Volcanoes and Extinctions: Round Two

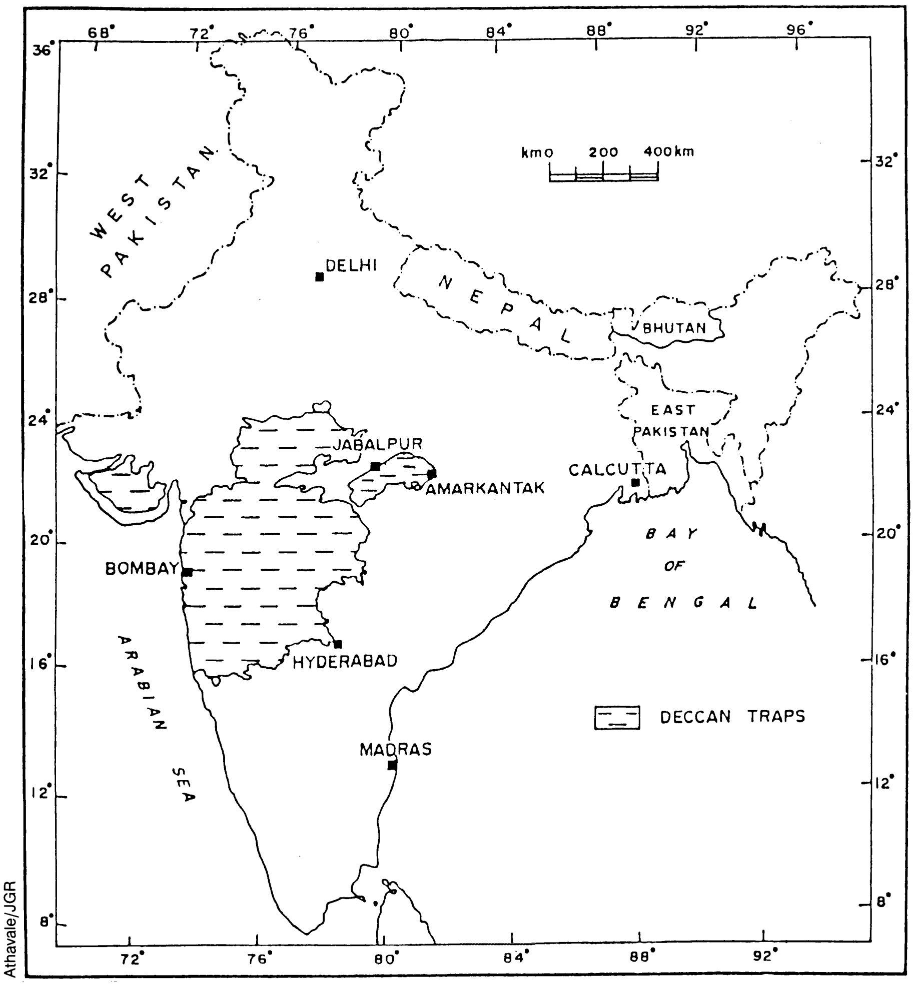
Were the dinosaurs victims of volcanoes? Armed with new data, some scientists emphatically answer yes, but others continue to say no.

By STEFI WEISBURD

In 1979, a group of researchers injected new life into an old study of death. Led by Walter Alvarez at the University of California at Berkeley, they proposed that an asteroid had crashed into the earth at the end of the Cretaceous period, 65 million years ago. This impact, they suggested, threw a blanket of dust into the atmosphere, which blocked out the sunlight, causing famine and mass extinctions (SN: 6/2/79, p.356). The most famous casualties were the dinosaurs.

Now, after stimulating a whirlwind of research in paleontology, stratigraphy, geochemistry, astrophysics and statistics, Alvarez believes the impact theory of the Cretaceous-Tertiary (K-T) extinctions is on solid enough ground for him to move on to other geologic pursuits. As he concluded last fall in Eos, the weekly newspaper of the American Geophysical Union, " . . . the unusual features of the K-T [stratigraphic] boundary layer are exactly compatible with a major impact." The competing theory that intense volcanic eruptions caused the extinctions (SN: 3/16/85, p.172), he suggested, simply cannot account for all of the evidence.

Alvarez may have hoped that his Eos article, by carefully outlining all the evidence and what he sees as the shortcomings of the volcanic hypothesis, would put the debate to rest. But for some researchers, it only sparked more arguments for the volcanic cause.



Athavale/JGR

Did India's Deccan Traps cause the demise of the dinosaurs?

