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Global Warming Can Trigger Extreme Ocean, Climate Changes, Scripps-led Study Reveals

Scientists use deep ocean historical records to find an abrupt ocean circulation reversal caused by greenhouse gas warming

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New research produced by scientists at Scripps Institution of Oceanography at UCSD, helps illustrate how global warming caused by greenhouse gases can quickly disrupt ocean processes and lead to drastic climatological, biological and other important changes around the world. Although the events described in the research unfolded millions of years ago and spanned thousands of years, the researchers say the findings provide clues to help better understand the long-term impacts of today's human-influenced climate warming.

Flávia Nunes and Richard Norris investigated the chemical makeup of tiny ancient sea creatures at various locations around the world. They probed a four- to seven-degree warming period that occurred some 55 million years ago during the closing stages of the Paleocene and the beginning of the Eocene eras. The unique data set they constructed uncovered for the first time a monumental reversal in the circulation of deep-ocean patterns around the world and helped the researchers conclude that it was triggered by the global warming the world experienced at the time. The research, published in the January 5 edition of the journal *Nature*, is one of the few historical analogs for large-scale sea circulation changes tied to global warming.

"The earth is a system that can change very rapidly. Fifty-five million years ago, when the earth was in a period of global warmth, ocean currents rapidly changed direction and this change did not reverse to original conditions for about 20,000 years," said Nunes. "What this tells us is that the changes that we make to the earth today (such as anthropogenically induced global warming) could lead to dramatic changes to our planet."

The global warming of 55 million years ago, known as the Paleocene/Eocene Thermal Maximum (PETM), emerged in less than 5,000 years, an instantaneous blip on geological time scales (the researchers indicate that 5,000 years can be considered an upper limit and they believe the warming could have unfolded much more quickly than geological records can show them). The PETM set in motion a host of important changes around the globe, including a mass extinction of deep-sea bottom-dwelling marine life. Fossil records indicate key migrations of terrestrial mammal species during this time-including evidence of the first horses and primates in North America and Europe -likely allowed by warm conditions that opened travel routes not possible under previously colder climates.

Nunes and Norris analyzed carbon isotopes, chemical signatures that reveal a host of information, from the shells of single-celled animals called foraminifera. Such organisms exist in a variety of marine environments and their vast numbers per research sample allow scientists to uncover a range of details about the state of the seas.

"It's really interesting how a tiny little shell from a sea creature living millions of years ago can tell us so much about past ocean conditions," said Nunes. "We can tell approximately what the temperature was at the bottom of the ocean. We also have an approximate measure of the nutrient content of the water the creature lived in. And, when we have information from several locations, we can tell the direction of ocean currents."

In the *Nature* study, the scientists analyzed foraminifera called *Nuttalides truempyi* from 14 sites around the world in deep-sea sediment cores maintained by the Integrated Ocean Drilling Program. The isotopes were used as nutrient "tracers" to reconstruct changes in deep-ocean circulation through the PETM period. Nutrient levels tell the researchers how long a sample has been near or isolated from the sea surface, thus giving them a way to track the age and flow path of deep sea water.

The results revealed that deep-ocean circulation abruptly switched from "overturning"-a conveyor belt-like process in which cold and salty water exchanges with warm surface water-in the Southern Hemisphere, where it virtually shut down, and became active in the Northern Hemisphere. The researchers believe this shift drove unusually warm water to the deep sea, likely releasing stores of methane gas that led to further global warming and a massive die off in deep sea marine life.

Overturning is a fundamental component of the global climate conditions that we know today. For example, overturning in the modern North Atlantic Ocean is a primary means of drawing heat into the far north Atlantic and keeping temperatures in Europe relatively warmer than conditions in Canada, for example. Today, "new" deep-water generation does not occur in the Pacific Ocean because of the large amount of freshwater input from the polar regions that prevents North Pacific waters from becoming dense enough to sink to more than intermediate depths. In the case of the Paleocene/Eocene period, however, deep-water formation was possible in the Pacific Ocean because of the global warming-induced changes. The Atlantic Ocean also could have been a significant generator of deep waters during this period.

In the paper, the authors note that modern carbon dioxide input from fossil fuel sources to the earth's surface is approaching the same levels estimated for the PETM period, which raises concerns about future climate and changes in ocean circulation. Thus they say the Paleocene/Eocene example suggests that human-produced changes may have lasting effects not only in global climate, but in deep ocean circulation as well.

