

# 'True polar wander' may have caused ice age

November 19 2018

---

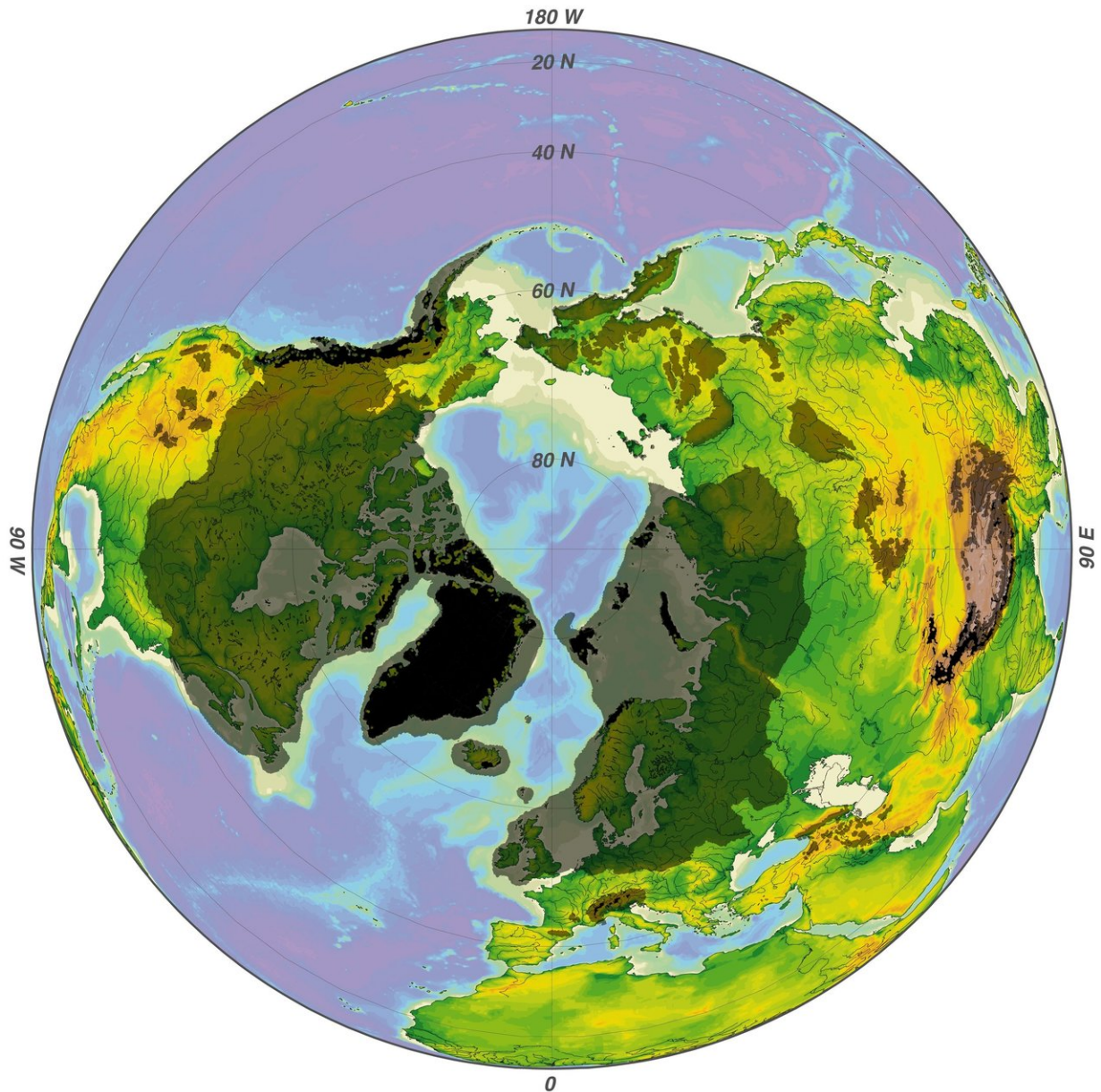


Illustration depicting the minimum (interglacial, black) and maximum (glacial,

grey) glaciation of the northern hemisphere during the ice age that began about 3.2 million years ago. Credit: Hannes Grobe/AWI/Wikimedia Commons

Earth's latest ice age may have been caused by changes deep inside the planet. Based on evidence from the Pacific Ocean, including the position of the Hawaiian Islands, Rice University geophysicists have determined Earth shifted relative to its spin axis within the past 12 million years, which caused Greenland to move far enough toward the north pole to kick off the ice age that began about 3.2 million years ago.

Their study in the journal *Geophysical Research Letters* is based on an analysis of fossil signatures from deep ocean sediments, the magnetic signature of oceanic crust and the position of the [mantle](#) "hot spot" that created the Hawaiian Islands. Co-authors Richard Gordon and Daniel Woodworth said the evidence suggests Earth spun steadily for millions of years before shifting relative to its [spin axis](#), an effect geophysicists refer to as "true polar wander."

