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# Geological Time Scale: A Window To Spatiotemporal Episodes In The History Of The Earth

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***Abstract:***
*Geological time scale is an attempt to put the past geological events in an order. The present article aims at achieving this order with the correlation of this interdependent events in the past. Subjective explanation of the correlations of interdependent and interrelated events may become lengthy and quite descriptive. All these events on the Earth are put forward in a framework of structural outline, in correspondence to the geological age and age in million years to portray a clear picture of this complex phenomena.*
***Key Word****: Time scale ; interdependent events ; structural framework ; geological age ; portray.*

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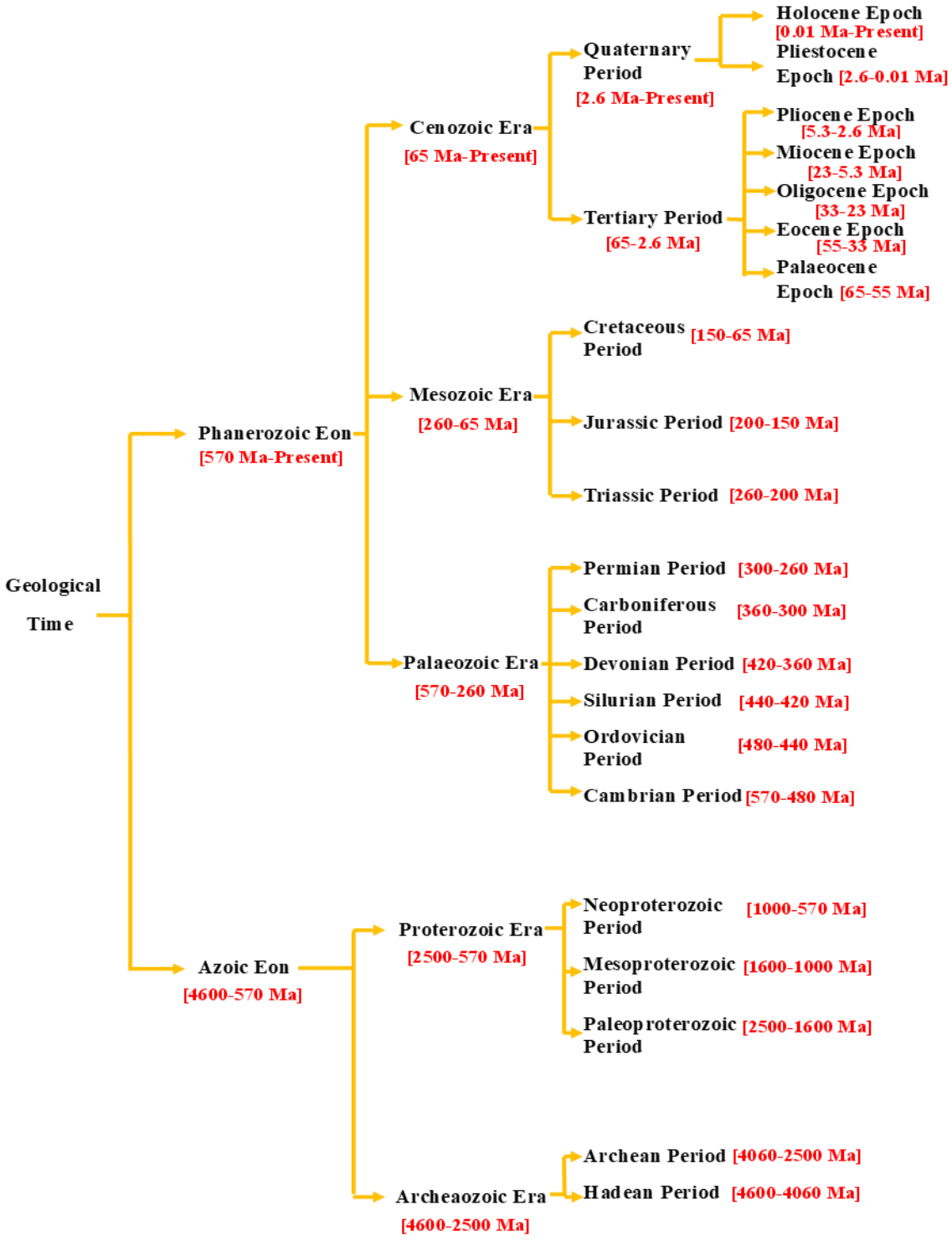
## I. Introduction

Nicolaus Steno (1638-1686) introduced basic principles of stratigraphy, the study of layered rocks. By noting the relationships of different rock units, he described two basic geologic principles. He first stated that sedimentary rocks are laid down in a horizontal manner, and the second stated that younger rock units were deposited on top of older rock units. The geologic time scale is the "calendar" for events in Earth history. It subdivides time lapsed in the history of the Earth into named units of abstract time called—in descending order of duration—eons, eras, periods, epochs, and ages.

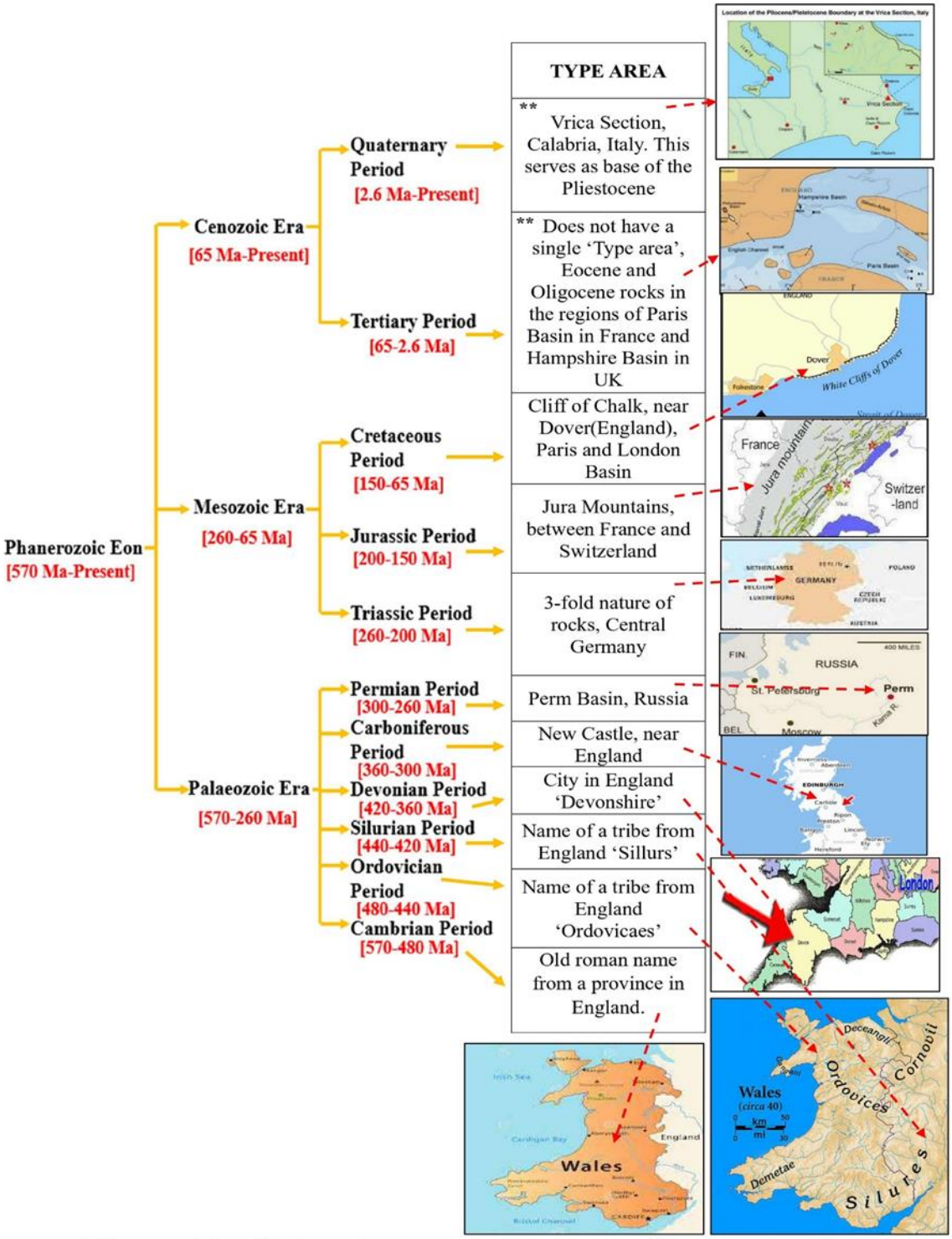
The enumeration of these geologic time units is based on stratigraphy, which is the correlation and classification of rock strata. One of the most widely used standard charts showing the relationships between the various intervals of geologic time is the International Chronostratigraphic Chart, which is maintained by the International Commission on Stratigraphy (ICS).

