Department of Botany
Suri Vidyasagar College
Suri, Birbhum, WB
Study material for Sem-IV class
Dated: 20.04.2024 Teacher: SA sir

Geological Time Scale

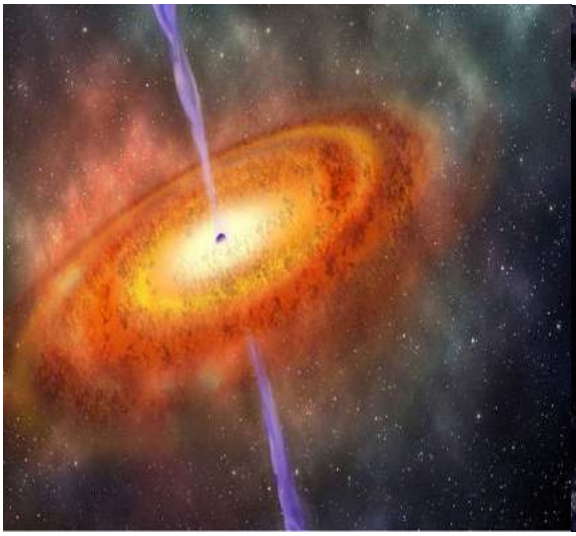
The geological time scale is a method of relating the timing and relationship between events that have occurred during the history of the Earth. This chart shows the sequence of major evolutionary events that appear in the geologic record. The first geologic time scale that included absolute dates was published in 1913 by British geologist **Arthur Holmes**.

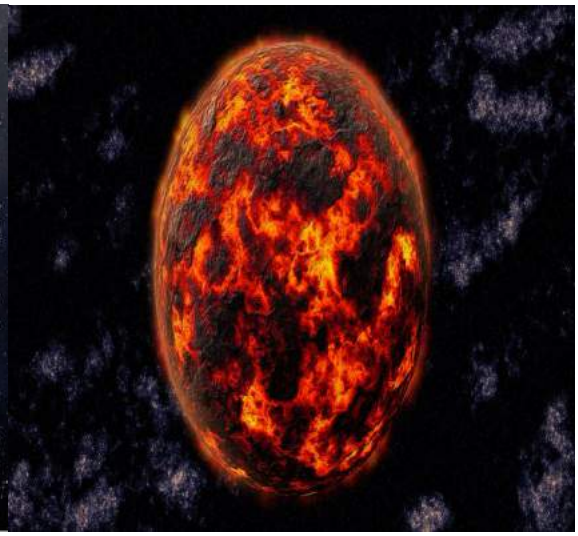
Eon		Era	Period	Epoch	Starting Age(MYA)	Major events
Phanerozoic (The Eon of Visible Life)		**Coenozoic** (The Era of Angiosperms)	Quaternary	Holocene	0.01	Historic time
				Pleistocene	2.5	Ice age, Appearance of humans
			Neogene	Pliocene	5	
				Miocene	23	
			Paleogene	Oligocene	34	
				Eocene	56	
				Palaeocene	65	
		Mesozoic (The Era of Gymnosperms)	Cretaceous		145	Origin of Angiosperms
			Jurassic		199	Gymnosperms dominant
			Triassic		251	
		Palaeozoic (The Era of Pteridophytes)	Permian		299	Major Extinction
			Carboniferous		359	Seed ferns, Trees
			Devonian		416	Dominance of Pteridophytes
			Silurian		444	Earliest records of vascular plants
			Ordovician		488	Bryophytes appear
			Cambrian		542	
PRECAMBRIAN	Proterozoic				2500	Eukaryotic multicelullar Life(***Grypania spiralis***) begins; Oxygen begins accumulating in atmosphere
	Archean				4000	Oldest rocks; Oldest prokaryotic fossils(**Stromatolites**); Earth crust forms
	Hadean				4600	Earth forms

MYA= Million Years Ago

1 Million = 10,00,000

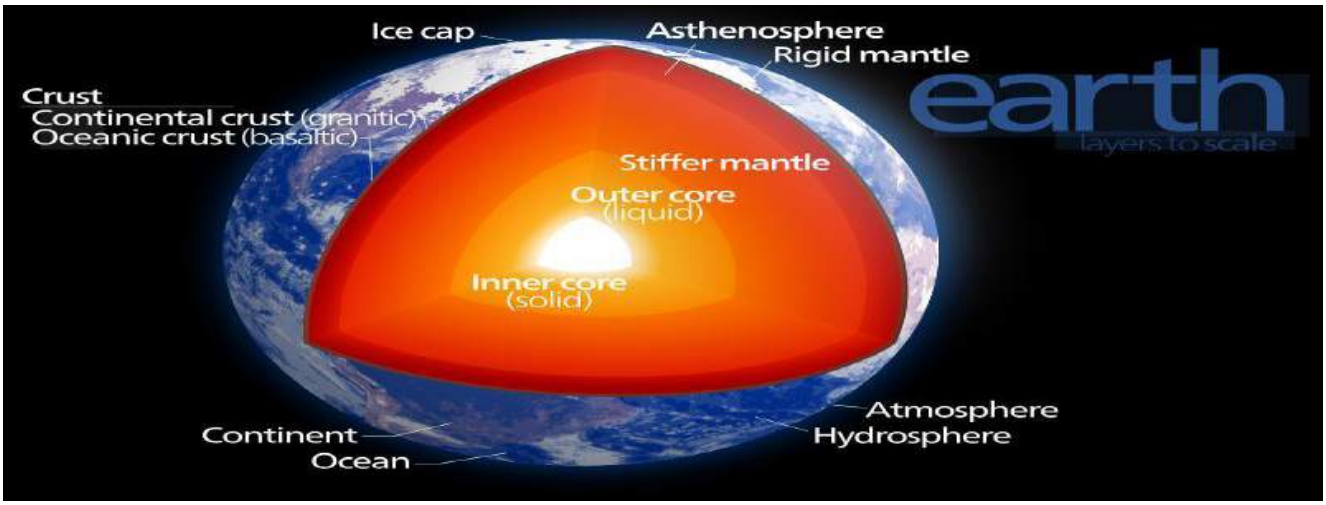
Hadean Eon (4600-4000mya)





