Geologists: Opening of passage may be tied to Antarctic cooling

April 21 2006

Ancient fish teeth are yielding clues about when Antarctica became the icy continent it is today, highlighting how ocean currents affect climate change.

University of Florida geologists have used a rare element found in tiny fish teeth gathered from miles below the ocean surface to date the opening of a passage at the bottom of the globe between the Atlantic and Pacific. The opening, which occurred millions of years ago in a much warmer era, allowed the formation of an ocean current around the pole. That event preceded — and may even have brought about — Antarctica's transformation from a forested continent to an icy moonscape.

"We're saying we now have a date for the opening of the Drake Passage that looks like it's early enough that it may have contributed to the cooling," said Ellen Eckels Martin, a UF associate professor of geology.

Martin and H.D. Scher, a UF doctoral graduate now at the University of Rochester in New York, co-authored a paper on the research set to appear Friday in the journal Science.

Scientists have long puzzled over the rapid cooling that seemed to sweep over Antarctica more than 30 million years ago, replacing boreal pine forests with ice and snow. The cooling occurred in a very warm era when levels of carbon dioxide, the gas responsible for the greenhouse warming effect, were three to four times today's levels.

Theorists had suggested the plummeting temperatures could be related to the opening of the Drake Passage, a connection between the Atlantic and Pacific named after Sir Francis Drake, the English captain who circumnavigated the globe in the 16th century. But there has been a longstanding debate over when that passage opened. That's a key point because Antarctica is known to have been covered with ice by about 33.6 million years ago, meaning the circumpolar current would have had to be established before that event if it could be considered a cause of the cooling.

Estimates for the passage's opening have ranged from 15 million years to 49 million
years ago. Martin and Scher's research confirms the older dates.

The scientists' source: neodymium isotopes retrieved from fish teeth the size of grains of sand – teeth themselves retrieved from sediment cores recovered from the deep ocean bottom more than two miles beneath the surface.

Martin said neodymium has a chemical signature that varies depending on whether it came from the Atlantic or Pacific. Once the element erodes from rocks into the ocean, it becomes trapped in clays and minerals, which settle on the seabed. That means scientists can use it to determine the origin and movement of ocean currents, Martin said.

Fish teeth are composed of a mineral called apatite, which takes up neodymium on the seafloor. This is why the UF researchers focused on the teeth.

The geologists obtained the teeth from sedimentary cores retrieved from the South Atlantic ocean. The sediments were dated to more than 40 million years ago. Measurements using a technique called thermal ionization mass spectrometry revealed the teeth neodymium had a

signature of the Pacific, indicating at least a surface connection between the oceans.

The presence of neodymium with a Pacific signature in the deep Atlantic suggests that Pacific surface waters flowed into the South Atlantic, where they cooled and sank.

Martin said the opening of the Drake Passage could have precipitated the plunge in temperatures because the newly developed circumpolar current would have isolated Antarctica from warm subtropical water carrying heat from the tropics. In addition, the circumpolar current sets up conditions leading to upwelling of cold, nutrient-rich water. This in turn may have spurred the growth of algae and higher forms of biological life, which consumed carbon dioxide, reducing levels and contributing to cooling the continent's climate, she said.

The UF researchers "proved that the formation of early ocean circulation patterns coincided with, and possibly caused, the initial buildup of ice in Antarctica," said Gabriel Filippelli, professor and chairman of the department of earth sciences at Indiana University-Purdue University Indianapolis.

Filippelli said the paper shows that ocean currents can have a big impact on the West Antarctic Ice Sheet, which would raise sea levels substantially if it were to melt. Some evidence already shows the sheet is becoming less stable due to warmer air and surface water temperatures, he said. "Circulation patterns and surface warmth of waters around Antarctica can be critical factors in the stability of the West Antarctic Ice Sheet, as they were in the buildup of ice around 40 million years ago," he said.

Source: University of Florida