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Rare-earth metal reveals ancient ocean currents linked to climate triggers

Sophie Hines (right) and a colleague during a deep-sea drilling expedition off the coast of South Africa in 2016. The sedimentary cores recovered from this two-month long trip were used in her later research on ancient ocean currents. (Sophie Hines)

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By Marisa Sloan
Medill Reports

Despite the sci-fi name of this rare-earth element, neodymium is actually pretty common. The silvery metal is used in everything from cell phones and wind turbines to tanning booths and electric guitars.

But it's the neodymium found thousands of meters below the ocean's surface that captured the interest of Dr. Sophie Hines, a postdoctoral research fellow at Columbia University's Lamont-Doherty Earth Observatory (https://www.ldeo.columbia.edu/).

Hines traced the metal trapped within ancient marine sediments to reconstruct changes in ocean circulation reaching as far back as one million years ago. She presented her research at the Comer Climate Conference (https://www.comerfamilyfoundation.org/comer-climate-conference), an annual meeting of climate scientists that was held virtually this October.

"The ocean neodymium cycle is something that people have been studying for a long time," she said. "But there are still parts that we're learning."

Because the global ocean circulation system brings water from the surface down to the deep ocean, it is thought to play an important role in trapping atmospheric carbon dioxide and triggering global climate changes.

According to Hines, different forms of neodymium wind up in the ocean through the weathering of various rocks and minerals. The neodymium composition of the North Atlantic Ocean, which is characterized by older continental crust, is distinct from that of the Pacific Ocean, which has more volcanoes and newly erupted material. These differences make it easier for climate scientists to trace the movement of seawater away from its sources and reconstruct changes in deep ocean currents.

"Trying to figure out how the ocean impacted climate in the past is interesting in and of itself," Hines said. "But it also serves as an important calibration data set to make sure that the models we're using to look at future climate change are accurate."

Right now, the oceans provide a huge "carbon sink," absorbing much of the carbon dioxide emissions from fossil fuels that are warming the planet at a threatening pace. The less carbon dioxide there is in the atmosphere, the colder the planet becomes.

According to a 2019 report (https://www.ipcc.ch/srocc/) by the Intergovernmental Panel on Climate Change, smaller glaciers will melt by more than 80% by the end of the century if greenhouse gas emissions continue on their current trajectory. The resulting influx of fresh water will likely disrupt ocean currents and, by extension, the climate in a way humans have yet to see.

Even if emissions were stabilized tomorrow, it would take many years for the oceans to adjust to the 1° C rise in global temperatures that has already occurred.

In 2016, Hines joined a two month-long deep-sea drilling expedition to South Africa's Cape Basin on a whim when another researcher couldn't make the trip. Although she was wrapping up the final year of her PhD program, she had yet to work in the field and didn't know what to expect.

Location map of Integrated Ocean Drilling Program Site U1479, approximately 85 nautical miles southwest of Cape Town, South Africa. Water in this region comes from a complex mix of sources, including the North Atlantic, Indian and Southern Oceans. (Marisa Sloan/MEDILL)

"I was on the day shift, which [was] from noon until midnight," Hines said. "Every day we did all this science, and then in the time we had off we hung out and watched movies and watched the stars at night."

The first few weeks were new and exciting, she said. Each scientist onboard had his or her own tasks to do, ranging from dating the 9-meter-long sediment cores by their micro-fossils to squeezing water out of them with a hydraulic press.

By the time the sixth week rolled around, however, everyone was stepping on each other's toes.

"Then we made it to Cape Town and had a big party," she said, laughing. "I remember being most excited to have a beer and eat a salad by the end."

The Cape Basin, where Hines traveled in search of ancient sediment cores, lies in The South Atlantic Ocean between the North Atlantic and the Pacific. Her chemical analysis shows a shift toward more Pacific-like water in the area during the last glacial period, from approximately 110,000 to 12,000 years ago, perhaps revealing an ocean circulation that sequestered carbon dioxide-rich water in the Pacific and stored it in the South Atlantic.

Bob Anderson, a founder of the international program GEOTRACES (https://www.geotraces.org/) and professor at Columbia's Lamont-Doherty Earth Observatory, said her results correlate well with similar studies on carbon and carbonate ions.

"I agree [with Hines], but I don't think we can make that as a final conclusion yet," he said. "We know from a lot of neodymium data coming out right now that it's more complicated than people used to think."

In fact, another study (https://doi.org/10.1016/j.quascirev.2020.106396) published earlier this year posits an opposite conclusion. It suggests the changes in neodymium concentration in the South Atlantic may actually be a result of changes in the North Atlantic, rather than a switch to water from the Pacific.

"What I think we need are more records from the shallow to mid-depth North Atlantic and from the Pacific," Hines said.

That's the goal of Anderson's program GEOTRACES, which is designed to study traces of neodymium and a barrage of other elements found within all of the earth's major ocean basins. So far, scientists from approximately 35 nations have been involved in the expeditions to better understand how the chemical environment affects ecosystem function and vice versa.

Anderson said he expects those mysteries will be better understood in the next few decades, although he will likely be cheering on scientists like Hines from the sidelines by then.

"It will take combining the data that I collected with other people's data to try and get a more holistic understanding of what happened," Hines said. "That's the hard part. And it's also the fun part."

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