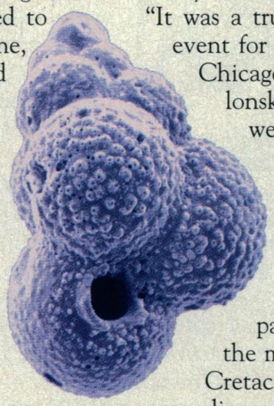
Testing an Ancient Impact's Punch

Did the impact at the end of the dinosaur age deliver a haymaker to life on Earth? Results newly reported from a "blind test" of the marine fossil record suggest it did

HOUSTON—The provocative idea that a huge meteorite blasted Earth 65 million years ago and wiped out the dinosaurs and other creatures faced a formidable struggle when it was proposed 15 years ago this spring. Its proponents were forced to fight on two fronts at once. On one, they did battle with geologists and geochemists who disputed the evidence of the impact; on the other, they engaged paleontologists who doubted that the mass extinction 65 million years ago took place in a geologic instant, as the impact hypothesis requires.



R. OLSSON

Lucky survivor... One of two or three foram species that rode out the K-T crisis.

That the first battle has finally ended was clear at last month's conference here on catastrophes in Earth history (dubbed Snowbird III after the Utah location of the first two meetings). In something of a first, not a single researcher at the meeting publicly questioned the reality of a giant impact on the Yucatán coast. Even a peripheral question about the origin of 65-million-year-old deposits around the Gulf of Mexico seemed settled in favor of an impact (see box).

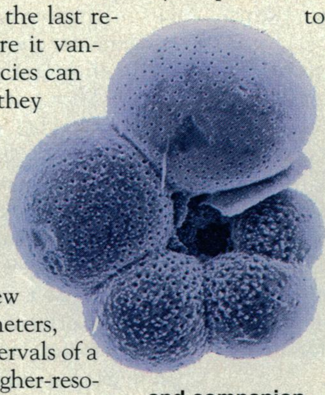
The second dispute continues, but Snowbird III saw a major shift in its battle lines. The fossil record of microscopic marine protozoans called forams, which should provide the most reliable measure of the pace of extinction, has for the first time yielded a widely, though not universally, accepted verdict. "It sure looks catastrophic to me," says paleontologist Peter Ward of the University of Washington, who once viewed the extinctions as gradual and has since seen evidence for both gradual and abrupt disappearances, depending on the species.

There are holdouts, but the innovative strategy that yielded this initial verdict on the pace of the extinctions may have the potential to resolve the issue once and for all. The results, first presented at the Snowbird meeting, are from a blind test, in which investigators examined samples and identified the species in them without having any idea of the samples' ages in relation to the impact. While investigators working on their own haven't been able to agree on whether or not forams died out gradually, the blind test showed all of the forams persisting until the impact, when at least half suddenly disappeared.

In a field often rife with subjective judgments, that novel strategy generated as much excitement as the results. "Paleontology has finally entered the 20th century," says Ward. "It was a true scientific test, a watershed event for my field." Adds University of Chicago paleontologist David Jablonski: "It's marvelous it was done; we should do more of this."

The new results from marine microorganisms add to the mounting evidence of an abrupt extinction from other fossils. When the impact hypothesis was first proposed, paleontologists tended to view the mass extinction that ended the Cretaceous Period and the age of the dinosaurs as a gradual affair, taking place over hundreds of thousands if not millions of years—a pattern more likely to have resulted from sea level fall or global cooling than an impact.

But in the 1982 proceedings of the first Snowbird conference, two marine micropaleontologists, Philip Signor and Jere Lipps of the University of California, Davis, cautioned their colleagues not to take the fossil record at face value. They pointed out that how abrupt a mass extinction appears in the record can depend on how closely paleontologists examine it. The rarer the fossil—dinosaurs are the worst case—the less likely paleontologists are to find the last remains of that species before it vanished. As a result, rarer species can appear to die out before they actually do.



R. OLSSON

...and companion. Another survivor, less than 100 micrometers across.

