, thereby contributing to diamond formation.

Skoltech researcher Leyla Ismailova, one of the study's co-authors, said: "This finding can provide us with a better understanding on self-oxidation reactions in the Earth and the role our planet plays in the carbon cycle."

To simulate deep mantle conditions, the team generated high pressures and temperatures using laser-heated diamond anvil cells. A very small sample (10 to 15 microns) was squeezed between a pair of diamonds with a laser beam focused on them. The team then used synchrotron X-rays to examine the content and the structure of the samples at the European Synchrotron Radiation Facility (France) and the Advanced Photon Source (United States). At the same facilities, using a synchrotron Mössbauer spectroscopy, they were able to measure tiny changes in the Fe atomic energy levels, which is crucial to determining the valence state of new high-pressure iron carbonates.

More information: Cerantola, Valerio, Elena Bykova, Ilya Kupenko, Marco Merlini, Leyla Ismailova, Catherine McCammon, Maxim Bykov, et al. "Stability of Iron-Bearing Carbonates in the Deep Earth's Interior." *Nature Communications* 8 (July 19, 2017): ncomms15960. DOI: 10.1038/ncomms15960

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