Acknowledgment

First of all thanks to "Allah"

For whom I always pray, always asking him to give me the ability to do my work kindly and faithfully.

Special thanks and gratitude are offered to my supervisor,

Prof. Dr. Ail Soliman

Geology department, Faculty of Science, Tanta University for his suggestion, kind help, constructive encouragement and continuous guidance during the progress of this work.

I would like to thank my Mother for helping me to reach this stage of education, fordoing everything to be better and for encouragement to appear my best.

Mai Hosny El-Gayar

الانقراضات الرئيسية في العصور الجيولوجية

مقال مقدم الى قسم الجيولوجيا – كليه العلوم – جامعه طنطا لاستكمال متطلبات الحصول على

درجه البكالوريوس فى العلوم (قسم الجيولوجيا)

إعداد

مي حسني الجيار

(المستوى الرابع شعبة جيولوجيا خاصة)

تحت إشراف

أ.د/ علي سليمان

قسم جيولوجيا

كلية العلوم

جامعة طنطا

2017/2016

The Major Extinctions in The geological Ages

Essay submitted to Geology Department, Faculty of Science, Tanta University, in partial fulfillment of the requirement of the degree of B.Sc. in Geology

By

Mai Hosny El-Gayar

(4rd year, Special geology)

Supervised by

Prof. Dr.\ Ali Soliman

Geology Department

Faculty of Science

Tanta University

2016/2017

Contents

Page no.

Abstract

There is an old Chinese curse: 'May you live in interesting times.' According to those who know about such things, we live in a momentous time, the time of the Sixth Mass Extinction! But most of us do not feel at all cursed. Because, in fact, the Sixth is quite different to the previous Big Five, no-one would notice this one if we were not repeatedly reminded of it by ecologists. Previous mass extinctions were not so bashful, so discreet. The fossil record reveals the disappearance of pollen during previous ones, replaced by an abundance of fungus spores, telling us of a world of devastated forests rotting away. The earliest sediments after the mass extinction that did away with the dinosaurs are barren of fossils: so it is not just that species were going extinct, conditions for life itself were bad. Not only did species diversity drop, the abundance of life did as well.

The discipline-wide effort to database the fossil record at the occurrence level has made it possible to estimate marine invertebrate extinction and origination rates with much greater accuracy. The new data show that two biotic mechanisms have hastened recoveries from mass extinctions and confined diversity to a relatively narrow range over the past 500 million years (Myr). First, a drop in diversity of any size correlates with low extinction rates immediately afterward, so much so that extinction would almost come to a halt if diversity dropped by 90%. Second, very high extinction rates are followed by equally high origination rates. The two relationships predict that the rebound from the current mass extinction will take at least 10 Myr, and perhaps 40 Myr if it rivals the Permo-Triassic catastrophe. Regardless, any large event will result in a dramatic ecological and taxonomic restructuring of the biosphere. The data also confirm that extinction and origination rates both declined through the Phanerozoic and that several extinctions in addition to the Permo-Triassic event were particularly severe. However, the trend may be driven by taxonomic biases and the rates vary in accord with a simple log normal distribution, so there is no sharp distinction between background and mass extinctions. Furthermore, the lack of any significant autocorrelation in the data is inconsistent with macro-evolutionary theories of periodicity or self-organized criticality.

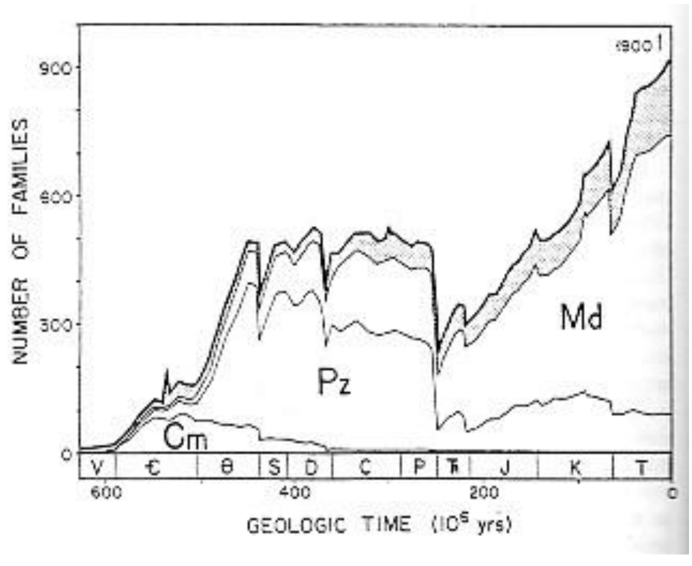
CHAPTER I:

Introduction

It's about the Permian extinction 250 million years ago, when about 90% of all species died out. This was much more serious extinction than the "end of the age of the dinosaurs", in which about half of all species died out. But it's also much more mysterious!

Nowadays many scientists blame the death of the dinosaurs on an asteroid impact about 65 million years ago. This asteroid was about 10 kilometers in diameter, and it slammed into shallow waters covering what is now the Yucatan peninsula. The resulting crater, called Chicxulub or "Tail of the Devil", is about 150 kilometers across! The resulting tsunami would have hit Texas with a wave 50 to 100 meters high. Millions of tons of material were hurled into the atmosphere, causing wildfires across the world as they landed. Rocks called "tektites" formed from droplets of molten quartz can be found as far as Wyoming. A layer of dust from the impact can be found in rocks world-wide, marking the boundary between the Cretaceous and Tertiary. Scientists guess that this dust made it too dark to see for 1 to 6 months, and too dark for photosynthesis for sometime between 2 months and a year. Carbon dioxide released from heated limestone would have also had effects on the climate.

But this disaster at the end of the Cretaceous was only one of the 5 big extinctions life on Earth has suffered throughout the Phanerozoic eon, which began with the Cambrian period 540 million years ago. You can see the "Big Five" as sudden declines in this graph of biodiversity:



This graph shows how many "families" of marine animals there have been as a function of time. A "family" is a grouping of organisms that's bigger than a genus but smaller than an order. For example, if you're reading this, your genus is probably Homo and your species sapiens - but your family is Hominidae, which also contains gorillas, chimpanzees, bonobos and orangutans.

In the above graph, created by an expert on the statistics of mass extinctions named John J. Sepkoski Jr., families have been divided into Cambrian (Cm), Paleozoic (Pz), and Modern (Md) fauna.

Despite the popularization of these five events, there is no fine line separating them from other extinction events; using different methods of calculating an extinction's impact can lead to other events featuring in the top five.

The older the fossil record gets, the more difficult it is to read. This is because:

- Older fossils are harder to find as they are usually buried at a considerable depth.
- Dating older fossils is more difficult.
- Productive fossil beds are researched more than unproductive ones, therefore leaving certain periods unresearched.
- Prehistoric environmental events can disturb the deposition process.
- The preservation of fossils varies on land, but marine fossils tend to be better preserved than their sought after land-based counterparts.