In the following years, some paleontologists tried to overcome the Signor-Lipps effect by sampling up and down their favorite fossil records every few centimeters or even millimeters, rather than at the usual intervals of a few meters. In these new higher-resolution studies, some extinctions that had seemed to be gradual, such as that of plants in North America and coil-shelled ammonites from the Bay of Biscay, now looked relatively quick (*Science*, 11 January 1991, p. 161).

But the microscopic fossils in the ocean, which because of their abundance should provide the strongest evidence about the pace of the extinctions, yielded an ambiguous verdict. Gerta Keller of Princeton University argued in a 1989 paper that 29% of the Cretaceous foram species she identified at El Kef in Tunisia became extinct over the 300,000 years leading up to the impact. Therefore, it must have been global cooling or the sea level drop that did them in, she said. Since only 26% of the species become extinct right at the end of the Cretaceous—the K-T boundary—"the effect of the impact was of more limited scope than generally assumed," she wrote. But Jan Smit of the Free University of Amsterdam couldn't find any forams disappearing before the boundary at El Kef, where he saw all but a few species going extinct.

To resolve the dispute, sedimentologist Robert Ginsburg of the University of Miami took up a novel proposal that had been made at the previous Snowbird meeting: a blind test of gradual versus abrupt extinctions. With the assistance of Smit and Keller, he collected new samples at El Kef, split them into coded subsamples, and distributed them to four foram investigators. Unaware of how far below or above the impact each sample had been collected, each analyst identified the species present. The investigators then sent their results back to Ginsburg.

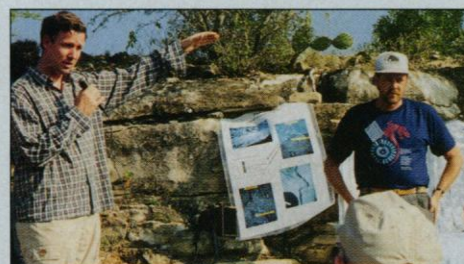
When the results were unveiled at the meeting, both sides claimed victory. Keller pointed out that each of the blind investigators had some fraction of the Cretaceous species—ranging from 2% to 21%—disappearing before the K-T boundary. That "basically confirms the pattern" of gradual extinctions, Keller told the meeting.

Smit saw it differently. "That's typical Signor-Lipps effect," he says. To minimize the influence of rare or misidentified species on the results, Smit combined all four efforts, including only those species that two or more of the blind investigators spotted somewhere in their sample set. In the case of the seven species that, by Keller's analysis, disappeared before the impact, one or another of the blind investigators found all seven in the last sample before the boundary. "Taken together,

Searching for the Tracks of Impact in Mexican Sand

After years of contention about the effects of the giant impact that struck the Yucatán peninsula 65 million years ago, some researchers have decided that the best hope for settling these issues is to call on panels of experts. So while paleontologists at the Snowbird conference discussed the findings of investigators who took part in a "blind test" of the impact's effects on marine life (see main story), an informal group of sedimentologists—geologists who worry about how sediments came to be laid down—was conducting its own deliberations.

The question facing the sedimentologists: Was a deposit of sand several meters thick laid down off northeast Mexico by gigantic tidal waves after the impact? Or were the layers—now exposed on land in sandstone outcrops—actually built up over thousands of years as coastal deposits repeatedly slumped into deeper water? The experts had taken their own look at the evidence on a preconference field trip organized by sedimentologist Robert Ginsburg of the University of Miami (who also organized the blind test of extinctions). And among those new to the debate, the impact won the day.



R. GINSBURG

Geologists on the rocks. Smit *(left)* and Stinnesbeck *(right)* address participants on a field trip to study whether some Mexican rocks *(rear)* were deposited catastrophically or gradually.

Ginsburg had felt he'd heard enough dueling interpretations from individual investigators. It was time, he thought, to get everybody out on the outcrops—and let the best geology win. Hence his field trip, which was open to all comers but included all the necessary personnel for a critical evaluation. Paleontologist Wolfgang Stinnesbeck of the Autonomous University of Nuevo León headed the gradualist contingent, sedimentologist/paleontologist Jan Smit of the Free University in Amsterdam headed the impact side, and they were joined by several more or less disinterested experts, among them four ex-presidents of the Society for Sedimentary Geology, including Ginsburg.

