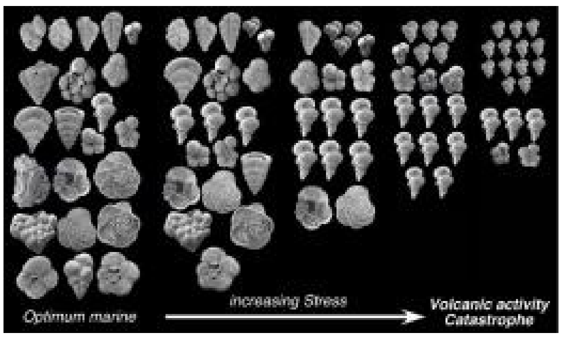
Massive volcanoes, meteorite impacts delivered one-two death punch to dinosaurs: study

November 17 2011, by Morgan Kelly



Princeton University researchers found that massive, prolonged eruptions of the Deccan Traps in India gradually eliminated species and resulted in the Cretaceous-Tertiary mass extinction that killed the dinosaurs 65 million years ago. Marine sediment trapped between Deccan lava flows revealed that a species known as planktonic foraminifera -- widely used to gauge the severity of prehistoric disasters -- succumbed to lava mega-flows and volcano-induced environmental stress such as acid rain and drastic climate changes. As conditions on Earth worsened, large, variedspecies (left) were eliminated. The no more than seven or eight smaller species (right) that remained dwarfed further. Credit: Courtesy of Gerta Keller

(PhysOrg.com) -- A cosmic one-two punch of colossal volcanic eruptions and meteorite strikes likely caused the mass-extinction event at the end of the Cretaceous period that is famous for killing the dinosaurs 65 million years ago, according to two Princeton University reports that reject the prevailing theory that the extinction was caused by a single large meteorite.

Princeton-led researchers found that a trail of dead plankton spanning half a million years provides a timeline that links the mass extinction to large-scale eruptions of the Deccan Traps, a primeval volcanic range in western India that was once three-times larger than France. A second Princeton-based group uncovered traces of a meteorite close to the Deccan Traps that may have been one of a series to strike the Earth around the time of the mass extinction, possibly wiping out the few species that remained after thousands of years of volcanic activity.

Researchers led by Princeton Professor of Geosciences Gerta Keller report this month in the Journal of the Geological Society of India that marine sediments from Deccan lava flows show that the population of a plankton species widely used to gauge the fallout of prehistoric catastrophes plummeted nearly 100 percent in the thousands of years leading up to the mass extinction. This eradication occurred in sync with the largest eruption phase of the Deccan Traps — the second of three — when the volcanoes pumped the atmosphere full of climate-altering carbon dioxide and sulfur dioxide, the researchers report. The less severe third phase of Deccan activity kept the Earth nearly uninhabitable for the next 500,000 years, the researchers report. A substantially weaker first phase occurred roughly 2.5 million years before the second-phase eruptions.

Another group based in Keller's lab found evidence in Indian sediment of a meteorite strike from the time of the mass extinction that would have been sufficient to finish off the few but weakened species that survived the Deccan eruptions, according to a report in the journal Earth and Planetary Science Letters (EPSL) in October. This same sediment -- located in Meghalaya, India, more than 600 miles east of the Deccan Traps -- portrayed the Earth during this period as a harsh environment of acid rain and erratic global temperatures.

Once three-times larger than France, the Deccan Traps were a primeval volcanic range in western India that pumped Earth's atmosphere full of climate-altering carbon dioxide and sulfur dioxide at the end of the Cretaceous period. Princeton researchers analyzed sediment trapped in Deccan lava flows -- the largest flows on Earth -- near Rajahmundry in the Krishna-Godavari Basin, the remnant of an ancient sea on the Bay of Bengal coast. Credit: Courtesy of Gerta Keller

Taken together, Keller said, the Princeton findings could finally put to rest the theory that the mass-extinction event -- known as the Cretaceous-Tertiary, or KT, for the periods it straddles -- was triggered solely by a large meteorite impact near Chicxulub in present-day Mexico. That impact -- which occurred around the time of the second-phase Deccan eruptions -- is thought to have been 2 million times more powerful than a hydrogen bomb and generated an enormous dust cloud and gases that radically altered the climate. Keller has long held that the Chicxulub impact was not catastrophic enough to cause the KT mass extinction -- the newest work from her lab, however, shows that the largest Deccan eruptions were.

"Our work in Meghalaya and the Deccan Traps provides the first one-to-one correlation between the mass extinction and Deccan volcanism," said Keller, who is lead author of the Geological Society paper and second author of the EPSL paper after lead author Brian Gertsch, who earned his Ph.D. from Princeton in 2010. Gertsch is now a postdoctoral researcher at the Massachusetts Institute of Technology.