## II. Classification of Geological Time

| Geological Time Scale | | | |
|---|---|---|---|
| **Eon** | **Era** | **Period** | **Epoch** |
| **Phanerozoic** | **Cenozoic** | **Quaternary** | **Holocene** |
| | | 0.01 MY | **Pliestocene** |
| | | 2.6 MY | **Pliocene** |
| | | **Tertiary** | 5.3 MY **Miocene** |
| | | | 23 MY **Oligocene** |
| | | | 33 MY **Eocene** |
| | | | 55 MY **Palaeocene** |
| | 65 MY **Mesozoic** | **Cretaceous** | |
| | | 150 MY **Jurassic** | |
| | | 200 MY **Triassic** | |
| | 260 MY **Palaeozoic** | **Permian** | |
| | | 300 MY **Carboniferous** | |
| | | 360 MY **Devonian** | |
| | | 420 MY **Silurian** | |
| | | 440 MY **Ordovician** | |
| | | 480 MY **Cambrian** | |
| 570 MY **Azoic** | **Proterozoic** | **Neoproterozoic** | |
| | | 1000 MY **Mesoproterozoic** | |
| | | 1600 MY **Palaeoproterozoic** | |
| | 2500 MY **Archeaozoic** | **Archean** | |
| | | 4060 MY **Hadean** | |

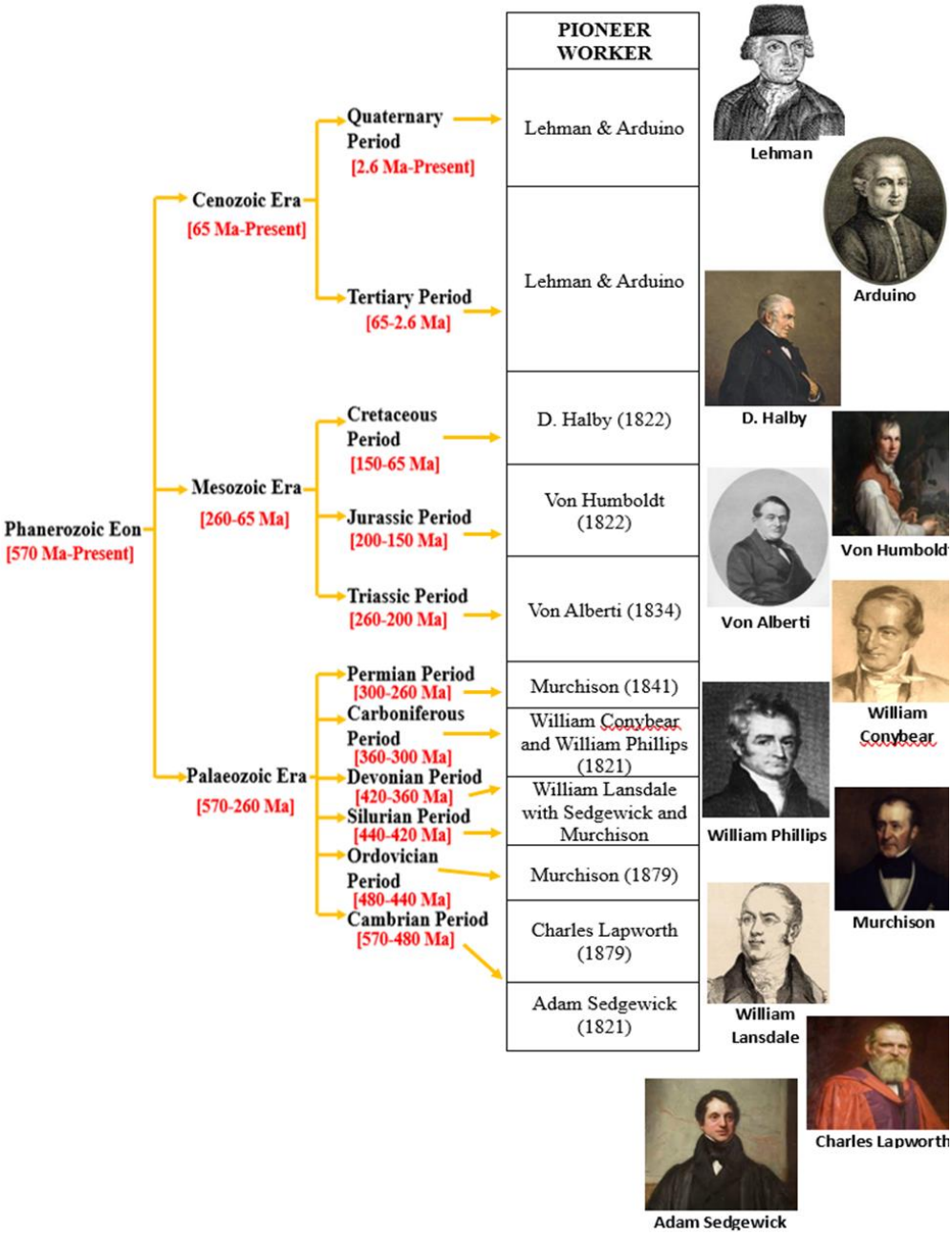

Geological Time
Phanerozoic Eon [570 Ma-Present]
Azoic Eon [4600-570 Ma]
Cenozoic Era [65 Ma-Present]
Mesozoic Era [260-65 Ma]
Palaeozoic Era [570-260 Ma]
Proterozoic Era [2500-570 Ma]
Archeaozoic Era [4600-2500 Ma]
Quaternary Period [2.6 Ma-Present]
Tertiary Period [65-2.6 Ma]
Holocene Epoch [0.01 Ma-Present]
Pliestocene Epoch [2.6-0.01 Ma]
Pliocene Epoch [5.3-2.6 Ma]
Miocene Epoch [23-5.3 Ma]
Oligocene Epoch [33-23 Ma]
Eocene Epoch [55-33 Ma]
Palaeocene Epoch [65-55 Ma]
Cretaceous Period [150-65 Ma]
Jurassic Period [200-150 Ma]
Triassic Period [260-200 Ma]
Permian Period [300-260 Ma]
Carboniferous Period [360-300 Ma]
Devonian Period [420-360 Ma]
Silurian Period [440-420 Ma]
Ordovician Period [480-440 Ma]
Cambrian Period [570-480 Ma]
Neoproterozoic Period [1000-570 Ma]
Mesoproterozoic Period [1600-1000 Ma]
Paleoproterozoic Period [2500-1600 Ma]
Archean Period [4060-2500 Ma]
Hadean Period [4600-4060 Ma]

## III. Type Area To Deduce Periods In Geological Time Scale




****The nomenclature of tertiary and quaternary is not based on rocks of type area or place of type area but these terminologies are assigned in geological time scale on the basis of time fractions of the period.**

## IV. Pioneer Workers For Denoting Periods In Geological Time Scale




## V. Geological Time Scale And Palaeogeography

What was there before Pangea:-

A number of studies have been carried out on this topic, but the authors are of the opinion that paleogeographical reconstruction of continents cannot be confined to the brackets of geological time periods due to lack of conclusive robust data but the reconstruction of supercontinents from late Archean to Pre Pangea according to Condie has been illustrated in the table given below.

