MASS EXTINCTIONS THROUGH TIME

INTRODUCTION

- **A mass extinction** is an event where there is a massive decrease in the number of different species, over a relatively short period of time, perhaps spanning several thousand or a few million years.

For any one species, extinction is termed to be catastrophic.

- **Extinction** is where a species are no longer alive. It is usually judged as when the last member of a species dies and therefore can't reproduce.
- **Background extinction** is the natural process of extinctions that occur continually, generating a regular change of all the species living on Earth.

Mass extinction events are rare and some environmentalists and biologists believe we are in the middle of another major mass extinction event, fuelled by **man's effect on the environment**.

- **Genera (genus)** is a subdivision in taxonomy, a broader category than species.
- **Hypothesis** is a testable statement that can be accepted, refined or rejected as new information or research comes to light.
  It has not strictly been proven but is possible, and sometimes even a well-accepted assumption.
- **Sedimentary facies**: A facies is a term used to describe a rock that has characteristic properties making it unique compared to adjacent rock. A sedimentary facies or marker horizon can be important in stratigraphy as it is easily distinguished against surrounding sedimentary strata.

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There have been five major, and many more minor, extinction events through geological time.

Extinction event	Time	Organisms most affected	% extinction of groups alive at the time
Cretaceous-Tertiary (K-T)	**65 Ma**	Bivalves, belemnites, dinosaurs, ammonites, pterosaurs, plesiosaurs, mososaurs, many families of fish, echinoids and many others. The **Cretaceous-Tertiary** mass extinction is famous for causing the extinction of **dinosaurs**. The **K-T extinction** is the **most recent large-scale** mass extinction event and is also **well-documented**.	17% of all families 50% of all genera
Triassic-Jurassic	**200 Ma**	**Sea and land animals** (**amphibians and reptiles**). Many **ammonoids**. 35% of all animal families die out. Most **early dinosaur** families die out.	23% of all families 48% of all genera
Permo-Triassic	**251 Ma**	Marine organisms, 95% of all marine species – most brachiopods, corals, ammonoids, echinoids and trilobites. Land reptiles – 50% of all animal families and many trees die out.	57% of all families 83% of all genera
Late Devonian	**375 Ma**	Shallow marine ecosystems, especially corals, brachiopods and trilobites.	19% of all families 50% of all genera
Ordovician-Silurian	**443 Ma**	Plankton and bottom dwellers, particularly brachiopods and trilobites. 100 families extinct – more than half of the bryozoan and brachiopod species extinct.	27% of all families 57% of all genera

Mass extinctions kills off many species, but the **empty niches left behind** may allow other genera to adapt to new ecological niches, allowing life **to diversify**. Mass extinctions are usually followed by a massive increase in the number of species and so **fuel adaptive radiation.**

K-T (CRETACEOUS-TERTIARY) MASS EXTINCTION → 65 MA

This is a large **extinction event** and 75% of species became extinct around 65 million years ago. This marks the **end of the Mesozoic Era**. Once again, the **event was gradual**, showing a decline in species over **several million years**, leading finally to an abrupt extinction event.

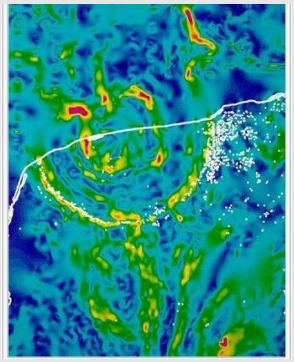
Marine casualties included **large reptiles** (**ichthyosaurs and mososaurs and plesiosaurs**), **brachiopods, echinoids, ammonites, coccoliths, foraminifera**, **belemnites, fish and some bivalves and Plesiosaurs (marine reptiles).**

Terrestrial losses included **dinosaurs, pterosaurs (flying).**

Some animals were relatively unaffected by the event(s), and these were: **crocodiles, lizards, turtles, mammals** and **birds** who all made it through without many casualties. The extinction of the dinosaurs did leave a **large ecological niche**, which **mammals largely filled**.

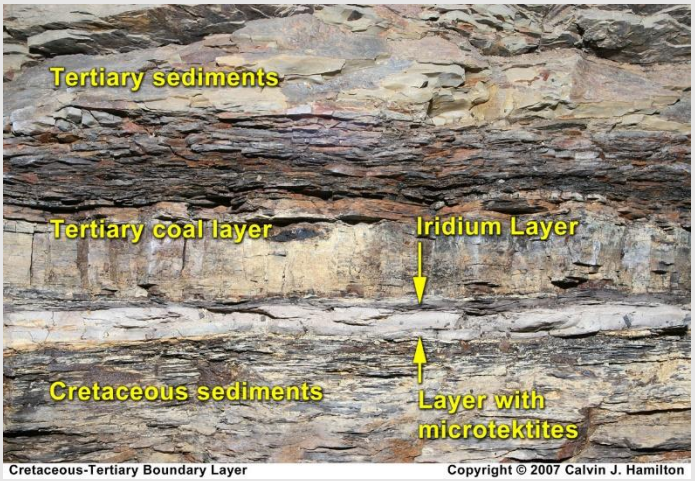
Evidence that supports the asteroid impact hypothesis:

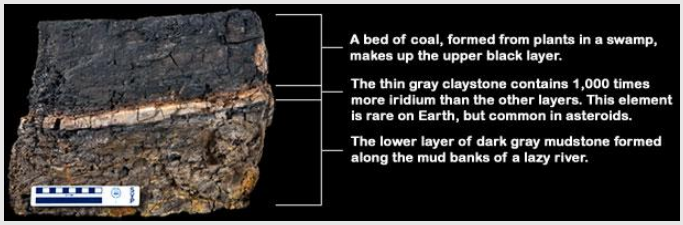
1. A large (180km diameter) crater at the **Yucatan Peninsula, Mexico**: parti**ally buried and partially covered** by the sea this crater was discovered by geophysical survey techniques.



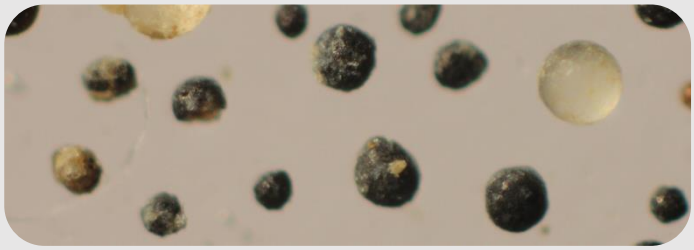
Gravity anomaly map of the Chicxulub impact structure. The coastline is shown as a white line. A striking series of concentric features reveals the location of the crater. White dots represent water-filled sinkholes (solution-collapse features common in the limestone rocks of the region) called *cenotes* after the Maya word *dzonot*. A dramatic ring of cenotes is associated with the largest peripheral gravity-gradient feature. The origin of the cenote ring remains uncertain, although the link to the underlying buried crater seems clear.

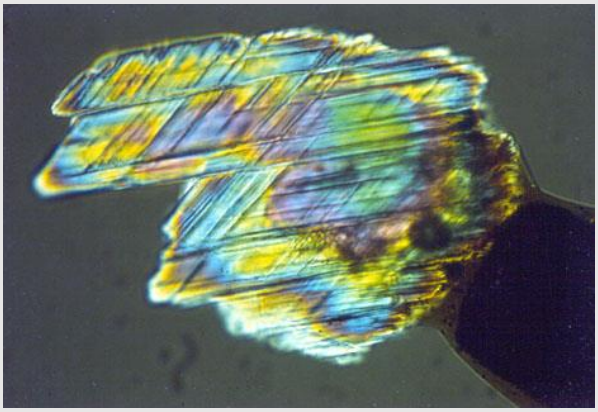
2. **Iridium spi**ke found in the **boundary clay**, this deposit hosts the **trace element iridium** in concentrations orders of magnitudes **higher than background levels**. Iridium mainly comes from space.





3. **Shocked quartz** grains are quartz grains exposed to **extremely high pressures (5-10 GPa)** and are exposed **at the surface and** found **in sediments** at the **boundary layer.**





4. The presence of **Tektites** found near the impact crater, these are **debris** from the **host rock**, that has been **melt-reprocessed on collision with the surface.** They have such **low water content t**hat it suggests they did **not form on Earth.** Also known as **impact melt breccia**, suggestive of a **high velocity, large-scale impact.**

5. **Sedimentary evidence in Texas of a large-scale tsunami that dates to this time.**

Originally proposed by a team of scientists led by Luis Alvarez, it is now generally believed that the **K-T extinction** was triggered by a **massive asteroid impa**ct and its **catastrophic effects on the global climate**, including a **lingering impact winter** that made it impossible for **plants and plankton** to carry out **photosynthesis.**

The impact hypothesis was bolstered by the discovery of the **180-kilometre-wide Chicxulub** crater in the Gulf of Mexico in the early 1990s. This provided conclusive evidence that the K-**T boundary clay** represented debris from **an asteroid impact.** Moreover, the K-T extinction event occurred at the **same time as the impact** and **boundary layer** so the asteroid impact is likely the **cause of the extinction**.

