crofossil foraminifera found near the boundary, 6 became extinct 25 centimeters below the boundary, or some thousands or tens of thousands of years before the impact. Another 8 species disappeared 5 centimeters below the boundary, 12 species at the boundary, and 10 species 7 centimeters above it. The mass extinction appears to have been gradual or perhaps stepwise. Keller concluded from this site and others that "Although the onset of the mass extinction appears to have been related to global climatic changes, the K-T boundary event hastened the demise of a fauna already on the decline."

Smit could not disagree more. He found that virtually all of his 30 Cretaceous foraminifera species at El Kef continued to within 2 centimeters of the boundary. The mass extinction would thus appear to have been catastrophic and coincident with the large impact. Smit and Keller briefly discussed why one of them should see microfossils the other does not and agreed that they should get together to resolve their differences.

The debate over gradual versus instantaneous mass extinction also cropped up in discussions of land plants and marine clams and cephalopods. One conclusion was that apparent gradual extinctions well before the Cretaceous-Tertiary boundary can sometimes, but not always, be shown to be catastrophic extinctions at the boundary. It may just take lots of looking in the right places.

Peter Ward and Kenneth MacLeod of the University of Washington reported that, contrary to most earlier work, the spiraled mollusks called ammonites did not die out before the boundary. Searching beyond a classic exposure at Zumaya, Spain, around the Bay of Biscay, they found ammonite fossils, which are centimeters to up to a meter across, within 13 centimeters of the boundary. With more work and more luck, said Ward, even that gap should disappear.

On the other hand, Ward and MacLeod found that the bivalve mollusks called inoceramids disappeared over about 40 meters of sediment 120 meters below the boundary, or roughly half a million years before the impact. That is not a result of poor sampling because they found inoceramid shell fragments and prisms disappearing in deep sea cores at the same time.

Clearly, in addition to resolving questions about the boundary itself, paleontologists will have to look hard and long at many sites within a region, at many regions around the world, and over more than 1 or 2 millions years of time around the boundary in order that they can distinguish just what is unusual about mass extinctions.

■ RICHARD A. KERR

AMPTE Outfoxed by Magnetosphere

How do you lose track of 2×10^{25} lithium ions in the emptiness of space? That was the question space physicists have been asking themselves since the release of six such batches of chemical tracers near Earth in 1985. It is easy enough, it turns out, if the tracers are making their way through the complex and poorly understood magnetosphere of Earth. Recent studies suggest how things might have gone wrong.

A primary goal of the Active Magnetospheric Particle Tracer Explorers (AMPTE) mission was to show how the low-energy ions blown off the sun in the form of the solar wind can cross the barrier at the edge of Earth's magnetosphere, the teardrop-shaped enclosure formed by the magnetic field, and become energized within the magnetosphere (*Science*, 28 June 1985, p. 1519). The ions that reach the close-in radiation belts have a thousand to a million times more energy than those in the solar wind. The easiest approach seemed to be the tagging of the solar wind with some exotic, easily identified ions released by a distant satellite and the measurement of their properties by a second satellite on their arrival near the radiation belts.

Under the best of conditions, the two lithium releases sunward of and outside the magnetosphere would yield few ions to be detected near Earth, according to the best models of ion transport then available. Unfortunately, the best models were thought to be uncertain by a factor of 10. Conditions were not the best during the releases in the fall of 1984 and no lithium was detected, which was not too surprising.

More surprising was the failure to detect the ions from two barium and two lithium releases within the tail of the magnetosphere during the spring of 1985. John Cladis and William Francis of the Lockheed Palo Alto Research Laboratory have run an improved model of tracer ion behavior within the magnetic and electric fields of the magnetosphere. Their model showed that the barium clouds probably presented too small a target for the AMPTE detector satellite. Ionizing within 30 seconds of release, the barium remained at high concentrations but in such tight bundles that the detector satellite never came closer than 12,000 kilometers to the bundles in the model simulations.

All this was a bit discouraging, but from the beginning the lithium releases had looked like the best bet. Lithium took about an hour to ionize, allowing it to spread across a volume of space a few times larger than Earth. The target was certainly big enough and the simulations showed the satellite hitting the target. For the first lithium release, the simulated concentrations after the 2- to 4-hour transit time were even in the detectable range, although just barely. The fatal problem on that run may have been the natural high electron flux prevailing at the time, which created a background in the detector that swamped the lithium signal. By the time of the next release, the satellite's most sensitive detector had failed and the simulated lithium concentration was half what it was in the earlier run.

Would Cladis endorse another try at releasing magnetospheric tracers, now that the models are better? "We were very close to measuring lithium," he says, "but a repeat would not be a good idea. Even at the present time we don't have a good model of the electric fields in the deep magnetotail."

As is often the case in the data-poor field of magnetospherics, there is an opposing opinion, at least in the case of the 13 May barium release. Theodore Fritz of Los Alamos National Laboratory and his colleagues are suggesting that instead of the barium slowly diffusing toward Earth, as in the model, the strain that it created on the magnetic field formed a small blob of closed field lines containing much of the barium. From ground-based imaging of the barium and other observations, this group concludes that the so-called plasmoid promptly headed down the magnetotail toward deep space at the hefty clip of 200 kilometers per hour, taking the barium with it. Unlike Cladis, who would look to the use of a satellite-borne, repeating-ion gun to study ion transport, Fritz and his colleagues would like to see more AMPTE-like releases to tag such small plasmoids as well as the large ones that some researchers believe break off the magnetotail like drops from a dripping faucet (*Science*, 14 December 1984, p. 1298).

■ RICHARD A. KERR

ADDITIONAL READING

J. B. Cladis and W. E. Francis, "On the transport of ions released in the magnetotail by the AMPTE-IRM satellite," *Adv. Space Res.* **8**, (1)5 (1988).