- Continental drift might have also been existed in the times of earlier to Triassic too, but since not much evidences are found, we can only predict the existence of Continents.
- Evidences showing Pre-Triassic drifts are: -
- The orogenies formed such as Caledonian Orogeny, Algoman Orogeny, Pan-African Orogeny, etc. are a result of continental collision.
- As Earth's magnetic field changes orientation over geologic time, magnetic signatures recorded in magnetized grains in some rocks allow geoscientists to retrace the movements of continents.
- Sedimentation in proto-geosynclines on the margins of continents.

What happened after breakup of Pangea: -

- Continental Drift: - Wegener's **continental drift** hypothesis stated that the continents had once been joined to form a single supercontinent.

Wegener proposed that the supercontinent, **Pangaea,** began to break apart 200 million years ago '**Post Triassic'** and form the present landmasses.

Continental drift was originally proposed by Alfred Wegener, a German meteorologist, in 1912.

- **Wegener's Post Triassic Continental Drift idea** was supported by:

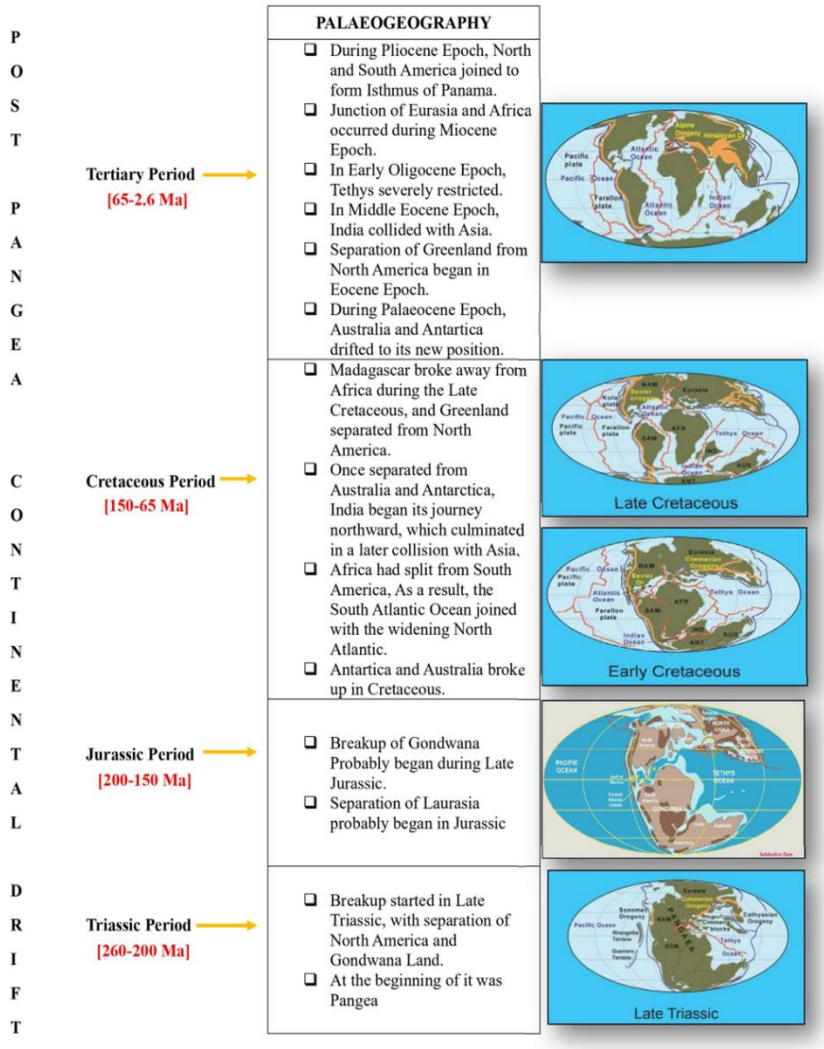
o the fit of the continents
o the distribution of fossils
o a similar sequence of rocks at numerous locations
o ancient climates
o Glacial evidence
o the apparent wandering of the Earth's pole.

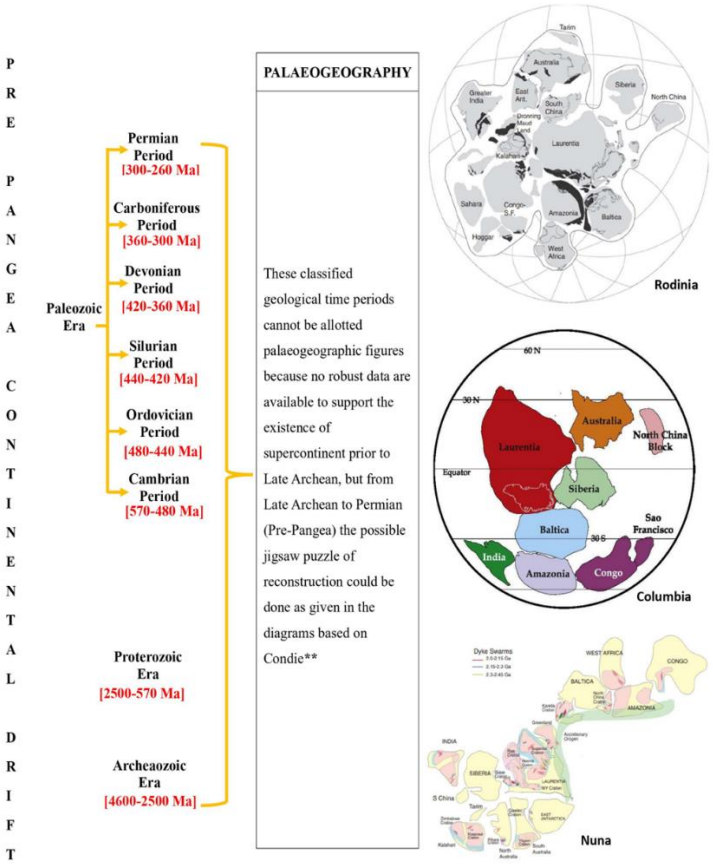
- Wegener used his observations to hypothesize that all of the present-day continents were once part of a single supercontinent called Pangaea.
- *Species: -*

o Fossils of the same species were found on several different continents.
o Wegener proposed that the species dispersed when the continents were connected and later carried to their present positions as the continents drifted apart.

- *Rock Sequences*

o Presence of Rock sequences in South America, Africa, India, Antarctica, and Australia very similar.
o Wegener showed that the same rock sequences occur at each of these localities.
o Wegener proposed that the rock layers were made when all the continents were part of Pangea.



