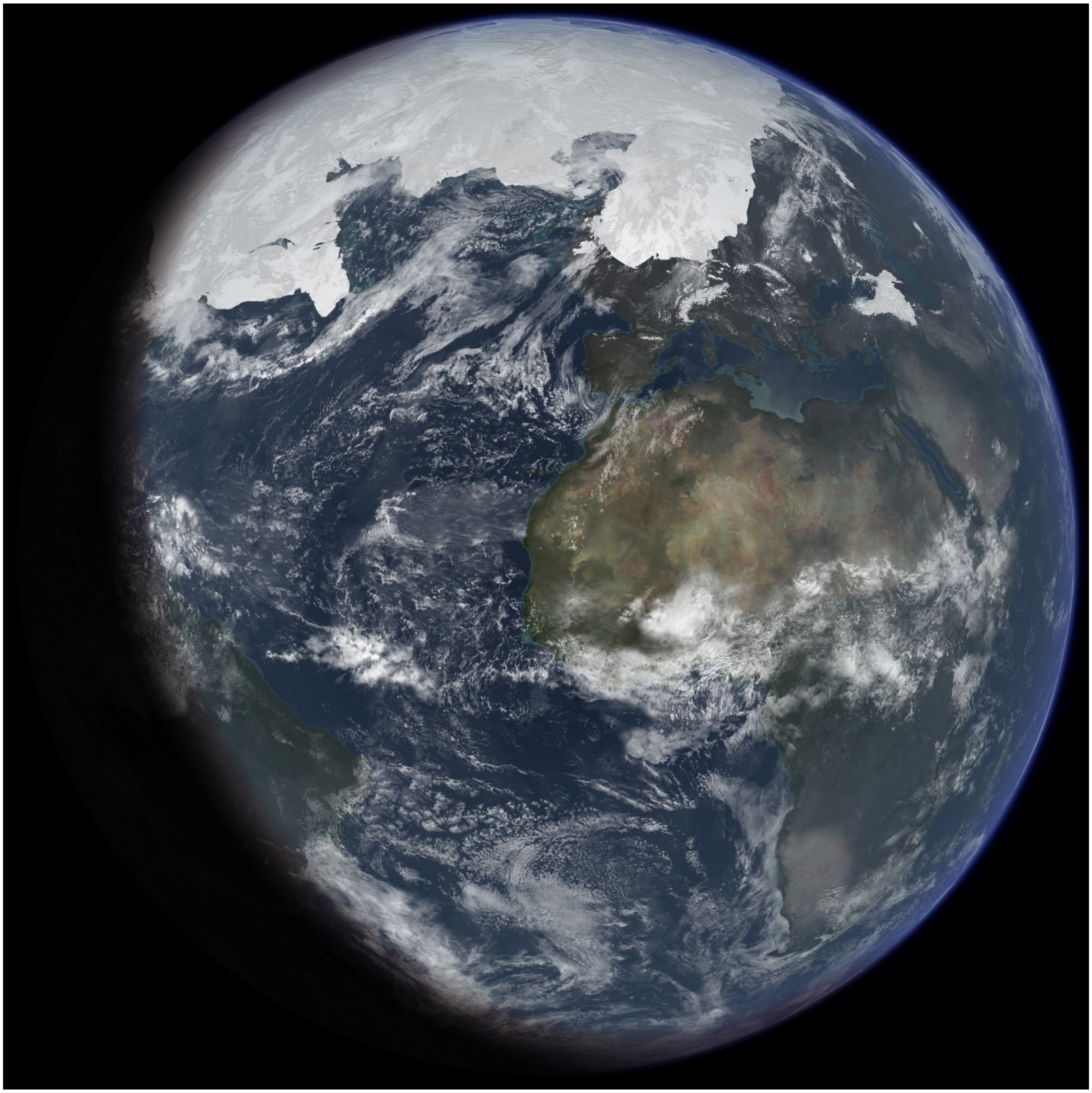


Posted on November 25, 2018 by Matt Williams

The Earth's Wandering Poles Could Have Caused the Ice Age

Earth's last great ice age, known as the Quaternay Glaciation, began roughly 3.2 million years ago. This period was characterized by the expansion of ice sheets out of Antarctica and Greenland, as well as the fluctuation of the Laurentian ice sheet, which covered most of Canada and the United States. The retreat of this glacier is responsible for the creation of millions of standing bodies of water across North America, including the Great Lakes.

