Leg 198

Ocean Drilling Program Probing Warming in the Earth's Past

October 2001 A two-month expedition to probe the seafloor in search of evidence for global warming in Earth's distant past ended in Honolulu, Hawaii on October 23. Twenty-seven scientists from seven countries and 62 crew spent 35 days doing research on Shatsky Rise, a remote plateau in the northern Pacific Ocean. From the deck of the JOIDES Resolution, a drillship chartered by the Ocean Drilling Program, the expedition party lowered enough pipe to recover sediment cores from the ocean floor, 2-3.5 km below sea level. The cores contain color-banded layers produced by subtle variations in Earth's climate due to periodic changes in its orbit around the sun. These layers allowed the scientists to read the Earth's climate record and match time frames from one drill hole to another. The scientists hoped the cruise would help them better understand life in the ocean - both at the surface and the seafloor -- during climatically warm periods. They also hoped to use the cores to determine the causes of global warming at different times in Earth's past.

Led by expedition co-chiefs Dr. Timothy Bralower, a marine geologist from the University of North Carolina at Chapel Hill, and Dr. Isabella Premoli-Silva, a micropaleontologist and stratigrapher from the University of Milan, Italy, the scientists recovered sixteen sections of core from eight locations on Shatsky Rise. These sections range from 150 to 600 meters in length and contain an archive of sediment layers from the last 145 million years. After the cores were extracted, and while the scientists were busy studying them, remote instruments were guided into the empty holes to obtain additional information about the layers.

The cores show vivid signs of multiple bursts of warming that began almost instantaneously in geologic terms -- over a period of about one thousand years. Evidence for these warming bursts and their impact on the marine environment was found in cores

that date back to 135 and 120 million years ago in the Cretaceous Period. These bursts may have been triggered by large volcanic eruptions that released greenhouse gases, mainly carbon dioxide (CO2). The warming apparently decreased the ocean's oxygen-carrying capacity and caused the waters to become devoid of oxygen (anoxic) and therefore more corrosive, producing striking layers of black, organic-carbon rich mud deep in the ocean. In addition, the corrosive waters dissolved the shells of surface-dwelling organisms before reaching the bottom, leaving only remains of algae and bacteria to settle to the sea floor. The scientists' findings indicate that vast reaches of the Pacific Ocean were devoid of oxygen for intervals of about a million years. "These ocean-wide anoxic events" said co-chief Bralower, "were some of the most radical environmental changes experienced by Earth in the last several hundred million years."

Sudden changes in ocean temperature can have dramatic impacts on marine life. Bottom-dwelling clams appear to have adapted well to the warm ocean conditions, and their fossilized shells are abundant in the sediment. However, these shells later disappear from the cores, indicating their extinction. The likely culprit for the disappearance is a sudden change in the circulation of the deep ocean, which brought colder waters to the clam habitat than they could tolerate.

Another major warming event found on Shatsky Rise occurred about 55 million years ago at the end of the Paleocene Epoch, and is represented in the cores as a 10-20 cm thick dark-brown clay layer. Cores show that this 200,000-year warming event caused extinction of 30-50% of deep ocean life, while simultaneously allowing new species to evolve in the surface layer. "Clearly, environmental conditions were hostile on the seafloor, but quite favorable at the ocean surface," says co-chief Premoli-Silva. Previous studies have proposed that this event was triggered by a burst of methane from under the seafloor that depleted the deep ocean of oxygen and caused several degrees of warming of the Earth's atmosphere. The clay layer supports this theory, as it shows clear evidence for a short pulse of increased acidity in the oceans that dissolved fossil shells. This dissolution was likely caused by the burst of methane which

sapped the ocean of its alkaline compounds.

Sedimentary layers from Shatsky Rise show that the abnormally warm Cretaceous and Paleocene conditions gradually began to moderate about 50 million years ago, and a pulse of rapid cooling about 33 million years ago finally shut the door on the warm interval. This cooling pulse happened at the same time that glaciers began to cover Antarctica.

Although these past episodes of warming were far more severe than temperature rises over the last century and conditions on earth were different millions of years ago, the lessons learned on Shatsky Rise could provide valuable insight into modern global warming. The cores from Shatsky demonstrate most clearly that climate change can occur in a geologic heartbeat and that, once warming gains a certain amount of momentum, a series of rapid environmental changes can quickly follow.

The Ocean Drilling Program is an international partnership of scientists and research institutions organized to study the evolution and structure of the Earth. ODP is funded principally by the National Science Foundation, with substantial contributions from its international partners. The program is managed by the Joint Oceanographic Institutions, a consortium of 16 U.S. academic institutions. Texas A&M University is responsible for science operations, and Lamont-Doherty Earth Observatory of Columbia University is responsible for logging services.

Photos showing life on board the drillship during this leg, both at work and play, are available on the web at http://www-odp.tamu.edu/public/life/leg198.html