It has been suggested that the apparent variations in marine biodiversity may actually be an artifact, with abundance estimates directly related to quantity of rock available for sampling from different time periods. However, statistical analysis shows that this can only account for 50% of the observed pattern, and other evidence (such as fungal spikes)provides reassurance that most widely accepted extinction events are real. A quantification of the rock exposure of Western Europe indicates that many of the minor events for which a biological explanation has been sought are most readily explained by sampling bias

What really matters for us, though, are the five biggest dips! These are the "Big Five":

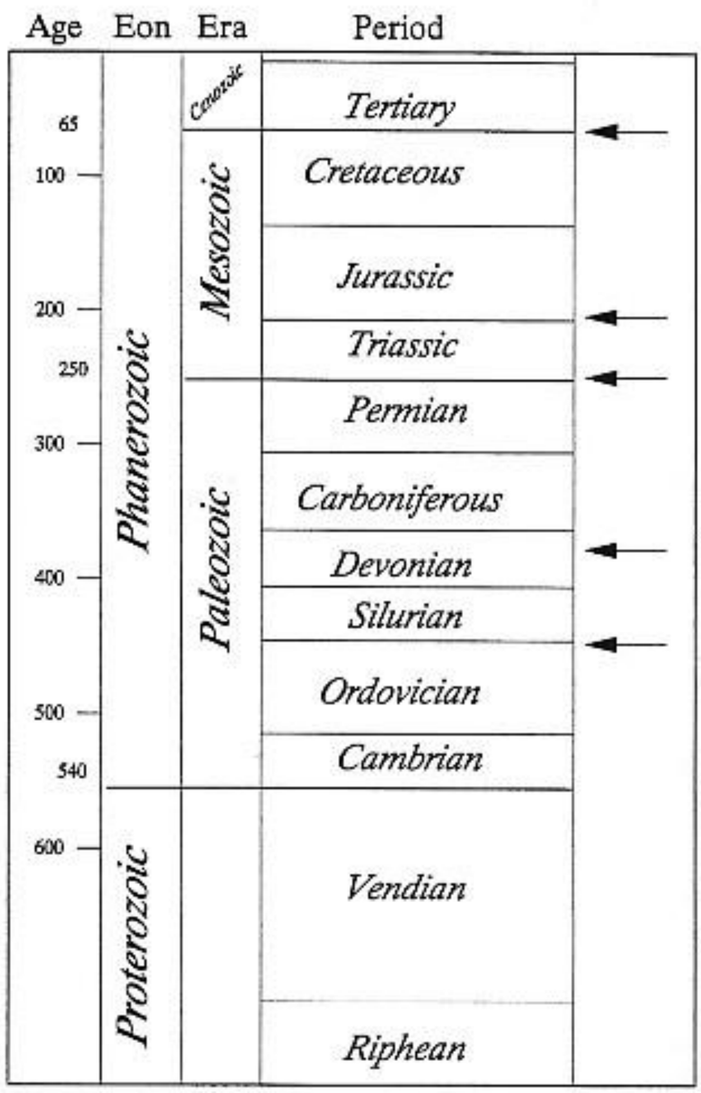


Figure 4. Geologic time scale for the last 600 million years, showing the eras and periods of the Phanerozoic. The five major mass extinctions are marked by arrows in the righthand column.

CHAPTER II:

Major Extinctions

1. *The Ordovician-Silurian Extinction*:

440-450 million years ago at the end of the Ordovician Period.27%of all families and 57% of all genera went extinct.

This was the second biggest extinction of marine life, ranking only below the Permian extinction. There was only life in the seas at this time, and more than one hundred families of marine invertebrates died, including two-thirds of all brachiopod and bryozoan families. One theory is that as the continent Gondwana drifted over the south pole, there was a phase of global cooling, and so much glaciation took place that sea levels were drastically lowered.

2. *The Devonian Extinction:*

375 million years ago at the end of the Frasnian Age in the later part of the Devonian Period. 19% of all families and 50% of all genera went extinct.

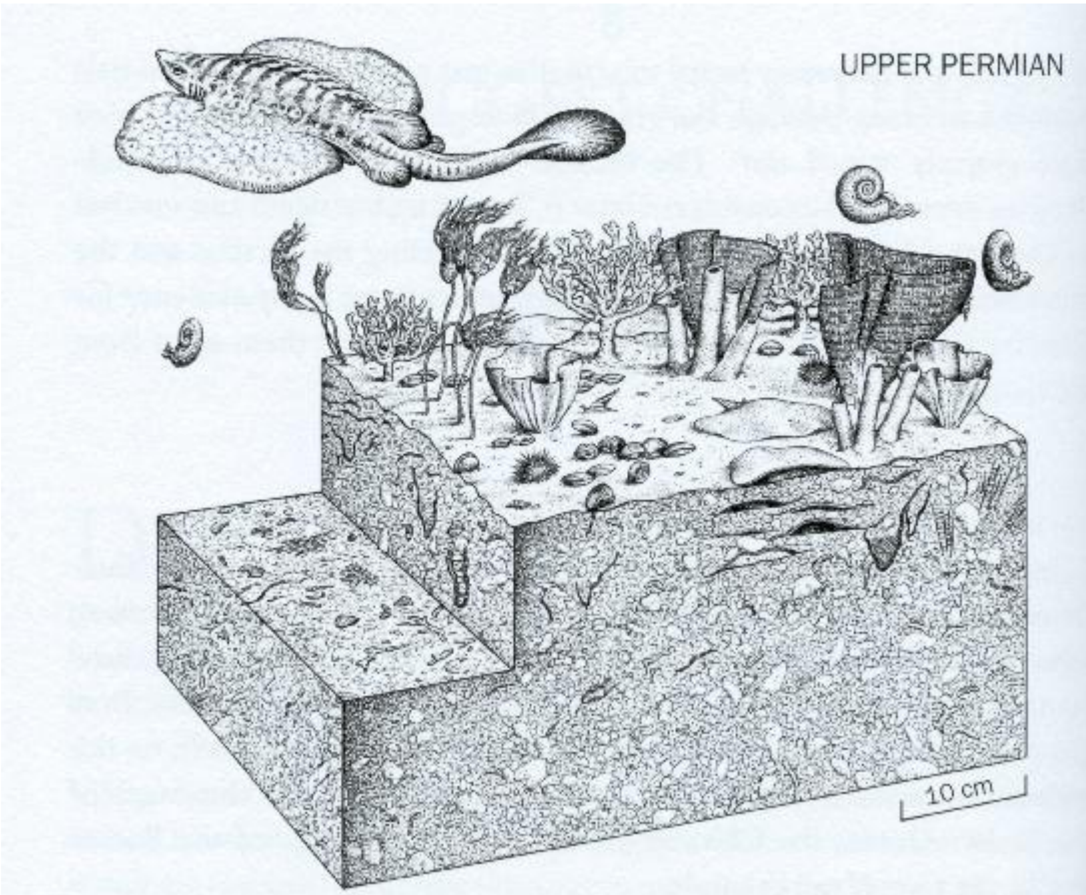
By this point there were plants, insects and amphibians on land, fish in the seas, and huge reefs built by corals and stromatoporoids. The continents of Uramerica and Gondwana were just beginning to move together to form Pangea. The extinction seems to have only affected marine life, but 70% of marine species went extinct! Reef-building organisms were almost completely wiped out, so that coral reefs returned only with the development of modern corals in the Mesozoic. Brachiopods, trilobites, and other sorts got hit hard. Since warm water species were the most severely affected, many scientists suspect another bout of global cooling. There may have also been a meteorite impact, but it seems this extinction was not a sudden event.

