CLIMATE CHANGE

A Smoking Gun for an Ancient Methane Discharge

Off Florida, oceanographers have drilled into what appears to be the remains of a globe-altering event 55 million years ago

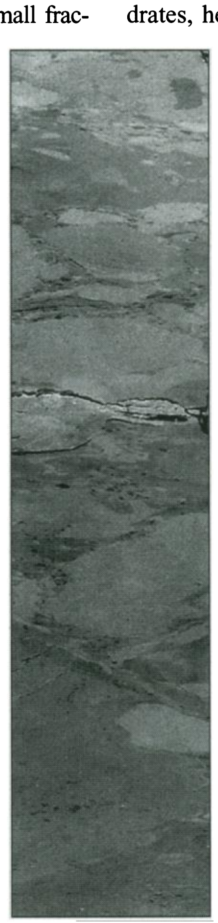
It's not often that researchers probing pivotal events in the ancient history of life can put their finger on causes. One striking exception is the meteor that hit Earth 65 million years ago, doing in the dinosaurs. Now paleoceanographers are closing in on a possible cause for another evolutionary watershed 55 million years ago. This watershed brought modern mammals—the ancestors of horses, cows, deer, apes, and us—into global dominance. And its trigger may have been a vast belch of climate-changing methane from under the sea floor.

Proposed less than 5 years ago, the "methane burp" hypothesis gets its most direct support yet on page 1531 of this issue of *Science*. Paleoceanographer Miriam Katz of Rutgers University in Piscataway, New Jersey, and her colleagues report the discovery of a sequence of sediment layers buried half a kilometer below the sea floor off Florida, which records the exact sequence of deep-sea changes—including vast submarine landslides—predicted by the scenario. "It's real good, consistent evidence" for the hypothesis, says paleoceanographer Timothy Bralower of the University of North Carolina, Chapel Hill. "It's not 100% proof, but it's compelling."

If not for the evolutionary turning point the methane burp might explain, we might be eating egg-laying mammals for Thanksgiving—if we had evolved at all. Ten million years after the demise of the dinosaurs, mammals in the fossil record were still "archaic," a mix of odd, unfamiliar animals that have no direct descendants today. But 55 million years ago, an array of modern forms burst on the scene in North America. In recent years, researchers have tied this transition to an extraordinary surge of global warming recorded in fossils and sediments. The warming would have allowed mammals that had already evolved into modern forms in a presumed Asian enclave to march across otherwise frigid polar lands and usurp North American archaics (*Science*, 18 September 1992, p. 1622).

Several researchers proposed that the methane from the sea floor could have driven the warming (*Science*, 28 February 1997, p. 1267), and paleoceanographer Gerald Dickens of James Cook University in Townsville, Australia, used clues in sea-floor sediments to develop a detailed scenario for what happened. His hypothesis assumes that 55 million years ago, as today, something like 15 trillion tons of methane hydrate—a combination of ice and methane—had formed beneath the sea floor, where microbes digesting organic matter release methane. Then, for whatever reason, ocean bottom waters warmed enough to decompose a small fraction of the methane hydrate into water and methane gas—roughly a trillion tons of it. This methane disrupted the sediment, triggering landslides down the continental slope that let the methane burst into the ocean. Upon its release, theorized Dickens, the methane probably oxidized to form carbon dioxide, which eventually reached the atmosphere, driving greenhouse warming.

Katz and her colleagues found signs of most of what Dickens called for, 512 meters down a sediment core that the Ocean Drilling Program (ODP) retrieved 350 kilometers off the northeast Florida coast. The deep-ocean warming killed off bottom-dwelling microscopic animals called foraminifera, they saw. Then the isotopically distinctive carbon of the methane left its mark in carbonate sediments. Finally, carbonic acid from the dissolved carbon dioxide partially dissolved some of the sediment.



Oceanic indigestion. A subsea burp of methane may have triggered this muddy debris deposit.

CREDIT: KATZ ET AL./ODP

Other researchers had made similar findings in various cores. But Katz also turned up a never-before-seen 20-centimeter-thick layer of soft mud containing chunks, or clasts, of the same mud. That's just the sort of debris deposit you'd expect to see downslope of where methane burst from the bottom, she notes. Indeed, the mud-clast layer was laid down just where debris from a hydrate-triggered slide should be—in the layer that settled while the foraminifera were going extinct and just before the isotopic shift that recorded the surge of methane. In addition, seismic probing beneath the sea floor reveals a "chaotic zone" of disturbed sediment 15 kilometers upslope from the drill site. This zone, like the mud-clast layer, just predates the isotopic signal of methane in the sediment, says Katz, making it the likely source.

"You can't do much better than that" at getting the predicted events in the predicted order, says paleoceanographer James Zachos of the University of California, Santa Cruz. "This is all consistent with Dickens's original proposal." Paleoceanographer Ellen Thomas of Wesleyan University in Middletown, Connecticut, notes that "this is the first place we have evidence [that methane] came out anywhere; it's a really neat development. But it's not completely solved."

Charles Paull of the Monterey Bay Aquarium Research Institute in Moss Landing, California, agrees. A specialist in methane hydrates, he finds the sea-floor methane hypothesis "absolutely fascinating, but I wonder about whether or not it's correct." Among his doubts: whether the hydrate deposits 55 million years ago contained enough methane to drive the climate shift and whether a deep-water warming could have penetrated far enough into the sediments to decompose the deep hydrates that could cause landslides.

Still, things do seem to keep falling into place for the methane burp. In the 21 October issue of *Nature*, for example, Richard Norris and Ursula Röhl of the University of Bremen in Germany reported that the same core Katz studied contains a time marker in the form of rapid, periodic variations in iron content. Because the iron cycles are about 21,000 years long, equal to the time for one wobble of Earth's axis to alter climate and thus sediment composition, Norris and Röhl assume that the iron cycles provide a reliable clock for geologic time. Applying this clock to the isotopic change recorded in the sediments, they find that two-thirds of the trillion tons of methane was released in a few thousand years or less, about as fast as humans are releasing carbon dioxide by burning fossil fuel. No one has figured out how that much carbon could have found its way into the environment so quickly 55 million years before cars and power plants, except by destabilizing methane hydrates. "Things just sort of line up," says Norris. "The other hypotheses just don't explain the data as well."

–RICHARD A. KERR