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Earth's missing lead mystery may finally be solved

By Rodielon Putol,

Lead is at the center of one of Earth's strangest mysteries. A big chunk of it is gone. Not just misplaced, but missing in a way that has puzzled scientists for decades.

Lead is more than just a heavy metal. It acts like a timekeeper for our planet. Scientists use different forms of lead to figure out how old rocks are and how Earth formed billions of years ago.

These clues help build the story of our planet from its earliest days. But when researchers compare Earth's rocks to ancient meteorites, something doesn't add up.

There's too much "young" lead in surface rocks and not enough of the original kind that should have been there from the start.

This makes Earth look younger than it really is, which clearly isn't right. So where did the missing lead go?

The answer may lie far beneath the surface, in a place no human has ever reached.

How lead behaves under pressure

Researchers from Nanyang Technological University, Singapore's (NTU Singapore) Asian School of the Environment (ASE) began pointing toward a new explanation.

The study suggests that Earth didn't lose its lead at all. It simply hid it deep inside.

The team, led by Professor Simon Redfern and Dr. Liu Siyu, looked at how lead behaves under extreme pressure. These are the same crushing conditions found in Earth's mantle, the thick layer between the crust and the core.

Instead of drifting into the core as many had believed, lead may have bonded with sulfur and settled into the mantle early in Earth's history. There, it could have stayed locked away for billions of years.

Why lead matters so much

Lead comes in several forms, called isotopes. Three of them form over time through radioactive decay. Uranium and thorium slowly break down and turn into lead, acting like a natural clock.

The fourth type, lead-204, is different. It has been around since Earth first formed and does not come from decay. That makes it a key marker for ancient material.

By comparing these forms, scientists can estimate the age of rocks. A rock with more decay-produced lead is younger, while one with more original lead is older.

The problem is that Earth's surface rocks don't show enough of that original lead. It seems to be missing, and that gap has been hard to explain.

Locked in minerals we can't see

The research team focused on lead sulfide, a compound formed when lead bonds with sulfur. Lead tends to stick with sulfur naturally, so this was a strong candidate.

Using advanced computer simulations, the experts found that lead sulfide becomes extremely stable under high pressure. It can stay solid even at temperatures reaching 9,000°F, hotter than conditions in much of the mantle.

This means ancient lead could have been trapped in solid form deep underground, cut off from the processes that shape surface rocks. That would explain why it doesn't show up where scientists expected to find it.

New minerals hiding in the mantle

The simulations revealed something else too. The team predicted two new types of lead-sulfur compounds: PbS_2 and PbS_3.

These minerals likely form in parts of the mantle rich in sulfur. One of them stays solid under upper mantle conditions. The other can melt more easily.

When the softer compound melts, it can move upward. As it rises, it may carry small amounts of ancient lead with it. This could explain why very old lead sometimes appears in volcanic rocks.

It's not that the lead vanished. It just leaks out slowly over time.

A virtual journey to Earth's interior

No one can travel thousands of miles below the surface to check this directly, so the researchers turned to powerful computer models.

They used software that predicts how atoms arrange themselves under extreme conditions. By feeding in the right temperatures and pressures, they recreated the environment deep inside Earth.

The results showed that these lead-sulfur minerals are stable enough to survive for billions of years. They can handle the heat and pressure while remaining locked in place.

This gives weight to the idea that the missing lead has been sitting quietly in the mantle all along.

Implications for Earth and beyond

This finding reshapes how scientists think about Earth's chemistry. It shows that sulfur plays a bigger role than expected in storing metals deep underground.

It also helps explain odd patterns seen in volcanic rocks. Those traces of ancient lead now have a clear source.

Beyond Earth, the research opens doors to understanding other rocky planets. If sulfur can trap metals like lead here, it may do the same on planets like Mars.

That could change how scientists study planetary formation across the solar system.

The next step underground

The work isn't finished yet. The team plans to recreate mantle-like conditions in the lab to test their predictions.

The researchers will use high-pressure equipment to see if these minerals form the way the models suggest.

They will also study rock samples brought up by volcanic activity, searching for real-world signs of these hidden compounds.

The missing lead mystery may finally be close to an answer. And as often happens in science, solving one puzzle is already pointing to new ones waiting below the surface.

The full study was published in the journal Nature Communications.

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