3. *The Permian-Triassic Extinction:*

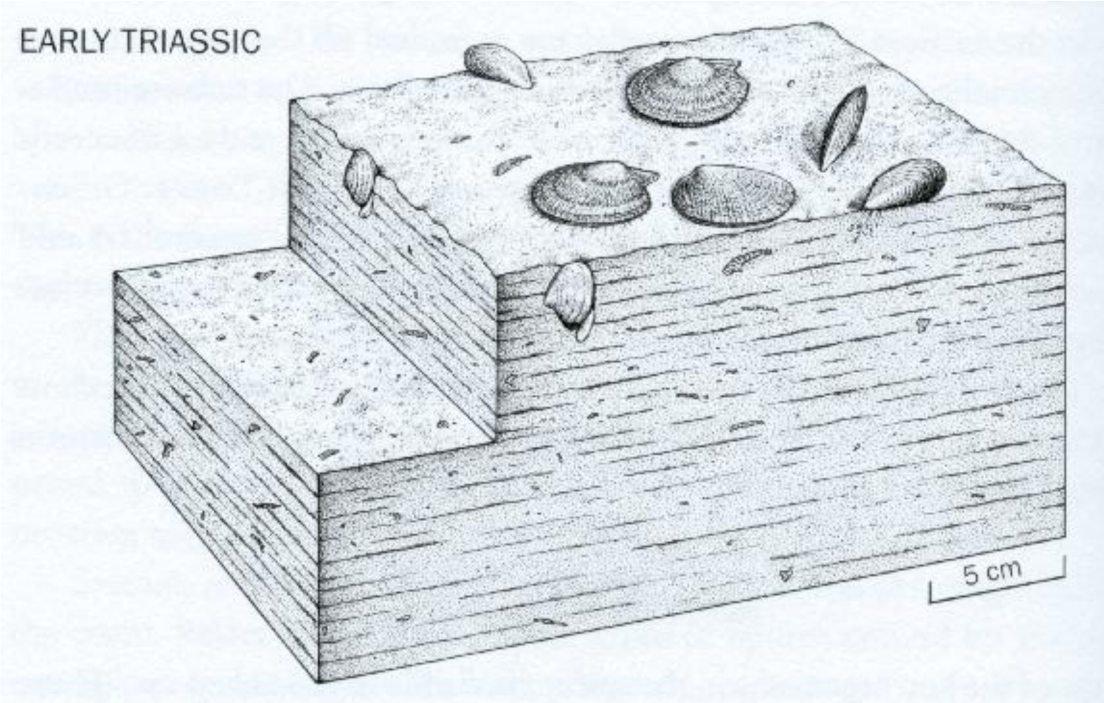
251 million years ago at the end of the Permian Period .57% of all families and 83% of all genera went extinct.

At the end of the Permian there was one supercontinent, Pangea. There were many sorts of reptiles and amphibians on land, together with many plants, especially ferns but also conifers and gingkos. There were also complicated coral reef ecologies undersea. After the extinction, we mainly see fossils of one species of reptile on land: a medium-sized herbivore called Lystrosaurus. We also mainly see fossils of just one species of sea life, a brachiopod called Lingula. Eventually other species seem to reappear - the so-called "Lazarus taxa", named after the Biblical character who returned from the dead. Clearly they must have survived the extinction event, but in very low numbers.

This was the largest disaster that life has ever yet faced on our planet. Before it happened, the seabeds near China looked something like this:



After it happened, they looked like this:



Some people estimate that perhaps 90% or even 95% of all species went extinct! (The figure of 83% above comes from some papers by Sepkoski, who tried to calculate the number of families and genera that died out in each of the Big Five extinctions. Take all these numbers with a grain of salt.)

It took about 50 million years for life on land to fully recover its biodiversity, with the rise of many species of dinosaurs. Nothing resembling a coral reef shows up until 10 million years after the Permian extinction, and full recovery of marine life took about 100 million years.

The causes remain controversial: some scientists blame an asteroid impact, while others blame severe global warming and a depletion of oxygen in the atmosphere due to prolonged massive volcanic eruptions in Siberia - we see signs of these in lava beds called the "Siberian traps". On the other hand, Benton and others argue that the rise of carbon in the atmosphere at this time is only explicable if there was also a catastrophic release of methane from gas hydrates under the ocean.

4. *The Triassic-Jurassic Extinction:*

205 million years ago at the end of the Triassic Period. 23%of all families and 48% of all genera went extinct.

By the end of the Triassic there was again a variety of reptiles on land and in sea. But the reptiles were completely different from those at the end of the Permian, and the biodiversity had not completely recovered: for example, there were no truly large predators. There were primitive conifers and gingkos; ferns were not so dominant as before. There were also frogs, lizards, and even the first mammals.

The extinction at the end of the Triassic destroyed about 20% of all marine families, many reptiles, and the last of the large amphibians - opening niches for the dinosaurs of the Jurassic. The cause of this extinction remains obscure, but it's worth noting that this was about the time when the supercontinent Pangea began splitting into Laurasia and Gondwanaland, with massive floods of lava in the Central Atlantic Magmatic Province - perhaps one of the largest igneous events in the earth's history.

5. *The Cretaceous-Tertiary Extinction:*

65 million years ago at end of the Cretaceous Period. 17% of all families and 50% of all genera went extinct.

By the Cretaceous there were dinosaurs and flowering plants on land, many new insects taking advantage of the flowering plants, and modern fish. Continents were beginning to resemble the current configuration. In the disaster at the end of this period all the dinosaurs died out, as well as many species of plants, diatoms, dinoflagellates, ammonoids, brachiopods, and fish. Often called the "KT" extinction, this was the smallest of the Big Five - it's mainly interesting because it led to the rise of mammals, and in particular, us. As explained above, many scientists believe this extinction was due to an asteroid impact at Chicxulub. Another popular theory is that it was caused by the enormous volcanic eruptions which formed the lava beds in India known as the

"DeccanTraps". Either way, we know it took 10 million years for biodiversity to recover from this mass extinction.

By the Cretaceous there were dinosaurs and flowering plants on land, many new insects taking advantage of the flowering plants, and modern fish. Continents were beginning to resemble the current configuration. In the disaster at the end of this period all the dinosaurs died out, as well as many species of plants, diatoms, dinoflagellates, ammonoids, brachiopods, and fish. Often called the "KT" extinction, this was the smallest of the Big Five - it's mainly interesting because it led to the rise of mammals, and in particular, us. As explained above, many scientists believe this extinction was due to an asteroid impact at Chicxulub. Another popular theory is that it was caused by the enormous volcanic eruptions which formed the lava beds in India known as the "Deccan Traps". Either way, we know it took 10 million years for biodiversity to recover from this mass extinction.

