Abrupt Climate Change

Using Corals to Determine the Strength of the Ocean Circulation during Times of Abrupt Climate Change

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When reconstructing past climate, one of the major challenges is finding archives that record abrupt events – such as a shift in the rate or strength of the world ocean circulation – on timescales that are relevant to modern climate-change processes. Many promising approaches rely on chemical proxies to infer circulation rates and other variables. The skeletons of corals form some of the best records of climate variability within the ocean, because corals build their shells by incorporating elements derived from the seawater around them. There have been numerous climate studies using tropical corals. However, their symbiotic relationship with photosynthetic algae limits them to the warm shallow waters of the low latitudes. Luckily, some corals do not use algal symbionts and are able to live in cold or dark waters, extending their range throughout the globe. These globally distributed corals are critical to our climate study, because we are interested in tracking water along its travels to the deep ocean.

There are many species of deep-sea (also known as cold-water) corals, and they have a wide range of habitats and growth morphologies. For example, the solitary coral *Desmophyllum dianthus,* which has a life expectancy of about a hundred years, can live close to the surface in the high latitude fjords and also at thousands of meters water depth in the North Atlantic (see figure). Although we know very little about the biology and ecology of these organisms, we do know enough to infer the likely conditions of their habitats during their lifetimes. We can use fossil samples of these organisms to reconstruct changes in ocean variability over tens of thousands of years.

With support from the Comer-funded program, we are working to develop new chemical tracers of past ocean circulation. We know from previous work that deep-sea corals can alter the chemical composition of the elements that are incorporated into their skeletons. It is, therefore, necessary to identify chemical and isotopic systems that are not susceptible to chemical alteration during the skeleton-forming calcification process. The relatively stable rare earth element Neodymium (Nd) is proving to be very useful for this purpose. In collaboration with Tina van de Flierdt at Lamont Doherty Earth Observatory (LDEO) and using coral samples loaned to us by S. Cairns at the Smithsonian Institution, we have found that the Neodymium isotopes are not altered when incorporated into coral skeletons. We have also shown that this isotopic signature is well preserved even in corals that are over two hundred thousand years old. Coupled with radiocarbon analyses, this new chemical tracer is now ready to be used to improve our understanding of past ocean circulation rates in the deep ocean.

In the spring of 2008, WHOI coral biologist Rhian Waller and I will head to the Southern Ocean on the R/V *Nathanial Palmer* to map, image and collect deep-sea corals from the Drake Passage and the Scotia Sea. These samples will be critical in reconstructing how the deep water that forms in the Southern Ocean has changed over time, and how these changes have influenced the deep waters that are found throughout the global ocean today. Support from the Comer-funded program at WHOI was instrumental in our securing funding from the National Science Foundation for this upcoming cruise and for our ongoing collaboration with Tina van de Flierdt at LDEO.

Deepwater corals such as *Desmophyllum dianthus* provide a record of climate change. The photo on the left shows live coral from the New England Seamounts. *D. dianthus* is the pink pleated coral in the center of the photograph. The photo on the right shows a patch of fossilized *D. dianthus* on the Corner Rise Seamounts off the coast of New England. Fossil skeletons such as these enable researchers to construct climate records spanning tens of thousands of years.