But only if it's built, of course. DOE's Decker says that no decision on the project is imminent, assigning it a status that makes U.S. supporters uncomfortable. Last week, Germany's Science Council set priorities for major science projects, and a $675 million heavy-ion laboratory is among the experiments that it deemed deserving of attention. This unnamed laboratory, which would be built at the GSI heavy-ion research center in Darmstadt, Germany, has a great deal of overlap with RIA, although Gelbke says it probably won't put the r-process problem to rest; its broader mission means that it wouldn't be able to study quite as many elements as RIA would.

"We're poised and ready to go," he adds. "All we need is a decision." **–CHARLES SEIFE**

EVOLUTION

A Trigger for the Cambrian Explosion?

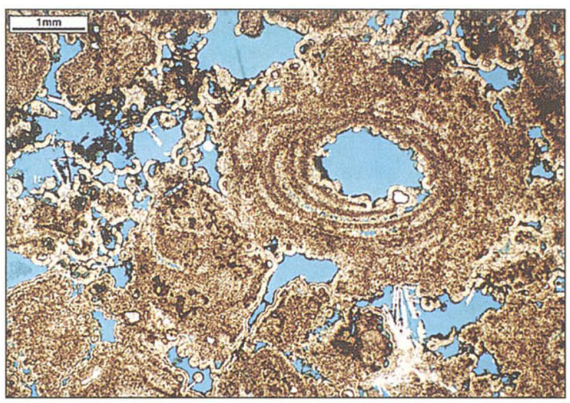
Sediments in Oman provide evidence that an extinction 542 million years ago set the stage for a proliferation of wild and wonderful life forms

Before the Cambrian period began 542 million years ago, life was microscopic, vegetative, or just so odd that it now seems otherworldly. Then, in a geologic moment, an evolutionary explosion littered the fossil record with the recognizable remains of every basic form of animal that we know today. What caused this change is controversial. Some think of the lead-in to this explosion as a "slow fuse" of gradually accumulating genetic traits that finally produced large, complex animals; others believe a "trigger" of some sort set off the mechanism that suddenly produced Cambrian animals.

At last month's annual meeting of the Geological Society of America in Denver, Colorado, sedimentologist John Grotzinger of the Massachusetts Institute of Technology and his colleagues reported the latest evidence of a trigger for the Cambrian explosion: an extinction 542.0 million years ago, possibly brought on when the deep sea disgorged noxious waters. "We do have evidence for point-blank extinction," says Grotzinger. But even in the data-sparse realm of early life, this one page from the fossil record of Oman isn't enough to prove that a near-knockout punch to primitive life set off the Cambrian explosion. Despite the rarity of sediment and fossils preserved from that time, more records must be found.

Forming the Oman record entailed some geologic happenstance; finding it required some lingering crude oil. Late in Precambrian times, what is now Oman on the far eastern tip of the Arabian Peninsula held a deep basin filled with water from the adjacent ocean, a sea much like the Mediterranean today. In the basin's shallower waters, great reefs formed as microorganisms helped precipitate millimeter-scale clots of carbonate, known as thrombolites. But the water level would sometimes fall enough to cut off the sea's shallow connection to the open ocean, the seawater would evaporate, and salt instead of carbonate would be deposited. Six pairs of salt and carbonate layers were laid down in Oman, and, to the Omanis' good fortune, oil eventually filled the spaces (blue in figure) between the carbonate clots.

Enter the age of fossil fuel. Drilling for oil has penetrated all six thrombolite layers. In a drill core provided by Petroleum Development Oman, Grotzinger found two of the late Precambrian's emblematic inhabitants —cone-shaped *Cloudina* and gobletlike *Namacalathus*—throughout the first three thrombolite layers. Apparently, these carbonate-shelled animals of uncertain affinities thrived attached to or lying on top of Oman's carbonate reefs. But in the next three reef deposits, *Cloudina* and *Namacalathus* were gone, even though the abundance of thrombolite would suggest that the living conditions were pretty much as they had been during earlier intervals. To Grotzinger, that's strong evidence that *Cloudina* and *Namacalathus* were gone from the world, not just missing from this little corner of it.



Loser. Did the extinction of *Cloudina* (cross-sectioned as oval) and others trigger the Cambrian explosion?

CREDIT: J. GROTZINGER/MIT

By the best measures of time in this distant era, the apparent extinction comes right at the jump from the Precambrian to the Cambrian. Grotzinger and his colleagues found that the carbon isotopic signature of the first thrombolite layer that lacks the Precambrian creatures is significantly lighter than the signatures of those below it. A similar isotopic shift marks the boundary between the Precambrian and the Cambrian elsewhere in the world. And radiometric dating of volcanic ash layers shows that the shift took less than a million years and occurred by 542.0 ± 0.5 million years ago, within the documented age range of the boundary's carbon isotopic shift elsewhere.

If *Cloudina* and *Namacalathus* were not alone in disappearing, the resulting extinction at the dawn of the Cambrian could have set off an evolutionary explosion, Grotzinger argues. Such an explosion might occur, he says, "if you cleared the playing field [through an extinction] and started over again." Such a dramatic event could open up new possibilities for life in the same way the extinction of the dinosaurs opened the way for mammals. But rather than envisioning an asteroid impact, Grotzinger sees geochemical signs in the Oman cores—similar to those others have seen elsewhere—that oxygen-deficient, carbon dioxide–rich waters welled up into the shallow sea at the same time. That could have been enough to wipe out any marine species not adept at taking up oxygen or fending off the toxic carbon dioxide (*Science*, 1 December 1995, p. 1441).

No one, including Grotzinger, thinks the case for a global Precambrian-Cambrian extinction is closed. "It would be consistent with an extinction," says paleontologist Sören Jensen of the University of California, Riverside, "but you wouldn't want to say it proves it." First, the evidence so far involves only two species at a single place. Second, no extinction this abrupt has been proposed before, notes paleontologist Douglas Erwin of the National Museum of Natural History in Washington, D.C., but "the Omani data provides further support of there having been a biological crisis then. It's certainly an increasingly reasonable idea." Major extinctions mark the other important turning points of evolution that have occurred since the Cambrian explosion, such as the end of the "old life" of the Paleozoic era 250 million years ago. Proving that a trigger set off the most fundamental evolutionary event since life's origin will take some more digging or perhaps drilling. **–RICHARD A. KERR**