At issue is the resolution of one of the most intriguing puzzles in science. By understanding what killed off the dinosaurs and three-quarters of the species living on earth 65 million years ago, researchers not only would solve a longstanding mystery of the past, but might catch a glimpse of what could befall the planet in the future.

"Walter [Alvarez] says the volcanic road is shut. I think, on the contrary, it is very wide open," says Vincent E. Courtillot, who is visiting the University of California at Santa Barbara (UCSB) from the Institut de Physique du Globe in Paris. In a letter in the April 7 Eos, Courtillot and Stanley Cisowski of UCSB respond to Alvarez's Eos paper.

"The purpose of this letter," they write, "is to stress that answers have changed rapidly in recent years and may still evolve, and that the case for a volcanic cause may have been determined extinct by Alvarez somewhat prematurely."

Courtillot and Cisowski are not alone. Charles Officer at Dartmouth College in Hanover, N.H., and his colleagues published a paper in the March 12 NATURE that outlines the volcanic arguments and looks in detail at how a series of large volcanic eruptions could affect the environment and life.

Among the recent lines of evidence and theory that have motivated Courtillot and Officer to write their papers are:

• **A date for the Deccan Traps.** The Deccan Traps in India are vast flood basalts, or lava flows, that today cover an area about the size of France and may once have contained 1 million cubic kilometers of volcanic material. Proponents of the volcanic theory have suggested that the Deccan eruptions caused the K-T extinctions by spewing out sulfur and other volcanic material that darkened the skies, cooled the planet and produced acid rain.

But the correlation between the K-T extinctions and the Deccan Traps has been sketchy at best, says Courtillot, because the traps have not been very precisely dated. While the most frequently quoted age for the traps falls around 60 million to 65 million years old, he says, other estimates, determined

Science Service, Inc. is collaborating with JSTOR to digitize, preserve, and extend access to *Science News*. www.jstor.org

primarily from potassium-argon dating, range from 80 million to 30 million years old.

Using a combination of geochemical, paleontologic and paleomagnetic data, Courtillot and his co-workers believe they now have obtained a more precise age estimate: about 66 million years.

Even if the impact hypothesis is correct, says Courtillot, "we hope that our contribution will be to demonstrate that the Deccan was the largest volcanic catastrophe in the last 200 million years and that it occurred precisely at the K-T boundary."

The researchers also believe that the traps, consisting of 100 flows, were erupted over a 500,000-year period.

Alvarez doesn't put much significance in Courtillot's conclusion that the K-T extinctions occurred during the Deccan eruptions. "You can't say they happened at the same time," he says. "That is roughly the same as saying it's a strange coincidence that Super Bowl XII and the 20th century happened at the same time" – the two events are on entirely different time scales.

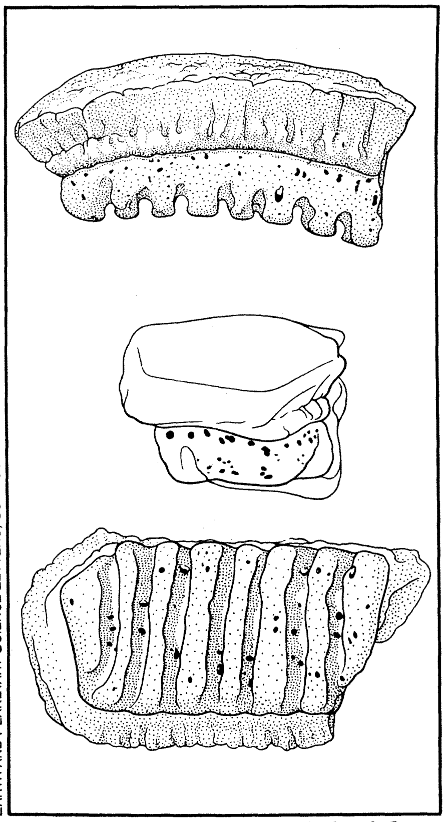
Courtillot, however, argues that the eruptions were probably not continuous; there may have been brief periods of intense volcanism, coincident with the K/T extinctions, that affected life on the planet, he says.

• **Worldwide distribution of material.** Alvarez and others have doubted whether quiet, nonexplosive eruptions, such as those at the Deccan Traps and the Kilauea volcano in Hawaii, could spew material all over the globe. But Courtillot became convinced that this would be possible after reading a paper in the August 1986 GEOPHYSICAL RESEARCH LETTERS by Richard B. Stothers at the NASA Goddard Space Flight Center's Institute for Space Studies in New York City and his colleagues.

