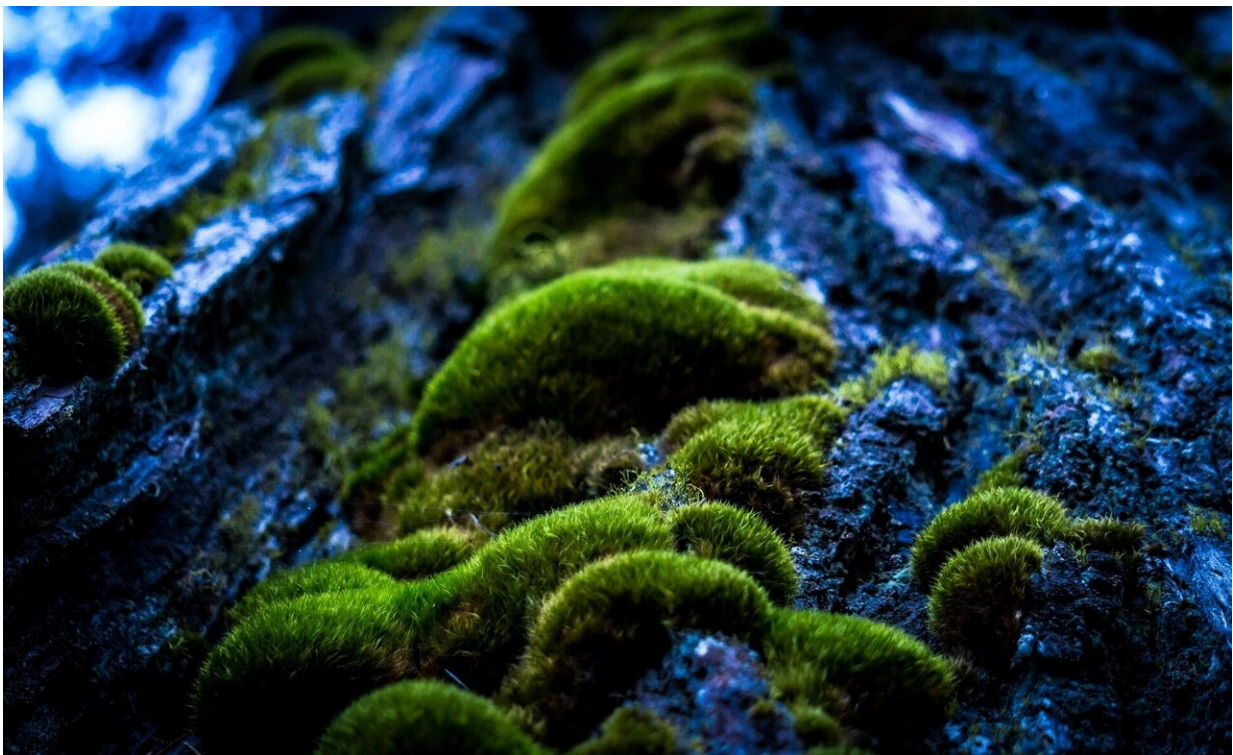


Fossil pollen preserved in rocks for 56 million years provides new insights into carbon-fueled global warming

December 11 2023, by Vera A. Korasidis and Scott L. Wing



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Through our burning of fossil fuels and other activities, we humans have raised atmospheric carbon dioxide (CO₂) concentrations more than 40 percent in the last 150 years. This increase in CO₂, and in another

greenhouse gas—methane—has warmed the planet more than 1°C.

Present [greenhouse gas](#) concentrations and temperature are not only unprecedented in [human history](#), but exceed anything known in the last 2.5 million years.

We need to look deeper into Earth's history for examples of how giant carbon emission events like ours affect climate and life.

A significant time period to study rapid carbon release and [global warming](#) is 56 million years ago, with an event called the Paleocene-Eocene thermal maximum ([PETM](#)).

The PETM is the most rapid global warming event known in Earth's history.

Over a period of about 5,000 years, an amount of carbon roughly equal to the total modern fossil fuel reservoir was released into the atmosphere, probably from a combination of volcanism and carbon stored in sea-floor sediments.

This carbon release caused global temperature to rise by about 6°C and to remain elevated for more than 100,000 years.

Although the initial carbon release and climate change were perhaps ten times slower than what we are doing today, they enormously affected ocean chemistry and the geographic distributions of plants and animals.

Our team is interested in how the PETM affected [terrestrial ecosystems](#), and a great place to study this is the Bighorn Basin—a deep and wide valley amidst the northern Rocky Mountains in Wyoming, U.S..