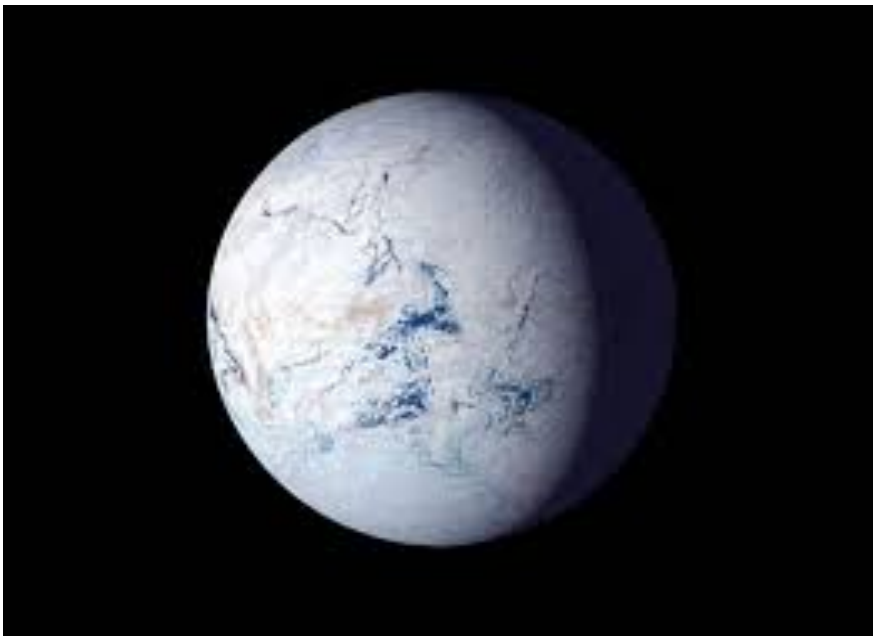
- Birth of planet Earth: Big Bang Theory
- Solar system (Accretion disk) formation
- Large cloud of gas & dust around sun

Archean Eon (4000-2500mya)



❖ Earth crust formation due to gradual cooling ❖ Formation of continents ❖ Stromatolites :The Earliest fossil identified dated 3.5 bya	❖ **Stromatolites,** the sedimendary rock formed by **cyanobacteria,** photosynthetic prokaryotes. ❖ Earliest oxygen.	**Challenges:** UV rays (UV-B ray damaging DNA& PS-II system) **Remedy:** Phenolic compounds (flavonoids) synthesized to shield DNA from UV-B ray Ozone layer formation

Proterozoic Eon (2500-542mya)



1.Palaeoproterozoic Era:	2.Meso-protrerozoic Era:	3.Neo-proterozoic Era:
2.5-1.6 billion ➢ Atmospheric oxygen. ➢ **Oxygen catastrophe-** The majority of anaerobic life on earth died around this time due to sudden development of free oxygen. ➢ The starting of formation of **multicelllular organisms.**	1.6-1billion ➢ Dominance of Stromatolites ➢ Oxygen levels had risen to **1 % of today's O_2 level.**	1billion- 542Million ➢ The most severe glaciation "**Snowball Earth**" formed when even the equator region was under snow. ➢ The earliest fossils of multicellular life. ➢ Decline of Stromatolites. ➢ Average global temperature was slightly **cooler (12C)** than today's(14C).

