In Mass Extinction, Timing Is All

A new, apparently improved, way to date the greatest mass extinction points to a volcanic cause but fails to resolve geochronologists' long-running differences

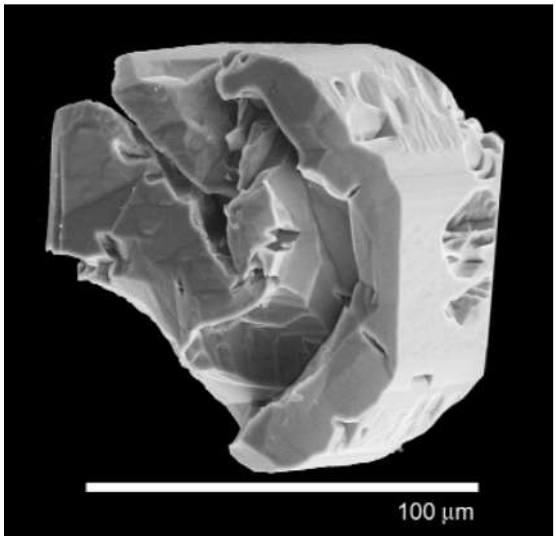
For earth scientists trying to lay the blame for the all-time greatest mass extinction some 250 million years ago, the secret is in the timing. The professional timekeepers—the geochronologists—are trying to place a volcanic catastrophe at the moment of the extinction, thus linking cause and effect to explain an event that wiped out 95% of animal species on Earth.

But nailing down the time of the Permian-Triassic (P-T) extinction has revealed problems in the often competitive business of geochronology. P-T daters must draw their conclusions from vanishingly small isotopic remains of radioactive decay. For years, different laboratories using uranium-lead radiometric dating—the gold standard of geochronology—have been getting entirely different ages for the P-T extinction.

On page 1760 of this issue of *Science*, Roland Mundil of the Berkeley Geochronology Center in California and colleagues weigh in with their latest P-T age using a new way of preparing samples for uranium-lead dating. By their reckoning, the extinction and the largest volcanic eruption of all time are older than thought, but coincided precisely. "It's an impressive piece of work," says geochronologist Michael Villeneuve of the Geological Survey of Canada in Ottawa. The new treatment seems to remove much of the subjectivity of traditional approaches, but still, "all dates are interpretations," Villeneuve notes. "It needs a bit more proving out."

Uranium-lead dating seems straightforward enough. The analyst simply crunches a rock, picks out microgram grains of the mineral zircon, grinds off an outer layer, dissolves the remaining grain in acid, spikes the solution with a calibration standard, and measures the amounts of four isotopes using mass spectrometry. Two are isotopes of radioactive uranium that have not yet decayed, and two are picogram quantities of lead isotopes that have accumulated from the steady decay of the uranium since the zircon crystallized in magma. The ratio of each uranium isotope to its decay-product lead isotope tells how long each of the two radioactive clocks has been running and thus how old the rock is.

Geochronologist Samuel Bowring of the Massachusetts Institute of Technology and colleagues followed just such an approach to date rocks bearing fossils from the time of the P-T extinction in southern China. Analyzing zircons from nearby layers of volcanic ash, they got an age of 251.4 ± 0.3 million years (*Science*, 15 May 1998, p. 1039). And late last year Sandra Kamo of the University of Toronto, Canada, and colleagues published a uranium-lead date of 251.4 million years—right on Bowring's P-T age—for the eruption of the massive Siberian Traps, thick layers of ancient lava that once covered millions of square kilometers (*Science*, 21 November 2003, p. 1315).



Better for it. Hot acid has removed degraded parts of this zircon that would have skewed its apparent age.

Mundil, however, doesn't believe that either the eruption or the extinction happened that recently. He thinks Bowring engaged in "arbitrary data culling" by throwing out more than half his zircon ages before averaging the rest of them together. But Bowring says his choices were judicious, although "necessarily somewhat subjective." In some of his zircons, the two different uranium-lead ratios gave different ages, suggesting that lead had leaked out of those zircons during the past quarter-billion years. And other zircon ages looked distinctly old, as if those zircons had crystallized earlier than the rest and had later gotten mixed in with them. By taking into account how volcanic ash beds are stacked around the rock layer that shows the extinction, Bowring believes he can confidently select the reliable zircon ages and discard the rest.

Mundil set out to take this "picking and choosing" out of uranium-lead dating. Over the years, researchers had tried various pretreatments to get rid of the parts of a zircon that had lost lead. To prepare new samples from southern China, Mundil and colleagues adopted a technique recently developed by James Mattinson of the University of California, Santa Barbara. They baked the southern China zircons at 850°C for 36 hours and then leached them with hydrofluoric acid under pressure at 220°C for 16 hours, with the intention of removing the parts most weakened by radiation damage.

This rugged pretreatment narrows the range of zircon ages from a single ash bed from about 20 million years to a few million years, with no picking and choosing. Of the 79 zircons dated in the P-T study reported in this issue, the researchers discarded only three, all for being obviously too old. Their age for the P-T extinction is then 252.6 ± 0.2 million years—about a million years older than Bowring's age but coincident with a decade-old argon-argon radiometric age for the Siberian Traps that Mundil and his colleagues—after making a 2-million-year correction to it—prefer over Kamo's uranium-lead age.

The new preprocessing technique "is very promising," says Drew Coleman of the University of North Carolina, Chapel Hill. "It appears to be very fruitful." Bowring agrees. "This is a step in the right direction," he says. "Mattinson's annealing is the big breakthrough, though I have no idea why it works." But Bowring points to the later date that his group estimated for the P-T extinction in China and Kamo's group independently got for zircon and other minerals from the lavas of the Siberian Traps. Mundil hasn't explained how subjective interpretation could have produced such a coincidence, he says.

What uranium-lead geochronologists need now, all agree, is more cooperation. "They've been competitive and secretive for decades," says geochronologist Randall Parrish of the British Geological Survey in Keyworth, U.K. "There's not enough cooperation among workers seeking out best practice, but we're going to hash out a lot of these issues in October." That's when uranium-lead and argon-argon daters will gather near Boston under the auspices of the new EARTHTIME program for a frank and open discussion of all those little details that don't make it into the literature.

–RICHARD A. KERR

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