"We demonstrate a clear cause-and-effect relationship that these massive volcanic eruptions were far more destructive than previously thought and could have caused the KT mass extinction even without the addition of large meteorite impacts," Keller said. "But given the environmental instability caused by the massive Deccan eruptions, an impact could easily have killed off the few survivor species at the end of the Cretaceous. It would have been a double whammy."

Vincent Courtillot, a geophysicist and professor at Paris University Diderot, said that the Princeton papers are based on a closer examination of Deccan volcanism and its aftermath than has been conducted previously. As such, he said, the researchers' "impressive analysis" confirms the timing of the Deccan eruptions and environmental fallout reported in recent years by various research teams, including his own.

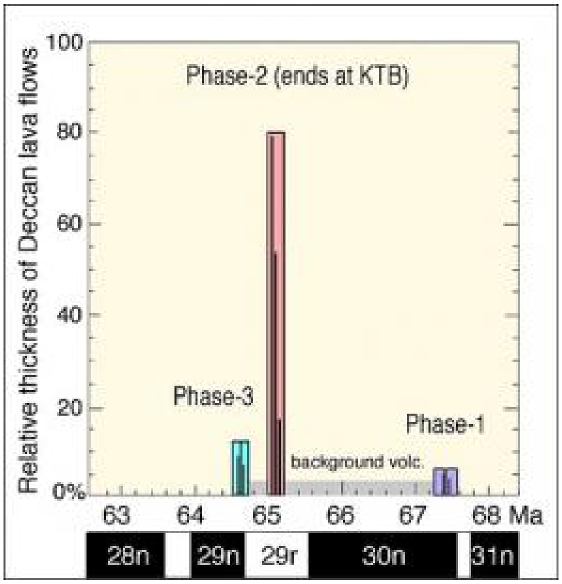
Courtillot, who is familiar with the Princeton work but had no role in it, led the team that reported in the Journal of Geophysical Research in 2009 that Deccan volcanism occurred in three phases, the second and largest of which coincides with the Cretaceous-Tertiary mass extinction; the Keller-led study published in the *Journal of the Geological Society of India* confirms the second and third phases, he said.

"The significance of this recent work is that the analysis was conducted in important sections near the volcanic action, and not thousands of kilometers away as had been the case previously," Courtillot said. "They provide support for the idea that carbon and sulfur dioxide emissions were the principal agents of environmental change and stress, and conclude that the characteristics of the second-phase eruptions were such that it could alone have caused the mass extinction."

In addition, Courtillot said, the approach the teams used could prove valuable to understanding the part volcanoes played in other extinction events in Earth's history. "Exceptional, massive volcanism, I am now quite sure, is the general cause of mass extinctions," he said. "But in order to be considered as proven and quantitatively explained, we need the kind of extensive, detailed work described by these teams to be conducted for all other extinctions."

The case for Deccan over the Chicxulub impact as the cause of the KT extinction

Keller is prominent among scientists who reject the Chicxulub impact's role in the end-Cretaceous mass extinction. She is well known for leading a team of researchers who announced in 2003 that a sediment core from the Chicxulub crater revealed that the impact predated the mass-extinction event by about 300,000 years.



In the past several years, improved dating technology has allowed geologists to identify three distinct phases of Deccan volcanism. The first and weakest began roughly 67.5 million years ago. The second and largest phase accounted for 80 percent of the total volcanism and produced the largest lava flows in Earth's history (represented by vertical black bars). Princeton researchers found that thisactivity wiped out nearly 100 percent of planktonic foraminifera and ultimately initiated the Cretaceous-Tertiary mass-extinction event. They further reported that a less severe third eruption phase occurred roughly 300,000 years after the mass extinction and kept the Earth nearly uninhabitable for another half-million years. Credit: Courtesy of Gerta Keller

Keller and her co-authors published their findings in the journal Proceedings of the National Academy of Sciences in 2004 and suggested that the Chicxulub meteorite was instead one of several meteorite strikes that occurred in the several hundred thousand years leading up to the mass-extinction event. They concluded that while destructive, the Chicxulub impact was not powerful enough to have caused widespread annihilation. Keller and her collaborators have since supported these findings with additional evidence from Texas and northeastern Mexico published in EPSL in 2007 and the Journal of the Geological Society of

London in 2009, respectively.

Keller has joined other scientists in focusing her research on the 30-year-old idea first championed by Virginia Tech geologist Dewey McLean that Deccan volcanism was the root of the Cretaceous mass extinction. Until recently, the theory was in question because the eruptions were thought to have been stretched out over a period of more than 1 million years, leaving plenty of time for the Earth to recover between eruptions, Keller said.

Improved dating technology, however, allowed scientists -- particularly the team led by Courtillot -- to narrow the time of the largest eruptions to a few hundred thousand years at the end of the Cretaceous. Known as Deccan phase-2, this period accounted for 80 percent of the total volcanism. The first and weakest phase of activity occurred about 67.5 million years ago; the third and final eruption phase began about 300,000 years after the KT mass extinction.