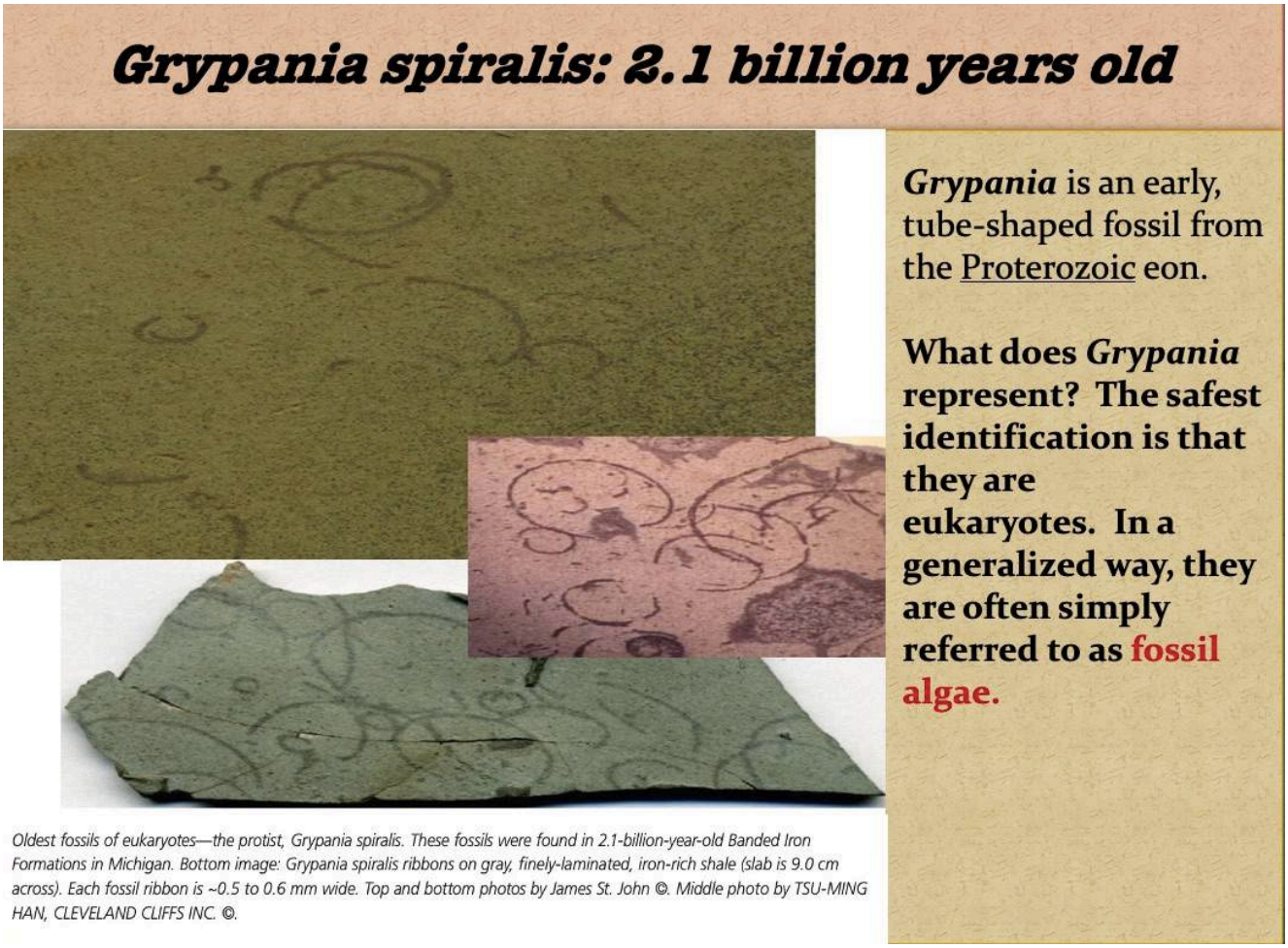
First eukaryotic fossil alga

The oldest eukaryotic body fossil is the **multicellular alga**, ***Grypania spiralis.***

Coiled ***Grypania*** is found as thin films of carbon in the **2.1 billion-year-old** Negaunee iron formation at the Empire Mine near Ishpeming, Michigan,USA.

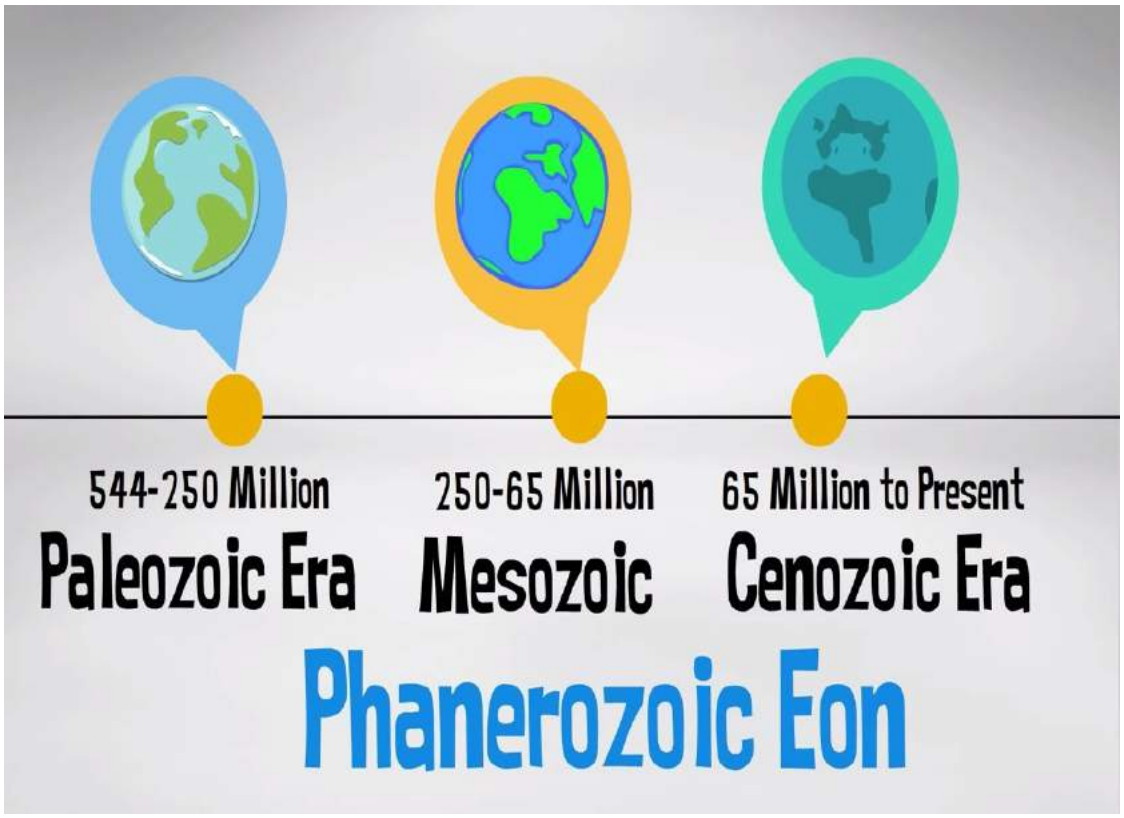
The fossils are coiled forms of marine life that, if unwound, would stretch up to 9 cm (3.54 inches). Young specimens have been recovered from **1.1-billion-year-old rocks in China**.

Grypania is a **photosynthetic eukaryotic algae** that both produces and requires oxygen to function. Its discovery in 2.1-billion-year-old rock means that by then, oxygen must have been present in the atmosphere in concentrations high enough to support oxygen-using organisms.