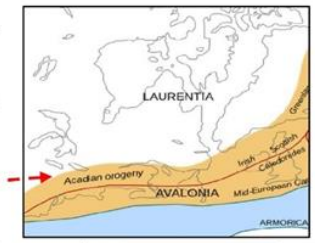


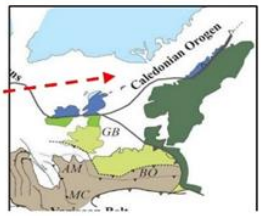

## VI. Palaeoclimate In Geological Time Scale

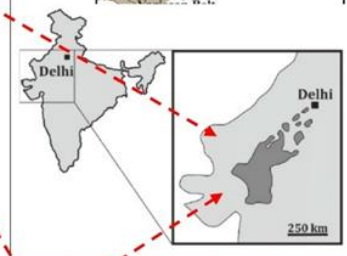
| | PALAEOCLIMATE | EVIDENCES |
|---|---|---|
| Permian Period [300-260 Ma] | ❑ By the end, climate became warm.<br>❑ 4th Ice Age Karoo Ice Age 360-260 Ma | Glacial tills found in the Karoo regions of South Africa |
| Carboniferous Period [360-300 Ma] | ❑ Climate was warm and humid at the end.<br>❑ It was the time of cooling in the vicinity of South Palacopole. | Warm climate led to coal deposition in the basins of western Europe Boulder beds found in South America indicate cold climate. |
| Devonian Period [420-360 Ma] | ❑ Devonian was a relatively warm period<br>❑ At the end of Devonian, Earth rapidly cooled into an icehouse, marking the beginning of the Late Palaeozoic Ice Age. | Devonian salt deposits indicative of high evaporation rates, and of high temperatures, range from western Canada to Ukraine and Siberia and are found locally in Australia. |
| Silurian Period [440-420 Ma] | ❑ In Silurian, climate was warm and arid.<br>❑ Cap rock of Niagra falls were also formed during this period | Evidences are coral reefs, rock salt, gypsum, famous pot dolomite |
| Ordovician Period [480-440 Ma] | ❑ 3rd Ice Age Andean-Saharan Ice Age:- 460-420 Ma<br>❑ Levels of carbon dioxide were several times higher than today<br>❑ Generally warm at the beginning. | Evidence of glaciation can be seen in places such as North Africa, South Africa, Brazil, Peru<br>Warm climate is indicated by Ordovician limestone dep osits with features like coral reefs of Bahamas. |
| Cambrian Period [570-480 Ma] | ❑ Climate at the beginning of Cambrian was rather cool but later it warmed up. | Salt range of Pakistan were formed. |
| Proterozoic Era [2500-570 Ma] / Archeaozoic Era [4600-2500 Ma] (Azoic Eon) | ❑ 2nd Ice Age Cryogenian Ice Age:- 850-630 Ma<br>❑ 1st Ice Age Huronian Ice Age:- 2400-2100 Ma<br>❑ It is evident that equatorial zones generally warm. | Presence of diamictites in the Pongola Supergroup and the Witwatersrand Basin of South Africa suggests that the climate was glacial. |

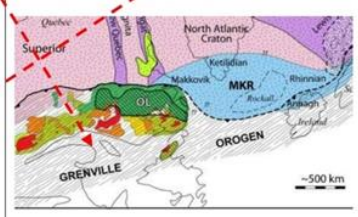
## VII. Major Orogenic Events In Geological Time Scale

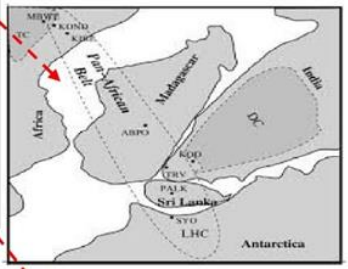
| | MAJOR OROGENIC EVENTS | COLLISION BETWEEN PLATES | AGE IN Ma |
|---|---|---|---|
| Devonian Period | Acadian Orogeny | Convergence between American and Canadian Craton | 375-325 Ma |
| Silurian Period, Ordovician Period, Cambrian Period | Caledonian Orogeny | Collision between proto-North American plate and Eurasian Plate | 460-390 Ma |
| AZOIC EON — Proterozoic Era | Aravalli Orogeny | Collision between the Bundelkhand craton and the Marwar craton (India) | ~1800 Ma |
| | Greenville Orogeny | Collision between the North American tectonic plate and the African tectonic plate. | 1250-980 Ma |
| | Delhi Orogeny | Collision between the Bundelkhand craton and the Marwar craton (India) | ~1100 Ma |
| | Pan-African Orogeny | Formed between much older African cratons. | ~600 Ma |
| Archeaozoic Era | Algoman Orogeny | Collision between Superior Province and Minnesota river valley Province (USA) | 2760-2500 Ma |



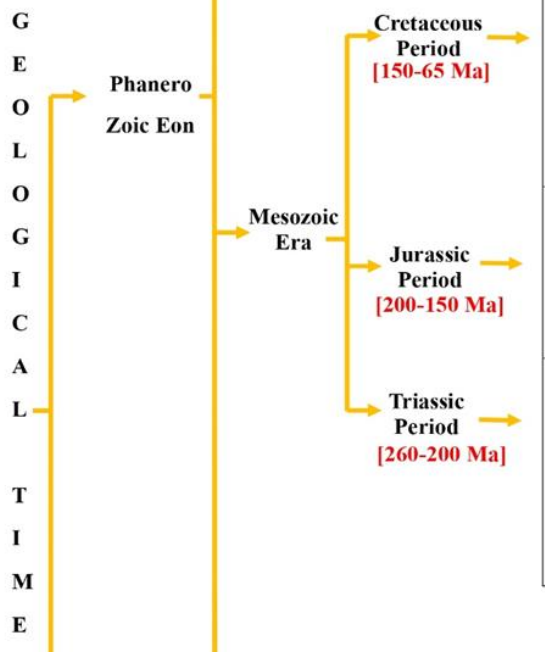




## VIII. Evolution Of Life

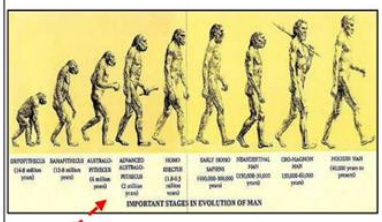



| PALEOCLIMATE | EVIDENCES |
|---|---|
| ❑ Glaciation took place during this Quaternary Ice Age and continues till the present day.<br>❑ Nearly 30% area of Earth was covered by ice sheets and glaciers. | In the Northern Hemisphere, vast areas were indeed covered with ice.<br><br>Expansion of the Antarctic ice sheets |
| ❑ Cenozoic Ice Age:- 2.58 MY-Present<br>❑ At the end of Pliocene, Ice Age began.<br>❑ Cooling trend continued in Miocene.<br>❑ During Oligocene, permanent ice began to develop.<br>❑ During Eocene, Earth entered a period of cooling.<br>❑ During the Palaeocene, Climate was warm. | Ice Age evidences are glaciation in the poles.<br><br>Warm climate was caused by the dissolution of methane hydrates on the ocean floor. |
| ❑ The climate of the Cretaceous Period was much warmer than at present.<br>❑ Temperatures were lower at the beginning of the period, rising to a maximum in the mid-Cretaceous and then declining slightly with time | Occurrence of evaporites from Western China,Thailand,Laos,etc. indicate an arid climate. |
| ❑ An warm and arid belt existed on the western side of Pangea, while more-humid conditions existed in the east. | Fossils of warm-adapted plants such as Conifers,Cycads suggest an expanded arid tropical zone. |
| ❑ The climate was generally arid. | Several indicators of an arid climate: red sandstones and shales that contain few fossils, lithified dune deposits with cross-bedding, salt pseudomorphs in marls, mudcracks, and evaporites. |

