Was There a Prelude to the Dinosaurs' Demise?

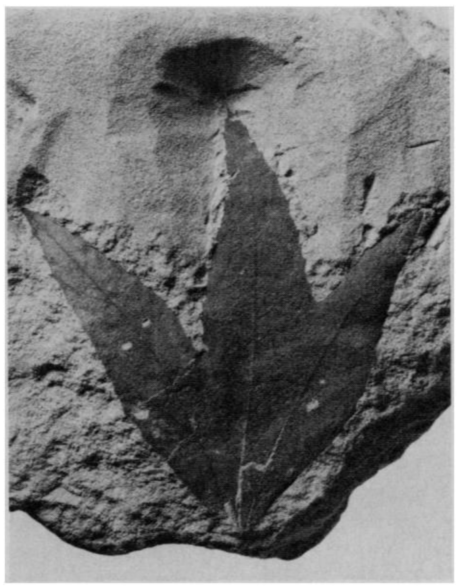
Something seems to have been going on just before the geologic instant of the Cretaceous-Tertiary boundary and its large impact

SIGNS of changes in the flora and fauna just before the catastrophic event that marked the end of the age of the dinosaurs 65 million years ago are leading researchers to reconsider the idea that a single catastrophe was the sole cause for the mass extinction then. For some years the proposed catastrophe—whether an impact of an asteroid or comet or a mammoth volcanic eruption—has diverted attention from more mundane influences on extinction. But these findings renew considerations of multiple, perhaps unrelated, causes for one of the greatest of mass extinctions.

The hypothesis of a large impact focused the attention of paleontologists on a tiny, rather neglected sliver of geologic time, the boundary between the Cretaceous and Tertiary periods (K-T boundary). Any time when more than half of existing species became extinct is going to be of special interest, but previously paleontologists had tended to think of the boundary as the end of the story, not the whole story. Changing environmental conditions, most notably deteriorating climate and receding seas, over millions and tens of millions of years must have come together to nearly obliterate the living world, the thinking went.

At first, after the proposal of an impact, paleontologists looked most closely at the few centimeters or a meter of mud from the deep sea that recorded the last of Cretaceous microorganisms and the first of those appearing in the Tertiary. The transition appeared to be quite abrupt and consistent with a purely catastrophic cause, but that picture of the K-T boundary is being refined as paleontologists look at different kinds of records.

William Zinsmeister of Purdue University and his colleagues reported recently at the annual meeting of the Geological Society of America* that extinctions seem to have proceeded gradually across the K-T boundary that they studied on Seymour Island at the tip of Antarctica's Palmer Peninsula. Fauna of the outgoing period were gradually replaced by the those of the new period as a section of marine sedimentary rock 35 meters thick was deposited. He cannot be precise, but it probably took at least 100,000 years of continuous sedimentation on a continental shelf to form those 35 meters of record, Zinsmeister says.



W. K. Sacco, Yale University

Extinct before the catastrophe. *The plant that produced this leaf fossil 65 million years ago disappeared less than 250,000 years before the K-T catastrophe, along with most of the rest of the forest's taxa.*

Roughly that same period of time is compressed into a meter or less of deep-sea sediments, notes Zinsmeister, because of the slower accumulation rate there. What might seem abrupt and simultaneous in deep-sea sediments, such as the first appearance of microfossil dinocysts and the disappearance of nautilus-like ammonites, are gradual at Seymour Island. Either the expanded, more detailed record at Seymour Island can reveal a gradual transition that looks abrupt elsewhere, says Zinsmeister, or the environmental changes responsible for the extinctions were damped in high southern latitudes.