*Some scientists, however, maintain the extinction was caused or exacerbated by other factors, such as **volcanic eruptions, climate change, or sea level change,** separately or together.*

- **Iridium** is a transition element, rare on Earth, but found in meteorites. Luis Alvarez (1980) first proposed this as evidence that a giant object hit the Earth.
- **Shocked quartz** is grains of that have characteristics of a material deformed under high pressure. It was first discovered at nuclear testing sites and has been linked to meteors.
- **Tektites** are spheres or irregular lumps of molten rock, a few centimetres in diameter, black or green in colour. They are thought to have formed due to extremely high temperatures and pressures.
- **Tetrapod** is a four-limbed vertebrate**.**
- A tsunami is a massive wave formed either due to an underwater earthquake or meteorite impact.
- **Traps** are formed by large-scale volcanism that resulted in the formation of dark-coloured igneous rocks (mafic)

Evidence that supports an alternative hypothesis → Mass flood basalt volcanism

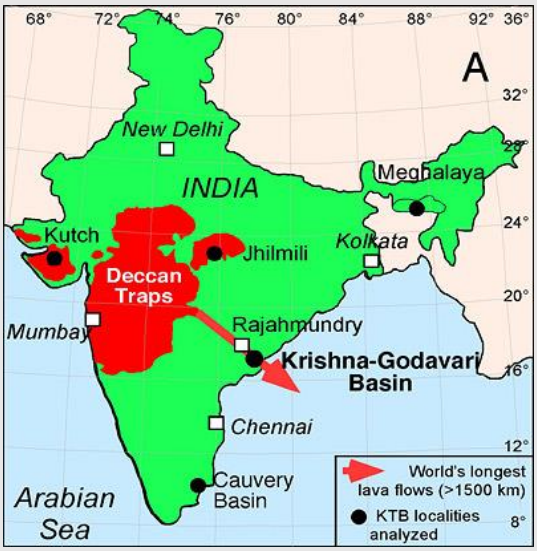
The **Deccan Traps** correlate to approximately the time of the **K-T event**. There was an **extensive outpouring** of **basaltic lavas** on the order of **500, 000 km^2.**

The enormous eruptions took place **in India over about 30,000 years long**. The effect of this volcanism was probably devastating:

- The emission of **poisonous gases would kill** many plants and animals in close proximity.
- The **gases and ash particles** emitted during the eruption could have initially resulted in a **decrease in global temperatures**. They act as **particulates** which **block and reflect the sun's** rays from reaching Earth's surface. This would resultantly **kill photosynthesizing** species such as **vegetation, plankton** and

algae. Global temperatures would reduce and glaciation would occur causing sea levels to fall. The cooling event would have lasted for hundreds to thousands of years.

- In the long-term, the increased emissions of **carbon dioxide and sulfur dioxide** could have caused an **increase in global temperatures**, causing **oceans to release furthermore carbon dioxide**. These are greenhouse gases that absorb energy from infrared radiation produced by the reflection of the sun's radiation from the Earth's surface. After the cooling event caused by the particulates had ceased, the global warming effect would have lasted for thousands to millions of years.
- **Basalt lava flows** would have destroyed vegetation and terrestrial, land animals.



A wide range of species went extinct in the **K-T extinction** event. The most well-known victims are non-avian dinosaurs. However, the extinction also destroyed a variety of other terrestrial organisms. The devastation caused by the extinction provided an **evolutionary opportunity**, as in the wake of the extinction, many groups underwent **adaptive radiations** – sudden and prolific divergence into **new forms and species** within the **distributed ecological niches r**esulted from the event.

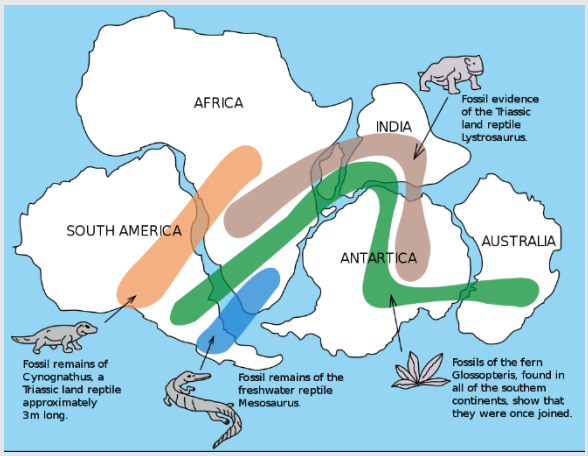
PERMO-TRIASSIC MASS EXTINCTION 251MA

This was the largest in all of geological history. It marked the end of the Palaeozoic Era although the event was not abrupt, species gradually declined over several million years.

Around 95% of **Marine invertebrates** became extinct. This included, **trilobites, tabulate and rugose corals, many brachiopod**s, echinoids. Other groups like **foraminifera and cephalopods** (many ammonoids) were greatly reduced.

On land, 50% of tetrapods and lots of vegetation/**plants died**. **Large amphibians** and **some insects** became extinct indicating a truly global event.