<u>CHAPTER III:</u>

Speculated Causesof the Extinctions

- *The Cambrian extinction:*

The two most accepted current hypotheses for the Cambrian extinction are:

1. Glaciation in the early Ordovician
2. Cooling and depletion of oxygen in marine water

Glacial Cooling Hypothesis

The advancement of the theory of glaciation as the predetermining agent for the Cambrian extinctions has been developed by James F.Miller of Southwest Missouri State University. Through research undertaken by Miller, evidence of early Ordovician sediment of glacial origin has been uncovered in South America. Miller suggests in his hypothesis that this evidence of continental glaciation at the Cambrian-Ordovician boundary is responsible for a decrease in global climatic conditions. Such a decline in temperature is implied by Miller to destroy Cambrian fauna which are intolerant of cooler conditions, producing a mass extinction of mostly warm water species. He also suggests that a significant continental glaciation would bring large amounts of ocean water onto the land in the form of frozen glacial ice. This trapping of ocean water inevitably results in the decrease of sea-level and the withdrawal of shallow seas. Miller implicates that this reduction in sea-level would produce reduced habitat for marine species as continental shelves are obliterated. Ecological competition would consequently ensue, perhaps acting as a driving agent.

Oxygen Depletion Hypothesis

The development of a hypothesis invoking the cooling and depletion of water in marine waters as a causative agent for the Cambrian extinctions has been advanced by several geologists, primarily Allison Palmer and Michael Taylor of the U.S. Geological Survey and James Stilt of the University of Missouri. The cooling and oxygen depletion would occur when cool waters from deep zones of the ocean spread up onto the continent, eliminating all organisms not able to tolerate cool conditions. The cooling would also result in stratification of the water column. Thus, species would ultimately perish due to their inability to tolerate dramatic shifts in such limiting factors as temperature and oxygen availibility. Further research is required to more fully test the validity of the above outlined Cabrian extinction hypotheses.

- *The Ordovician Extinction:*

Glaciation and Sea-Level Lowering Hypothesis

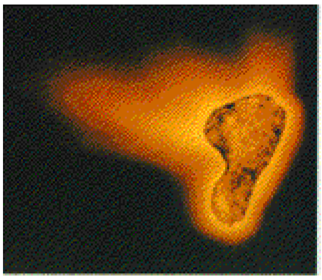
The Ordovician mass extinction has been theorized by paleontologists to be the result of a single event; the glaciation of the continent Gondwana at the end of the period. Evidence for this glaciation event is provided by glacial deposits discovered by geologists in the Saharan Desert. By integrating rock magnetism evidence and the glacial deposit data, paleontologists have proposed a cause for this glaciation. When Gondwana passed over the north pole in the Ordovician, global climatic cooling occured to such a degree that there was global large-scale continental resulting in widespread glaciation. This glaciation event also caused a lowering of sea level worldwide as large amounts of water became tied up in ice sheets. A combination of this lowering of sea-level, reducing ecospace on continental shelves, in conjunction with the cooling caused by the glaciation itself are likely driving agents for the Ordovician mass extinction.

- *The Devonian Extinction:*

Glaciation

Evidence supporting the Devonian mass extinction suggests that warm water marine species were the most severely affected in this extinction event. This evidence has lead many paleontologists to attribute the Devonian extinction to an episode of global cooling, similar to the event which is thought to have cause the late Ordovician mass extinction.

According to this theory,the extinction of the Devonian was triggered by another glaciation event on Gondwana, as evidenced by glacial deposits of this age in northern Brazil. Similarly to the late Ordovician crisis, agents such as global cooling and widespread lowering of sea-level may have triggered the late Devonian crisis.

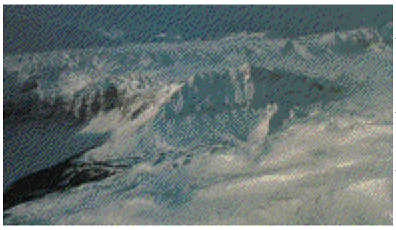


Meteorite Impact

Meteorite impacts at the Frasnian-Famennian boundary have also been suggested as possible agents for the Devonian mass extinction.

Currently, the data surrounding a possible extra-terrestrial impact remains inconclusive, and the mechanisms which produced the Devonian mass extinction are still under debate.

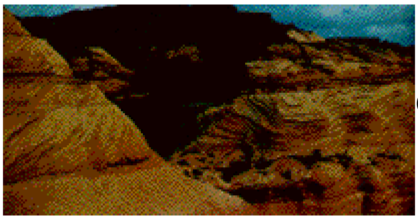
- *The Permian Extinction:*



Although the cause of the Permian mass extinction remains a debate, numerous theories have been formulated to explain the events of the extinction. One of the most current theories for the mass extinction of the Permian is an agent that has been also held responsible for the Ordovician and Devonian crises, glaciation on Gondwana. A similar glaciation event in the Permian would likely produce mass extinction in the same manner as previous, that is, by a global widespread cooling and/or worldwide lowering of sea level.

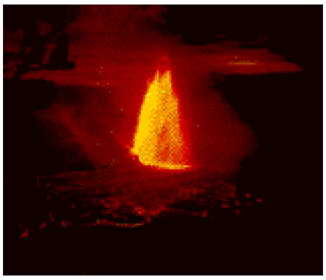
The Formation of Pangea

Another theory which explains the mass extinctions of the Permian is the reduction of shallow continental shelves due to the formation of the super-continent Pangea. Such a reduction in oceanic continental shelves would result in ecological competition for space, perhaps acting as an agent for extinction. However, although this is a viable theory, the formation of Pangea and the ensuing destruction of the continental shelves occurred in the early and middle Permian, and mass extinction did not occur until the late Permian.



Glaciation

A third possible mechanism for the Permian extinction is rapid warming and severe climatic fluctuations produced by concurrent glaciation events on the north and south poles. In temperate zones, there is evidence of significant cooling and drying in the sedimentological record, shown by thick sequences of dune sands and evaporites, while in the polar zones, glaciation was prominent. This caused severe climatic fluctuations around the globe, and is found by sediment record to be representative of when the Permian mass extinction occurred.



Volcanic Eruptions

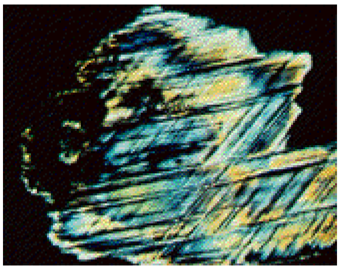
The fourth and final suggestion that paleontologists have formulated credits the Permian mass extinction as a result of basaltic lava eruptions in Siberia. These volcanic eruptions were large and sent a quantity of sulphates into the atmosphere. Evidence in China supports that these volcanic eruptions may have been silica-rich, and thus explosive, a factor that would have produced large ash clouds around the world. The combination of sulphates in the atmosphere and the ejection of ash clouds may have lowered global climatic conditions. The age of the lava flows has also been dated to the interval in which the Permian mass extinction occurred.