The widespread badlands of the modern-day Bighorn Basin expose

remarkably fossil-rich sediments lain down by ancient rivers eroding the surrounding mountains.

And it's a paradise for any paleontologist interested in the PETM.

Efforts by earlier scientists have shown an array of changes in Bighorn Basin ecosystems during the PETM. A horde of new types of mammals first appeared in North America during the PETM, probably migrating from other continents across northern land bridges made habitable by the [warmer temperatures](#).

Many kinds of mammals evolved much smaller body sizes—probably related to the high temperatures and possibly related to some plants becoming less nutritious in a high CO₂ atmosphere.

There are [studies of fossil leaves](#) that show many kinds of plants disappeared from the region and were replaced by plants better adapted to hot, dry climates.

Our team studied fossil pollen grains because we wanted to understand the changes in the flora in the finest possible detail. Pollen is invaluable for this kind of research because it is abundantly produced, widely dispersed in air and water, and resistant to decay so that it is easily preserved in ancient rocks.

Our [new research](#), published in *Paleoceanography and Paleoclimatology*, shows that floras began to change in the last few tens of thousands of years just prior to the big carbon release. The deciduous broad-leaved tree families still common in moist Northern Hemisphere temperate regions today became rarer, and subtropical palms and other plants of warm climates became more common.

Those pre-PETM changes show the climate was already warming and

drying, perhaps because of the buildup of greenhouse gases in the atmosphere from the [volcanic activity documented](#) in the North Atlantic.

But then, when the PETM began, we found dramatic changes in plants—over a few tens of thousands of years, all plants that lived in wetland habitats disappeared, and plants that can tolerate a hot and dry climate invaded the Bighorn Basin.

Imagine a shift from vegetation that resembled modern-day swamps in Georgia and Florida to something like the dry tropical forests of southern Mexico and Costa Rica.

You may be wondering, as we did, where these tropical plants that temporarily appeared in Wyoming came from.

In a study published in *Palynology*, [our team described](#) some new species from the PETM in Wyoming.

After sharing illustrations of the pollen grains of these species, some industry experts were able to confirm that they'd seen the same species in Paleocene rocks a few million years older on the Gulf Coast in the southern United States, some 2000 kilometers away.

This suggests that these trees migrated north as the continent warmed and dried but then retreated back south when conditions cooled.

As the PETM waned and the Earth cooled—moist, temperate forest trees returned to the Bighorn Basin. A few hundred thousand years after the PETM, the swamp forests of the Bighorn Basin were dominated by many of the same trees that were abundant before the PETM, along with a few new types that probably entered North America across Arctic land bridges from other continents during the warmest time.

You might think that such rapid change in a short time—a few tens of thousands of years is very long by human standards but geologically very sudden—would lead to high levels of extinction, but we don't see this in either the pollen or the leaf fossils.

We now strongly suspect that the lack of extinction among the plants reflects local refuges at higher elevations in the then-rising Rocky Mountains or perhaps in other nearby basins less affected by drought.

The PETM shows a concerning glimpse into our future—global warming, ocean acidification, and a dramatic alteration of ecosystems on land and in the sea that are very long-lasting.

It could take 100,000 years to remove all of the carbon from the atmosphere by natural processes if we were to burn Earth's entire fossil fuel reservoir.

Much of what the PETM tells us confirms the [grim forecasts of climate models](#) and [predictions of ecological disruption](#).

We do see one result, though, with less dire implications.

Even amid the major and geologically rapid [climate change](#) at the beginning of the PETM, plant populations survived somewhere in this mountainous region.

Also heartening, if we take a very long-term perspective, is that without mass extinction, the wet forests returned to the Bighorn Basin in the Eocene epoch. After more than 100,000 years of hot, dry climate—these forests were very similar to those that existed before the event.

A walk in the woods of the early Eocene epoch would have been quite similar to one near the end of the Paleocene.

This suggests that forests could return to something like their previous equilibrium even after a very long period of altered [climate](#)—as long as we find a way to preserve all of the species that make up these unique ecologies.

More information: Vera A. Korasidis et al, Palynofloral Change Through the Paleocene-Eocene Thermal Maximum in the Bighorn Basin, Wyoming, *Paleoceanography and Paleoclimatology* (2023). [DOI: 10.1029/2023PA004741](#)

Vera A. Korasidis et al, Biostratigraphically significant palynofloras from the Paleocene–Eocene boundary of the USA, *Palynology* (2022). [DOI: 10.1080/01916122.2022.2115159](#)

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