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NAAC ACCREDITED 'A' GRADE



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Geological time scale

Definition:

It is a system of chronological measurement that related stratigraphy(the study of rock strata, especially the distribution, description and age of sedimentary rocks) to time and it is used by geologist, paleontologist and other earth scientists to describe the time and relationship between the events that have occurred throughout earth's history.

Geological time scale was proposed by british geologist Arthur Holmes. He estimated that the earth was about 4 billion years old.

The geological time scale is divided into five main eras-

- 1.cenozoic,
2. mesozoic,
3. Paleozoic,
4. Proterozoic,
5. Archeozoic.

Each era is divided into periods and each period is divided into epochs.

There is another kind of time division used- the eon.The entire interval of the existence of visible life is called the phanerozoic eon. The great precambrian expanse of time is divided into the proterozoic, archean, and Hardean eons in order of increasing age.

The names of the eras in phanerozoic eons (the eon of visible life) are :

1. cenozoic (recent life),
2. mesozoic (middle life), and
3. paleozoic (ancient life).

The further subdivision of the eras into 12 periods is based on the identifiable but less profound changes in life forms.

Major events of geological time scale:

1. Bryophytes evolved on the earth during the Silurian period of the paleozoic era and are still surviving.
2. Pteridophytes evolved sometimes in silurian, dominated the earth during carboniferous and are still surviving.
3. Gymnosperms evolved sometimes at the end of the triassic period, mesozoic era dominated the earth sometime during the paleocene epoch and are still surviving.
4. Angiosperms evolved during the Jurassic period of the mesozoic era and are now dominating the earth in the recent epoch of the quaternary period of the cenozoic era.

Fossil Records of Precambrian Era:

The Pre-Cambrian includes approximately 90% of the geologic time which covers approximately 4,200 million years (m.y.) of the earth history (Table 1.2). The Precambrian world was almost certainly as diverse and complex a place as today's world.

The Pre-Cambrian divided into **three Epochs or Eons**, viz. Hadean, Archaean or Archaeozoic and Proterozoic.

(a) Hadean (4700-3,800 m.y. old):

There is no fossil record in this Epoch. A major time of this epoch was involved in the origin of the earth and solar system, ultimately leading to the differentiation of the earth to form crust, mantle and core.

The events that took place in the Hadean are:

- origin of primary and secondary atmosphere;
- condensation of water vapour,
- formation of rain;
- run off leads to lakes, rivers and oceans;
- origin of continental crust.

The oldest dated Hadean rock is 3,960 million years old, located in Canada (e.g. Canadian shield).

(b) Archean or Archaeozoic (3,800-2,500 m.y. old):

The earliest known life forms (Prokaryotes) from Archean rocks are known.

- They are **microscopic rod-shaped bacteria and spherical coccoid bacteria** recovered from Onverwacht series and
- Fig Tree series of South Africa (3,700-3,200 m.y. old).
- **A plenty of stromatolites** containing the colony of chroococcalean cyanobacteria or blue-green algae has been recovered from the carbonate sediments (3,500-3,400 m.y. old) .
- The earliest bacterial cells had to form and exist in anoxic (oxygen-free environment) conditions probably chemosynthetic in nature, produced CO₂, or H₂S. They were obviously heterotrophs which consumed simple organic compounds. Eventually, some

amount of oxygen was released by the cyanobacteria which might have been used up by minerals through oxidation.

(c) Proterozoic (2,500-570 m.y. old):

- The **first autotrophic chlorophyllous algae** (possibly blue green alga) was reported from Gunflint rock of Canada which dated back to 2,000 m.y.
- The best-known alga was Animikiea (similar to modern blue-green alga, Oscillatoria) which was able to perform photosynthesis to liberate oxygen, eventually giving rise to ozone.
- It is believed that the **stratospheric ozonosphere was formed** through this process.
- The **existence of free oxygen** was established by the occurrence of chemosynthetic bacteria
- The putative eubacterial spores were reported from Gunflint rock.
- The ozone layer screened the lethal UV rays forming a situation conducive to the growth of other autotrophic primitive (Cyanobacteria) as well as advanced (Green algae) algae, etc. in free- floating condition.

Fossil Records of the Palaeozoic Era:

At the onset of the Proterozoic Epoch the earth's climate was found to change rapidly resulting in the formation of diversified life forms. Some of which invaded the land escaping from aquatic habit and initially being amphibian in nature.

While acquiring land habit from water, the **basal part of the Bryophytes** (moss-like plants) developed in such a way that it served the purpose of anchorage and absorption, whereas the **erect part performed photosynthetic function and some part of the branching system became flattened to form rudimentary leaves and, finally, simple reproductive organs at maturity.**

- ❑ The **Cambrian** and the **Ordovician** periods were characterised by
 - a diverse group of algae and bryophytes in the warm ocean and inland seas.
- ❑ About 410 m.y. ago, during the **Silurian** period,
 - The early plants added oxygen which was 20% of the modern level in the atmosphere through photosynthesis.
 - Ozone (a product of oxygen) prevented UV rays from reaching the earth's surface.
 - To acquire terrestrial habit leaving their aquatic habitat, the plants needed to be self-supporting and they had to be able to withstand the drying effect of the air leading to a series of

adaptation. *Cooksonia* was the foremost successful land invader (Middle to Upper Silurian).

❑ In the following geological period, the **Devonian** (410-345 m.y. old),

- more and increasingly complex plants appeared with some modifications, through the formation of vascular tissue (for conduction), epidermal cuticle (to check desiccation of water) and stomata (for gaseous exchange), which were visualised in the three early vascular plant groups, viz. **Rhyniopsida** (primitive land plants). **Zosterophyllopsida** (ancestor of microphylls) and Trimerophytopsida (ancestor of megaphylls).