**Cenozoic Era**

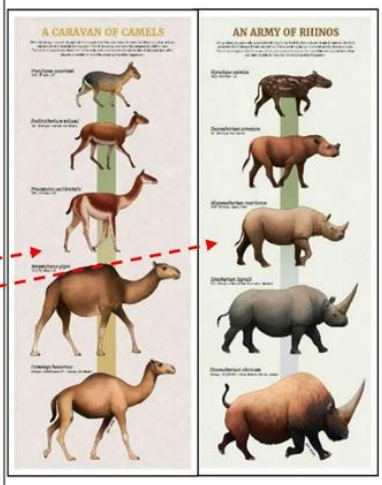
**Quaternary Period**

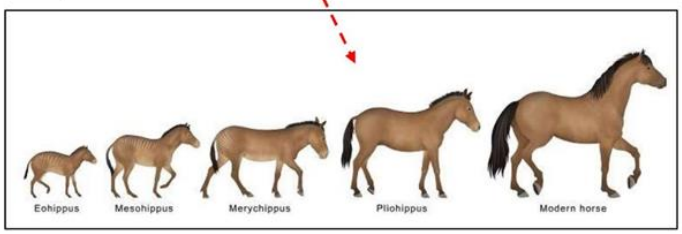
| FLORA AND FAUNA |
| --- |
| ❑ 90% of animals represented by Quaternary fossils were recognized by Charles Lyll, as being similar to modern forms.<br>❑ Many genera and even species of shell-fish, insects, marine, microfossils and terrestrial mammals.<br>❑ Pliestocene is generally recognized as time of gigantism. Examples:- Giant Beaver, Giant Sloth.<br>❑ Many mammalian fauna such as Woolly Rhino, Woolly Mammoth, Cave lion adopted the cold climatic conditions.<br>❑ In the beginning, there were still Hominids<br>❑ Modern humans appeared about two hundred thousands years ago.<br>❑ The variety of ecosystems during the Holocene period supports an amazing diversity of life. |