In 2008, Keller and her team reported in EPSL the first direct link that the KT extinction coincided with the end of the second phase of Deccan eruptions. She explained that marine sediments preserved between lava flows from the second- and third-phase eruptions contained evidence of the KT boundary, a thin, worldwide geological layer that marks the mass-extinction event.

Deccan volcanism behind the mass extinction, so say the plankton

The work published Nov. 1 by the Geological Society of India builds on Keller's 2008 paper in EPSL. She and her co-authors examined cores from Deccan lava flows near Rajahmundry in the Krishna-Godavari Basin, the remnant of an ancient sea on the Bay of Bengal coast, and found that lava flows from the second and third Deccan phases are separated by marine sediments.

Keller worked with P.K. Bhowmick, H. Upadhyay, A. Dave, A.N. Reddy and B.C. Jaiprakash, scientists with India's government-operated Oil and Natural Gas Corporation, which owns the sediment cores. Also included is Thierry Adatte, a geologist with the University of Lausanne in Switzerland, who is Keller's long-time collaborator and a co-author on the papers challenging the time of the Chicxulub impact, as well as previous papers on Deccan volcanism.

The team examined the basin's sediment layers to determine the size and number of a species known as planktonic foraminifera that remained following each eruption phase. These plankton are single-celled micro-organisms ranging in size from the point of a needle to a pinhead that are highly sensitive to changes in oxygen, salinity, temperature and nutrients, Keller said. Their sensitivity to environmental changes and their near extinction at the end of the Cretaceous makes the species key to determining the timespan, pace and severity of the mass extinction.

After studying microplankton remains in sediment from below, between and above the second-phase lava flows, the researchers observed that the number of living species dropped 50 percent at the onset of eruptions. The species count plunged by another 50 percent after the first of what would be four lava mega-flows. No more than seven to eight of the species that were most tolerant to environmental changes survived after the first mega-flow, and no recovery occurred between subsequent mega-flows. By the end of the fourth mega-flow the mass extinction was complete, the researchers wrote.

The Deccan Traps near Mahabaleshwar, India. (Image courtesy of Gerta Keller)

The vast amounts of carbon dioxide and sulfur dioxide poured into the atmosphere by the end of the second volcanic phase -- estimated to be 30-times more than the levels produced by the Chicxulub impact -- resulted in, among other crises, heavy acid rain, acidic oceans and global temperatures that swung between scorching and frigid, the researchers report. The third eruption phase prolonged these conditions.

Thus, the number of species evolving remained low, and existing species dwarfed during the 500,000-year period after the mass extinction, although no significant extinctions occurred again, Keller and her co-authors found. New, larger marine species did not appear until after the third phase when Deccan eruptions went dormant, suggesting that life began to recover as the atmosphere became less poisonous.

"In my work, I had always observed evidence of marked changes in species abundance with gradually higher levels of stress and extinction during the last several hundred thousand years, rather than one single instantaneous annihilation," Keller said. "For lack of better evidence, scientists had interpreted this steady decline as the result of climate and sea-level changes."

Evidence that a large meteorite helped finish the job

For the paper published Oct. 15 in *EPSL*, Keller and her co-authors provide a supporting and more nuanced depiction of conditions during the Deccan period. They examined sediments from an ancient shallow sea in Meghalaya where rock layers are known to contain among the clearest fossil records of the Cretaceous-Tertiary mass extinction, Keller said. She worked with lead author Gertsch; the geologist Adatte; Rahul Garg and Vandana Prasad from the Birbal Sahni Institute of Palaeobotany in India; Zolt Berner from the Karlsruhe Institute of Technology in Germany; and Dominik Fleitmann at the University of Bern in Switzerland.

Analysis of the Meghalaya sediment revealed an inhospitable planet rife with high humidity, severe storms and massive blooms of the plankton species Guembelitria cretacea, a disaster opportunist that flourished in devastated environments when few other species survived.

At the same time, the team detected large amounts of iridium, an element typically associated with meteorite impacts, Keller said. Iridium is rare on Earth yet is found in high concentrations in the KT boundary, a phenomenon known as the iridium anomaly. Remnants of iridium at the KT boundary in Meghalaya coincide with the global KT boundary iridium anomaly, she said.

The new evidence of a meteorite strike at Meghalaya that coincides with the KT mass extinction supports the theory Keller proffered in 2003 that multiple meteorites struck the Earth around the time of the Deccan eruptions, adding to the volcano-fueled misery of the mass-extinction era.

"Our data suggest that the mass extinction of the dinosaurs and other species was caused by the harsh conditions resulting from massive

Deccan eruptions and the coincidence of multiple meteorites," Keller said. "In light of this new evidence, the single-impact story seems more like an article of faith at this point."

Provided by Princeton University

Citation: Massive volcanoes, meteorite impacts delivered one-two death punch to dinosaurs: study (2011, November 17) retrieved 18 April 2024 from https://phys.org/news/2011-11-massive-volcanoes-meteorite-impacts-one-two.html