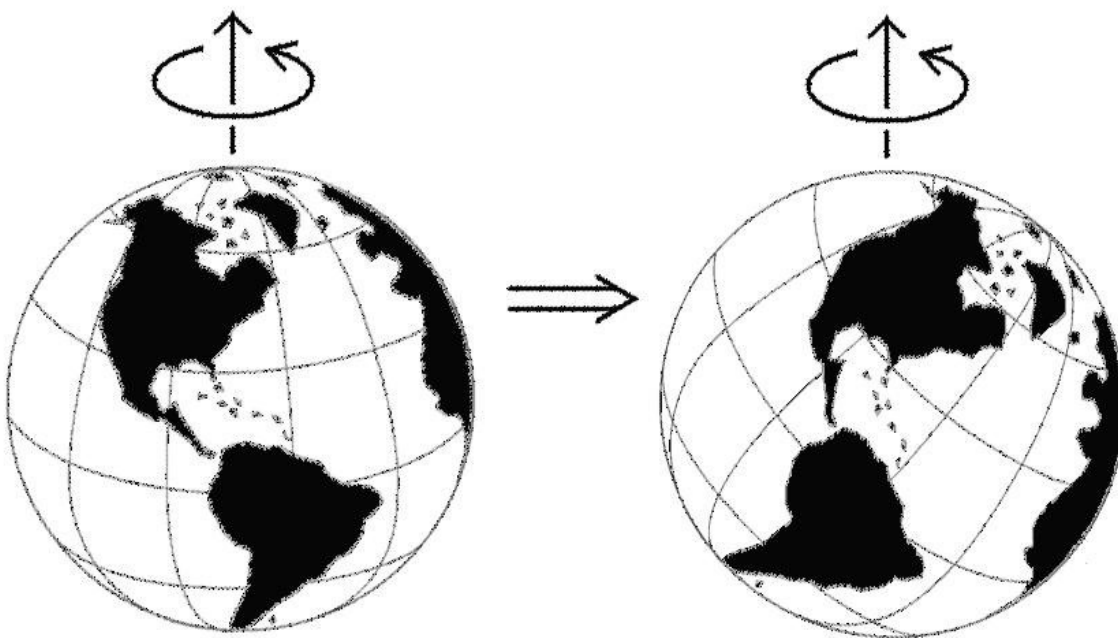
"The Hawaiian hot spot was fixed, relative to the spin axis, from about 48 million years ago to about 12 million years ago, but it was fixed at a latitude farther north than we find it today," said Woodworth, a graduate student in Rice's Department of Earth, Environmental and Planetary Sciences. "By comparing the Hawaiian hot spot to the rest of the Earth, we can see that that shift in location was reflected in the rest of the Earth and is superimposed on the motion of tectonic plates. That tells us that the entire Earth moved, relative to the spin axis, which we interpret to be true polar wander."

By volume, Earth is mostly mantle, a thick layer of solid rock that flows under intense pressure and heat. The mantle is covered by an interlocking puzzle of rocky tectonic plates that ride atop it, bumping

and slipping against one another at seismically active boundaries. Hot spots, like the one beneath Hawaii, are plumes of hot solid rock that rise from deep within the mantle.

Gordon, the W.M. Keck Professor of Earth, Environmental and Planetary Science, said the new findings build on two 2017 studies: one from his lab that showed how to use [hot spots](#) as a global frame of reference for tracking the movement of tectonic plates and another from Harvard University that first tied true polar wander to the onset of the ice age.

"We're taking these hot spots as marked trackers of plumes that come from the deep mantle, and we're using that as our reference frame," he said. "We think the whole global network of hotspots was fixed, relative to the Earth's spin axis, for at least 36 million years before this shift."



True polar wander occurs when the entire Earth shifts relative to its spin axis.

Credit: Victor C. Tsai/Wikimedia Commons

Like any spinning object, Earth is subject to centrifugal force, which tugs on the planet's fluid interior. At the equator, where this force is strongest, Earth is more than 26 miles larger in diameter than at the poles. Gordon said true polar wander may occur when dense, highly viscous bumps of mantle build up at latitudes away from the equator.

"Imagine you have really, really cold syrup, and you're putting it on hot pancakes," Gordon said. "As you pour it, you temporarily have a little pile in the center, where it doesn't instantly flatten out because of the viscosity of the cold syrup. We think the dense anomalies in the mantle are like that little temporary pile, only the viscosities are much higher in the lower mantle. Like the syrup, it will eventually deform, but it takes a really, really long time to do so."