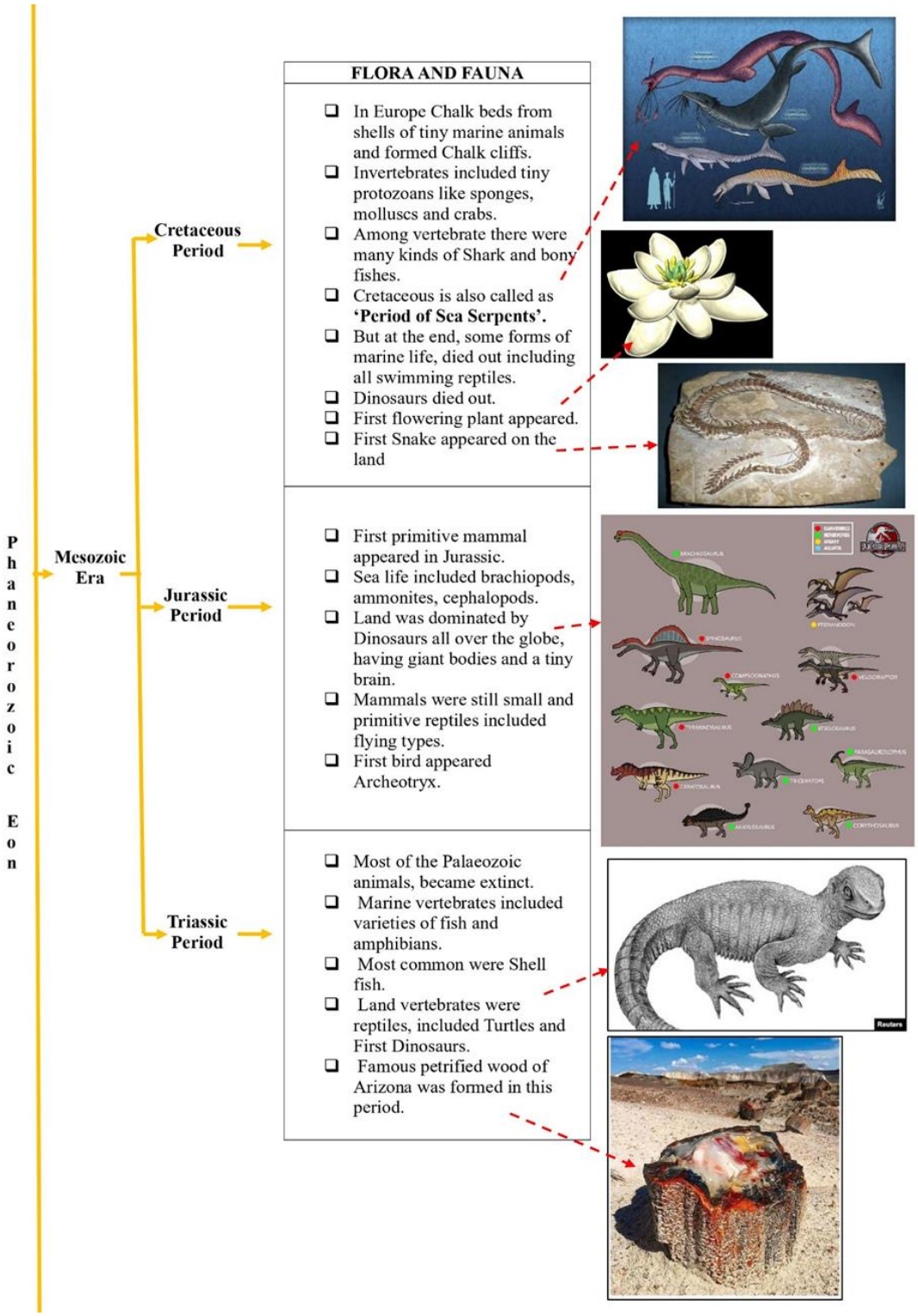


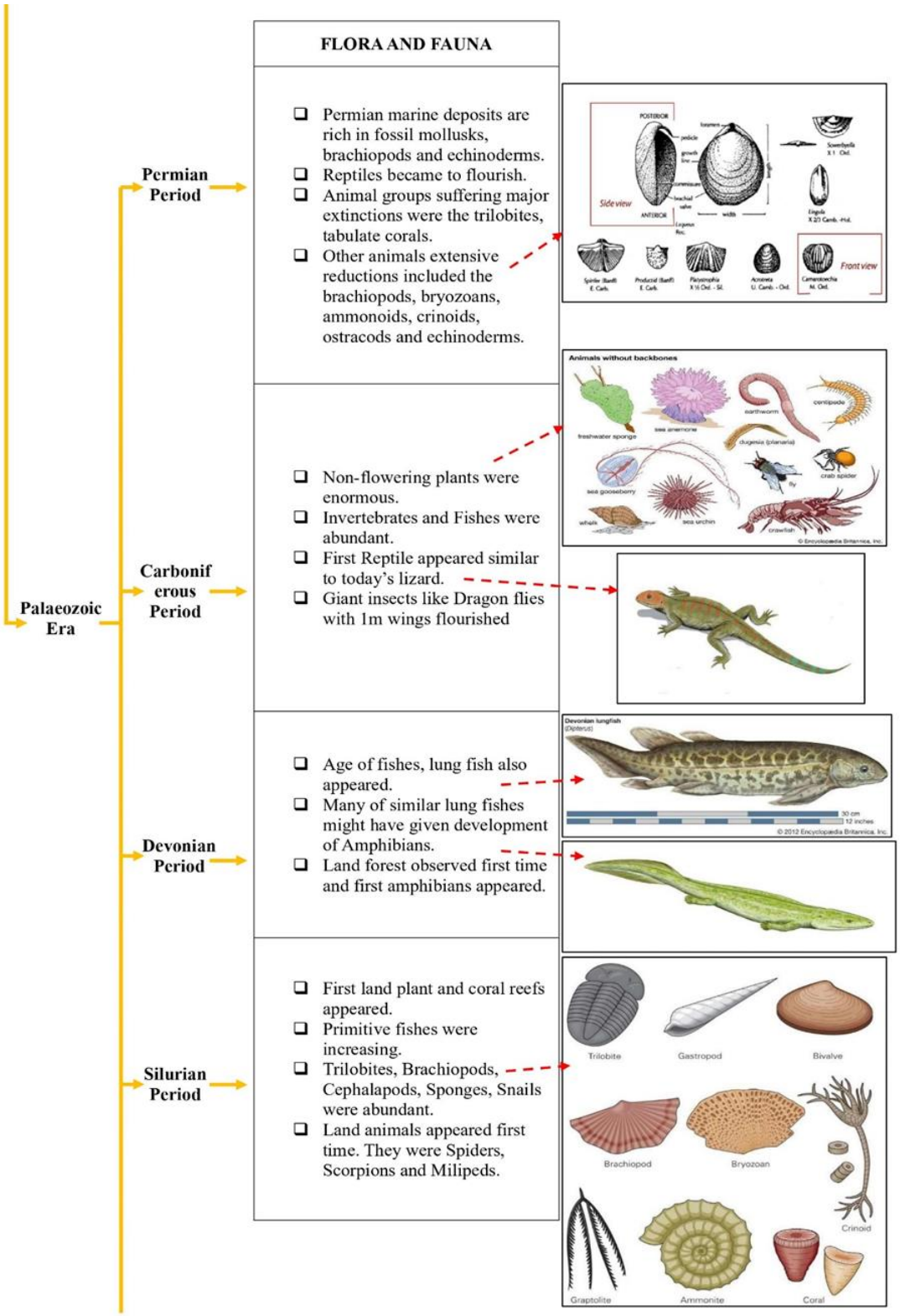

**Tertiary Period**

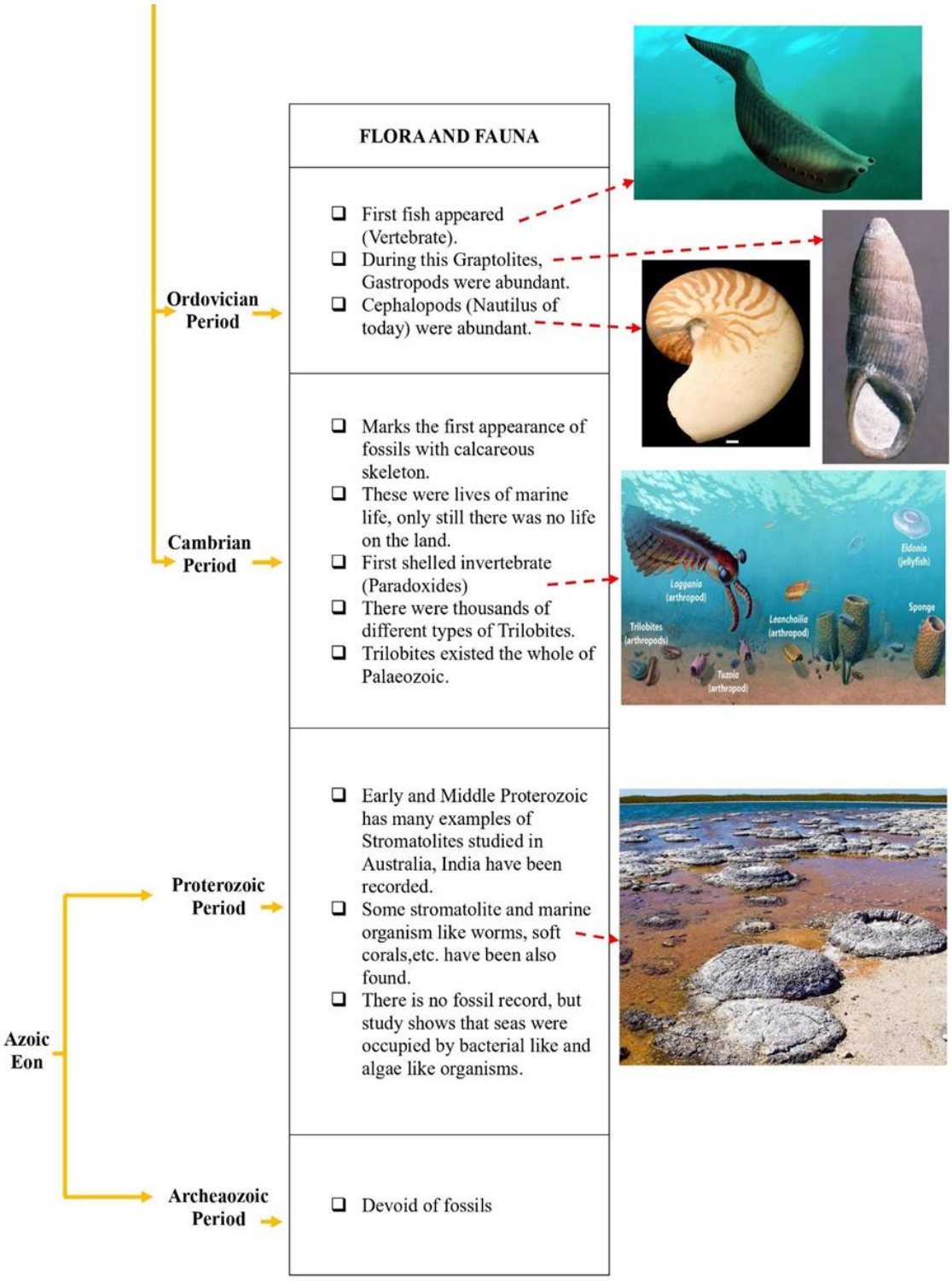
| |
| --- |
| ❑ Tertiary witnessed the dramatic evolutionary expansion of not only mammals but also flowering plants, insects, birds, deep sea organisms.<br>❑ This period is also called as **'Age of Mammals'.**<br>❑ By the beginning of period, mammals replaced reptiles.<br>❑ During the **Pliocene**, first Hominids appeared our human ancestors.<br>❑ Horses, Camels and Rhinos appeared during **Miocene.**<br>❑ Dogs, Cats and Pigs Entered during **Oligocene**.<br>❑ **Eocene** marked presence of Eohippus- the first horse, whales, elephant ancestors.<br>❑ **Palaeocene** marked the presence of Rodents. |