While the causes of ice ages have been attributed to a combination of astronomical cycles, atmospheric conditions, ocean currents and plate tectonics, a complete explanation has been lacking thus far. However, according to a new research findings by a team of Rice University geophysicists, Earth's last ice age may have been caused by shifts in the Earth relative to its spin axis that caused its poles to wander.

This study was conducted by Daniel Woodworth and Richard G. Gordon – a graduate student and the W.M. Keck Professor of Earth, Environmental and Planetary Science at Rice University, respectively – and recently appeared in the journal *Geophysical Research Letters.* For the sake of their study, which was supported by the National Science Foundation (NSF), Woodworth and Gordon analyzed geophysical evidence from the Pacific Ocean.

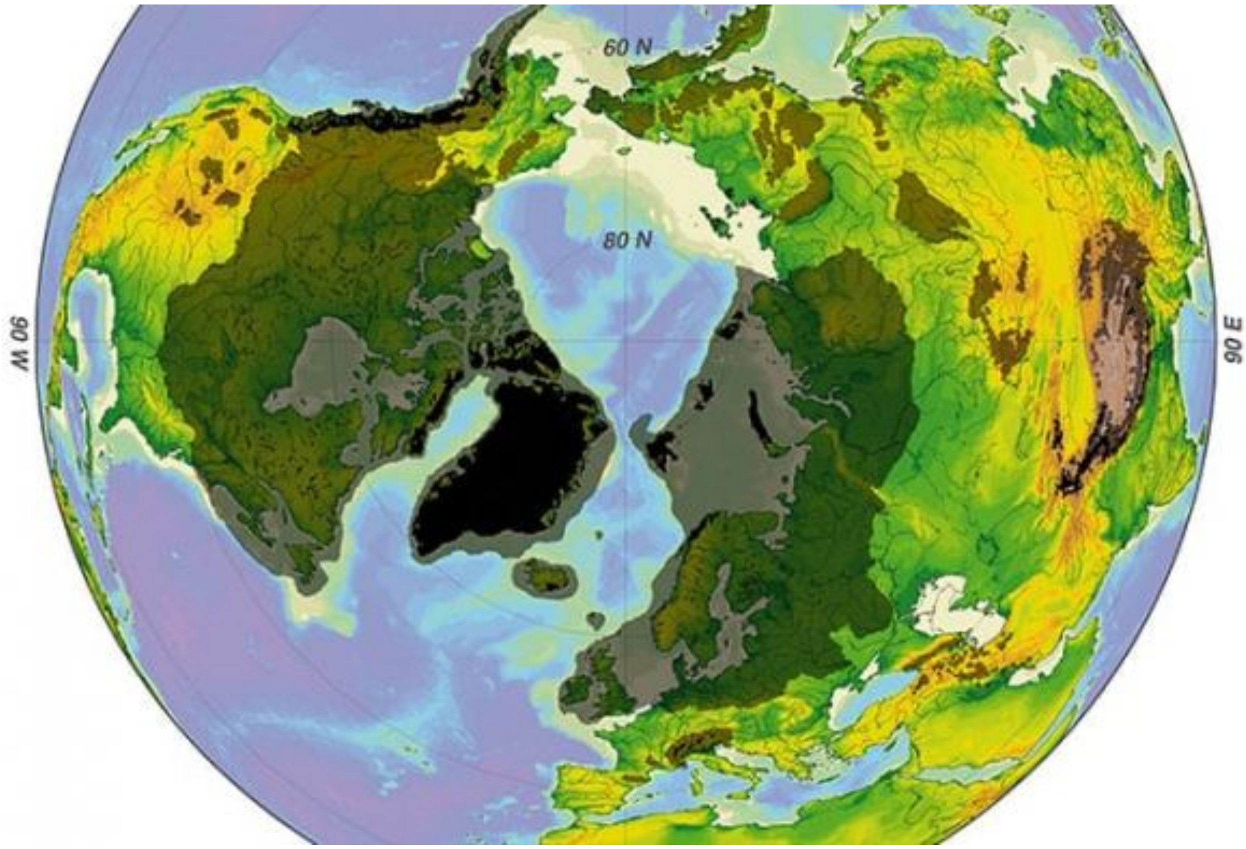


Illustration depicting the minimum (interglacial, black) and maximum (glacial, grey) glaciation of the northern hemisphere during the ice age that began about 3.2 million years ago. Credit: Hannes Grobe/AWI/Wikimedia Commons

This included 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. From this, the team deduced that within the past 12 million years, the Earth experienced "true polar wander" – a phenomenon where the planet shifted relative to its spin axis.

