Science You Can Use

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Dear Science: Was the demise of the dinosaurs caused by an asteroid colliding with the Earth? -- Buck R.

Dear Buck: According to the "an-asteroid-destroyed-the-dinosaurs" story, about 66 million years ago a rock about 6 miles in diameter roared out space at about 30 miles per second and smashed into a shallow sea near what is now Chicxulub on the Yucatan Peninsula in Mexico. The impact hurled millions of tons of molten rock and vapor into the atmosphere, briefly creating a crater nearly 60 miles in diameter and 12 miles deep. Ejecta from the collision ignited massive fires across the planet. The largest land animals, including the dinosaurs of the time, were destroyed. Some variant of this story is standard fare in scores of scientific papers.

But is the story correct? The short answer is "maybe". For the longer answer, let's look at some arguments for the story, then consider some problems with those arguments. In the following, I will use "ADD" to stand for "an asteroid destroyed the dinosaurs".

Arguments for ADD

The iridium layer. In the geological record worldwide, there is a sharp boundary between the layers of rock that contain dinosaur fossils, and the layers above that boundary, none of which contain dinosaur fossils. This boundary is variously called the "K-T", "Cretaceous-Tertiary", "KPg ", or "Cretaceous-Paleogene", boundary. The boundary can be dated by geological means to about 66 million years before present.

In tens of locations throughout the world, there is thin layer at the Cretaceous-Paleogene boundary that contains a significantly higher concentration of the element iridium than is found elsewhere in the Earth's crust. Proponents of the ADD hypothesis note that stony meteorites contain a much higher concentration of iridium than is found in the Earth's crust, and many if not most stony meteorites are thought to have been created when the asteroids were formed, or are remnants of the asteroids. Thus, the argument goes, the iridium in the Cretaceous-Paleogene boundary layer likely came from a collision with an asteroid.

The crater. Underwater, near Chicxulub in the present-day Yucatan Peninsula in Mexico, is a large impact crater. Ejecta that can be dated to about 66 million years ago has been found in the Yucatan and elsewhere.

Global fires. In many locations worldwide, there is evidence of massive widespread fires at the Cretaceous-Paleogene boundary. Computer simulations suggest that an impactor large enough to have created the Chicxulub crater could have caused global fires that rendered the Earth uninhabitable for dinosaurs for thousands of years.

Some problems with the ADD hypothesis

Timing. In order for the ADD hypothesis to be correct, the asteroid of interest had to impact the Earth *before* the dinosaur extinction began, because an effect can't come before its cause. The best dating of the Chicxulub impact has an uncertainty of about 50,000 years. The best dating of the extinction of the dinosaurs has an uncertainty of about 100,000 years. Given these uncertainties, it's not possible to determine whether the Chicxulub impact occurred *before* the extinction.

Asteroid size. In order for the Chicxulub asteroid to have been the source of the iridium layer at the Cretaceous-Paleogene boundary, the asteroid must be large enough to contain the mass of iridium estimated to be in the iridium layer. Computer simulations show that the Chicxulub crater could have been caused by an asteroid that had only 10% of the mass typically assumed for the Chicxulub asteroid. Such an asteroid could account for only about 10% of the estimated mass of iridium in the Cretaceous-Paleogene boundary layer. (It's possible, of course, that about 10 asteroids, each with mass about 10% of that typically assumed for the Chicxulub asteroid, and each containing about 10% iridium, struck the Earth at about the same time. But we have not discovered any other Chicxulub-sized craters of the right age.)

Other contributors. A worldwide mass extinction was likely already in progress prior to the asteroid impact. If we look carefully in the fossil record at the distribution of mollusc genera, we notice that at about 70 million years ago – 4 million years before Chicxulub – 90% of mollusc genera disappeared in about 100,000 years. It is highly unlikely that whatever caused this die-out was limited to molluscs; more likely, the die-out reflects some planet-wide phenomenon, such as a change in the Earth's surface temperature of a few degrees for a few years. Most vegetation on Earth today would not survive a temperature change of more than about 10 degrees Celsius over 100 years, and vegetation is the ultimate source of nutrition and much of the oxygen for land-dwelling creatures. Thus, even a 100-year change of only a few degrees – much less than the ADD hypothesis requires -- would have made life for the dinosaurs (and most other creatures) impossible.

In short, the Chicxulub asteroid impact was real. Beyond doubt the dinosaurs disappeared quickly. But whether the Chicxulub asteroid alone annihilated the dinosaurs is far more difficult to determine.

For more information, see Peter Schulte et al. , "The Chicxulub asteroid impact and mass extinction at the Cretaceous-Paleogene boundary", *Science* 327 (5 March 2010), pages 1214-1218.

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