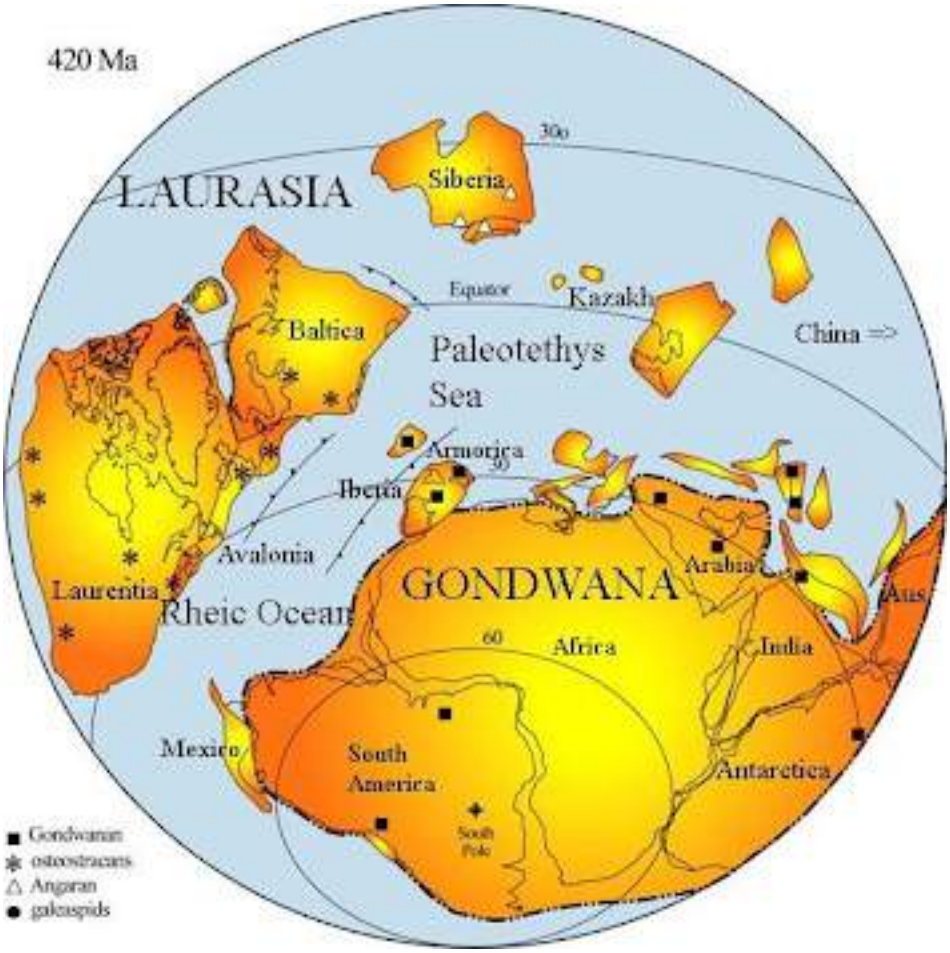
Pre-Cambrian Time: Hadean, Archean & Proterozoic eon:- These three eons collectively called Pre-cambrian age.

- **The time between the birth of the planet and the appearance of complex forms of life is known as Pre-cambrian**
- **More than 80% of earth's geologic time falls within this.**



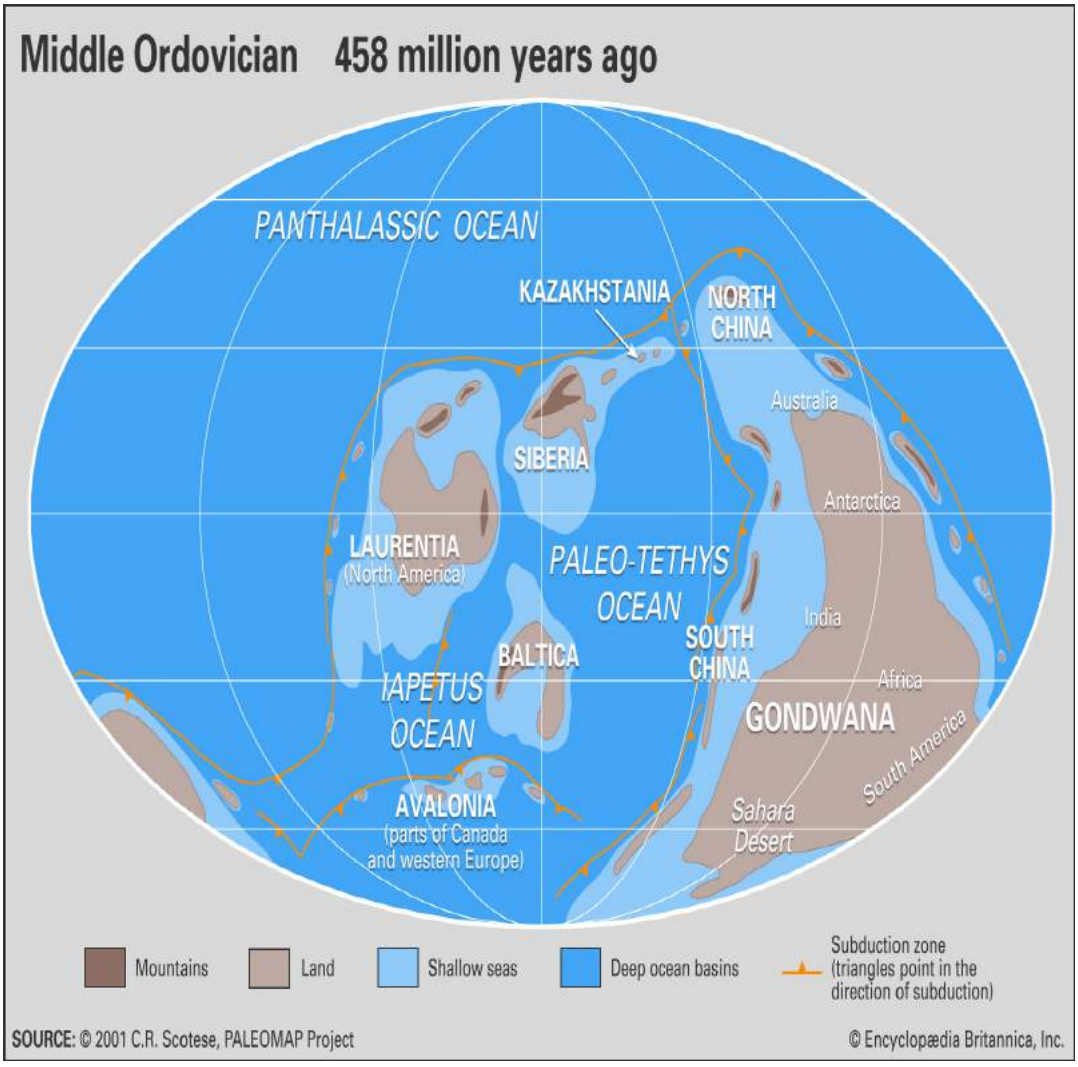
Era	Period	Starting age (MYA)	Major event
Paleozoic	**Permian**	**299**	3rd & Deadliest mass extinction
	Carboniferous	**359**	Glaciation
	Devonian	**416**	Dominance of Pteridophytes
	Silurian	**444**	First vascular land plant
	Ordovician	**488**	Bryophytes appear
	Cambrian	**542**	Warm atmosphere

Cambrian Period (542-488mya)