Sediments deposited on land by running water can also accumulate far faster than in the deep sea, but the land does not have the sea's abundance of microscopic fossils. It does have fossil pollen, at least from some plants. To expand that terrestrial record, Garland Upchurch of the University of Colorado and Jack A. Wolfe of the U.S. Geological Survey are pioneering the use of leaf cuticle as a supplement to pollen. Leaf cuticle is the waxy outer coating that seals water into the leaf. Being far more resistant to degradation, bits of it tend to persist even when the rest of the leaf decomposes into unrecognizable organic debris or coal. By good fortune, cuticle also retains an imprint of the underlying epidermal cells that can be used as a fingerprint for identification.

Upchurch and Wolfe reported that, using leaf cuticle recovered in centimeter-by-centimeter sampling as well as less abundant whole-leaf fossils, they found four different patterns of extinction across the K-T boundary in New Mexico and Colorado. Three of them differed in the extent of losses at the boundary from generic groupings of plants, ranging from minor to complete. The fourth pattern consisted of a rapid depletion of three-lobed or three-veined members of the laurel family before the boundary and the group's complete disappearance at the boundary. These laurels seemed to have been on the way out for some unrelated reason when the K-T event delivered the coup de grace, says Upchurch.

Kirk Johnson of Yale University, using 10,000 leaf fossils from western North Dakota and eastern Montana, has found even more dramatic changes before the K-T event. Twenty meters below the boundary or some 100,000 to 250,000 years earlier, a forest of broad-leaved trees and shrubs was replaced by another of completely different composition. Of the 32 taxonomic categories of plants that constituted the first forest, less than 10% survived among the 18 taxa that composed the new forest. But once again at the K-T boundary, 30 new taxa appeared to replace all but a few of the members of the pre-K-T forest. "Each of these forests would be completely different," says Johnson, "You wouldn't recognize the new from seeing the old."

Another indicator of environmental change before the boundary is suggested by the boundary's position relative to a layer of lignite, a remnant of plants that have not quite developed into coal. Typically, the boundary, as marked by a thin layer of enhanced iridium and the last of the Cretaceous pollen, is at the base of the first of many lignite layers. One possible inference is that the climate there became wetter after the boundary, encouraging the deposition of the lignite. But near Marmarth, North Dakota, the K-T is at the top of a lignite layer, suggesting a distinct environmental change there before the boundary event.

Gerta Keller of Princeton University also

*The annual meeting of the Geological Society of America was held 26–29 October in Phoenix.

reported a prolonged period of change around the boundary, as recorded in marine microfossils at El Kef, Tunisia, and the Brazos River of Texas. At El Kef, species extinctions began 20 to 30 centimeters or more than 30,000 years before the boundary and ended 15,000 years after the boundary, she said. As many species became extinct before or after as at the boundary.

Keller's conclusions from her marine studies sum up much of what these and other studies seem to suggest, that there may well have been a confluence of causes that created the K-T mass extinction. That does not argue against a large impact at the precise boundary; the evidence for such an impact grows steadily stronger (*Science*, 8 May 1987, p. 666). Most recently, the first really promising candidate for the K-T impact crater has appeared. Michael Kunk of the U.S. Geological Survey in Reston, Virginia, and his colleagues have dated the Manson crater in Iowa as 67 ± 2 million years old. The K-T boundary is dated at 65 to 66 million years. In addition, the debris found globally at the boundary seems most abundant in North America. "Manson is in the right place and is certainly quite close in age," says Kunk. "It's certainly tantalizing." One problem with Manson, however, is its small size, which would require other, simultaneous impacts (*Science*, 21 August 1987, p. 856).

The chore now is to tease apart the sources of all the important environmental changes that led to extinctions while distinguishing between regional and truly global events. Given the demonstrated influence of the Milankovitch cycles on the past couple hundred million years of climate on time scales of 20,000 to 100,000 years, a background of changing climate seems inevitable. Did this background play a role? Sea level was indeed falling, reducing habitats such as the inland sea of North America that the dinosaurs found so congenial. A huge volcanic outpouring was forming the Deccan Traps of India, possibly increasing atmospheric carbon dioxide and turbidity even if it were not the boundary event.