- ***The End-Cretaceous Extinction:***

The End-Cretaceous mass extinction has generated considerable public interest in recent years, in response to the controversial debates in the scientific community over its cause. The more prominent of these new hypoteses invoke extra-terrestrial forces, such as meteorite impacts or comet showers as the causative extinction agent. Older hypotheses cite earthly mechanisms such as volcanism or glaciation as the primary agent behind this mass extinction.

The K-T Boundary

Evidence for catastrophism at the Cretaceous-Tertiary boundary is found in a layer of sediment which was deposited at the same time that the extinction occurred. This layer contains unusually high concentrations of Iridium, found only in the earth's mantle, and in extra-terrestrial meteors and comets. This layer has been found found in both marine and terrestrial sediments, at numerous boundary sites around the world.



Meteorite Impact

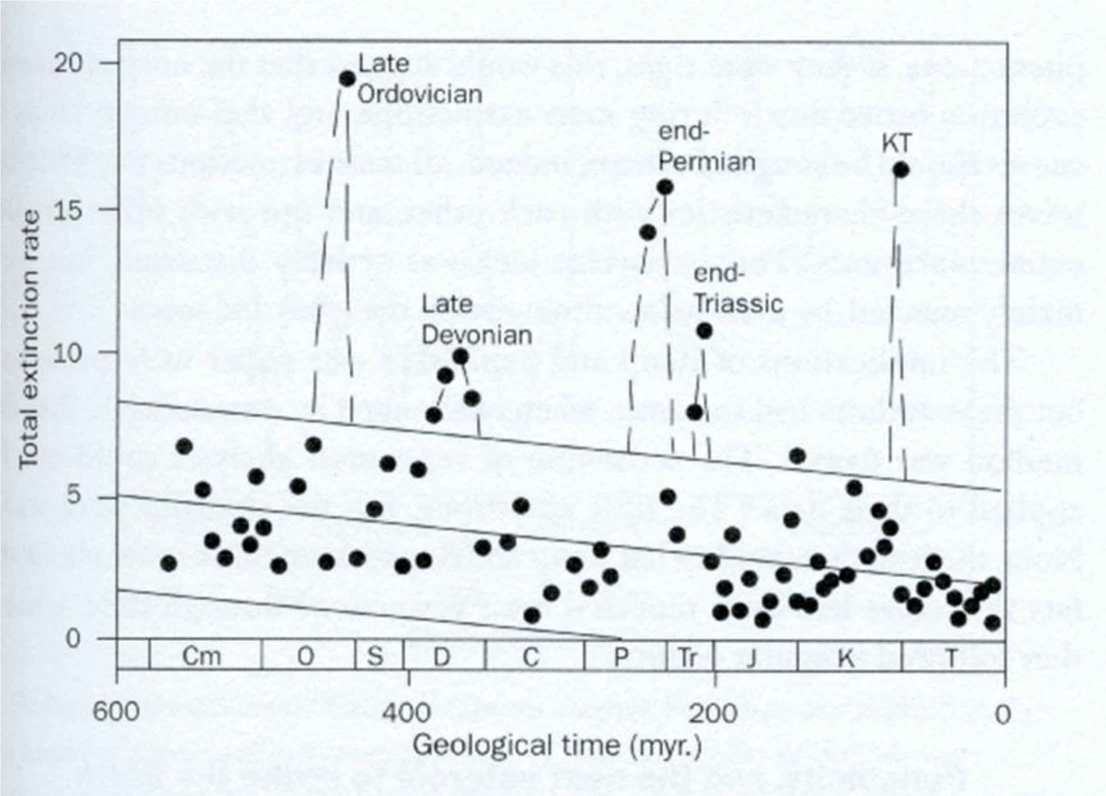
Some paleontologists believe that the widespread distribution of this Iridium layer could have only been caused by meteorite impact. Further, these researchers cite the abundance of small droplets of basalt, called spherules, in the boundary layer as evidence that basalt from the earth's crust that were melted and flung into the air upon impact. The presence of shocked quartz - tiny grains of quartz that show features diagnostic of the high pressure of impact - found in the boundary layer provides additional evidence of an extra- terrestrial impact at the Cretaceous-Tertiary boundary layer. Recent research suggests that the impact site may have been in the Yucatan Peninsula of Mexico.

Volcanic Eruptions

The high concentrations of Iridium in the boundary layer has also been attributed to another source, the mantle of the earth. It has been speculated by some scientists that the Iridium layer may be the result of a massive volcanic eruption, as evidenced by the Deccan Traps - extensive volcanic deposits laid down at the Cretaceous-Tertiary boundary - of India and Pakistan. These lava flows came about when India moved over a "hot spot" in the Indian Ocean, producing flows that exceeded one hundred thousand square kilometers in area and one hundred and fifty meters in thickness. Such flows would have produced enormous amounts of ash, altering global climatic conditions and changing ocean chemistry. Evidence that volcanism was a primary extinction agent at this boundary is also relatively strong. In addition, and the presence of spherules and shocked quartz worldwide in the boundary layer may also have been the result of such explosive volcanism. Thus at present, both the volcanic and meteorite impact hypotheses are both viable mechanisms for producing the Cretaceous mass extinction, although the latter is more popular.

CHAPTER IV:

Diversityof the Extinctions

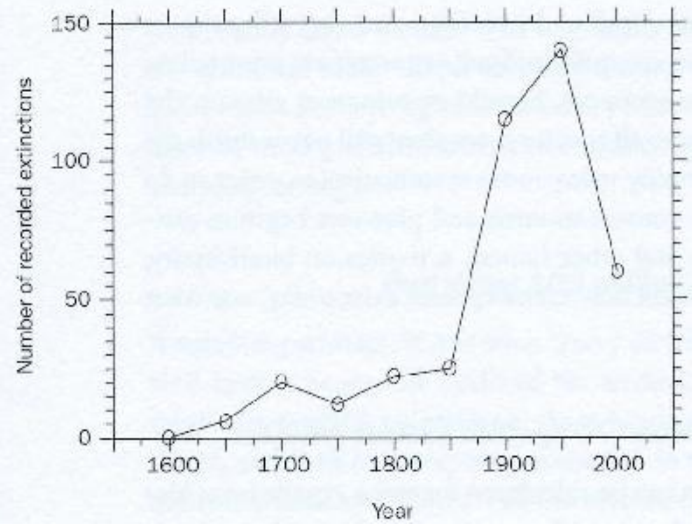


You can also see them as peaks in this graph by Sepkoski and Raup, which plots the number of extinctions of marine families per million years (or "Myr"):

The advantage of working with marine life, by the way, is that it's much more likely to get fossilized than life on land.

Another fascinating feature of the above graph is the general downwards trend in the rate of extinction: the middle line is the average rate, while the two outlying lines represent a 95% confidence interval. So, perhaps life is getting better.We may now be in the middle of yet another mass extinction! The Pleistocene began around 1.8 million years ago, bringing with it an erratic fluctuation between ice ages and warmer periods. The latest of these ice ages ended around 8000 years ago, right around when Homo sapiens was starting to really take over the planet. Starting around 11,000 years ago, most of the large mammals went extinct: mammoths, saber-toothed tigers, dire wolves, elephant-sized ground sloths, and so on. Though there is much debate about the causes, it seems that human hunting contributed to their demise. This is called the "Pleistocene overkill hypothesis".