Everyone who took part agreed on one thing about the sand—it had to have been deposited by strong currents. Next to silt and clay particles, sand grains are gigantic. They require powerful flows of water to move them, and obvious ripples and layering in the formation speak of fast-flowing water. In Stinnesbeck's interpretation, the rapid flows could have been generated when near-shore deposits repeatedly collapsed to form powerful sediment-laden bottom currents that swept the sand into deeper water.

After inspecting the outcrops, the four sedimentologists disagreed with Stinnesbeck. Sand-laden currents had not simply flowed downhill, they argued, because there are signs in the rippled layering of the sand that water flowed both up- and downhill. Dense bottom currents only flow downhill, but huge impact waves rolling through and then sloshing back off the land might do the trick. And the four ex-presidents agreed there were no convincing signs that burrowing animals had a chance to settle into one layer before the next was laid down, requiring the whole deposit to form within days or months, not years or millennia.

"For [the sedimentologists], I think we were impressed with the evidence that this sequence was very rapidly deposited," Robert Dott of the University of Wisconsin told the meeting. It must have taken "closer to 100,000 seconds than 100,000 years." And the event most likely to be energetic enough to lay down the sand bed beneath several hundred meters of water, concluded the sedimentologists, seems to be an impact-induced tsunami.

Like the blind test of the extinctions, this sedimentologic "test" didn't change many minds. Stinnesbeck continued to argue that the sand layer is too uniform and too extensive—at least 300 kilometers end to end—to be the result of an impact. Still, Edward Clifton of Conoco Inc. in Houston sums up the mood of most sedimentologists on the trip: "If you don't have [an impact], you'd be hard put to come up with an alternative."

–R.A.K.

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they found them all," says Smit. "This eliminates any evidence for pre-impact extinctions in the [open-ocean] realm."

Many others at the meeting agreed that the results seem to point to abrupt extinctions. James Pospichal of Florida State University, for example, had already concluded from his own high-resolution work that marine nannofossils, the remains of planktonic algae, had continued to be abundant right up to a disastrous extinction at the time of the impact, but he says he was open minded about the fate of the protozoans. To judge by the blind test results, he says, the forams behaved the same way.

Keller, though, thinks the evidence for abrupt extinctions still involves "major taxonomic problems." For example, if the blind investigators lumped together separate species that look similar, she says, what was actually a series of extinctions could appear to be a single, abrupt extinction. But now her own taxonomy is under fire. Brian Huber of the National Museum of Natural History had examined forams from a deep-sea sediment core of K-T age, drilled from the far South Atlantic, that Keller used in a 1993 *Marine Micropaleontology* paper to support a claim of gradual extinctions. "None of her taxonomy or quantitative studies [of this core] can be reproduced," says Huber. "The gradual side of the debate doesn't hold water because of her inconsistencies" in identifying foram species.

Keller isn't conceding anything, however. She presented her latest analyses of the El Kef forams at the meeting and will be presenting a reply to Huber's comments, which he is now preparing for publication. "The data stand and the data will be published," she told *Science*.

An extension of the test might settle the sticky points of taxonomy—if all the combatants were willing. Ideally, the adversaries would gather around a single microscope and examine each disputed species, conferring until everyone agreed on how it should be identified. As a more practical solution, Ginsburg may circulate the samples among the investigators and tally their votes.

Even if further tests can definitively resolve the gradual-versus-abrupt dispute at El Kef, however, plenty of disputes would remain about the K-T extinctions. Were they really less severe at high latitudes, as Keller and others suggested at the meeting? Did many foram species survive the impact, as Keller argues? And once the nature of the K-T extinctions has been settled, the fossil record has plenty of other mysteries to which investigators might turn a blind eye.

–Richard A. Kerr

Additional Reading

New Developments Regarding the KT Event and Other Catastrophes in Earth History, **abstracts from a meeting (Lunar and Planetary Institute, Houston, 1994).**