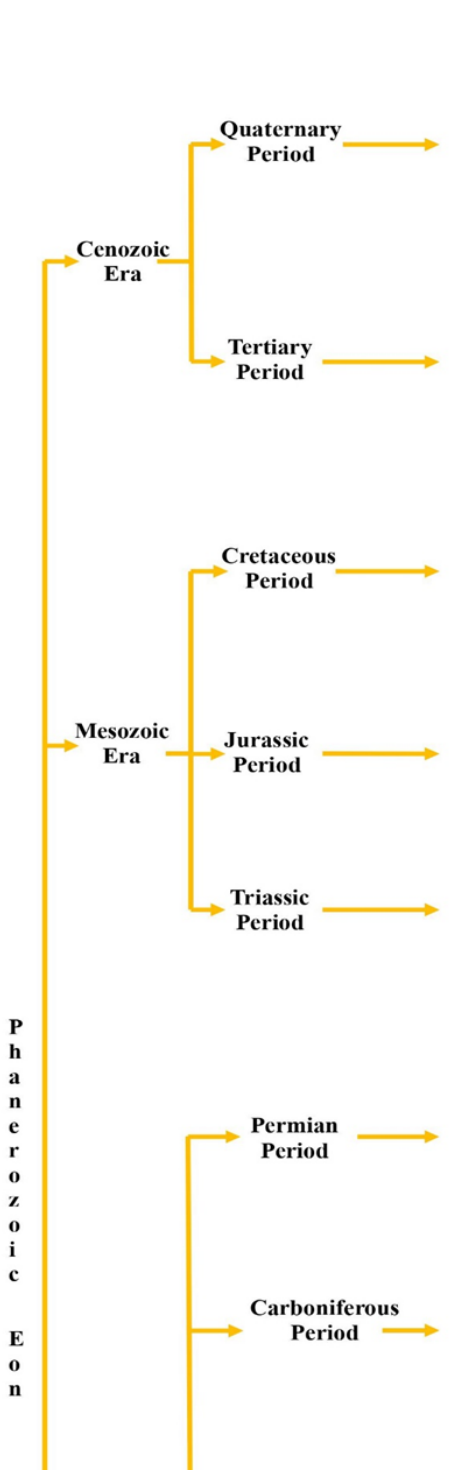




Phanerozoic Eon
Mesozoic Era
Cretaceous Period
Jurassic Period
Triassic Period
FLORA AND FAUNA
In Europe Chalk beds from shells of tiny marine animals and formed Chalk cliffs.
Invertebrates included tiny protozoans like sponges, molluscs and crabs.
Among vertebrate there were many kinds of Shark and bony fishes.
Cretaceous is also called as 'Period of Sea Serpents'.
But at the end, some forms of marine life, died out including all swimming reptiles.
Dinosaurs died out.
First flowering plant appeared.
First Snake appeared on the land
First primitive mammal appeared in Jurassic.
Sea life included brachiopods, ammonites, cephalopods.
Land was dominated by Dinosaurs all over the globe, having giant bodies and a tiny brain.
Mammals were still small and primitive reptiles included flying types.
First bird appeared Archeotryx.
Most of the Palaeozoic animals, became extinct.
Marine vertebrates included varieties of fish and amphibians.
Most common were Shell fish.
Land vertebrates were reptiles, included Turtles and First Dinosaurs.
Famous petrified wood of Arizona was formed in this period.

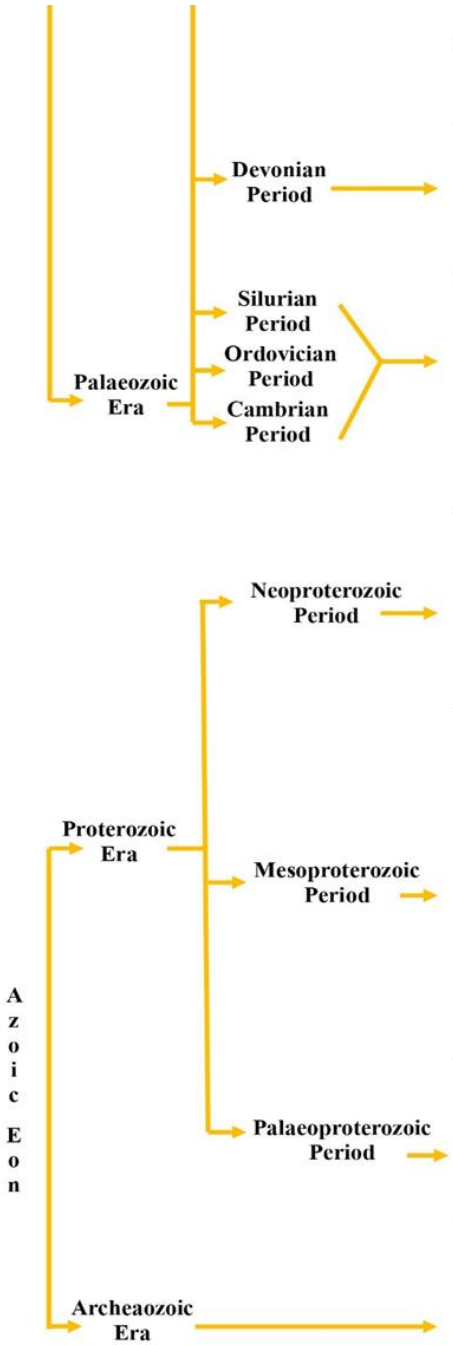

FLORA AND FAUNA
Palaeozoic Era
Permian Period
Carboniferous Period
Devonian Period
Silurian Period
Permian marine deposits are rich in fossil mollusks, brachiopods and echinoderms.
Reptiles became to flourish.
Animal groups suffering major extinctions were the trilobites, tabulate corals.
Other animals extensive reductions included the brachiopods, bryozoans, ammonoids, crinoids, ostracods and echinoderms.
Non-flowering plants were enormous.
Invertebrates and Fishes were abundant.
First Reptile appeared similar to today's lizard.
Giant insects like Dragon flies with 1m wings flourished
Age of fishes, lung fish also appeared.
Many of similar lung fishes might have given development of Amphibians.
Land forest observed first time and first amphibians appeared.
First land plant and coral reefs appeared.
Primitive fishes were increasing.
Trilobites, Brachiopods, Cephalapods, Sponges, Snails were abundant.
Land animals appeared first time. They were Spiders, Scorpions and Milipeds.
Side view
Front view
Animals without backbones
Trilobite
Gastropod
Bivalve
Brachiopod
Bryozoan
Crinoid
Graptolite
Ammonite
Coral


FLORA AND FAUNA
Ordovician Period
First fish appeared (Vertebrate).
During this Graptolites, Gastropods were abundant.
Cephalopods (Nautilus of today) were abundant.
Cambrian Period
Marks the first appearance of fossils with calcareous skeleton.
These were lives of marine life, only still there was no life on the land.
First shelled invertebrate (Paradoxides)
There were thousands of different types of Trilobites.
Trilobites existed the whole of Palaeozoic.
Laggania (arthropod)
Eldonia (jellyfish)
Trilobites (arthropods)
Leanchoilia (arthropod)
Sponge
Tuzoia (arthropod)
Azoic Eon
Proterozoic Period
Early and Middle Proterozoic has many examples of Stromatolites studied in Australia, India have been recorded.
Some stromatolite and marine organism like worms, soft corals,etc. have been also found.
There is no fossil record, but study shows that seas were occupied by bacterial like and algae like organisms.
Archeaozoic Period
Devoid of fossils

