Primeval Reservoirs Under Earth's Mantle May Be Older Than the Moon

By Tia Ghose, Senior Writer | February 9, 2017 12:12pm ET

Matthew Jackson takes a sample of lava from a flow in Hawaii. New research suggests that this lava may contain traces of a primeval Earth that dates back 4.5 billion years.
Credit: WHOI Geodynamics program
Lava from Earth's hottest spots may be flecked with primordial rock that existed 4.5 billion years ago, before the moon had formed, new research suggests.

The traces of ancient Earth likely come from dense primordial reservoirs buried deep below the Earth's surface, at the boundary between the mantle and the core. As plumes of molten rock in the Earth's mantle rise toward the surface, they pull in some of this primeval rock. These plumes then warm Earth's surface at volcanic hotspots, oozing lava that contains signatures of the young planet, according to the study, which was published on Monday (Feb. 6) in the journal Nature.

"We're finding the hottest plumes are sampling the oldest domains on the Earth," said study co-author Matthew Jackson, a geochemist at the University of California, Santa Barbara. "These lavas are sampling a domain in the Earth that had to have formed in the first 100 million years of Earth's history." [Photo Time Line: How the Earth Formed]

Smashing beginning

Around 4.54 billion years ago, Earth formed during several massive collisions, the last of which occurred about 100 million years after the solar system's coalescence, when Earth crashed into the planetoid Theia. The vaporized remains of this planetoid then condensed to form the moon.

Though the violent churning of the Earth has erased almost all traces of this early history, in the past few decades, scientists have found evidence that bits of this young Earth may still exist in places like Hawaii and Iceland. These locations are among the 50 volcanic hotspots on the planet, where heat from the Earth's mantle rises in a plume, melting rock at the base of the tectonic plates that form Earth's surface. The molten rock, or magma, then oozes through fissures in the Earth to erupt and form volcanoes.

In the 1980s, scientists sampling lava in Hawaii noticed that in some spots, the ratio of helium-3 (helium with just one neutron per atom) to the version with two neutrons per atom, called helium-4, was higher than expected based on the surrounding rock's composition.

"This ratio is associated with the building blocks of the planet, primitive meteorites, the atmosphere of Jupiter, the solar wind," Jackson said. (Jupiter's atmosphere likely formed early in the solar system's history.)

In other words, the high ratio of helium-3 to helium-4 suggested a very ancient source, he said. Follow-up studies produced ratios of other isotopes, such as tungsten and xenon, that suggested these lavas may come from the first 50 million years of Earth's history.

"It records the earliest history of the planet," Jackson told Live Science.

Hottest spots, oldest rock

However, only some hotspots held lava with high helium-3/helium-4 ratios. Why then were some hotspots sampling this primordial soup when others weren't?

To answer that question, Jackson and his colleagues took helium-isotope data from 38 volcanic hotspots around the world and combined that information with data on how fast seismic waves travel through the upper mantle. Seismic waves travel more slowly through hotter mantle. They found that the areas with the slowest seismic waves (and therefore the hottest mantle) also had a helium signature associated with primordial reservoirs.

The new research suggests that the hottest of hotspots may be the only ones pulling from this primordial pool of ancient rock, the study said. The hottest spots are likely fed by the most buoyant plumes in the mantle, meaning the plumes are better able to rise up in relation the surrounding mantle rock, the researchers said. These ultrahot plumes are also able to cause more melt, the scientists added.

Under this hypothesis, these dense blobs of primordial rock lie about 1,860 miles (3,000 kilometers) below the Earth's surface, at the boundary with the core. Because these blobs are so dense, only the hottest mantle plumes can melt bits of this material and transport it, Jackson said.

The high density "also explains how something so ancient could survive in the chaotically convecting mantle for 4.5 billion years," he said in a statement. "The density contrast makes it more likely that the ancient helium reservoir is preserved rather than mixed away."

While the findings suggest an explanation for why only some lava contains traces of ancient Earth, the results don't answer larger questions about these primeval reservoirs, Jackson said. For instance, scientists have little idea what these primordial reservoirs are made of or how they formed, he said.

Originally published on Live Science.