From One Coral Many Findings Blossom

Old coral from drowned Barbados reefs is yielding measures of everything from glacial ice to Earth's magnetic field

RICHARD FAIRBANKS HAD LONG felt the lure of Barbados's offshore reefs—not for their scuba diving potential but for the clues they might hold to Earth's climatological past. As a paleoceanographer at Columbia University's Lamont-Doherty Geological Observatory, he had for years analyzed the ancient corals exposed on Barbados itself, where they had been lifted by the slow rising of the island. But offshore, flooded by the melting at the end of the last ice age, lay submerged coral reefs that he figured would provide a unique record of the height of the rising sea as the ice age ended between 17,000 and 8,000 years ago.

So, in late 1988, Fairbanks exchanged his geologist's hammer and hand-held corer for a 60-meter-long drill ship and proceeded to drill hundreds of meters into the reef.

For Fairbanks, the switch to big science has been a resounding success. The ancient coral that he cored out of the reef has confirmed that the melting of the glaciers at the end of the ice age was a stop-and-go affair. But it has undermined a theory that linked this pattern of melting to a sudden cold period in Europe. And, in a curious twist, it has cast serious doubt on the dates of archeological sites beyond 10,000 years ago that were determined by the widely used carbon-14 method (see box).

All this from an otherwise undistinguished species of coral called *Acropora palmata*. Since this species only grows within 5 meters of the sea surface, Fairbanks was able to reconstruct ancient sea levels simply by dating each sample by carbon-14 and noting its depth relative to present sea level.

Fairbanks' first goal was to analyze the pattern of deglaciation. In the early 1980s, some paleoceanographers concluded from analyses of deep-sea sediments that there was a surge of melt water into the ocean about 12,000 years ago, followed by a pause in melting, or even regrowth of the ice, and then another surge about 9,500 years ago. But the cause was unexplained, and researchers harbored lingering doubts.

The Barbados samples have put all the suspicions to rest. They show that the melt water from the polar ice sheets gushed into the oceans as fast as 14 trillion cubic meters per year during the surges. That's the equivalent of 30 additional present-day Mississippi Rivers. Sea level was rising at 2.5 to 4 meters per century, more than ten times faster than today and perhaps fast enough to prompt legends of a Great Flood. During the pause between the two surges, however, melt water flow slowed to 2.7 trillion cubic meters per year.

But while the coral record shows the two-step deglaciation in detail, it causes some serious problems for Fairbanks' colleague at Lamont, Wallace Broecker. Broecker had suggested that a sudden but temporary cooling in Europe between the two surges 11,000 to 10,000 years ago, a period called the Younger Dryas event, was triggered when melt waters that had been flowing down a bloated Mississippi were diverted by shifting drainage channels into the St. Lawrence River. The result: this rush of cold freshwater could have flooded across the surface of the far North Atlantic and cooled Europe, among other climate effects (*Science*, 15 January 1988, p. 259).

But Fairbanks' sea level record shows that, during the Younger Dryas, melting slowed so dramatically that there was probably too little melt water to drive Broecker's climate change mechanism. Broecker hasn't abandoned the melt water mechanism as a trigger for the Younger Dryas, but he no longer sees it as the sole driving force.

More is coming from the Barbados samples. Fairbanks has measured a total sea level fall during the last deglaciation of 121 ± 5 meters, which hits the middle of a much debated range of estimates. And another colleague at Lamont, geochronologist Edouard Bard, is suggesting that the carbon-14 error implies that Earth's magnetic field had half its present strength 20,000 years ago. All from bits of long-dead coral.

■ RICHARD A. KERR

Coral Pushes Back the Past

When Richard Fairbanks drilled into a submerged coral reef off Barbados, few people outside paleoceanography took much notice. But any researcher who uses carbon-14 dating is now aware of his work, for the Barbados corals have shown that early carbon-14 dates are inaccurate. The method, widely used to date wood, campfire charcoal, seeds, or coral, involves measuring how much radioactive carbon-14 is left in the sample and estimating how much there was to begin with, when the carbon was incorporated from the atmosphere or ocean water. That's tricky because the proportion of atmospheric carbon-14 has been increasing, as shown in trees where apparent carbon-14 ages have been corrected by counting tree rings. But the tree ring record peters out around 10,000 years ago. Researchers knew that carbon-14 ages older than that were off, but by how much no one was sure—until now.

Geochronologist Edouard Bard and colleagues at Lamont dated the Barbados coral using the uranium-thorium isotope technique that has recently been refined by the use of mass spectrometry (*Science*, 6 April, p. 31). Bard told the spring meeting of the American Geophysical Society early this month that 8,000 years ago the uranium-thorium dates were 1,000 years older than unadjusted carbon-14 ages, as tree ring calibrations showed. But the discrepancy grew to 3,500 years by 20,000 years ago. In part, Bard believes the uranium-thorium ages are accurate because they show every sign of being unaffected by chemical alteration of the samples.

The errors in carbon-14 dates will not lead to a wholesale reinterpretation of archeology, however. The carbon-14 technique so dominates dating of the past 40,000 years that events such as the arrival of man in the Americas will simply be pushed back a bit, but the sequence of the events will be unchanged.

In some other fields, however, the implications are more interesting. For example, the new calibration moves the peak of the last ice age back from 18,000 years ago to 21,500 years ago. That greatly eases or eliminates an uncomfortably large lag between the upturn in sunlight falling on Northern Hemisphere ice calculated to begin 23,000 years ago, which according to the theory of orbital variations triggered the deglaciation and the glacial peak. Some paleoclimatologists had been hard-pressed to explain why so much ice hung around so long in the sun's increasing glare. ■ R. A. K.

ADDITIONAL READING

E. Bard *et al.*, "Calibration of the ^{14}C timescale over the past 30,000 years using mass spectrometric U-Th ages from Barbados corals," *Nature* **345**, 405 (1990).

R. G. Fairbanks, "A 17,000-year glacio-eustatic sea level record," *ibid.* **342**, 637 (1989).