How the darkness and the cold killed the dinosaurs

January 16 2017

Tyrannosaurus Rex "Tristan", on display at the Museum für Naturkunde - Leibniz Institute for Evolution and Biodiversity Science in Berlin with which PIK is cooperating. Credit: Carola Radke/Museum für Naturkunde

66 million years ago, the sudden extinction of the dinosaurs started the ascent of the mammals, ultimately resulting in humankind's reign on Earth. Climate scientists have now reconstructed how tiny droplets of

sulfuric acid formed high up in the air after the well-known impact of a large asteroid, which blocked the sunlight for several years, and had a profound influence on life. Plants died, and death cascaded through the food web. Previous theories focused on the shorter-lived dust ejected by the impact. New computer simulations show that the droplets resulted in long-lasting cooling, a likely contributor to the death of land-living dinosaurs. An additional kill mechanism might have been a vigorous mixing of the oceans caused by the surface cooling, severely disturbing marine ecosystems.

"The big chill following the impact of the asteroid that formed the Chicxulub crater in Mexico is a turning point in Earth history," says Julia Brugger from the Potsdam Institute for Climate Impact Research (PIK), lead author of the study to be published today in *Geophysical Research Letters*. "We can now contribute new insights for understanding the much-debated ultimate cause for the demise of the dinosaurs at the end of the Cretaceous era."

To investigate the phenomenon, the scientists for the first time used a specific kind of computer simulation normally applied in other contexts, a climate model combining atmosphere, ocean and sea ice. They build on research showing that sulfur-bearing gases that evaporated from the violent asteroid impact on the planet's surface were the main factor for blocking the sunlight and cooling down Earth.

"It became cold. I mean, really cold," says Brugger. Global annual mean surface air temperature dropped by at least 26 degrees Celsius. The dinosaurs were used to living in a lush climate. After the asteroid's impact, the annual average temperature was below freezing for about three years. Evidently, the ice caps expanded. Even in the tropics, annual mean temperatures went from 27 degrees to a mere five degrees. "The long-term cooling caused by the sulfate aerosols was much more important for the mass extinction than the dust that stayed in the atmosphere for only a relatively short time. It was also more important than local events like the extreme heat close to the impact, wildfires or tsunamis," says co-author Georg Feulner who leads the research team at PIK. It took the climate about 30 years to recover, the scientists found.

Additionally, ocean circulation became disturbed. Surface waters cooled down, thereby becoming denser and thus heavier. While these cooler water masses sank into the depths, warmer water from deeper ocean layers rose to the surface, carrying nutrients that likely led to massive blooms of algae, the scientists argue. It is conceivable that these algal blooms produced toxic substances, further affecting life at the coasts. Yet in any case, marine ecosystems were severely altered, and this likely contributed to the extinction of species in the oceans, including the ammonites.

The dinosaurs, until then the masters of the Earth, made space for the rise of the mammals, and eventually humankind. The study of Earth's past also shows that efforts to study future threats by asteroids are of more than just academic interest. "It is fascinating to see how evolution is partly driven by accidents like an asteroid's impact—mass extinctions show that life on Earth is vulnerable," says Feulner. "It also illustrates how important the climate is for all lifeforms on our planet. Ironically, today, the most immediate threat is not from natural cooling but from human-made global warming."

More information: Julia Brugger et al, Baby, it's cold outside: Climate model simulations of the effects of the asteroid impact at the end of the Cretaceous, *Geophysical Research Letters* (2016). DOI: 10.1002/2016GL072241

Provided by Potsdam Institute for Climate Impact Research