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Earth's 'Missing' Lead Has Puzzled Scientists for Decades—New Research Could Finally Solve This Ancient Chemical Mystery

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A massive amount of lead missing from the Earth's crust, long a quandary for geologists, may be hidden by the planet's mantle's immense crushing power, according to researchers in Singapore.

Geologists have long used lead as a natural record of our planet's geological history. Yet, compared to ancient meteorite samples, the Earth's crust contains far less lead than expected, an issue that has long perplexed scientists.

Now, a new paper from Nanyang Technological University (NTU) researchers, published in *Nature Communications*, finally offers an answer to how lead behaves deep in the planet's interior.

Lead Isotopes and Geological History

Lead variants (called isotopes, with different numbers of neutrons) provide important information about Earth's deep geological past. Three of lead's four forms—lead-206, lead-207, and lead-208—are radiogenic, meaning that the decay of uranium or thorium causes their conversion from one isotope to another over time. The fourth form is lead-204, the first type of lead to exist on our planet.

These separate isotopes allow researchers to track material as it moves between Earth's crust, mantle, and core, and to date it. The isotopes' steady rate of decay allows

researchers to accurately date samples by comparing the amount of uranium present with what would have been there in the original lead-204; in short, the less uranium, the older the lead.

The Meteorite Discrepancy

Despite how well scientists track lead as it moves through the Earth, they've long been stumped by a difference in lead levels between ancient meteorite samples and surface levels of lead. These samples represent the very space rocks that long ago slammed together to make our planet.

When analyzing surface samples, researchers are finding far more young lead than expected, suggesting that the Earth is far younger than the meteorites that formed it, which would be impossible. Where all the ancient lead that formed the Earth could be hiding has confused geologists, although one explanation has gained some popularity. Some scientists believe that most of this ancient lead sank into the Earth's molten core as the planet formed, yet the exact mechanism for how this occurred has eluded researchers.

Seeking Hidden Lead Reservoirs

In an attempt to locate our planet's missing lead, the NTU team focused on how it is stored in the Earth, noting its high likelihood to combine with sulfur. The researchers ran computer simulations of the compound lead sulfide under the extreme temperatures and conditions found deep inside Earth's mantle by using the powerful CALYPSO software. They noted that the compound was remarkably stable, able to withstand extreme temperatures approaching 5,000°C, while remaining solid.

Under such conditions, ancient lead could accumulate in hidden reservoirs in the mantle without ever contacting uranium or thorium or reaching the surface. This aligns with the previously confusing data demonstrating a very low proportion of original lead on the planet's surface.

Remarkably, lead sulfide under these conditions produced two new chemical structures in the simulations, further explaining the lead isotope ratios found on the surface. One of these, PbS_2, is more likely to remain solid under the harshest of conditions, while the other, PbS_3, has a lower melting point. That lower melting point means the latter form could seep to the planet's surface, leaving the lead found in today's volcanic rocks.

With this new understanding of Earth's crucial lead mystery, researchers will also gain fresh insight into how other planets form and evolve. To follow up on their research, the team will next attempt to recreate the extreme inner Earth conditions in the laboratory

to validate their findings, while continuing to seek further evidence from volcanic rock samples.

The paper, "Hidden Pressure-Stabilized Lead Reservoirs in Earth's Mantle," appeared in *Nature Communications* on February 16, 2026.

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