We're now seeing an intensification of the rate of extinctions as wilderness areas are obliterated throughout the planet. Nobody knows what the extinction rate is: since most species haven't even been catalogued yet, all we have are lower bounds. These are only close to being accurate for the biggest and most charismatic species (e.g. mammals, birds and trees), but these represent a tiny fraction of all the species that are out there. So, any reasonable guess of the extinction rate requires extrapolation. If we keep track only of recorded extinctions, the story looks like this:



44 *The rate of historical extinctions of species for which information exists. Rates of loss mount in the twentieth century. The apparent drop from 1950 to 2000 is not an indication of an improvement. the figures were recorded in 1990, and the full tally of species lost up to 2000 has not yet been calculated.*

But what about all the species we haven't even catalogued yet?

Phillip and Donald Levin estimate that right now one species is going extinct every 20 minutes, and that half of bird and mammal species will be gone in 200 to 300 years. Richard Leakey estimates a loss of between 50,000 and 100,000 species a year, and says that only during the Big Five mass extinctions was the rate comparably high. E. O. Wilson gives a similar estimate. In his book, Michael Benton reviews the sources of uncertainty and makes an estimate of his own: given that there are probably somewhere between 20 and 100 million species in total, he estimates an extinction rate of between 5,000 and 25,000 species per year. This means between 14 and 70 species wiped out per day.

Skeptics find these numbers alarmist. For example, in Chapter 23 of this book:

- BjørnLomborg, The Skeptical Environmentalist: Measuring the Real State of the World, Cambridge U. Press, Cambridge, 2001.

the author does his best to tear apart Leakey and Wilson's estimates. Wilson has issued a convincing rebuttal. However, the really interesting thing is that Lomborg's own estimates also point to a high extinction rate! He estimates that over the next 50 years, about 0.7 percent of all species will go extinct. This may not sound like much until you realize how short 50 years is on a geological time scale. To put things in perspective, note that given Lomborg's estimate that there are between 10 and 80 million species total, a loss of .7 percent of all species would mean between 70,000 and 560,000 extinctions in the next 50 years. This amounts to 1,200 and 10,000 per year, or between 4 and 30 a day - the same order of magnitude as what Benton suggests! Perhaps more to the point, Lomborg says the current extinction rate is about 1500 times the natural background rate.

In short, despite plenty of bickering, there seems to be agreement that humans are causing a vastly elevated extinction rate.

And there's also lots of other data pointing to a massive human-caused disruption of the biosphere. One in eight plant species are in danger of extinction within the next 30 years, according to the IUCN Red List of threatened species, along with one in eight bird species and a quarter of all mammals. The Audubon Society reports that 30% of North American songbird species are in significant decline. Worldwide populations of frogs and other amphibians have been declining drastically, and a recent detailed study shows that of 5743 known species of amphibians recorded in the last couple of centuries, 34 are now extinct, while another 122 are probably extinct: they can no longer be found. Even worse, of these 122 missing species, 113 have disappeared since 1980!

In the oceans, 90% of all large fish have disappeared in the last half century, thanks to overfishing. We see the spread of dead zones near the mouths of rivers, where nutrients from fertilizer create blooms of plankton leading to low-oxygen water where few organisms can survive. Coral reefs are becoming unhealthy around the world, with a strong upswing in the bleaching of reefs since the 1970s. "Bleaching" is the loss of algae called zooxanthellae which live in coral and give it its color. It seems to be caused by higher water temperatures due to global warming.

And so on, and on, and on....

So, lots of evidence suggests that are in the midst of a mass extinction. It's very different than all previous ones. It's governed by seemingly unstoppable demographic and economic forces. Until the configuration of these forces shifts, at best we can only ameliorate their effects. We can't save every species, but maybe we can save one from every genus, or one from every family. Every little bit helps! The Permian extinction offers a lesson of hope: from the feeblest glow life can eventually rekindle.

That's the one great thing about this crisis: even a small nudge can make the difference between extinct and not extinct. I think it's worthwhile contributing to these organizations:

- The World Wildlife Fund
- The Nature Conservancy
- The Sierra Club

Evolutionary importance

Mass extinctions have sometimes accelerated the evolution of life on Earth. When dominance of particular ecological niches passes from one group of organisms to another, it is rarely because the new dominant group is "superior" to the old and usually because an extinction event eliminates the old dominant group and makes way for the new one.

For example, mammaliformes ("almost mammals") and then mammals existed throughout the reign of the dinosaurs, but could not compete for the large terrestrial vertebrate niches which dinosaurs monopolized. The end-Cretaceous mass extinction removed the nonavian dinosaurs and made it possible for mammals to expand into the large terrestrial vertebrate niches. Ironically, the dinosaurs themselves had been beneficiaries of a previous mass extinction, the end-Triassic, which eliminated most of their chief rivals, the crurotarsans.

Another point of view put forward in the Escalation hypothesis predicts that species in ecological niches with more organism-to-organism conflict will be less likely to survive extinctions. This is because the very traits that keep a species numerous and viable under fairly static conditions become a burden once population levels fall among competing organisms during the dynamics of an extinction event.

Furthermore, many groups which survive mass extinctions do not recover in numbers or diversity, and many of these go into long-term decline, and these are often referred to as "Dead Clades Walking".

Darwin was firmly of the opinion that biotic interactions, such as competition for food and space the ‘struggle for existence’ were of considerably greater importance in promoting evolution and extinction than changes in the physical environment. He expressed this in The Origin of Species: "Species are produced and exterminated by slowly acting causes and the most import of all causes of organic change is one which is almost independent of altered…physical conditions, namely the mutual relation of organism to organism the improvement of one organism entailing the improvement or extermination of others".

Effects and recovery

The impact of mass extinction events varied widely. After a major extinction event, usually only weedy species survive due to their ability to live in diverse habitats. Later, species diversify and occupy empty niches. Generally, biodiversity recovers 5 to 10 million years after the extinction event. In the most severe mass extinctions it may take 15 to 30 million years.

The worst event, the Permian–Triassic extinction event, devastated life on earth and is estimated to have killed off over 90% of species. Life seemed to recover quickly after the P-T extinction, but this was mostly in the form of disaster taxa, such as the hardy Lystrosaurus. The most recent research indicates that the specialized animals that formed complex ecosystems, with high biodiversity, complex food webs and a variety of niches, took much longer to recover. It is thought that this long recovery was due to the successive waves of extinction which inhibited recovery, as well as to prolonged environmental stress to organisms which continued into the Early Triassic. Recent research indicates that recovery did not begin until the start of the mid-Triassic, 4M to 6M years after the extinction; and some writers estimate that the recovery was not complete until 30M years after the P-T extinction, i.e. in the late Triassic. Subsequent to the P-T extinction, there was an increase in provincialization, with species occupying smaller ranges – perhaps removing incumbents from niches and setting the stage for an eventual rediversification.

