Asteroids and dinosaurs: Unexpected twists and an unfinished story

Doing science can be quite an adventure! Sometimes trying to find an "answer" to a question or problem takes one on a twisted and unexpected journey. Walter Alvarez would agree. What began as a study of plate tectonics led him to pursue one of the greatest questions in paleontology—What caused the extinction of dinosaurs 65 million years ago?

Alvarez was in Italy with other scientists looking for patterns in layers of rocks to learn more about Earth's history. He observed an odd pattern. There was a clear layer of clay that was dated to be 65 million years old—the boundary between the Cretaceous and Tertiary time periods (called the KT boundary for short). Below the clay layer, there were lots of microscopic marine fossils but above it there were hardly any. He wondered: What happened to cause so much marine life to go extinct at that time? *And*, was their extinction related to the dinosaur extinction that also occurred then?

The first thing Alvarez wanted to know was whether the clay layer formed quickly or over a long period of time. If he knew this, he would know how quickly the marine life disappeared. But how could he measure this? He asked his father Luis Alvarez, who was a physicist, for help.

His dad suggested looking at the chemical elements in the layer. Some elements make their way into rock layers at a slow, but constant rate. By measuring the amount of one of these "timer" elements, they might be able to figure out whether the clay layer formed quickly or slowly. First, Luis suggested using an element called beryllium-10. But that was a dead end. Instead, he suggested using an element called iridium. Iridium is rare on Earth but common in meteors. Meteor dust containing iridium "rains down" on the Earth's surface all the time. Walter and Luis reasoned that since meteorite dust and hence, iridium, rain down upon Earth at a fairly constant rate, the amount of iridium in the clay would indicate how long it took for the layer to be deposited. A high amount of iridium would imply a slower deposition, and less iridium would imply rapid deposition and a sudden KT transition. Other scientists, Helen Michel and Frank Asaro, helped them test for iridium in the layer. Their results were a complete surprise! Not only did they find iridium, but they found more than 30 times the amount they expected. This finding made them ask all sorts of new questions. First, they wanted to know if the large amount of iridium (called a "spike") was found only in Italy, or in other parts of the world too.

Alvarez read many scientific articles to find another location where they could test KT rock layers for iridium. He eventually found one in Denmark and asked a colleague to check it for the element. The results were positive—the spike in iridium was there too. So, whatever happened at the end of the Cretaceous must have been widespread, occurring all over the Earth. This led to another new question: What caused these high iridium levels?

Ten years earlier, two other scientists came up with the idea that a supernova (an exploding star) caused the extinction of dinosaurs. Since iridium is produced by supernovas, Alvarez's discovery supported this hypothesis. But they needed to test their idea further by looking for other elements produced by supernovas, such as plutonium-244. Alvarez's team searched for plutonium in the clay layer and found it! They thought they had more evidence to support the supernova idea. But after double-checking their results, they realized the sample had been contaminated. No plutonium existed in the clay. As a result, they had to reject this hypothesis. Now they had to figure out a new explanation. What could have caused lots of iridium, but no plutonium?

They came up with the idea of an asteroid impact. Asteroids have lots of iridium but no plutonium. Perhaps an asteroid hit the earth during this time. This hypothesis led to a new question: How could an asteroid impact have caused the extinction of dinosaurs and life in the ocean?

To investigate this question, they shared ideas with other colleagues. Eventually, Luis Alvarez figured out that a really large asteroid hitting Earth could have blown millions of tons of dust into the atmosphere. According to his calculations, this amount of dust would have blocked out the sun around the world, stopping photosynthesis and plant growth. This would have caused a worldwide collapse of food webs, and therefore many animals would go extinct.

In 1980, Alvarez's team published their hypothesis linking the iridium spike and the dinosaur extinction. This caused a huge debate and more exploration. Over the next ten years, more than 2,000 scientific papers were published on the topic. Scientists in the fields of paleontology, geology, chemistry, astronomy, and physics joined the argument, bringing new evidence and new ideas to the table. Many different scientists studied many kinds of evidence to test hypotheses about this ancient event. Their tests included:

1) **Extinctions**: If an asteroid impact had caused a worldwide environmental disaster, many groups of plants and animals would not have survived. Therefore, if the asteroid hypothesis were correct, we would expect to find a large increase in the number of extinctions at the KT boundary. We do.
2) **The impact**: If a huge asteroid struck Earth at the end of the Cretaceous, it would have flung off particles from the site where it hit. So, if the asteroid hypothesis were correct, we should find these particles in the KT boundary layer. We do.
3) **Glass**: If a huge asteroid struck Earth at the end of the Cretaceous, it would have caused a lot of heat, melting rock into glass, and flinging glass particles away from the impact site. So, if the asteroid hypothesis were correct, we would expect to find glass at the KT boundary. We do.
4) **Shockwaves**: If a huge asteroid struck Earth at the end of the Cretaceous, it would have caused powerful shockwaves. So, if the asteroid hypothesis is correct, we would expect to find evidence of these shockwaves (like deformed quartz). We do.
5) **Tsunamis**: If a huge asteroid struck one of Earth's oceans at the end of the Cretaceous, it would have caused tsunamis, which would have moved ocean sediments around and deposited them somewhere else. So, if the asteroid hypothesis were correct, we would expect to see signs of these deposits at the KT boundary. We do.
6) **The crater**: If a huge asteroid struck Earth at the end of the Cretaceous, it would have left behind a huge crater. So, if the asteroid hypothesis were correct, we would expect to find a gigantic crater somewhere on Earth dating to the end of the Cretaceous. We do—the Chicxulub crater on the Yucatan peninsula.

Scientists agreed that the evidence was strong—dinosaurs had gone extinct and there was a giant asteroid impact at the end of the Cretaceous. However, scientists did not all agree that the evidence suggested there was a connection between the two.

Scientific ideas are always open to question and to new lines of evidence, so although many observations support the asteroid hypothesis, the investigation continues. The evidence shows that the end of the Cretaceous was a chaotic time on Earth. We have found evidence of massive volcanic eruptions that covered about 200,000 square miles of India with lava. We have found evidence of changes in climate: cooling trends and at least one period of global warming. We have also found evidence that sea levels were changing and continents were moving around. With all this change going on—including a giant asteroid impact—ecosystems were surely disrupted. These factors could certainly have played a role in triggering the mass extinction—but did they? Scientists are still studying these, and many more, questions.