Given these and other terrestrial influences, the great impact at the boundary could indeed have sent a destabilized ecological system over the brink. Even the prelude to the K-T event might have been extraterrestrial, a million-year swarm of smaller comets punctuated by the knockout punch. Or, perhaps the "prelude" was little more than a pulse in a background of climatic and biological change usually blurred beyond recognition in less detailed studies. Researchers will be taking quite some time considering all the possibilities. ■

RICHARD A. KERR

Superconductors Hotter Yet

It is almost a year since the discovery of a 90 K (90° above absolute zero) superconductor touched off an explosion of laboratory research and media interest in an area of enormous—but still elusive—technological potential. Within the past few weeks Japanese and American scientists have independently discovered a new material that is superconducting at temperatures up to 120 K, thus keeping alive the notion that superconductivity at practicable temperatures will one day soon transform activities ranging from microelectronics, to high speed trains, to high energy physics research.

The new material, a compound of bismuth, copper, strontium, calcium, oxygen, and (optionally) aluminum, has the potential for being dramatically cheaper and easier to work with than the other known high-temperature superconductors, which begins to address some of the practical issues of the technology. It was identified only weeks ago by Paul C. Chu and his colleagues at the University of Houston; its properties have since been confirmed by several other U.S. laboratories. Meanwhile, an apparently similar material has been reported by a team working under Hiroshi Maeda at the National Research Institute for Metals in Tsukuba, Japan. The Japanese team announced their discovery on 22 January, just 3 days before that of Chu and his colleagues.

It was Chu's team that last year discovered superconductivity at 90 K in a class of yttrium–barium–copper oxides—the so-called "1-2-3" compounds. That discovery, in turn, had followed close on the heels of 40 K superconductivity in lanthanum–barium–copper oxide, which had been announced in the fall of 1986 by Georg Bednorz and Karl Alexander Mueller of IBM's Zurich Research Laboratory, an achievement that earned them the 1987 Nobel Prize in Physics, the fastest-ever recognition of a discovery by the Nobel committee.

The new 120 K material thus represents a third fundamentally distinct class of high-temperature superconductors. As such it may well shed new light on the still mysterious mechanism of high-temperature superconductivity. In a telephone interview with *Science*, Chu said he was reluctant to discuss the exact formula of the new material before the discovery is published in the scientific literature, which should occur within the next few months. However, he did say that at the atomic level the new material is similar to the 40 K and 90 K superconductors in that it seems to have a layered structure—although it is not yet clear exactly what the arrangement of the layers is. Like the other two materials it also seems to have copper and oxygen atoms arrayed in long chains, a feature that many theorists think is central to the superconductivity.

In terms of practical applications, said Chu, the new material seems to have a number of potential advantages. Cost, for example: unlike the 40 K and 90 K compounds, which incorporate a variety of rare-earth elements, the new substance can be made from common and inexpensive raw materials. By the same token the new superconductor seems much more tolerant of variations in the precise ratio of its constituents.

Or consider stability: unlike the 1-2-3 compounds, in which oxygen can all too easily escape from the crystal lattice and destroy the superconductivity, the new compound retains its oxygen even when heated near its 900°C melting point.

On the other hand, said Chu, it has so far proved very difficult to make the material into a single, pure chemical phase. This is a problem that will certainly have to be overcome before the material can be useful. Also, there are still some major unknowns about the substance, the most notable being its critical current capacity—that is, the maximum current it can carry before losing its superconductivity. Practical large-scale applications will require critical currents on the order of 1 million amperes per square centimeter.

In short, it is still too early yet to say just what this new material will mean in practical terms. Nonetheless, as Chu pointed out, it will definitely provide "scope for flexibility": a new arena for studying the mechanism of high-temperature superconductivity, for exploring the effect of new variations in composition, and—who knows?—perhaps even for making the leap to still higher critical temperatures. ■

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