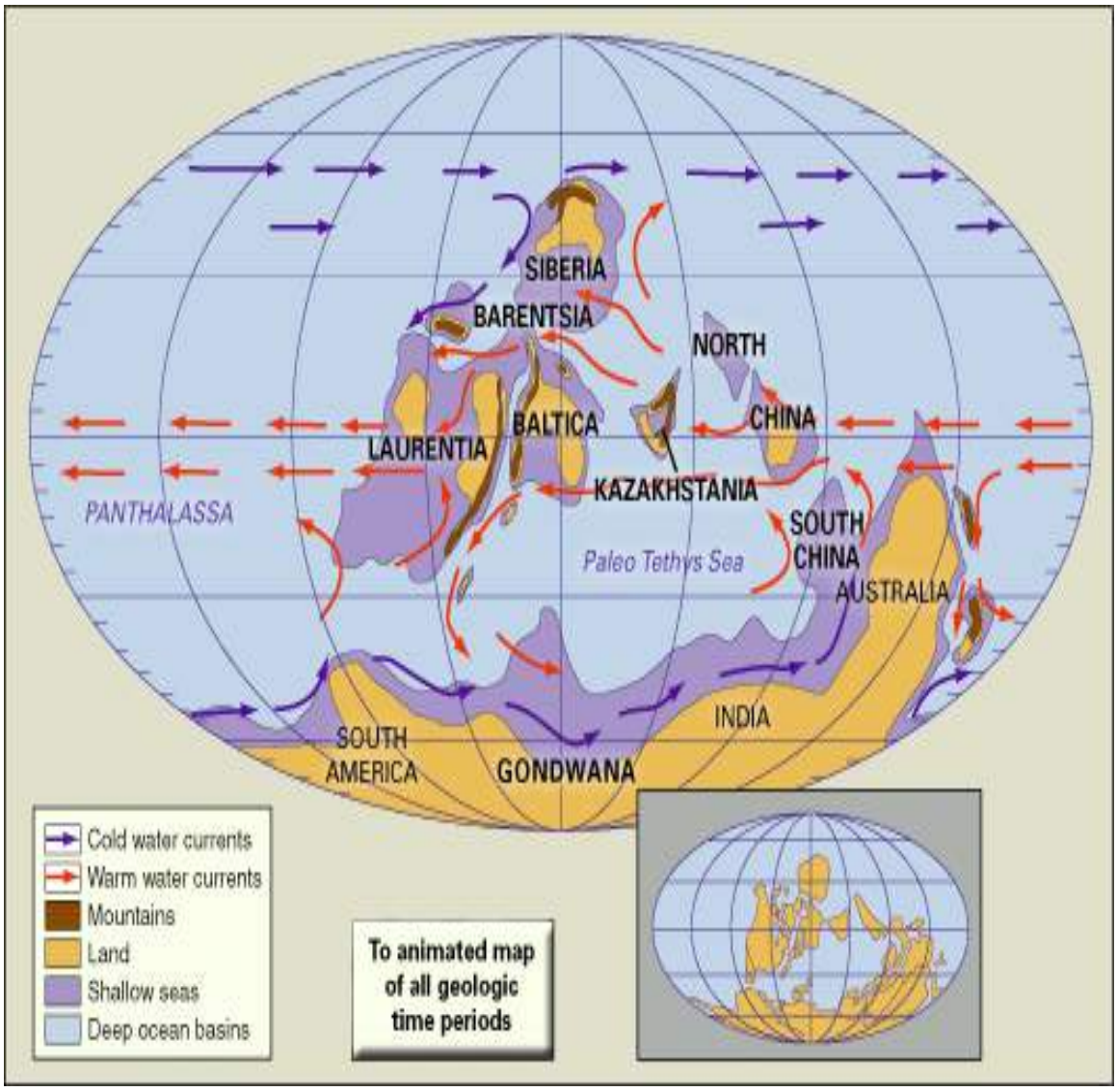
- **Cambrian:** The highest concentrations of CO2 during all of the Paleozoic era occurred during the Cambrian period, nearly **7000ppm** which is about 18 times higher than today (412ppm).
- **Average global temperature** was warmer**(22^0C)** than today's(14^0C).

Ordovician Period (488-444mya)



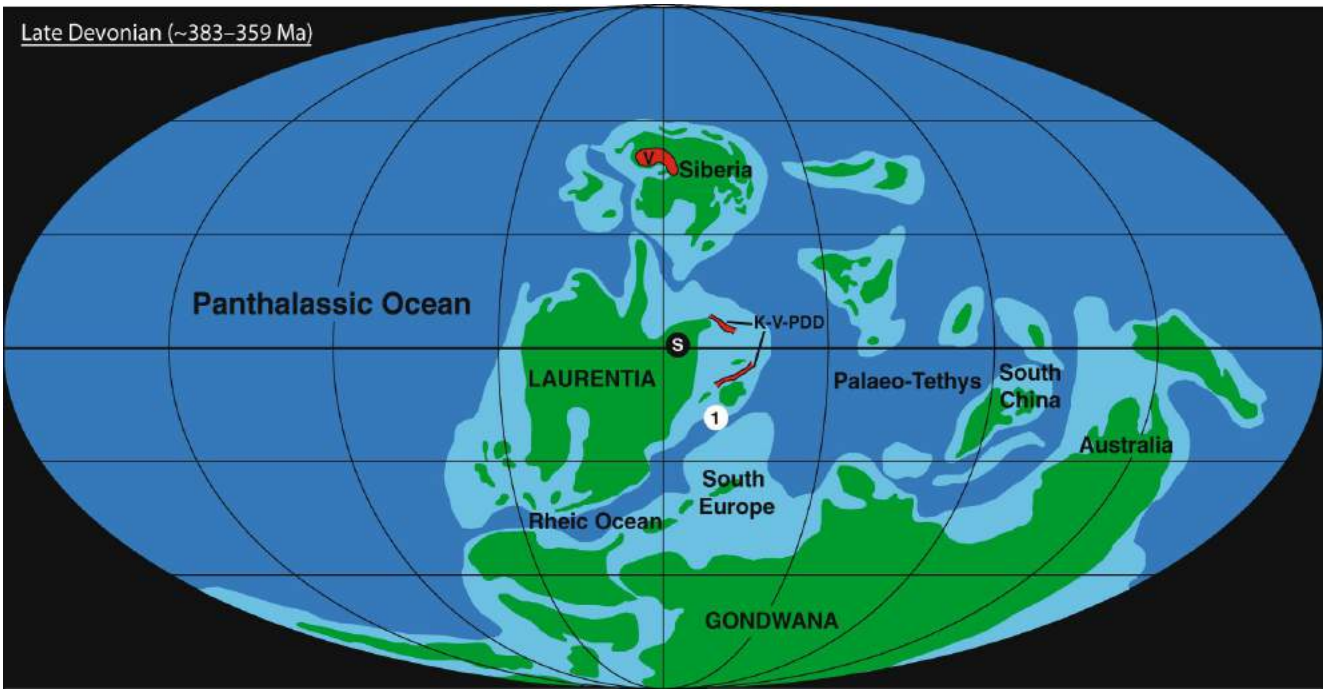
- **Appearance of Bryophytes**
- Land surface was colonized by bryophyte-like plants as evidenced by the presence of fossil spores & cuticles.
- **Plants invaded moist land surfaces**
- **Ordovician:** Origin of embryophytes. The first bryophytes (liverworts) appeared about 450 mya. First nonvascular land plants. Spores are arranged in permanent tetrads.
- ***Naiadita Lanceolata*** , the best known bryophyte fossil from **Upper Triassic**.

