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Dimitrik Johnson
Germanna Community College

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Germanna Community College

Abstract

The K-Pg extinction (or K-T extinction), more commonly referred to as the extinction of the dinosaurs, is the most recent mass extinction event in Earth's history. The causes of the event have been widely debated, with the two main theories being a large asteroid impact or volcanism. While some scientists disagree, the most popular and agreed upon theory is that a large asteroid impacted Earth 65 million years ago, creating a toxic dust cloud that filled the atmosphere, and resulted in the eventual extinction of most of the dinosaurs. This theory was first brought to life by Luis Alvarez, his son Walter, and their team based on their findings of large spikes of the rare element iridium in different locations around the world at the K-Pg boundary (formerly known as the K-T boundary). Volcanism, specifically Deccan volcanism, was formerly the most popular theory for what caused the mass extinction event before Alvarez published his findings on the impact theory in 1980. It has since been surpassed because of recent discoveries such as, the Chicxulub crater, the evidence found within the layers of sediment at the K-Pg boundary, and the re-analysis of evidence conducted by a group of experts in 2010.

Keywords: extinction, impact theory, Deccan volcanism, dinosaur extinction

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There have been five major mass extinctions in Earth's history, but none of them are more talked about than the K-T (Cretaceous-Tertiary) extinction. Also known as the extinction of the dinosaurs, the event happened 65 million years ago at the end of the Cretaceous period and beginning of the formerly named Tertiary period, now renamed the Paleogene period (Lydon, 2016, para. 2). Because of this, it is now often referred to as the K-Pg extinction. While the events "claim to fame" is the extinction of the dinosaurs, not much is ever made of the massive loss of plant life that was suffered, especially planktic foraminifera, which suffered the biggest loss of life compared to any other organism (Keller, Sahni, & Bajpai, 2009, p. 724). Over time, scientists have had many different theories about what caused the extinction event but the main two are a large asteroid impact and volcanism. To this day the most accepted theory is that of the asteroid impact, but it is still debated by many.

Impact Theory

The well-known and widely agreed upon theory is that a large asteroid crashed into the earth and put in motion the chain of events that caused the mass extinction. This conclusion was birthed when Nobel prize winner Luis Alvarez, his son Walter, and some coworkers discovered a large amount of iridium at the K-Pg boundary (formerly known as the K-T boundary) in Gubbio, Italy, in 1977 (Yarris, 2010, para. 3). This was a significant find because the element iridium is rarely found on Earth's surface, and the small amount that is on the surface came from asteroids (Benton, 2011, para. 21). After the iridium was found in Italy, they found similar spikes of the element in Denmark and New Zealand, which led to Alvarez's team coming up with the theory of a massive asteroid impact (Alvarez, Alvarez, Asaro, & Michel, 1980). But, something that is not usually mentioned when speaking about the extinction of the dinosaurs is that the main theory is that the impact itself did not cause the extinction; the lasting effects the impact had on the environment did. The team concluded that the asteroid impact would have created a massive cloud of dust that engulfed the earth, blocked out the sun, and prevented photosynthesis, ensuring death for plants and the many organisms that relied on plant life to survive (Benton, 2011, para. 23). After years of research, we now know that his theory was very accurate.

Impact Theory: Evidence For and Against

The place where the asteroid landed, Chicxulub (chick-shoo-loob) crater, was discovered in the 1940s (Urrutia-Fucugauchi, & Perez-Cruz, 2008, p. 248) but was not associated with the extinction event until 1991 (Yarris, 2010, para. 8) when it had been further investigated and dated. The 10-kilometer wide asteroid ("Experts Reaffirm," 2010, para. 15) touched down in modern day Mexico and created the crater, which is about 180-200 kilometers in diameter (Urrutia-Fucugauchi et al., 2008, p. 248). They know that this is the crater from the asteroid that caused the extinction because at the K-Pg boundary, the layers of sediment are thick and full of material ejected from the crash, but as you get further away from the site, the layers begin getting thinner and there is a decrease in the material until there is only one thin layer that is seen globally that perfectly coincides with the time of the extinction ("Experts Reaffirm," 2010, para. 9). This, along with the discovery of the Chicxulub crater, is solid evidence that proves the impact theory to be correct.