"Overturning is very sensitive to surface ocean temperatures and surface ocean salinity," said Norris, a professor in the Geosciences Research Division at Scripps. "The case described in this paper may be one of our best examples of global warming triggered by the massive release of greenhouse gases and therefore it gives us a perspective on what the long-term impact is likely to be of today's greenhouse warming that humans are causing."

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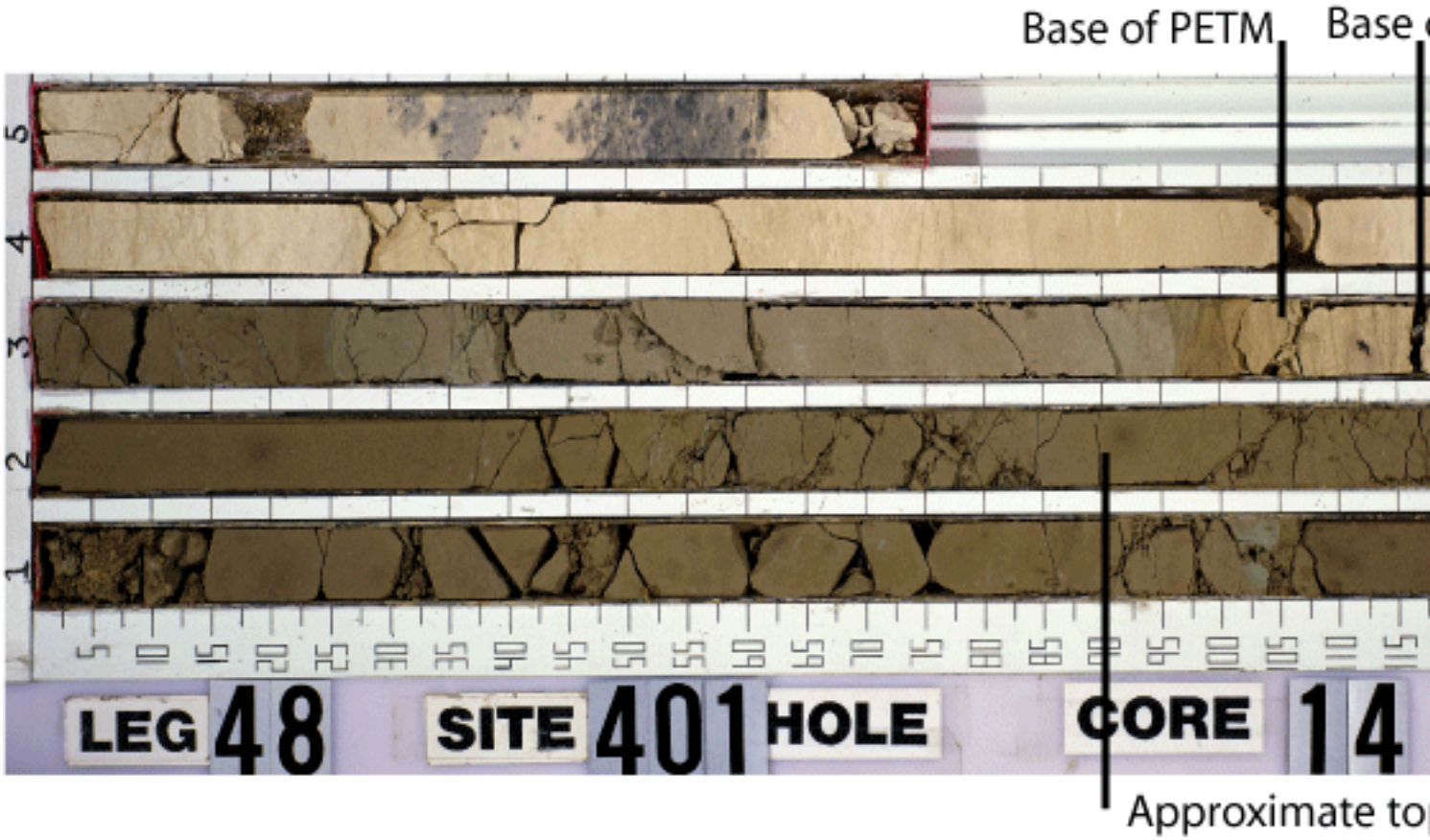
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