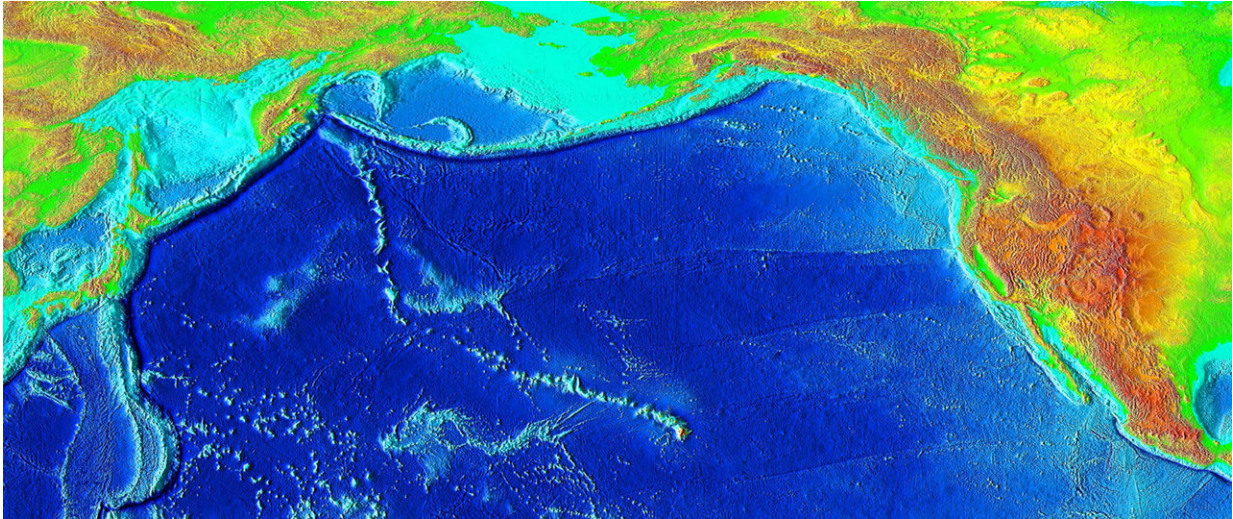
If the mantle anomalies are massive enough, they can unbalance the planet, and the equator will gradually shift to bring the excess mass closer to the equator. The planet still spins once every 24 hours and true polar wander does not affect the tilt of the Earth's spin axis relative to the sun. The redistribution of mass to a new equator does change Earth's poles, the points on the planet's surface where the spin axis emerges.

Woodworth said the hot spot data from Hawaii provides some of the best evidence that true polar wander was what caused Earth's poles to start moving 12 million years ago. Islands chains like the Hawaiians are formed when a tectonic plate moves across a hot spot.

"True polar wander shouldn't change hot spot tracks because the hot spot track is the record of the motion of the plate relative to the hot spot," Woodworth said.



Gordon said, "It was only about a 3 degree shift, but it had the effect of taking the mantle under the tropical Pacific and moving it to the south, and at the same time, it was shifting Greenland and parts of Europe and North America to the north. That may have triggered what we call the ice age."



The movement of the Pacific plate across a mantle hotspot created the Hawaiian islands over millions of years. Credit: National Geophysical Data Center/USGS/Wikimedia Commons

Earth is still in an ice age that began about 3.2 million years ago. Earth's poles have been covered with ice throughout the age, and thick ice sheets periodically grow and recede from poles in cycles that have occurred more than 100 times. During these glacial cycles, ice has extended as far south as New York and Yellowstone National Park. Earth today is in an interglacial period in which ice has receded toward the poles.

Gordon said true polar wander is not merely a change in the location of

Earth's magnetic poles. As the planet spins, its iron core produces a magnetic field with "north" and "south" poles near the spin axis. The polarity of this field flips several times every million years, and these changes in polarity are recorded in the magnetic signatures of rocks the world over. The paleomagnetic record, which is often used to study the movement of tectonic plates across Earth's surface, contains many instances of "apparent polar wander," which tracks the motion of the spin axis and which includes the effects of both plate motion and true polar wander, Gordon said.

He said Earth's mantle is ever-changing as new material constantly cycles in and out from tectonic plates. The drawing down and recycling of plates via subduction provides a possible explanation for the highly viscous mantle anomalies that probably cause [true polar wander](#).

"In class, I often demonstrate this with lead fishing weights and pliers," Gordon said. "It's easy to deform the lead with the pliers, and it's not brittle. It doesn't crack or fly apart when it fails. That's a pretty good analogy for mantle flow because that's the way silicate rock deforms under intense heat and pressure."

He and Woodworth are working with colleagues to extend their analysis, both from 12 million years ago to the present as well as further into the past than the 48-million-year start date in the newly published study.

**More information:** Daniel Woodworth et al, Paleolatitude of the Hawaiian Hot Spot Since 48 Ma: Evidence for a Mid-Cenozoic True Polar Stillstand Followed by Late Cenozoic True Polar Wander Coincident With Northern Hemisphere Glaciation, *Geophysical Research Letters* (2018). [DOI: 10.1029/2018GL080787](https://doi.org/10.1029/2018GL080787)

Provided by Rice University

Citation: 'True polar wander' may have caused ice age (2018, November 19) retrieved 28 April 2024 from <https://phys.org/news/2018-11-true-polar-ice-age.html>

This document is subject to copyright. Apart from any fair dealing for the purpose of private study or research, no part may be reproduced without the written permission. The content is provided for information purposes only.