The effects of mass extinctions on plants are somewhat harder to quantify, given the biases inherent in the plant fossil record. Some mass extinctions (such as the end-Permian) were equally catastrophic for plants, whereas others, such as the end-Devonian, did not affect the flora.

Conclusion

The Holocene epoch is the geologically brief interval of time encompassing the last 10,000 years. With the evolution of humans beginning in the Neogene, humans have evolved into a significant agent of extinction. For example, David Western of the New York Zoological Society, has speculated that for the destruction of every two hundred square kilometers of tropical forest and one hundred thousand square kilometers of rangeland there is a resultant loss of hundreds, if not thousands, of species. Most of these have never been (or ever will be) documented by science. Deforestation, agricultural practices, pollution, overhunting, and numerous other human activities result in numerous species being threatened everyday. However, more information is required to see if the level of extinctions being experienced today are the harbringer of a mass extinction or merely reflect natural background levels of species replacement.

But conditions for life itself have never been better than today. In the history of the planet, there has never been anything as productive of life as a wheat field in Kansas. It may not have a large diversity of species, but that is a different matter. In fact, one of the reasons for the ongoing loss of plant diversity from grasslands is the very reason the wheat field is so productive fertilization. We are pouring nitrogen fertiliser into the environment and, through the well-studied (paradox of enrichment), this reduces species diversity while increasing actual biomass. Now, there is no question that if current trends of habitat alteration and climate change continue then we will ultimately lose large numbers of species diversity will drop but this does not necessarily translate into a loss of abundance of life, and that is a big difference between now and previous mass extinctions. Looking at specific groups of organisms tells the same story. So, for example, many island bird species are threatened, like the kagu of New Caledonia, but British seabird populations, like puffins, are booming. Worldwide amphibian diversity is threatened, but cane toads are a pest in Australia. Introduced species pose a threat to diversity the

‘McDonald-isation’ of nature precisely because they achieve enormous abundances.

Actually, all six mass extinctions may have one very important thing in common: from the point of view of the vast bulk of life on the planet they are probably not mass extinctions at all. By any criterion number of individuals or total biomass the vast majority of life on earth is invisible microbial. So, for example, at least 10% of the living biomass on earth consists of bacteria living deep in the oceans' sediments: it would take more than an asteroid impact to disturb them. And microbial life is extraordinarily robust: microbes can be found living happily in pressurised water hotter than your boiling kettle, in concentrated acid, and in rock, and their spores can survive for years in the rigours of outer space.

References

- Nee, S. (2004). "Extinction, slime, and bottoms". PLoS Biology. 2 (8): E272. PMC 509315 Freely accessible. PMID 15314670. doi:10.1371/journal.pbio.0020272.
- Michael J. Benton, When Life Nearly Died: The Greatest Mass Extinction of All Time, Thames and Hudson, 2003.
- S. Culver and P. Wilson, editors, Biotic Response to Global Change - the Last 145 Million Years, Cambridge University Press, Cambridge, 2000.
- Douglas H. Erwin, The Great Paleozoic Crisis: Life and Death in the Permian, Critical Moments in Paleobiology and Earth History Series, Columbia University Press, New York, 1993.
- A. Hallam and P. B. Wignall, Mass Extinctions and Their Aftermath, Oxford University Press, Oxford, 1997.
- E. O. Wilson, The Diversity of Life, W. W. Norton and Company, New York, 1999.
- United Nations Environment Programme World Conservation Monitoring Centre (UNEP-WCMC), World Atlas of Biodiversity: Earth's Living Resources for the 21st Century, University of California Press, 2002.
- J. J. Sepkoski, Jr., A kinetic model of Phanerozoic taxonomic diversity, III. Post-Paleozoic families and mass extinctions, Paleobiology **10** (1984), 246-267.
- J. J. Sepkoski, Jr., Periodicity in extinction and the problem of catastrophism in the history of life, Journal of the Geological Society of London **146** (1989), 7-19.
- J. J. Sepkoski, Jr., The taxonomic structure of periodic extinction, in Global Catastrophes in Earth History, eds. L. Sharpton and P. D. Ward, Geological Society of America Special Paper **247**, Geological Society of America, Boulder, Colorado, 1990.

- D. M. Raup and J. J. Sepkoswki, Jr., Mass extinctions in the marine fossil record, Science **215** (1982), 1501-1503.

- ^ Benton, M.J. (2004). "6. Reptiles Of The Triassic". Vertebrate Palaeontology. Blackwell. ISBN 0-04-566002-6.

- ^ Van Valkenburgh, B. (1999). "Major patterns in the history of carnivorous mammals". Annual Review of Earth and Planetary Sciences. 27: 463–493. Bibcode:1999AREPS..27..463V. doi:10.1146/annurev.earth.27.1.463.

- ^ Jablonski, D. (2002). "Survival without recovery after mass extinctions". PNAS. 99 (12): 8139–8144. Bibcode:2002PNAS...99.8139J. PMC 123034 Freely accessible. PMID 12060760. doi:10.1073/pnas.102163299.

- Raup, D.; SepkoskiJr, J. (1982). "Mass extinctions in the marine fossil record". Science. 215 (4539): 1501–1503. Bibcode:1982Sci...215.1501R. PMID 17788674. doi:10.1126/science.215.4539.1501.

- ^ Fastovsky DE, Sheehan PM (2005). "The extinction of the dinosaurs in North America". GSA Today. 15 (3): 4–10. ISSN 1052-5173. doi:10.1130/1052-5173(2005)015<4:TEOTDI>2.0.CO;2.

- McGhee, G. R.; Sheehan, P. M.; Bottjer, D. J.; Droser, M. L. (2011). "Ecological ranking of Phanerozoic biodiversity crises: The Serpukhovian (early Carboniferous) crisis had a greater ecological impact than the end-Ordovician". Geology. 40 (2): 147–150. Bibcode:2012Geo....40..147M. doi:10.1130/G32679.1.

- ^ Sole, R.V., and Newman, M., 2002. "Extinctions and Biodiversity in the Fossil Record – Volume Two, The Earth system: biological and ecological dimensions of global environment change" pp. 297–391, Encyclopedia of Global Environmental Change John Wilely& Sons.

- Smith, Andrew B.; McGowan, Alistair J. (2007). "The shape of the Phanerozoic marine palaeodiversity curve: How much can be predicted from the sedimentary rock record of Western Europe?".Palaeontology. 50 (4): 765–774. doi:10.1111/j.1475-4983.2007.00693.x.

- Kluger, Jeffrey (July 25, 2014). "The Sixth Great Extinction Is Underway and We're to Blame". Time. Retrieved December 14, 2016.

- Kaplan, Sarah (June 22, 2015). "Earth is on brink of a sixth mass extinction, scientists say, and it's humans' fault". The Washington Post. Retrieved December 14, 2016.

- Hance, Jeremy (October 20, 2015). "How humans are driving the sixth mass extinction". The Guardian. Retrieved December 14, 2016.