In their paper, Stothers and his coauthors conclude that "flood basalt fissure eruptions that produce individual lava flows with volumes exceeding 100 cubic kilometers at very high mass eruption rates are capable of injecting large quantities of sulfate aerosols into the lower stratosphere, with potentially drastic short-term atmospheric consequences, like acid precipitation, darkening of the sky and climatic cooling."

In particular, they argue that plumes of hot air, gases, aerosols and ash can rise far above Kilauea-style lava fountains and fissures into the atmosphere.

Stothers and Courtillot make note of the 1783 Laki fissure eruption in Iceland, which sent a haze containing more than 10 million tons of sulfuric acid over Europe and into Asia and North Africa. This eruption, which released only 12 cubic kilometers of volcanic material in less than a year, caused famine and epidemics that killed 10,000 people and



EARTH AND PLANETARY SCIENCE LETTERS, 80 ©1986 Elsevier Science Pubs.

One of the discoveries that helped Courtillot nail down the age of the Deccan Traps was this tooth of a freshwater ray, which had previously been found only in rocks from the Maastrichtian age (66.4 million to 74.5 million years ago) in Africa.

resulted in a 5°C cooling of the Northern Hemisphere the following winter, according to Courtillot and others. And Stothers's group doesn't think the plumes from Laki even reached the stratosphere. The effects from the much larger Deccan eruptions, says Courtillot, could have been far more drastic if they had come in intense spurts.

However, James Whitney, an igneous petrologist from the University of Georgia in Athens, argues that if the Deccan flood basalts had released much sulfur gas, they would not have flowed over such great distances. Magmas that lose their gases, he says, become very viscous; only lavas that retain their gases are fluid enough to be flood basalts like those in the Deccan Traps.

Joseph Devine, a volcanologist at Brown University in Providence, R.I., disagrees, saying he doesn't believe that magmas need to retain sulfur in order to be fluid. Devine has shown that flood basalts have tended to release 10 times as much sulfur as do explosive eruptions. He has also demonstrated a link between climatic cooling and the amount of sulfur released by volcanoes in historic times.

• **Iridium levels at Kilauea.** Iridium is what originally inspired the impact idea. It is an element that is usually found on the earth's surface in only minuscule amounts, but it is abundant in meteorites. So when Alvarez and other researchers found high iridium levels at the K-T boundary, they argued that they had discovered a piece of evidence that could only point to an extraterrestrial cause of the extinctions.

But volcano proponents point instead to a January 1986 JOURNAL OF GEOPHYSICAL RESEARCH paper by Ilhan Olmez at MIT and his colleagues. These researchers found high levels of iridium in tiny airborne particles released from the Kilauea volcano. They estimate that if the Deccan eruptions were similar to Kilauea's, they could have emitted 30,000 tons of iridium, which is slightly less than what is believed to be contained in the K-T boundary layer.

Still, Olmez's group cautions that their work does not prove that volcanism is the source of the K-T iridium. In his Eos article, Alvarez also noted that iridium has not been detected at other volcanoes and "... it is not clear how this gaseous iridium would be deposited [worldwide] or whether any volcano could concentrate or emit enough [iridium] to account for the K-T anomaly."

• **Shocked-mineral findings.** Alvarez has argued that nonexplosive eruptions could not have produced the shocked-quartz particles – mineral grains that have been deformed by some explosive force – found at the K-T boundary layer. Courtillot concedes that the shocked quartz remains a problem for the volcanic theory, but Officer disagrees. He argues that shocked minerals have been found around the sites of violent eruptions, and he suggests that ash beds in the Deccan Traps indicate they too had experienced explosive intervals.

However, Bruce Bohor, at the U.S. Geological Survey in Denver, counters that the shocked-mineral grains found around volcanic sites are scarce compared with those found at either impact sites or K-T sites. Most important, he says, the volcanic grains look different from the K-T grains. Both impact and K-T shocked minerals look as though they've been stressed in a number of different directions, while the shock features of the volcanic materials point in one direction only.

• **Two large flood basalts.** Courtillot thinks the case for volcanism is helped by the North Atlantic Tertiary Igneous Province (NATIP), an enormous plateau of basalts along the coasts of Greenland and Scotland, which may have erupted at the same time as the Deccan Traps. Although studies of the NATIP have been far less detailed and comprehensive, he says, potassium-argon ages there are reported to be around 65 million years, and, like most of the Deccan Traps, the NATIP lavas erupted at a time when the earth's magnetic field was pointing toward the South Pole. (The geomagnetic field reverses direction every 500,000 years on average.)