## IX. Major Economic Deposits In Geological Time Scale

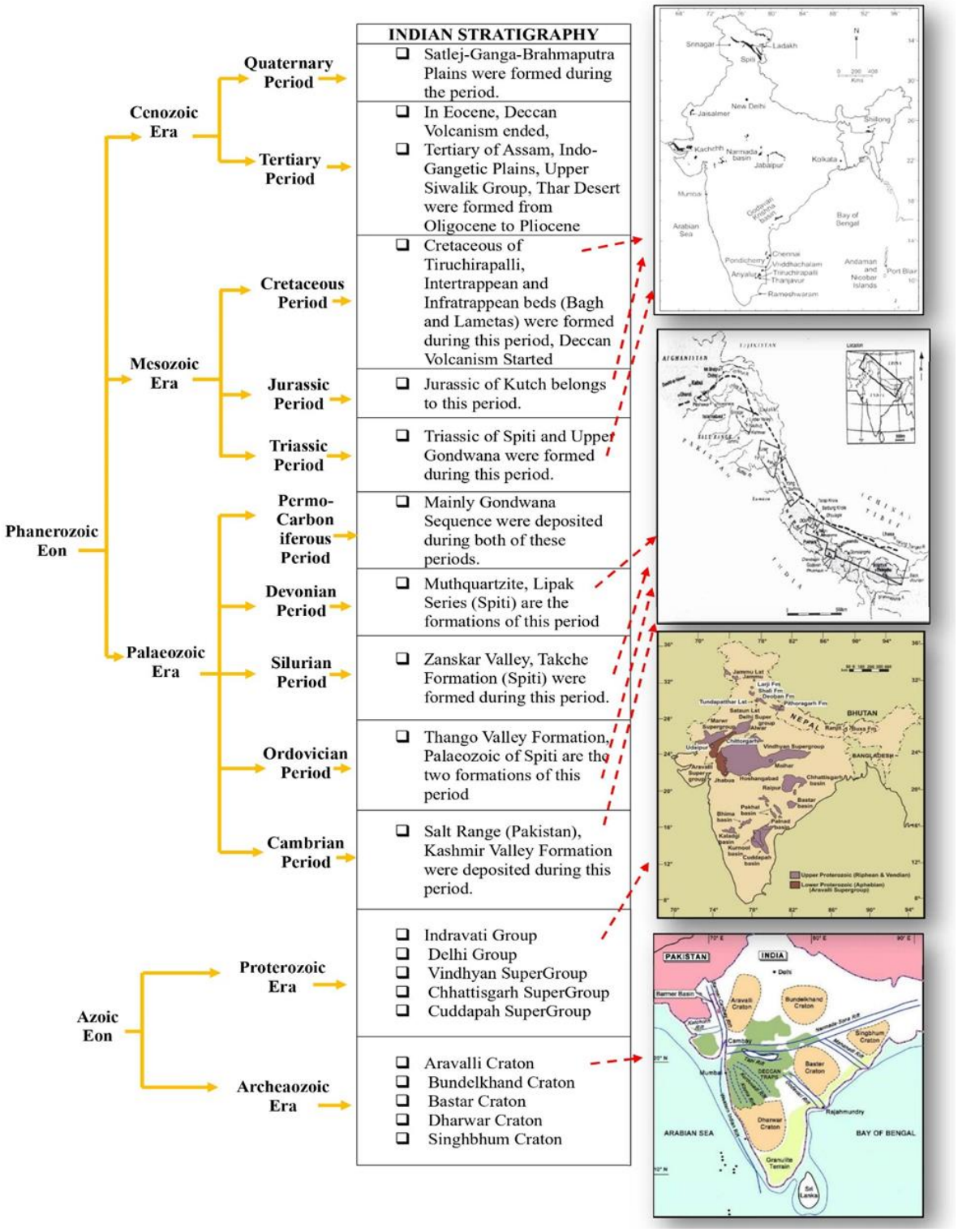



| MAJOR WORLD DEPOSITS | MAJOR INDIAN DEPOSITS |
|---|---|
| ❑ **Bauxite:-** Guianas,Brazil (South America) | ❑ **Bauxite :-** Deccan Trap (M.P. & Maharashtra), Coastal Deposits of EGMB |
| ❑ **Bauxite:-** Hungary, Yugoslavia, USA<br>❑ **Gold Lodes:-** Arizona, Nevada, California(USA)<br>❑ **Silver:-** Utah, Nevada(USA) | ❑ **Coal (Lignite):-** Rajasthan, Neyveli (Tamil Nadu)<br>❑ **Petroleum:-** Digboi, Moran, Ankleshwar |
| ❑ **Bauxite:-** France, Greece<br>❑ **Coal** deposits of South America, and Western Canada | ❑ **Coal** fields of Ghuneri, Kutch |
| ❑ **Coal** deposits of Siberia | ❑ **Iron :-** Ironstone-Rajmahal Trap (Bihar)<br>❑ **Coal** field of Maharashtra, Satpura region(M.P.) |
| ❑ **Coal** deposits of China, South America | ❑ **Iron :-** Haematite and Limonite, Udhampur (J&K) |
| ❑ **Coal :-** North Antelope (USA), Haerwusu Coal Mine (China), Heidaigou Coal Mine (China), Peak dowas (Australia), Moatize Coal Mine (Mozambique) | ❑ **Coal :-** Jharia, Bokaro, Raniganj, Godavari Valley<br>❑ **Iron :-** Ironstone-Shale (Raniganj Coal Field) |
| ❑ **Platinum:-** Ural Mountains, Dunitic Rock (New Zealand) | |




| MAJOR WORLD DEPOSITS | MAJOR INDIAN DEPOSITS |
|---|---|
| ❑ **Evaporite Deposits:-** Western Australia, South Africa | ❑ **Rock salt** deposits, **Gypsum** deposits of Pakistan |
| ❑ **Copper-Molybdenum-Gold Deposit :-** Bainaimia (North China Craton) | |
| ❑ **Lead-Zinc :-** Mississippi Valley type deposit of Carbonate hosted rock<br>❑ **Evaporite Deposit :-** Dashiqiao (Magnetite Deposit)(China) | ❑ **Lead-Zinc :-** Zawar(Rajasthan)<br>❑ **Evaporite Deposit:-** Magampeta Barite Deposit, Saline Series (Pakistan Sindh) |
| ❑ **Chromite :-** Great Dyke (Zimbabwe), Bushveld (South Africa)<br>❑ **Nickel :-** Sudbury Nickel (Canada)<br>❑ **Lead-Zinc :-** Broken Hill (Australia), Mount Isa (Australia)<br>❑ **Tin-Tungsten:-** Bushveld (South Africa) | ❑ **Sukinda Chromite Deposit**, Gangpur (Orissa) (Fe-Mn Deposit)<br>❑ **Copper:-** Malanjkhand, Khetri<br>❑ **Lead-Zinc:-** Agucha-Rajpura-Dariba (Rajasthan), Sargipali Mines (Andhra Pradesh)<br>❑ **Tin-Tungsten:-** In Pegmatites, Bastar Craton |
| ❑ **Iron :-** Algoma Type BIF (Canada), Pilbara (Australia)<br>❑ **Gold-Tungsten :-** Zimbabwe Archean Craton | ❑ **Gold:-** KGF (Karnataka), Hutti Gold Field<br>❑ **Iron:-** Singhbhum (Jharkhand), BMQ (South India) |
| ❑ **PGE :-** In Layered Intrusions, Bushveld (South Africa), Stillwater (USA)<br>❑ **Gold and Uranium:-** Witwatersrand (South Africa)<br>❑ **Gold:-** Barberton Greenstone Belt (South Africa) | ❑ **Gold:-** KGF (Karnataka), Hutti Gold Field<br>❑ **Iron:-** Singhbhum (Jharkhand), BMQ (South India) |

## X. Indian Stratigraphy And Geological Time Scale




## XI. Discussion And Conclusion

Geological Time scale is a systematic arrangement of geological history and different events that took place in the Earth's history. As Henry Adams tongue-in-cheeks assertion goes 'Anarchy is a law of nature and order is a dream of man'. Geological time scale is an attempt to put the past events in an order and if this is augmented with pictorial representation it becomes self-explanatory and easily understandable. This article is an attempt to portray geological history complemented with relevant illustrations so that it gives a complete and memorable picture of spatiotemporal panorama of episodes in the history of the Earth.

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