Asteroids and dinosaurs: Unexpected twists and an unfinished story

Walter Alvarez, an American geologist, was working with other scientists to look for certain rock patterns that would help to explain part of Earth's history. He examined rocks of the mountains in Italy. As he explored, he kept finding an unusual layer of clay that marked the 65-million-year-old boundary between the Cretaceous and Tertiary periods (referred to as the KT boundary). He noticed that there were many different sorts of marine fossils below the layer of clay, but few above. He questioned: Why the reduction in marine fossils? What had caused this apparent extinction of many types of marine life that seemed to happen so suddenly? *And*, could it be related to the extinction of dinosaurs that occurred at the same time on land?

Alvarez wanted to know how long it took for the mysterious clay layer to be deposited because then he would know how quickly the marine life disappeared. He discussed the question with his father, the physicist Luis Alvarez, who suggested using a chemical element called beryllium-10. Like some other substances, beryllium-10 can act as a timer because it is laid down in rocks at a constant rate. The more beryllium in the clay layer, the longer it must have taken for the layer to be deposited. Unfortunately, this investigation was a dead end. Luis suggested trying another element which acts as a timer: iridium. Iridium is often found in meteorites, and meteorite dust "rains down" on Earth's surface at a slow but constant rate.

The father-son team recruited scientists Helen Michel and Frank Asaro to help them look for iridium in the clay layer. Their results were a complete surprise! The team found more than 30 times the amount of iridium that regular meteorite dust might have caused. What could have caused this spike in iridium? Did the iridium spike occur in rock layers around the world? Now Alvarez and his team had even more questions.

Alvarez began digging through published studies to find the location of other KT boundary rock layers that might have the iridium spike. He eventually found one in Denmark and asked a colleague to check. The results were positive—the big spike in iridium was there too. So, whatever happened at the end of the Cretaceous must have been widespread. Now, another new question: What could have happened to cause these sky-high iridium levels?

It turned out that almost ten years earlier, two other scientists had proposed the idea that a supernova (an exploding star) at the end of the Cretaceous had caused the extinction of dinosaurs. Since supernovas throw off heavy elements like iridium, the Alvarez discovery seemed to support this hypothesis. To further test the supernova hypothesis, the team needed other lines of evidence. Alvarez realized that if a supernova had occurred, they should find other heavy elements, like plutonium-244, at the KT boundary. At first, the team thought they had found the plutonium! It looked like a supernova had occurred—but after double-checking their results, they found that the sample they used had been contaminated. There was no plutonium in the sample after all—and no evidence for a supernova.

So what could explain these different observations (plenty of iridium, but no plutonium) and tie them together so that they made sense? The team came up with the idea of an asteroid impact. That would explain the iridium because asteroids contain a lot of iridium but no plutonium-244. The hypothesis made sense, but also led to a new question: How could an asteroid impact have caused the dinosaur extinction?

After talking with colleagues, Luis Alvarez suggested that a really large asteroid striking Earth would have blown millions of tons of dust into the atmosphere. According to his calculations, this amount of dust would have blotted 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 for other scientists to consider. 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.

Alvarez's team was trying to learn about an event that happened 65 million years ago—when no one was around to see what happened. Many different scientists studied many lines of evidence to help test hypotheses about this ancient event. They studied:

- **Extinctions**: If an asteroid impact had actually 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.
- **The impact**: If a huge asteroid had 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 at the impact site in the KT boundary layer. We do.
- **Glass**: If a huge asteroid had 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.
- **Shockwaves**: If a huge asteroid had 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.
- **Tsunamis**: If a huge asteroid had 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.
- **The crater**: If a huge asteroid had 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 widespread iridium spike at the KT boundary. However, scientists did not all agree that the evidence supported 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 end of the Cretaceous seems to have been 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: a general cooling trend and at least one intense 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, 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.