Evidence that a supercontinent forming was responsible



Supercontinent formation – at the end of the Permian, **Pangaea** was formed when all the world's continents collided together. Evidence that supports this large landmass comes from **plate reconstructions and the stratigraphic record.** The presence of the landmass had several effects:

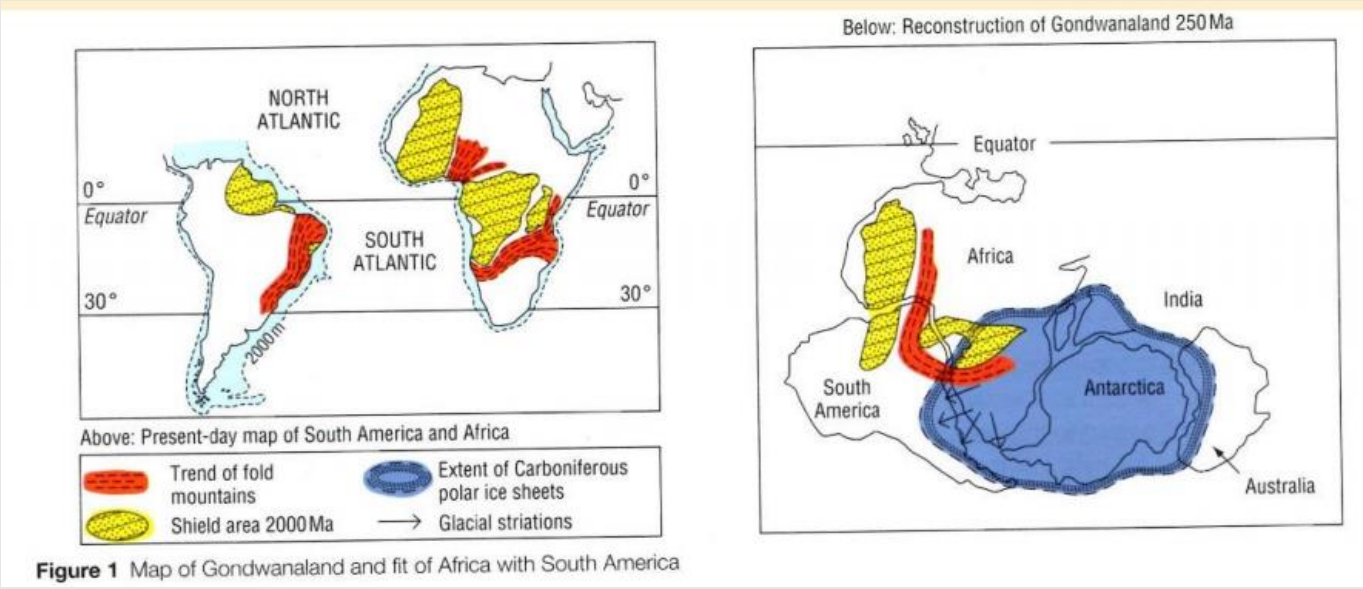


Figure 1 Map of Gondwanaland and fit of Africa with South America

1. There were **fewer continental shelves** and so there was a **lack of habitat for shallow marine dwellers**. This is backed up by evidence that shows a **massive decline in shallow marine species**.
2. Presence of a single continent caused rapid **fluctuations in climate** and **unstable weather patterns**.
3. **A single continent** reduces the **input of nutrients and sediments** from **rivers and estuaries** into the oceans. This decreases the number of nutrients available for **shallow marine life** and may **alter salinity** of the oceans.
4. **Widespread glaciations** occurred in the **southern hemisphere** (Australia, South Africa, South America and Antarctica). This caused the sea level to fall (**regression)**, **reducing shallow shelf environments**.

Major volcanic activity (Siberian Traps)

This is believed to have been the **largest volcanic eruption** in the history of Earth. The volcanic rocks are largely **flood basalts**, thought to be from a **very large mantle plume intersecting the surface**.

The volcanic rocks today cover an area larger than two million km^2. The eruptions lasted for roughly 1 million years.

1. The **emission of poisonous gases** would kill many plants and animals in **close proximity**.
2. The **gases and ash particles** emitted during the eruption could have initially resulted in a **decrease in global temperatures**. They act **as particulates** which block and reflect the sun's rays from reaching Earth's surface. This would resultantly kill photosynthesizing species such as vegetation, plankton and algae. Global temperatures would reduce and **glaciation would occur** causing **sea levels to fall. The** cooling event would have lasted for hundreds to thousands of years.

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Methane hydrates (methane ice)

This is a **solid form of methane** that remains as a **stable soli**d within sediments up to **around 18^{0}C**. The **global increase in temperature and the end-Permian** is thought to have triggered the **release of methane hydrates** from the seabed as they become **mobile and gaseous**. This could have **disrupted life in the seas** and increased the **greenhouse gases** in the atmosphere.

Summary

It is impossible to assess the real nature of any mass extinction as the fossil record is biased and such a small number of organisms are preserved.