Even after the revelation that the Chicxulub crater was the impact site of the asteroid, it was still not enough to convince some scientists that volcanic eruptions did not kill the dinosaurs, but for good reason. At the time, Alvarez's theory still had holes in it that had not yet been explained. For example, many articles point out the fact that when the Chicxulub impact zone was drilled into, the evidence they discovered showed that the impact occurred 300,000 years before the K-Pg boundary extinction, so it could not have been the cause of the event (Keller, Adatte, Stinnesbeck, Stuben, Berner, Kramar, & Harting, 2004). This find is so important because it is one of the main arguments used against the impact theory. However, in a 2010 study conducted by a panel of experts, they refuted that claim by explaining how the area around the impact site is unreliable because the sheer force of the asteroid impacting the Earth would have created a complex and disturbed layer of sediments compared to areas further away from the impact zone ("Experts Reaffirm," 2010, para. 7). Because of all the force the asteroid hit the earth with, the impact site is the most damaged area that could be studied. That fact does not completely invalidate the findings, but it provides a very good explanation for them.

Deccan Volcanism

Before the impact theory was introduced, the popular theory was volcanism, specifically Deccan volcanism. Deccan volcanism is the term used to describe the massive eruptions of the Deccan traps that covered India in lava 65 million years ago, with some eruptions spreading over 1,000 kilometers across India, according to Keller et al. (2009, p. 709). Keller, who is Professor of Paleontology and Geology at Princeton University, is a huge advocate for the theory of volcanism. She and her team state that studies have shown that there were three short phases of eruptions (p. 715). Phase one was very small, happened around 67.4 to 67.5 million years ago, and only lasted about 10 thousand years (p. 715). Phase two was much larger than phase one and phase three; it was about 80% of the full volume of Deccan traps eruptions (p. 715). The lasting time of phase two is unknown, but it ended either at or very close to the extinction event (p. 715). It is considered to be the main phase because of the amount of damage it caused. Phase three, much like phase one, was small, being less than 20% of the total volume of eruptions and occurred around 270 thousand years after the K-Pg boundary (p. 715). The theory is that when these eruptions occurred, mainly the first two, they would have initiated environment changes such as acidic rain, decreased pH levels in the water, depletion of the ozone, and global temperature changes that over a long period of time, would have caused a large portion of the life on Earth to die out (Tsujita, 2001, p. 279).

Deccan Volcanism: Evidence For and Against

The timing of the Deccan trap eruptions is one of the main cases made in defending the volcanism theory. The eruption of the traps was right around the time of the K-Pg extinction, and researchers at the University of California, Berkely insist that that is not a coincidence (Sanders, 2015, para. 3). Mark Richards, Professor of Earth and Planetary Science at UC Berkely stated:

> If you try to explain why the largest impact we know of in the last billion years happened within 100,000 years of these massive lava flows at Deccan … the chances of that occurring at random are minuscule […] It’s not a very credible coincidence (as cited in Sanders, 2015, para. 3).

This is a strong defense in favor of volcanism; it is highly unlikely that the two events are completely coincidental. Many authors and scientists agree with this idea including Keller et al. (2009) who believe the volcanism theory is overlooked because of the popularity of the impact theory and the lack of evidence directly linking the mass extinction to Deccan volcanism (p. 709). One reason that some people have believed in the volcanism theory is that it answers some questions about the extinction that they think the impact theory cannot. For example, Cameron Tsujita (2001), author and paleontology professor, states that one problem that has been a point of contention is the amounts of iridium found around the famous spike at the K-Pg boundary (p. 280). In his article, he speaks on behalf of both sides of the argument. He details that volcanism defenders have said that the vertical spread of the iridium tells us how long the activity of the Deccan traps lasted, therefore eliminating the need to suggest the impact event was the cause (p. 280). Conversely, for the impact theory, he states that scientists believe the lava from the eruptions of the Deccan traps would not have been able to produce the amount of iridium that is found around the large spike at the K-Pg boundary (p. 280). This statement completely negates the argument of the volcanism defenders, and if it is true, it also disproves it.

