North Atlantic Corals Could Lead to Better Understanding of the Nature of Climate Change

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The deep-sea corals of the North Atlantic are now recognized as "archives" of Earth's climatic past. Not only are they sensitive to changes in the mineral content of the water during their 100-year lifetimes, but they can also be dated very accurately.

In a new paper appearing in *Science Express* environmental scientists describe their recent advances in "reading" the climatic history of the planet by looking at the radiocarbon of deep-sea corals known as Desmophyllum dianthus.

According to lead author Laura Robinson, a postdoctoral scholar at the California Institute of Technology, the work shows in principle that coral analysis could help solve some outstanding puzzles about the climate. In particular, environmental scientists would like to know why Earth's temperature has been holding so steadily for the last 10,000 years or so, after having previously been so variable.

"These corals are a new archive of climate, just like ice cores and tree rings are archives of climate," says Robinson, who works in the Caltech lab of Jess Adkins, assistant professor of geochemistry and global environmental science, and also an author of the paper.

"One of the significant things about this study is the sheer number of corals we now have to work with," says Adkins, "We've now collected

3,700 corals in the North Atlantic, and have been able to study about 150 so far in detail. Of these, about 25 samples were used in the present study.

"To put this in perspective, I wrote my doctoral dissertation with two dozen corals available," Adkins adds.

The corals that are needed to tell Earth's climatic story are typically found at depths of a few hundred to thousands of meters. Scuba divers, by contrast, can go only about 50 to 75 meters below the surface. Besides, the water is bitter cold and the seas are choppy. And to add an additional complication, the corals can be hard to find.

The solution has been for the researchers to take out a submarine to harvest the coral. The star of the ventures so far has been the deep-submergence vehicle known as Alvin, which is famed for having discovered the Titanic some years back. In a 2003 expedition several hundred miles off the coast of New England, Alvin brought back the aforementioned 3,700 corals from the New England Seamounts.

The D. dianthus is especially useful because it lives a long time, can be dated very precisely through uranium dating, and also shows the variations in carbon-14 (or radiocarbon) due to changing ocean currents. The carbon-14 all originally came from the atmosphere and decays at a precisely known rate, whether it is found in the water itself or in the skeleton of a coral. The less carbon-14 found, the "older" the water. This means that the carbon-14 age of the coral would be "older" than the uranium age of the coral. The larger the age difference, the older the water that bathed the coral in the past.

In a perfectly tame and orderly environment, the deepest water would be the most depleted of carbon-14 because the waters at that depth would have allowed the element the most time to decay. A sampling of carbon-14 content at various depths, therefore, would allow a graph to be constructed, in which the maximum carbon-14 content would be found at the surface.

In the real world, however, the oceans circulate. As a result, an "older" mass of water can actually sit on top of a "younger" mass. What's more, the ways the ocean water circulate are tied to climatic variations. A more realistic graph plotting carbon-14 content against depth would thus be rather wavy, with steeper curves meaning a faster rate of new water flushing in, and flatter curves corresponding to relatively unperturbed water.

The researchers can get this information by cutting up the individual corals and measuring their carbon-14 content. During the animals' 100-year life spans, they take in minerals from the water and use the minerals to build their skeletons. The calcium carbonate fossil we see, then, is a skeleton of an animal that may have just died or may have lived thousands of years ago. But in any case, the skeleton is a 100-year record of how much carbon-14 was washing over the creature's body during its lifetime.

An individual coral can tell a story of the water it lived in because the amount of variation in different parts of the growing skeleton is an indication of the kind of water that was present. If a coral sample shows a big increase in carbon-14 about midway through life, then one can assume that a mass of younger water suddenly bathed the coral. On the other hand, if a huge decrease of carbon-14 is observed, then an older water mass must have suddenly moved in.

A coral with no change in the amount of carbon-14 observed in its skeleton means that things were pretty steady during its 100-year lifetime, but the story may be different for a coral at a different depth, or one that lived at a different time.

In sum, the corals tell how the waters were circulating, which in turn is profoundly linked to climatic change, Adkins explains.

"The last 10,000 years have been relatively warm and stable-perhaps because of the overturning of the deep ocean," he says. "The deep ocean has nearly all the carbon, nearly all the heat, and nearly all the mass of the climate system, so how these giant masses of water have sloshed back and forth is thought to be tied to the period of the glacial cycles."

Details of glaciation can be studied in other ways, but getting a history of water currents is a lot more tricky, Adkins adds. But if the ocean currents themselves are implicated in climatic change, then knowing precisely how the rules work would be a great advancement in the knowledge of our planet.

"These guys provide us with a powerful new way of looking into Earth's climate," he says. "They give us a new way to investigate how the rate of ocean overturning has changed in the past."

Robinson says that the current collection of corals all come from the North Atlantic. Future plans call for an expedition to the area southeast of the southern tip of South America to collect corals. The addition of the second collection would give a more comprehensive picture of the global history of ocean overturning, she says.

In addition to Robinson and Adkins, the other authors of the paper are Lloyd Keigwin of the Woods Hole Oceanographic Institute; John Southon of the University of California at Irvine; Diego Fernandez and Shin-Ling Wang of Caltech; and Dan Scheirer of the U.S. Geological Survey office at Menlo Park.

The *Science Express* article will be published in a future issue of the journal *Science*.

Source: California Institute of Technology