Silurian Period (444-416mya)



- **Appearance of vascular land plants**
- ***Cooksonia***, the first vascular land plant

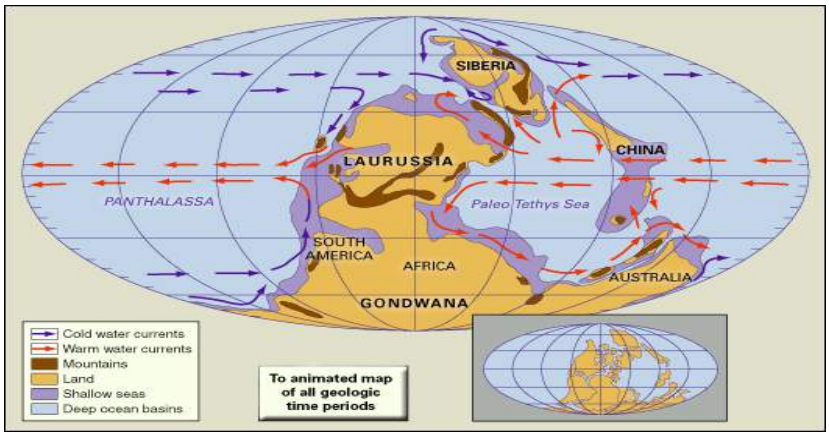
Devonian Period (416-359mya)



- **Dominance of Pteridophytes**
- **Devonian**: Dominance of Pteridophytes. Plants invaded upland areas around 380 mya with well developed root system.
- CO2 levels dropped to **400ppm**.
- Some examples of Devonian fossils:

  i) ***Leclercqia***, the earliest (middle Devonian) fossil lycopsid which shows ligule.
  ii) ***Archaeopteris***, a fossil progymnosperm of late Devonian
  iii) ***Rhynia***, a Devonian vascular plant
  iv) ***Psilophyton***, a Devonian vascular plant

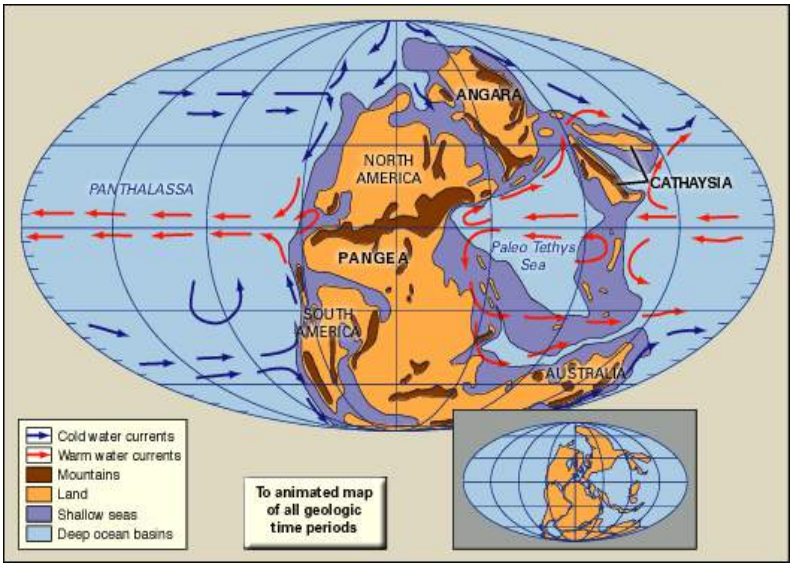
Carboniferous Period (359-299mya)



- Permo-Carboniferous glaciations during 350-260 mya.
- Starting of Formation of **Pangaea supercontitent**(323 million).
- **1.Mississippian** sub-period: 359- 323 Million
- **2.Pennsylvanian** sub-period:323-299 Million
- Some examples of Carboniferous fossils:

  i) ***Lepidodendron***, an arborescent lycopsid
  ii) ***Calamites***, an arborescent horsetail
  iii) ***Lyginopteris***, a seed fern stem

Permian Period (299-251mya)

