Researchers reveal that Earth's surface water can penetrate deep into the planet, transforming core's outer layer

November 14 2023

Illustration of silica crystals coming out from the liquid metal of the Earth's outer core due to a water-induced chemical reaction. Credit: Dan Shim/ASU

A few decades ago, seismologists imaging the deep planet identified a thin layer, just over a few hundred kilometers thick. The origin of this layer, known as the E prime layer, has been a mystery—until now.

An international team of researchers, including Arizona State University scientists Dan Shim, Taehyun Kim and Joseph O'Rourke of the School of Earth and Space Exploration, has revealed that water from the Earth's surface can penetrate deep into the planet, altering the composition of the outermost region of the metallic liquid core and creating a distinct, thin layer. Illustration of silica crystals coming out from the liquid metal of the Earth's outer core due to a water-induced chemical reaction.

Their research was published in *Nature Geoscience*.

Research indicates that over billions of years, surface water has been transported deep into the Earth by descending, or subducted, tectonic plates. Upon reaching the core-mantle boundary, about 1,800 miles below the surface, this water triggers a profound chemical interaction, altering the core's structure.

Along with Yong Jae Lee of Yonsei University in South Korea, Shim and his team have demonstrated through high-pressure experiments that subducted water chemically reacts with core materials. This reaction forms a hydrogen-rich, silicon-depleted layer, altering the topmost outer core region into a film-like structure. Additionally, the reaction generates silica crystals that rise and integrate into the mantle.

This modified liquid metallic layer is predicted to be less dense, with reduced seismic velocities, in alignment with anomalous characteristics mapped by seismologists.

"For years, it has been believed that material exchange between Earth's core and mantle is small. Yet, our recent high-pressure experiments reveal a different story. We found that when water reaches the core-mantle boundary, it reacts with silicon in the core, forming silica," said

Shim.

"This discovery, along with our previous observation of diamonds forming from water reacting with carbon in iron liquid under extreme pressure, points to a far more dynamic core-mantle interaction, suggesting substantial material exchange."

This finding advances our understanding of Earth's internal processes, suggesting a more extensive global water cycle than previously recognized. The altered "film" of the core has profound implications for the geochemical cycles that connect the surface-water cycle with the deep metallic core.

This study was conducted by an international team of geoscientists using advanced experimental techniques at the Advanced Photon Source of Argonne National Lab and PETRA III of Deutsches Elektronen-Synchrotron in Germany to replicate the extreme conditions at the core-mantle boundary.

More information: Taehyun Kim et al, A hydrogen-enriched layer in the topmost outer core sourced from deeply subducted water, *Nature Geoscience* (2023). DOI: 10.1038/s41561-023-01324-x

Provided by Arizona State University