When this occurs, the locations of the north and south poles change (or wander). In this case, Greenland moved far enough towards the north pole to kick off the last ice age. As Woodworth explained in a recent Rice University news release:

"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. 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."

Their work builds upon on two previous studies from 2017. The first, which was conducted by Gordon and researchers from his own lab, demonstrated that hot spots move slowly and can be used to define a global reference frame for plate motions. The second, which was conducted by researchers from Harvard University, was the first to show a connection between true polar wander and the onset of the last ice age.

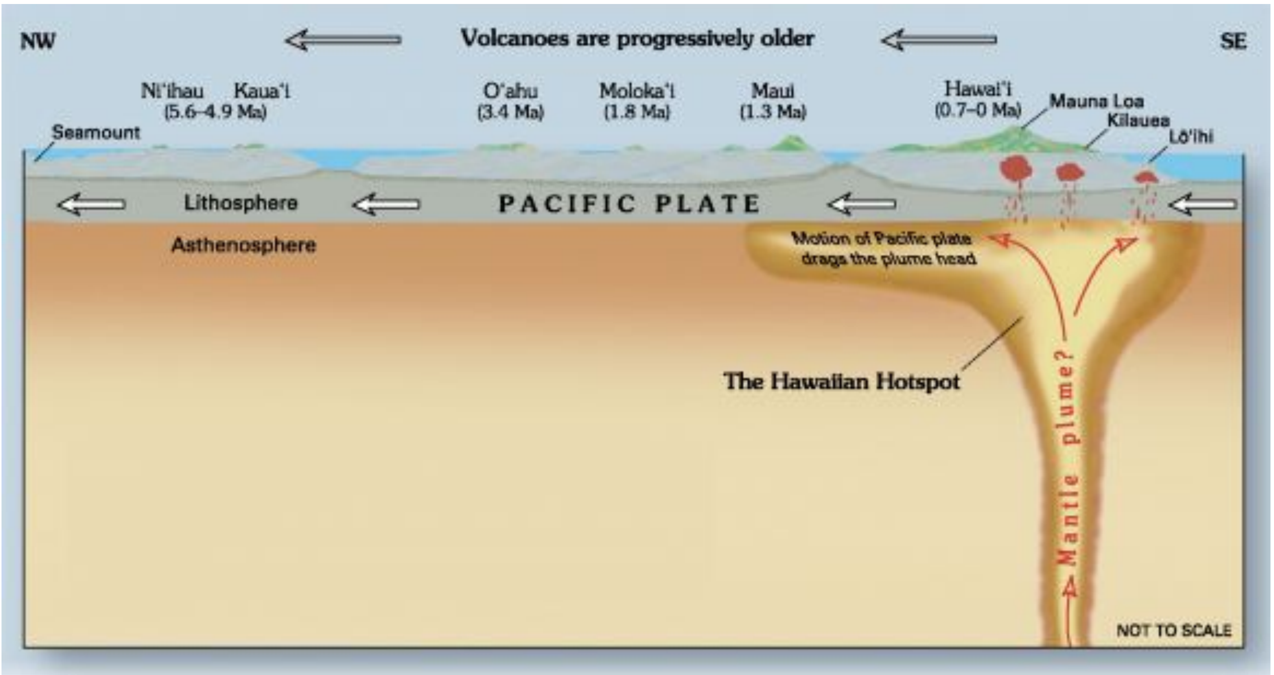


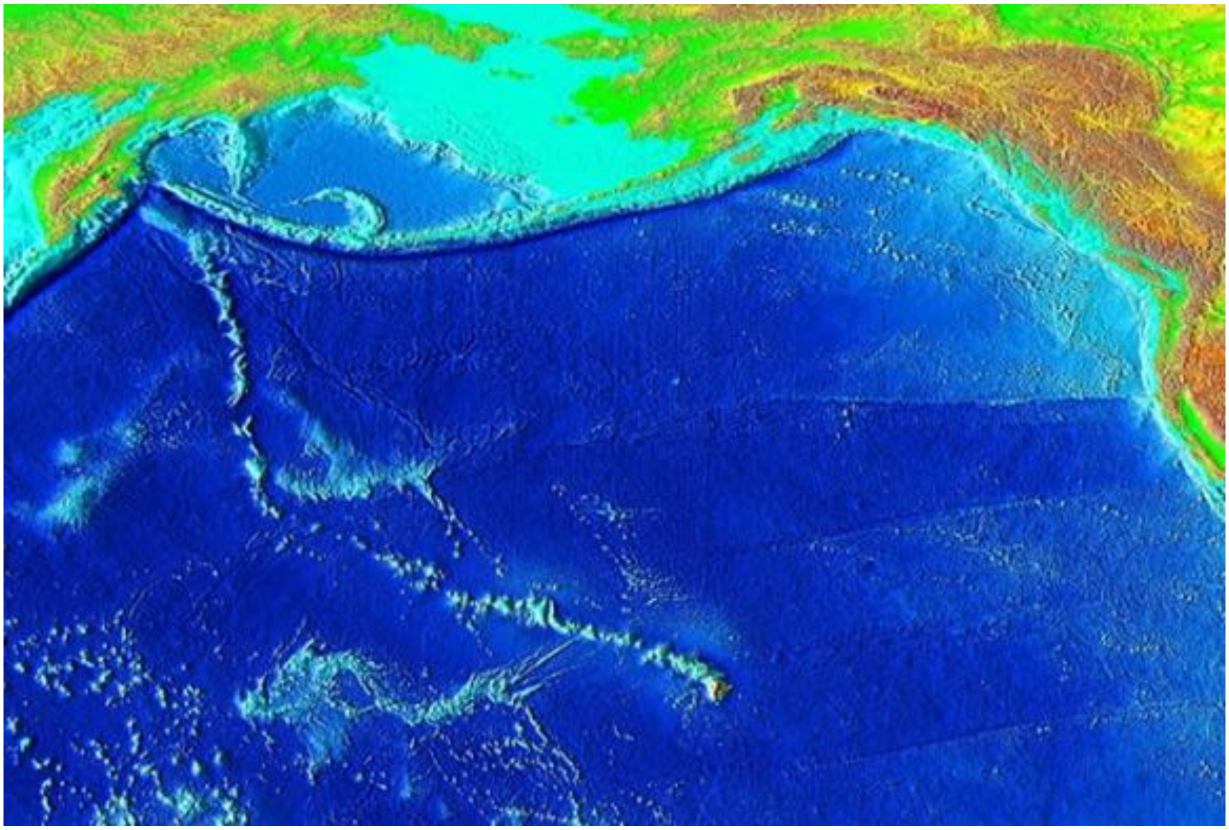
Diagram illustrating the hotspot area located under the island of Hawaii Credit: Joel E. Robinson, USGS

Hot spots, like the one located beneath Hawaii, are volcanic regions where plumes of hot magma rise from deep with the mantle. Unlike other forms of volcanic activity, these spots are not located at the boundaries of tectonic plates. Combined with the fact that they are hotter than the surrounding mantle, hot spots represent something of an anomaly to scientists.

"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," said Gordon. "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."

Since the Earth is a spinning object, its centrifugal force ensures that it is an "oblate spheroid" rather than a perfect sphere – measuring about 42 km (26 mi) more in diameter at the equator than from pole to pole. According to Woodworth and Gordon, true polar wander may also be the result of this, where the same force causes highly-viscous deposits to build up in the mantle at latitudes away from the equator. As Gordon explained:

"Imagine you have really, really cold syrup, and you're putting it on hot pancakes. 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."



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

If these anomalous clumps are massive enough, they could unbalance the planet, causing it to gradually shift and bring the excess mass closer to the equator. This redistribution of mass to a new equator would not change the tilt of Earth's spin axis, but would change the points on the surface where the spin axis emerges (aka. the poles).

While the shift they measured would only be by about 3%, it would have had the effect of moving the Earth's mantle. While the mantle under the tropical parts of the Pacific would have moved south, Greenland and parts of Europe and North America would have moved north. This shift would result in lower temperatures in these latter locations, which could have triggered the last ice age.

According to Woodworth, the hot spot data from Hawaii provides some of the best evidence that true polar wander is responsible for the way the Earth's poles starting moving 12 million years ago. However, they also suspect that past instances of polar wander may be recorded in the magnetic signatures of rocks, which are studied by geophysicists to determine when the Earth's magnetic field flipped in the past.

Looking ahead, Woodworth and Gordon are working with colleagues to build upon their analysis. In addition to extending it from 12 million years ago to the present, they also want to extend it further into the past, beyond the 48-million-year start date they used for this study. The result of this could be a more refined understanding of how Earth's geological history, its ice ages, and the evolution of life are interconnected.

Further Reading: Rice News, Geophysical Research Letters