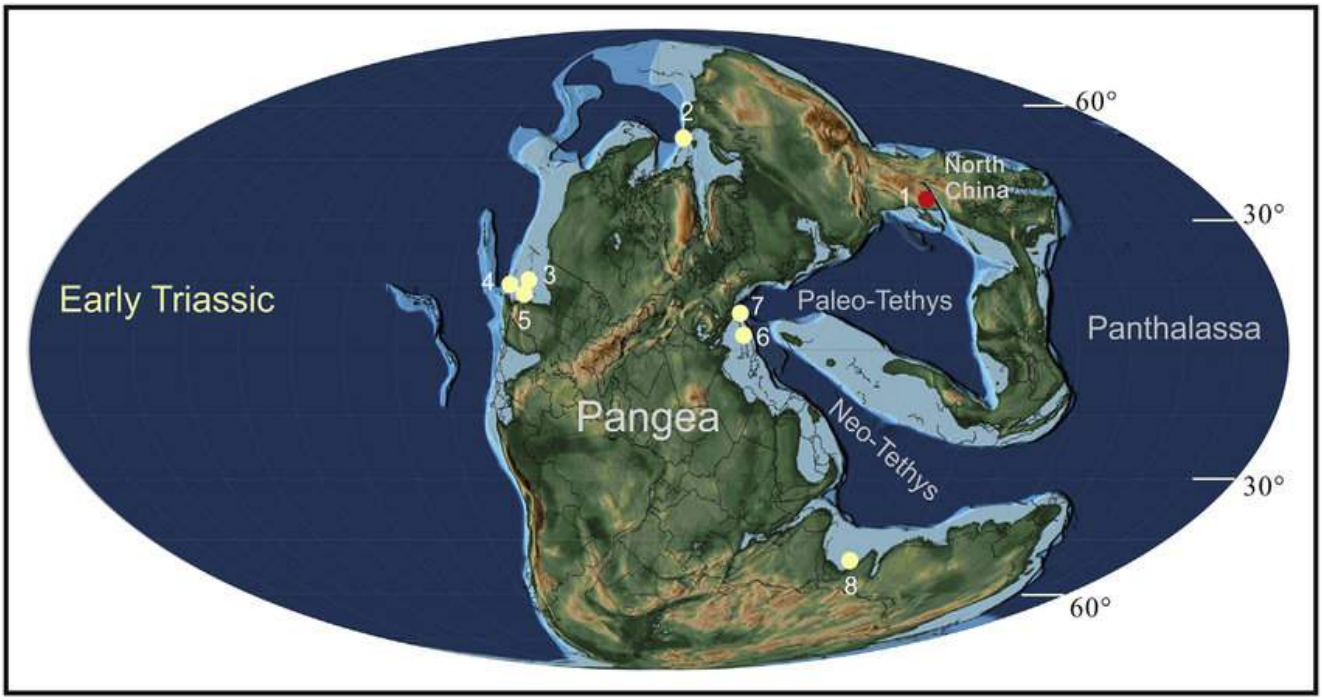


- ❑ Fully formed Pangaea supercontinent
- ❑ Permo-Carboniferous glaciation ends
- ❑ 3rd & Deadliest mass extinction event; 96% species wiped out.
- ❑ Some examples of Carboniferous fossils:

  i) ***Glossopteris***, an extinct seed fern leaves of Permian period

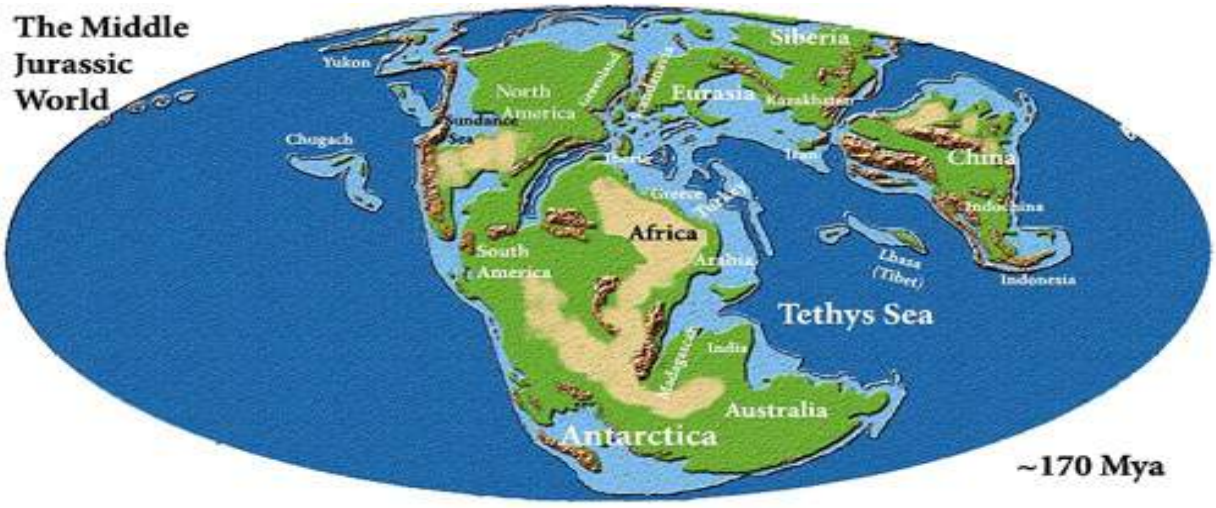
Era	Period	Starting age (MYA)	Major event
Mesozoic	**Cretaceous**	**145**	Origin of Angiosperms
	Jurassic	**199**	Dominance of Dinosaurs & Gymnosperms
	Triassic	**251**	Dinosaurs appear

Triassic Period (251-199mya)



- **Pangea begins to break up**
- **Early mammals**
- **First Dinosaurs**

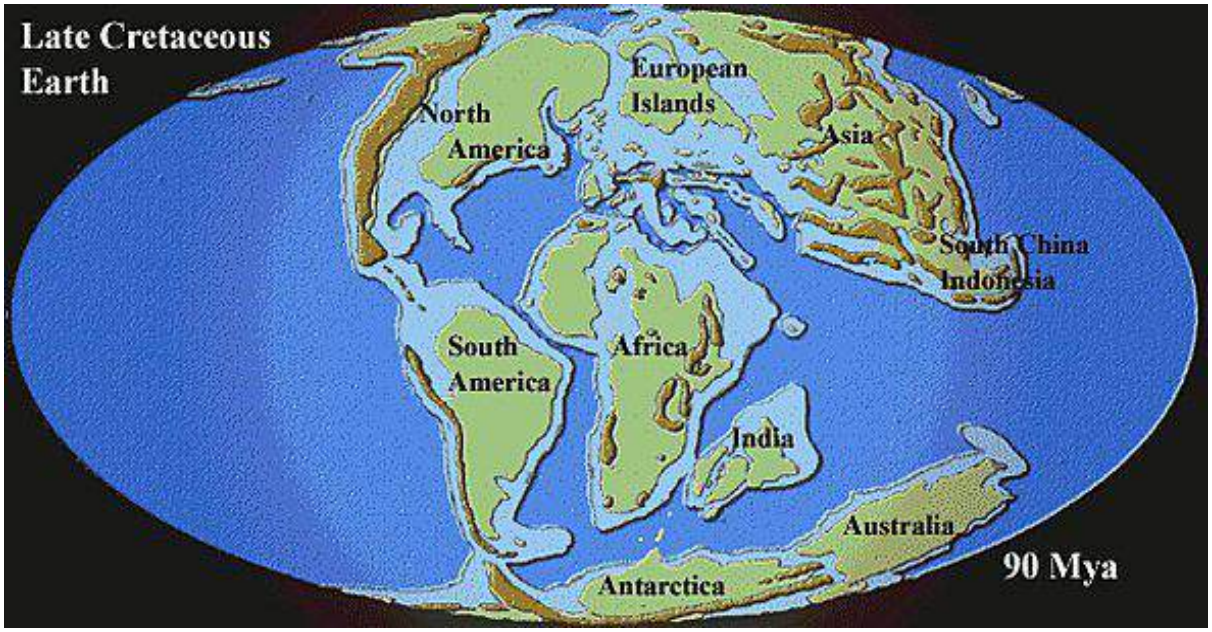
Jurassic Period (199-145mya)



