

Isotopic similarities seen in materials that formed Earth, moon

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Credit: NASA

Where did the materials that make up the Earth and moon come from—and when did they arrive?

Most scientific models contend the Earth formed gradually by addition from an assortment of [moon](#)- to Mars-sized masses that had a vast array of isotopic characteristics. New research published Jan. 26 in *Nature*

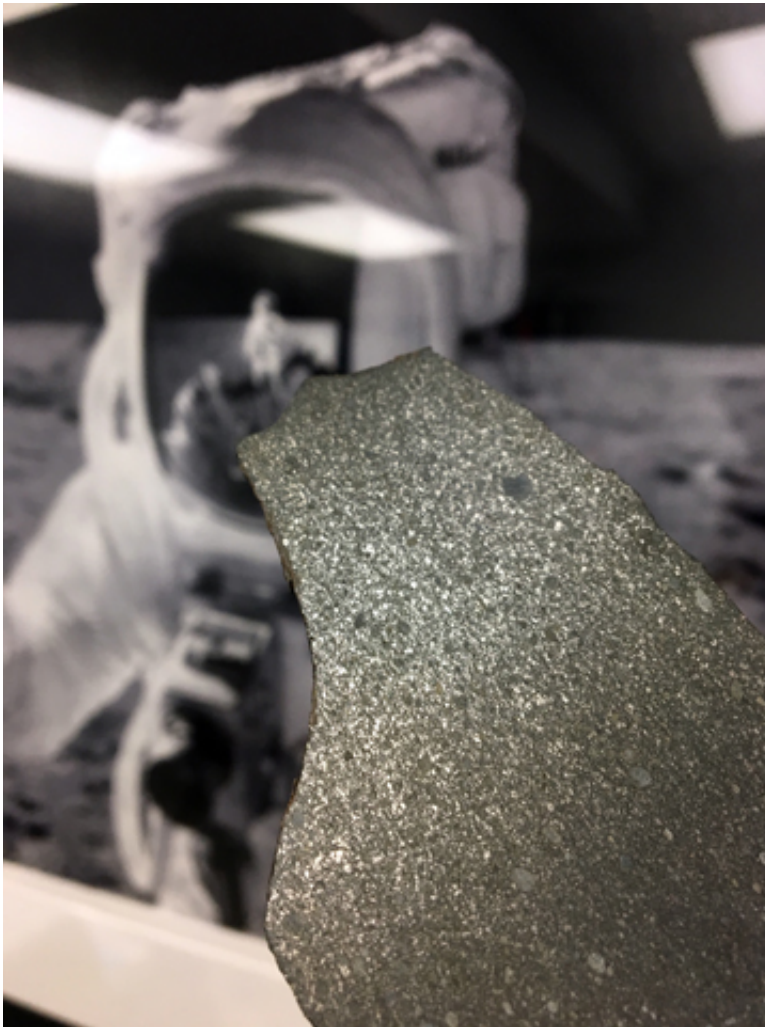
maintains the Earth, as well as the moon and certain meteorites, were formed from materials that were more similar, holding almost indistinguishable isotopic characteristics.

"The Earth accreted from an isotopically homogenous reservoir," said Nicolas Dauphas, the Louis Block Professor in Geophysical Sciences, the study's author. "In terms of colors, you could say that it was not 'green, blue, red,' but rather 'green, green, green.'"

By analyzing data for certain elements, Dauphas was able to decipher the isotopic nature of the material that formed the Earth. Anomalies in the elements provided "fingerprints" to recreate the formation process, helping to establish "genetic ties" between planetary bodies and their building blocks.

Dauphas used the isotopic similarities he found in select elements to record the stages of Earth's formation. Soon after the Earth formed 4.5 billion years ago and as its core grew, the core attracted elements that had strong affinities for metal. As [core formation](#) was almost complete, however, such elements—as they continued to arrive from space—were left to reside in the mantle.

This helps explain the age of parts of the Earth and the role they played in forming our planet, Dauphas said. "For example, I can tell you that the coin in your pocket with the image of Jefferson on it contains no nickel from the first 60 percent of the Earth's accretion because the core scavenged that early-to-arrive nickel."



Isotopic characteristics of the Earth, moon and meteorites (pictured here) help identify their origins. Credit: Courtesy of Prof. Nicholas Dauphas

In addition, Dauphas' research reveals that a rare type of extraterrestrial material known as enstatite meteorites (named after a mineral they contain in abundance) formed half of the first 60 percent of the Earth. After that, 100 percent of the rest of the Earth was formed by enstatite-type impactors.

"Before this work, the question of the nature of the Earth's accreting material through time was mostly rhetorical," said Dauphas. "By

studying high-precision measurements, we have shown that the Earth, the moon and meteorites with a high concentration of the mineral enstatite have almost indistinguishable isotopic compositions."

The formation of the moon

The findings shed light on the formation of the moon, which has been difficult to explain using the simplest models of the Earth's formation. Such models show the Earth and moon were formed by varied materials with different isotopic compositions.

"The moon is isotopically similar to the Earth," Dauphas said.

"Therefore the giant impactor that struck the Earth soon after it was created, thereby forming the moon, most likely had a similar isotopic composition to the Earth."

This work also shows that the material that was used to make the Earth was ordered, said David Stevenson, the Marvin L. Goldberger Professor of Planetary Science at Caltech, who was not involved in the research.

"The ordering was such that the Mars-mass projectile that hit the Earth and most probably led to the formation of the moon was very similar to the Earth at that time. This makes it easier to understand why the Earth and moon are so strikingly similar—a similarity that has been a major puzzle for more than a decade."

Dauphas' method offers "an elegant approach" for sourcing the materials that made up the Earth, Stevenson concluded.

More information: Nicolas Dauphas. The isotopic nature of the Earth's accreting material through time, *Nature* (2017). [DOI: 10.1038/nature20830](https://doi.org/10.1038/nature20830)

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