

Changes in Earth's orbit may have triggered ancient warming event

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Victoria Fortiz (right), then a graduate student at Penn State, and Jean Self-Trail, a research geologist at the U.S. Geological Survey, work on a core sample from the Howards Tract site in Maryland. Credit: Penn State

Changes in Earth's orbit that favored hotter conditions may have helped trigger a rapid global warming event 56 million years ago that is considered an analog for modern climate change, according to an international team of scientists.

"The Paleocene-Eocene Thermal Maximum is the closest thing we have in the [geologic record](#) to anything like what we're experiencing now and may experience in the future with [climate change](#)," said Lee Kump, professor of geosciences at Penn State. "There has been a lot of interest in better resolving that history, and our work addresses important questions about what triggered the event and the rate of carbon emissions."

The scientists analyzed [core samples](#) from a well-preserved record of the PETM near the Maryland coast using astrochronology, a technique for dating sediments against orbital patterns that occur over tens to hundreds of thousands of years, known as Milankovitch cycles.

They found the shape of Earth's [orbit](#) (eccentricity), and the wobble in its rotation (precession), favored hotter conditions at the onset of the PETM and that these orbital configurations together may have played a role in triggering the event.

"An orbital trigger may have led to the [carbon release](#) that caused several degrees of global warming during the PETM as opposed to what's a more popular interpretation at the moment that massive volcanism released the carbon and triggered the event," said Kump, the John Leone Dean in the College of Earth and Mineral Sciences.

The findings, published in the journal *Nature Communications*, also indicated the onset of the PETM lasted about 6,000 years. Previous estimates have ranged from several years to tens of thousands of years. The timing is important to understand the rate at which carbon was

released into the atmosphere, the scientists said.

"This study allows us to refine our carbon cycle models to better understand how the planet reacts to an injection of carbon over these timescales and to narrow down the possibilities for the source of the carbon that drove the PETM," said Mingsong Li, assistant professor in the School of Earth and Space Sciences at Peking University and a former assistant research professor of geosciences at Penn State who is lead author on the study.



Core sample from the Howards Tract site in Maryland. Credit: Penn State

A 6,000-year onset, coupled with estimates that 10,000 gigatons of carbon were injected into the atmosphere as the greenhouse gases carbon dioxide or methane, indicates that about one and a half gigatons of carbon were released per year.

"Those rates are close to an order of magnitude slower than the rate of carbon emissions today, so that is cause for some concern," Kump said. "We are now emitting [carbon](#) at a rate that's 5 to 10 times higher than our estimates of emissions during this geological event that left an indelible imprint on the planet 56 million years ago."

The scientists conducted a time series analysis of calcium content and [magnetic susceptibility](#) found in the cores, which are proxies for changes in orbital cycles, and used that information to estimate the pacing of the PETM.

Earth's orbit varies in predictable, calculable ways due to gravitational interactions with the sun and other planets in the solar system. These changes impact how much sunlight reaches Earth and its geographic distribution and therefore influence the climate.

"The reason there's an expression in the geologic record of these orbital changes is because they affect climate," Kump said. "And that affects how productive marine and terrestrial organisms are, how much rainfall there is, how much erosion there is on the continents and therefore how much sediment is carried into the ocean environment."

Erosion from the paleo Potomac and Susquehanna rivers, which at the onset of the PETM may have rivaled the discharge of the Amazon River,

carried sediments to the ocean where they were deposited on the continental shelf. This formation, called the Marlboro Clay, is now inland and offers one of the best-preserved examples of the PETM.

"We can develop histories by coring down through the layers of [sediment](#) and extracting specific cycles that are creating this story, just like you could extract each note from a song," Kump said. "Of course, some of records are distorted and there are gaps—but we can use the same types of statistical methods that are used in apps that can determine what song you are trying to sing. You can sing a song and if you forget half the words and skip a chorus, it will still be able to determine the song, and we can use that same approach to reconstruct these records."

More information: Mingsong Li et al, Astrochronology of the Paleocene-Eocene Thermal Maximum on the Atlantic Coastal Plain, *Nature Communications* (2022). [DOI: 10.1038/s41467-022-33390-x](https://doi.org/10.1038/s41467-022-33390-x)

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