The main reason that the theory of volcanism is not as accepted as the impact theory is that there are quite a few things that it cannot explain. Later in Tsujita's (2001) article, he explains that the volcanic hypothesis cannot explain the instant (in geologic time) extinctions that occurred at the K-Pg boundary (p. 280), but Keller et al. (2009) declares that no species' extinctions can be directly linked to the Chicxulub impact (p. 714). They state that this is true because when the effects the impact had on the environment were studied along the impact spherule layer, which is a layer that holds material after it is scattered from an asteroid impact, there were no outstanding changes in the frequency of any species appearances (p. 714). These differing opinions indicate incorrect evidence on one side, because both cannot be true. In the aforementioned re-analysis of evidence by a group of experts in 2010, it was discovered that while there was evidence of volcanic activity in India, there were no signs of the extinction period lasting for a long time as the Deccan volcanism hypothesis suggests ("Experts Reaffirm," 2010, para. 10). They know this because there were no significant changes found in any ecosystems in the 500,000 years before the K-Pg boundary (para. 10). The scientists also found that, at the K-Pg boundary, there was suddenly a major decrease in the amount of living things (para. 10), which was evidence of the asteroid suddenly striking the earth. Another factor in the volcanism hypothesis, much like the proposed effects of the impact, involves a release of gasses into the atmosphere that would have deadly environmental effects, but the experts also proved that that could not have happened. While large amounts of sulfur were released by the volcanic eruptions into the stratosphere, they would not have had the lasting effect to cause any significant damage (para. 11). On the other hand, the impact from the asteroid would have produced much larger amounts of sulfur and dust in a shorter time that lead to the world-wide dust cloud (para. 11). All of those discoveries led the experts to determine that the cause of the K-Pg extinction could not have been volcanism, and instead had to be the asteroid impact.

Conclusion

The debate between the impact and volcanism theories is a perfect example of people sometimes not letting go of past ideas. Most of the evidence points toward the impact theory being correct, with more and more evidence being found to further prove it. When Alvarez published his findings in 1980, he faced backlash from some scientists because they were very used to the idea that the K-Pg extinction was caused by volcanism (Yarris, 2010, para. 8). This is interesting because even after 38 years, some people are still unwilling to let go, even though they no longer have much of a leg to stand on.

References

Alvarez, L. W., Alvarez, W., Asaro, F., & Michel, H. V. (1980). Extraterrestrial cause for the Cretaceous-Tertiary extinction. *Science, 208*(4448), 1095-1108. doi:10.1126/science.208.4448.1095

Benton, M. J. (2011). Mass extinctions. *New Scientist, 209*(2802). Retrieved from *Academic Search Complete*

Experts Reaffirm Asteroid Impact Caused Mass Extinction. (2010). *UT News.* Retrieved from https://news.utexas.edu/2010/03/04/experts-reaffirm-asteroid-impact-caused-mass-extinction

Keller, G., Adatte, T., Stinnesbeck, W., Stuben, D., Berner, Z., Kramar, U., & Harting, M. (2004). More evidence that the Chicxulub impact predates the K-T mass extinction. *Meteoritics & Planetary Science, 39*(7), 1127-1144. doi:10.1111/j.1945-5100.2004.tb01133.x

Keller, G., Sahni. A., & Bajpai, S. (2009). Deccan volcanism, the KT mass extinction and dinosaurs. *J. Biosci, 34*(5), 709-728. Retrieved from *Academic Search Complete*

Lydon, S. (2016). Why dinosaur extinction is only half the story of the killer asteroid's impact. *The Guardian*. Retrieved from https://www.theguardian.com/science/2016/may/25/dinosaur-extinction-only-half-the-story-of-killer-asteroids-impact-plant-fossil

Sanders, R. (2015). Did dinosaur-killing asteroid trigger largest lava flows on Earth? *Berkely News*. Retrieved from http://news.berkeley.edu/2015/04/30/did-dinosaur-killing-asteroid-trigger-largest-lava-flows-on-earth/

Tsujita, C. J. (2001). The significance of multiple causes and coincidence in the geological record: from clam clusters to Cretaceous catastrophe. *Canadian Journal of Earth Sciences, 38*(2), 271-292. Retrieved from *Academic Search Complete*

Urrutia-Fucugauchi, J., & Perez-Cruz, L. (2008). Post-impact carbonate deposition in the Chicxulub impact crater region, Yucatan Platform, Mexico. *Current Science, 95*(2), 248-252. Retrieved from *Academic Search Complete*

Yarris, L. (2010). Alvarez theory on dinosaur die-out upheld: experts find asteroid guilty of killing the dinosaurs. *Berkely Lab*. Retrieved from http://newscenter.lbl.gov/2010/03/09/alvarez-theory-on-dinosaur/