

## Mass Extinctions, Climate Change and Meteorite Impacts on Earth

There have been several mass extinctions throughout geologic time on Earth. Many have been regional, and a few have been global in scope. The “Big Five” global extinction events are shown below:

Geologic Period	Time – Millions of years ago	Percent of extinct genera	Primary Victims
End of Ordovician	440	57	Marine Invertebrates
Late Devonian	365	50	Marine Invertebrates Plankton (Trilobites) Primitive Fish
End of Permian	250	83	Marine Invertebrates Mammal-like reptiles
End of Triassic	210	48	Marine Invertebrates Mammal-like reptiles Large amphibians
Cretaceous – Tertiary (K-T)	65	50	Marine Invertebrates Dinosaurs Plankton Marine reptiles

What caused these mass extinctions?

According to the BBC Mass Extinction web site (<http://www.bbc.co.uk/education/darwin/exfiles/permian.htm>) the following information is noted:

**The Late Cambrian Extinction Event:** The cause(s) of the late Cambrian extinction are not well known, but it seems almost certain that a change in sea

level occurred at this time, changing the habitat to which many of these early animals were adapted, and driving them to extinction.

**The Late Devonian Extinction Event:** Although it is clear that there was a massive loss of biodiversity towards the end of the Devonian Period, it is not clear over how long a period these extinctions took place, with estimates varying from 500 thousand to 15 million years. Neither is it clear whether it was a single mass extinction or a series of several smaller extinctions one after the other. Indeed it has been written that the late Devonian extinction is one in which not even the major facts are agreed on yet. However, the balance of evidence suggests that the extinctions took place over a period of some 3 million years, about 365 million years ago. As many as 70% of all species vanished from the Earth during the late Devonian extinction. Marine species were more severely affected than those in freshwater - Brachiopods, ammonites and many other invertebrate groups suffered heavily, as did Agnathan and Placoderm fish. On land, where plants were diversifying and amphibians were beginning their evolution, there seem to be have been far fewer losses. The causes of the Devonian extinction(s) are far from clear. the disproportionate losses amongst warm water species suggest that climate change, in this case a global cooling, was an important factor and it has been suggested that this was associated with (or may even have caused) a drop in the oxygen levels of these shallower waters.

**The Late Ordovician Extinction Event:** The Ordovician was a period of relative stability in the Earth's history, which may have been an important factor in the substantial growth of biological diversity which took place. However, as the period drew to a close, 440 million years ago, there was a huge extinction event-with some animal groups losing more than half their species. The Late Ordovician extinction seems to have been the result of a period of glaciation - an ice age. The seas retreated as more and more water was taken up into ice sheets, and the marine habitats (which harbored the vast majority life in the Ordovician) changed drastically, destroying habitats and reducing the number of ecological niches. There seem to have been two peak periods of extinction - one at the beginning of the glaciation, and another at the end of the extinction, between 500 thousand and 1 million years later, when sea levels rose rapidly. Echinoderms, trilobites, nautiloids and many other groups suffered significant losses, although the overall effect was less drastic than that of most other major extinctions.

**The Permian Extinction Event:** Specifically, what caused the major extinction at the end of the Permian? This is harder to define. The end of the Permian (245 million years ago) saw the largest extinction event in the Earth's history - far more devastating than the much more famous Cretaceous extinction, when the dinosaurs died out. It has been estimated that as many as 96% of all marine species were lost, while on land more than 3 quarters of all vertebrate families became extinct. Many causes have been proposed for the Permian extinctions -

including fluctuations in sea-level, a change in the salinity of the ocean, and volcanic activity. The most important factor seems, once again, to be climate change.

**The Triassic Extinction Event:** Whether the extinction was a single event or a cluster of smaller events, there is no doubt that sponges, cephalopods, brachiopods, insects and many vertebrate groups lost many of their families as the Triassic drew to a close, some 208 million years ago. Conodonts disappeared completely, as did the Labyrinthodonts. While the losses may not have been as drastic as in other extinction events, they were important for a relatively new group of animals. As the loss of species opened up new opportunities, the dinosaurs were ready to take advantage. The cause(s) of the Triassic extinction are poorly known, perhaps because it has attracted relatively little study, but climate change seems to be important and, in particular, an increase in rainfall.

**The End of the Cretaceous Extinction Event:** The extinction at the boundary of the Cretaceous and the Tertiary periods, 65 million years ago, is the most famous of all mass extinctions. Its fame comes not from its magnitude (the Permian extinction was far larger) but from the victims of the extinction - the dinosaurs. The Cretaceous-Tertiary (or 'K-T') extinction wiped out around 85% of all species. The dinosaurs were not the only victims - pterosaurs (flying reptiles), mosasaurs and other marine reptiles, fish, brachiopods, plankton and many plants either died out completely or suffered heavy losses. Even the ammonites, who had survived 4 previous extinctions, finally disappeared. For some reason though, some groups seem to have been almost entirely unaffected by the K-T extinction - crocodiles, turtles and lizards, mammals and birds all made it through relatively unscathed. The cause of the K-T extinction event has been the subject of intensive research, with many hundreds of research papers published since 1980, when Luis Alvarez reawakened interest in the subject, almost overnight. He suggested that the death of the dinosaurs, and all the other victims of the K-T extinction, was due to a giant meteorite crashing into the earth, severely disrupting the earth's ecosystem. While other theories suggest volcanic activity, climate change, environmental pollution or even cosmic radiation as causes, the meteorite impact theory remains the most probable - at least for the moment.

Could these mass extinction events be related to meteorite impacts on Earth?  
According to Michael Paine, as written on the Asteroid/Comet Impact Craters and Mass Extinctions and Shiva Hypothesis of Periodic Mass Extinctions web site:

Since multiple impacts appear to be very common throughout the solar system it is expected that some of the smaller craters are associated with other major impacts, evidence of which has not been discovered or has vanished over time. For example, the Triassic/Jurassic and Jurassic/Cretaceous boundaries appear to involve multiple impacts. Craters 40km diameter or more are likely to be caused by 2km diameter asteroids or comets. Such impacts would probably

result in severe global climate disruption but it takes an asteroid/comet 10km or larger to cause mass extinctions. It is estimated that such impacts occur, on average, once every 50 to 100 million years.

It's pretty well accepted that the end of the Cretaceous extinction was due to a meteorite or series of meteorite impact events. The impact or impacts had a dramatic affect on the global climate and ecosystem. Small changes in climate affect sea levels, rainfall, temperature, ocean currents and atmospheric circulation. Any one of these can impact both plants and animals regionally or globally.

Human history has been recorded over the last 10,000 years, which has generally been a very stable period on Earth. During the Jurassic and Triassic, in which the dinosaurs ruled the planet, the Earth's climate was also stable. It is also similar to the Ordovician period of climate stability, during which growth in biological diversity took place. However, each of these geologic periods were ended with mass extinctions due in part to climatic upheaval.

Dinosaurs lasted approximately 200 million years on Earth. Will humans last that long? Is there a mass extinction event in our future? How likely is a major meteorite impact event or series of events? Only time will tell.

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