With the NATIP erupting in the Northern Hemisphere and the Deccan Traps erupting in the Southern Hemisphere (though continental drift has since moved them to the north), the distribution of volcanic material could very well have been worldwide, says Courtillot. He proposes that both events resulted from an instability initiated at the bottom of the mantle some 20 million years previously. He notes that the magnetic period prior to the eruptions, in which the earth's magnetic field was pointing in the "normal" direction (toward the North Pole, as it does today), was unusually long, lasting from about 119 million to 84 million years ago.

"We now understand this long normal as a time when the earth's core, where the [magnetic] reversals are generated, was in a quiet state," he says. "The result is that a lot of heat was transferred from the core to the mantle."

At the end of the normal period, he suggests, the bottom layer of mantle material had become so hot that it was destabilized, and large plumes escaped from the layer and rose through the mantle. After 20 million years, these plumes reached the surface in the form of the Deccan Traps and the NATIP.

• **Other links between extinctions and volcanoes.** According to Courtillot, the previous largest extinction is at the Permo-Triassic boundary. Curiously enough, this extinction followed another long period in which the earth's field did not reverse (from 300 million to 250 million years ago). It is also thought to correspond to the eruption of very large traps in Siberia.

W. Jason Morgan at Princeton (N.J.) University is intrigued by these possible correlations. At last December's American Geophysical Union meeting he argued that there may also be a connection between a number of less extensive extinctions and smaller flood basalts.

The connection is not perfect, however. Morgan writes in the meeting abstracts that he has studied three extinction events that are not connected with any recognized flood basalts. And Whitney notes that the business of correlating eruptions with extinctions is a messy one because the geologic records are so fragmentary.

Whitney has also shown that a series of very violent eruptions 30 million to 26 million years ago from a band of volcanoes stretching from Colorado to Nevada seemed to have little effect on the nearby animal populations. He argues that these explosive eruptions would have been more effective than flood basalts at lofting sulfur and other volcanic materials high into the atmosphere; he estimates that one eruption in particular put 1 billion metric tons of sulfur into the atmosphere within a year.

But because there were no known mass extinctions in the Great Plains during that time, "I conclude that it's somewhat doubtful that volcanic eruptions by themselves can cause the kinds of mass extinctions that marked the end of the [Cretaceous] or the Permian," he says.

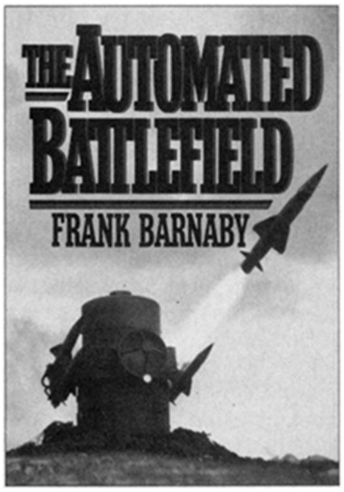
Could the impacts and eruptions have come together? Stothers and Michael R. Rampino at New York University in New York City believe that impacts, volcanism and extinctions are probably related. They have argued that there are very similar cycles in the starting times of major flood basalts, nonmarine extinctions and impact cratering over the last 250 million years. They suggest that impacts may initiate flood basalt eruptions, either by fracturing the crust or by disturbing mantle convection, causing plumes to form.

Courtillot is intrigued by this idea, but doesn't think the statistics are strong enough to clearly link cycles of impacts and volcanism. As for the K-T extinction, he stands by the volcanic theory.

"I'm not saying that the impact theory is ruled out," he says. "I don't personally believe that it occurred. What we have now from our work on the Deccan is a likely location and an internal mechanism that is much more in keeping with our understanding of how convection in the earth works. It may be wrong, but the way of science is to try the simplest thing before going back to something extraordinary." □

THE AUTOMATED BATTLEFIELD

Barnaby argues that advances in surveillance and target acquisition systems, the development of increasingly intelligent missiles and highly destructive conventional warheads, and the automation of command, control and communications operations foreshadow the advent of war fought entirely by machines. In *The Automated Battlefield*, Barnaby reveals an astonishing new perspective on the modern battleground where advancing forces are not men but mechanized drones, monitored on video screens by commanders who base their strategies on reconnaissance from satellites, unmanned aircraft, and underground sensors.



"Chilling reading about a new face of war." —*Kirkus Reviews*

By Frank Barnaby

Free Press/Macmillan, 1986,
180 pages, 6¼" x 9½",
hardcover, $18.95

Science News Books
1719 N Street, NW
Washington, DC 20036

Please send ________ copy(ies) of *The Automated Battlefield*. I include a check payable to Science News Books for $18.95 plus $1.00 handling (total $19.95) for each copy. Domestic orders only.

Name________________________

Address______________________

City_________________________

State______________ Zip__________

RB691