❑ During the **Carboniferous period**

- The subsequent emergence of a variety of arborescent (tree-sized) plants flourished in the Northern Hemisphere. The most dominant plants were *Lepidodendron* (giant club moss), *Calamities* (giant horsetail), etc. which attained a height of 30-50 metres.

❑ During **permian**

- a new plant group i.e. Gymnosperms (naked seeded plants) evolved. Those plants mostly comprising of Pteridosperms (the primitive seed bearing plants), Cordaites (the progenitors of the modern conifers), became more successful land plants because of their selective advantage of seed formation.
- The embryos of the seeds were well-protected and had the potential to overcome the adverse condition.

Fossil Records of Mesozoic Era:

❑ In the **Jurassic period** ,

- The gymnospermous plants mostly cycads, cycadeoids, conifers, ginkgos along with ferns reached their climax which constituted the world's dominant vegetation co-existent with the giant reptiles known as Dinosaurs.
- Glossopterids totally disappeared and
- sphenopsids and lycopsids were less conspicuous.
- Some angiosperm- like leaves and tectate pollen were reported from the Jurassic period.

❑ Still later, in **Cretaceous** period

- the **closed seeded plants i.e., angiosperms evolved** which subsequently became dominant in the Cenozoic Era replacing cycads, cycadeoids, conifers and ginkgos.
- There was a rapid diversification of angiosperms in the Cretaceous period where ferns and conifers still continued and **cycadeoids got extinct.**
- **The evidence of both monocot and dicot plants** were established by the occurrence of leaves, flowers with closed carpels, perianths and stamens, tectate collumellate pollen, etc.

The Mesozoic Era is called “The age of gymnosperms’ because of the diverse assemblage of cycads, ginkgos (maidenhair tree) and primitive conifers.

Fossil Records of Cenozoic Era:

In the Cenozoic Era ,

- the dominance of gymnosperms steadily declined in number and distribution, as in the meanwhile, the angiosperms diversified and occupied most of the land mass surface. Now the gymnosperms are represented by only 730 species while angiosperms are distributed globally by having over 300,000 species.
- Angiosperms grow in a greater range of environments (tropical, temperate, alpine, coastal etc.) and a variety of habitats (aquatic, terrestrial, epiphytic, etc.) displaying an astonishing array of morphological, anatomical and physiological variations, which include the world's major food- yielding plants and other plants of great economic importance. Hence the **Cenozoic Era is often known as “The age of angiosperms”**.
- Fruit-forming plants (angiosperms) exerted an influence on the evolution of birds and mammals. Birds, which feed on fruits, seeds, flowers, evolved rapidly in co-association with angiosperms.
- The emergence of herbivorous mammals coincided with the widespread distribution of grasses and herbs over the plains. In turn, the herbivores furnished the setting for the evolution of carnivorous animals, thus maintaining an intricate ecological balance by making interdependence between plants and animals.

The study of fossils has an applied significance in understanding the stratigraphic sequence which provides to trace the plant as well as animal evolution through ages.

Picture of geological column and time scale

ERA	Major Divisions	Periods	Epochs	Dominant Organisms	Advances in Plant Life
C O E N O Z O I C	Quaternary		Holocene .01	Age of Angiosperms, Birds and Mammals	Increasing dominance of herbs
			Pleistocene 1.8		Specialization of herbaceous plants
	Tertiary	Late Tertiary	Pliocene 5.3		Increasing restriction of plants distribution and forests rise in herbs
			Miocene 23.8		Restriction distribution in plants
		Early Tertiary	Oligocene 33.7		Dispersal of woody angiosperms
			Eocene 54.8		Development flowering plants
			Paleocene 65.0		Modernization of angiosperms.
	M E S O Z O I C	Late mesozoic	Upper Cretaceous		Higher Gymnosperms and Reptiles
Middle Cretaceous			Rapid development of angiosperms		
Lower Cretaceous 144			Origin of angiosperms, Dominance of cycads and conifers		
Early mesozoic		JURASSIC 206	Origin of angiosperms Dominance of cycads and conifers.		
		TRIASSIC 248	Disappearance of seed ferns, cycads, conifers and Ginkgoales increasing		

P A L E O Z O I C	Late Paleozoic	PERMIAN 290	LYCOPODS, SEED FORMS AND AMPHIBIANS	Rise of conifers and cycads	
		UPPER CARBONIFEROUS 323		Dominance of ferns, Calamitales, Lepidodendrales and Gymnosperms	
		LOWER CARBONIFEROUS 323		Development of Lycopsidea, Calamitales, seed ferns	
	middle paleozoic	DEVONIAN 417		FISHES AND EARLY PLANTS	Psilotopsida, Lycopsidea, Sphenopsida, ferns, Bryophytes and some algae
		SILVURIAN 443			First known land plants, Dominance of algae
	Early Paleozoic	ORDOVICIAN 490			Marine and green algae, The time of rising of land plants
CAMBRIAN 540		Evidence of algal origin			
P R O T E R O Z O I C			ALGAE AND BACTERIA	Marine invertebrates	
A R C H A E O I C			UNICELLULAR ALGAE	Probably very simple unicellular organisms	

Proterozoic and Archeozoic era together are known as Precambrian and comprises about 88% of the geological time (4500).		
P R E C A M B R I A N	COMPRISES ABOUT 88% OF THE GEOLOGICAL TIME 4500	First multicellular organisms First one celled organism Origin of earth