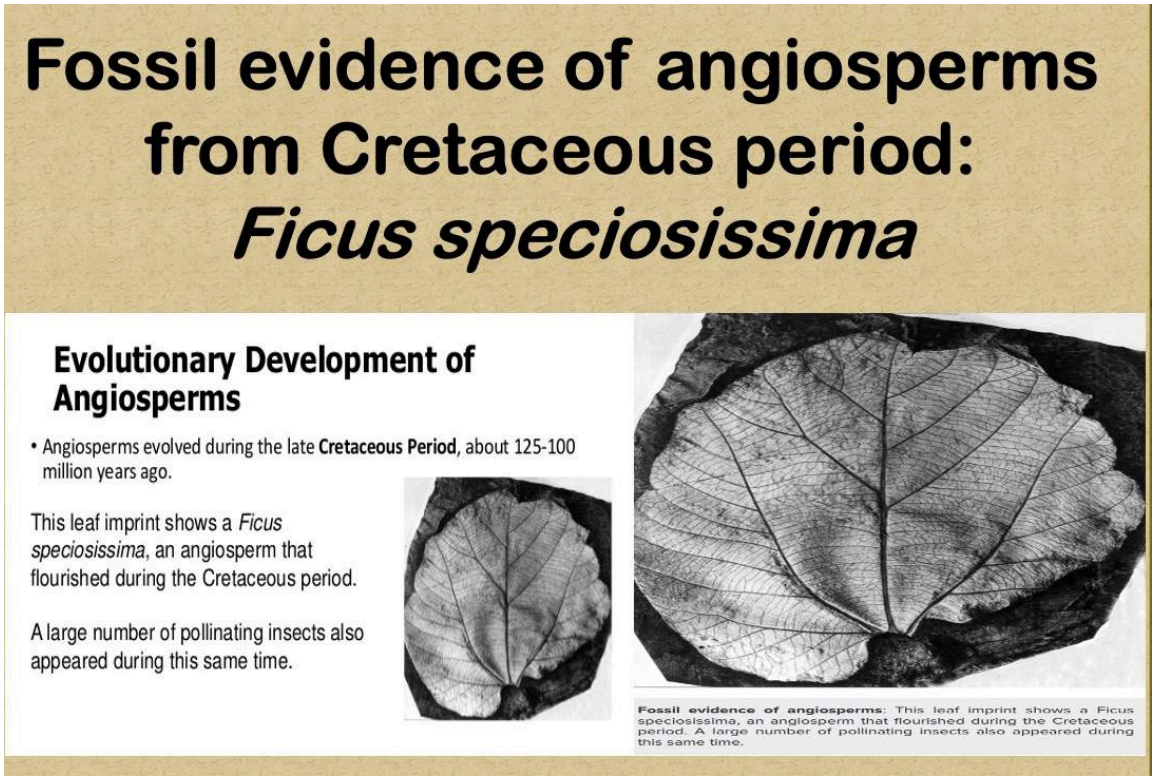
- **Dinosaurs dominant**
- **Gymnosperms dominant**
- First birds
- Some examples of abundant Jurassic gymnospermic fossils:

  i) ***Cycadeoidea***, an extinct genus of Bennettitalean plant
  ii) ***Williamsonia***, a Bennettitalean female flower
  iii) ***Weltrichia***, a Bennettitalean male flower
  iv) ***Bucklandia***, a Bennettitalean stem
  v) ***Ptilophyllum***, a Bennettitalean leaf

Cretaceous Period (145-65mya)



- Extinction of Dinosaurs
- First flowering plant; thus, Angiosperms appear.



Monocot fossil of palm stem from Cretaceous peroid: *Palmoxylon cheyennense*

Slab of fossil palm "wood." Transverse section of a portion of a fossil palm stem (*Palmoxylon cheyennense*, Cretaceous, Pierre Shale, South Dakota, U.S.A.). Note that palms and other "woody" monocots do not produce true wood. The dots in the palm stem are vascular bundles with associated bundle caps made up of fibers (compare to the cross section of the corn stem shown above). Credit: Model by Emily Hauf (Digital Atlas of Ancient Life, via Sketchfab, CC BY-SA 4.0).

Coenozoic Era

Era	Period	Epoch	Starting Age(MYA)	Major events
Coenozoic (The Era of Angiosperms)	Quaternary	Holocene	0.01	Historic time
		Pleistocene	2.5	Ice age, Appearance of humans
	Neogene	Pliocene	5	
		Miocene	23	
	Paleogene	Oligocene	34	
		Eocene	56	
		Palaeocene	65	

Big Five Mass Extinctions of Phanerozoic Eon:

1.Ordovician Mass Extinction

Duration:455-430mya; 85% marine species wiped out; This was the first extinction event of the big five.

2.Devonian Mass Extinction

Duration:375mya; 75% species wiped out

3.Permian Mass Extinction:

Duration:252.2-251mya; Severest; 96% species of life wiped out; Great Dying

4.Triassic Mass Extinction

Duration:200mya; 80% species wiped out

5.Cretaceous Mass Extinction

Duration:65.5-65mya; Dinosaurs wiped out; 76% species lost

Causes of Mass Extinctions:

- Climate change
- Asteroid impacts
- Massive Volcanic eruptions
- Combination of all these

--------Thank You-------