- "Vanishing: The Earth's 6th mass extinction". CNN. Retrieved December 19, 2016

التلخيص العربي

انقراض جماعي Mass extinction

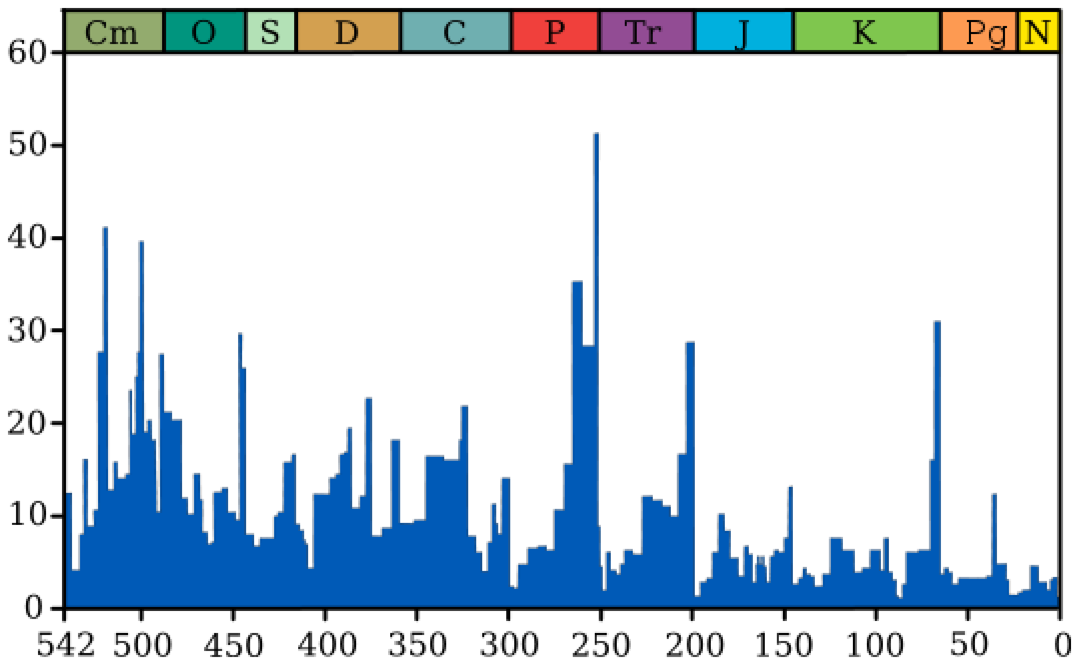
أو أزمة حيوية Biotic crisis هو نهاية وجود أنواع متعددة من الكائنات الحية.

تميزت حياة الأرض بظهور أشكال متنوعة من الكائنات الحية النباتية والحيوانية في البر والبحر، غير أن الملفت للنظر في قراءة تاريخ الأرض أن تجمعات الكائنات الحية تخضع دائما للإنقراض الجماعي الذي يليه ظهور كائنات حية جديدة تخضع بدورها بعد فترة حياة للإنقراض الجماعي. وهكذا خضع تاريخ الأرض لعدة دورات مكنت من تخزين في الأرض للمواد الأولية كالبترول والغاز والفحم الحجري تمهيدا لقدوم الإنسان.

من بين مئات الفرضيات عن أسباب حدوثها. أنها وقعت بسبب التنافس بين الثدييات أو الأوبئة أو بسبب حساسية الأحياء للنباتات الزهرية التي تظهر حديثا أو بسبب حبوب لقاحها . إلا أن هذه الفرضيات لاتفي بتوضيح كل أحداث وأشكال الانقراضات التي حدثت . لأنها وقعت لكائنات حية كانت تعيش فوق البر أو بالبحر . مما يوحي بأن ثمة حادثا عرضيا قد وقع وأثر علي البيئة العالمية. وضرب العلماء مثلا بالمذنب الذي ضرب الأرض منذ 65 مليون سنة وخلف وراء ارتطامه بشبه جزيرة ياكوتان بالمكسيك سحابة ترابية حجبت الشمس عن الأرض لمدة 6 شهور. مما أوقف التمثيل الضوئي للنباتات فوقها. وماتت لهذا معظم النباتات. فلم تجد الحيوانات ما تأكله من نباتات أو حيوانات كانت تعيش عليها . فنفق معظمها ومن بينها الديناصورات العشبية أوآكلة اللحوم. ولم يعش سوي الحيوانات الصغيرة الرمية كالحشرات والديدان التي أمكنها العيش على الحيوانات النافقة أو مواد النباتات الميتة . لهذا نجت. لكن المعارضين لنظرية ضرب الأرض بأجسام فضائية يقولون بأن البيئة يمكنها بسهولة تخطي هذا التأثير ولاسيما وأن الحفريات في رسوبيات شرق مونتانا بشمال غرب داكوتا وعمرها 2,2 مليون سنة تبين أن الديناصورات كانت تعيش هناك، وقد طمرت رواسب الفيضانات الكاسحة عظام هذه الديناصورات التي أظهرت أن اندثارها كان تدريجيا خلال عدة ملايين من السنين بالعصر الطباشيري.

قام العلماء بفحص قطاعات طولية في هذه الرسوبيات من أسفل لأعلى، فوجدوا 2000 حفرية ديناصورية وكل عظمة ترجع إلى فصيلة من الديناصورات سواء أكانت آكلة للعشب أو اللحوم . كما يقال أن من بين هذه الأسباب التي أدت إلي الانقراضات الجماعية عوامل كوارثية، كنظرية ضرب المذنبات أو بيئية كالبراكين أو جليدية كما في العصور الجليدية أو لتغير معدل الأكسجين أو الملوحة بالمحيطات أو لتغير المناخ العالمي . ورغم منطقية ومعقولية هذه الأسباب إلا أنها لا تفي ولا تقدم تأكيدات قاطعة . لأنها فرضيات استنتاجية أو تخمينية رغم أن هذه الأسباب ليست مؤكدة أو معلومة لدينا. لأنه ليس من السهل قتل أحياء أو كائنات إحيائية كثيرة وعلى نطاق واسع إلا من خلال كارثة شاملة وكاسحة . وقد اجتاح الأرض انقراض كبير منذ 11 ألف سنة بسبب استمرار العصر الجليدي الأخير الذي قضي على ثلثي الأحياء بشمال أمريكا وبقية القارات. وهذا العصر الجليدي لم ينحسر بعد من القطبين . لكن ثمة أنواعا قاومت هذا الفناء الكبير ومن بينها

نوع الإنسان الذي كان من الناجين وبلغ بعده لأعلي مراتبه   . فظهر الإنسان العاقل وتطوره للإنسان الحديث الصانع الماهر والمفكر.



شدة الانقراض البحري خلال دهر الحياة الظاهرة

يبين الرسم البياني الأزرق نسبة واضحة (ليس عدد مطلق) لأجناس الحيوانات البحرية المنقرضة خلال أي فترة زمنية معينة . ولا تمثل جميع الأنواع البحرية، بل فقط التي تحجرت بسهولة   . التسميات لأحداث الانقراض "الخمسة الكبرى"