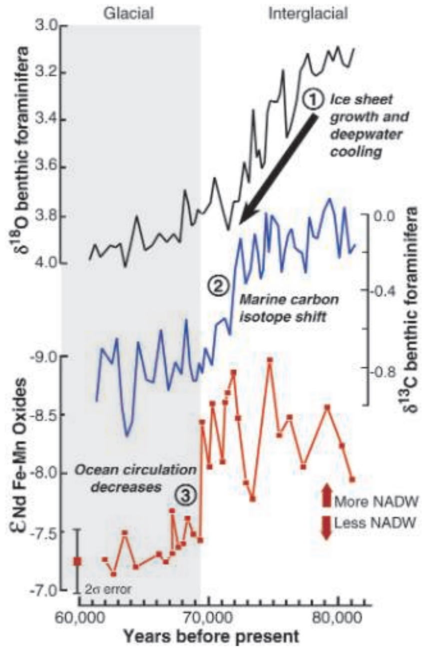
PALEOCLIMATE

Ocean Flow Amplified, Not Triggered, Climate Change



Lagged. Glacial cold and ice grew (1, top) thousands of years before ocean circulation flowed (3, bottom).

Figuring out what's going on with this year's weather is hard enough, so pity the poor paleoclimatologists trying to understand how the world drifted into the last ice age 70,000 years ago. For half a century, paleoceanographers have been studying elements or isotopes preserved in deep-sea sediments as markers of the workings of past climate. This "proxy" approach has worked, but only up to a point. Both the climate system and paleoclimate proxies can be unexpectedly subtle and complex.

On page 1933, a group of geochemists and paleoceanographers advances another proxy: isotopes of the rare-earth element neodymium, which they believe faithfully trace the ups and downs of the heat-carrying Gulf Stream flow. By their reading of neodymium, changes in the speed of the Gulf Stream—a much-discussed mechanism for altering climate—came too late in major climate transitions to have set the climate change in motion. "It's groundbreaking work," says paleoceanographer Christopher Charles of the Scripps Institution of Oceanography at the University of California, San Diego. "It's going to stimulate quite a bit of work either to try to extend the analysis or shoot it down."

Researchers at Columbia University's Lamont-Doherty Earth Observatory in Palisades, New York, began pursuing neodymium as a circulation tracer because it seemed to offer a prized trait: immutability. The ratio of neodymium-143 to neodymium-144 in North Atlantic and Pacific waters differs enough, thanks to the range of ratios of surrounding continental rocks, that it can be used to follow the mixing of waters as currents flow from basin to basin.

Ocean circulation changes should dominate the changes in the neodymium ratio, say Lamont group members Alexander Piotrowski (now a postdoc at the University of Cambridge, U.K.,), geochemists Steven Goldstein and Sidney Hemming, and paleoceanographer Richard Fairbanks. For example, plankton can't change the ratio—as it does the isotopic composition of carbon—because neodymium is too massive an element for biology to separate its isotopes. And in fact, the isotope ratio preserved in the microscopic bits of iron-manganese in a classic sediment core from the southeastern South Atlantic matches the story told by previous tracers. During each of four temporary warmings during the last ice age, the ratio swung down and then back up—just as it should have done if the warm, north-flowing Gulf Stream had temporarily sped up, as more North Atlantic water flowed south in the deep arm of the "conveyor belt" flow.

In the run-up to the ice age, by contrast, the core told a more complicated tale. Starting about 70,000 years ago, bottom waters cooled as glacial ice grew on the polar continents, as indicated by oxygen isotopes of microscopic skeletons of bottom-living organisms. Then, a couple of thousand years later, carbon isotopes shifted as the growing ice and climatic deterioration shrank the mass of plants on land, sending their isotopically light carbon into the sea. Only after another couple of thousand years did the conveyor belt flow slow down, according to neodymium.

Given that millennia-long lag behind the growing cold and ice, "ocean circulation responded to climate change," says Goldstein. At least at glacial transitions, the slowing of warm currents could have put the final chill on the ice age, but "it's not the trigger of climate change." Presumably, the initial cooling was an indirect response to the decline of solar heating over high northern latitudes brought on by the so-called Milankovitch orbital variations: the ever-changing orientation of Earth's orbit and rotation axis. However, changes in ocean circulation may have triggered abrupt climate shifts once the ice age was under way, Goldstein notes.

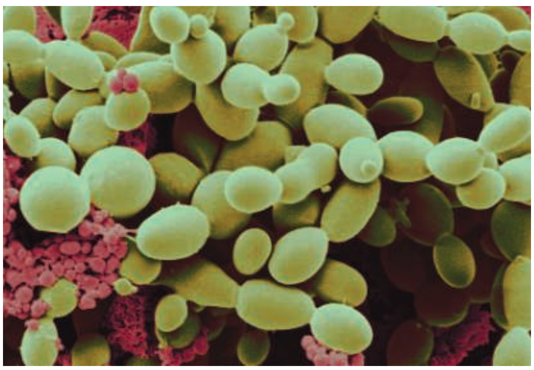
Although many paleoceanographers like the idea of ocean circulation as a follower rather than a leader, a single core is not likely to win the day. Neodymium "seems to be working remarkably well," says paleoceanographer Jerry F. McManus of Woods Hole Oceanographic Institution in Massachusetts. But the history of climate proxies and a few hints in the South Atlantic record tell him that neodymium may not be the perfect ocean circulation proxy. He and others will be looking for weaknesses.

–RICHARD A. KERR

PROTEOMICS

Protein Chips Map Yeast Kinase Network

Score another victory for high-throughput biology. In one fell swoop, researchers at Yale University in New Haven, Connecticut, have vastly extended decades' worth of research into the molecular communications between proteins that govern the lives of yeast cells. The Yale team, led by molecular biologist Michael Snyder, used glass chips arrayed with thousands of yeast proteins to track down the molecular targets of the organism's protein kinases, enzymes that modify the function of other proteins by tagging them with a phosphate group. About 160 interactions between specific yeast kinases and their targets had previously been identified; the chip study added more than 4000, allowing the Yale researchers to map out a complex signaling network within yeast cells. Snyder presented this large-scale survey of yeast protein phosphorylation last week in Arlington, Virginia, at the first annual symposium of the U.S. Human Proteome Organization.



En masse. Biochips reveal thousands of new interactions between kinases and their molecular targets in yeast cells like these.

"This is extremely important for the signal transduction community," says Charles Boone, a yeast geneticist at the University of Toronto in Canada. Drugmakers, Boone adds, are likely to pore over the new bounty of yeast results to find ▶

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