SUBJECT- ENVIRONMENTAL SCIENCE

SEMESTER –M.Sc 2nd SEMESTER (C22)

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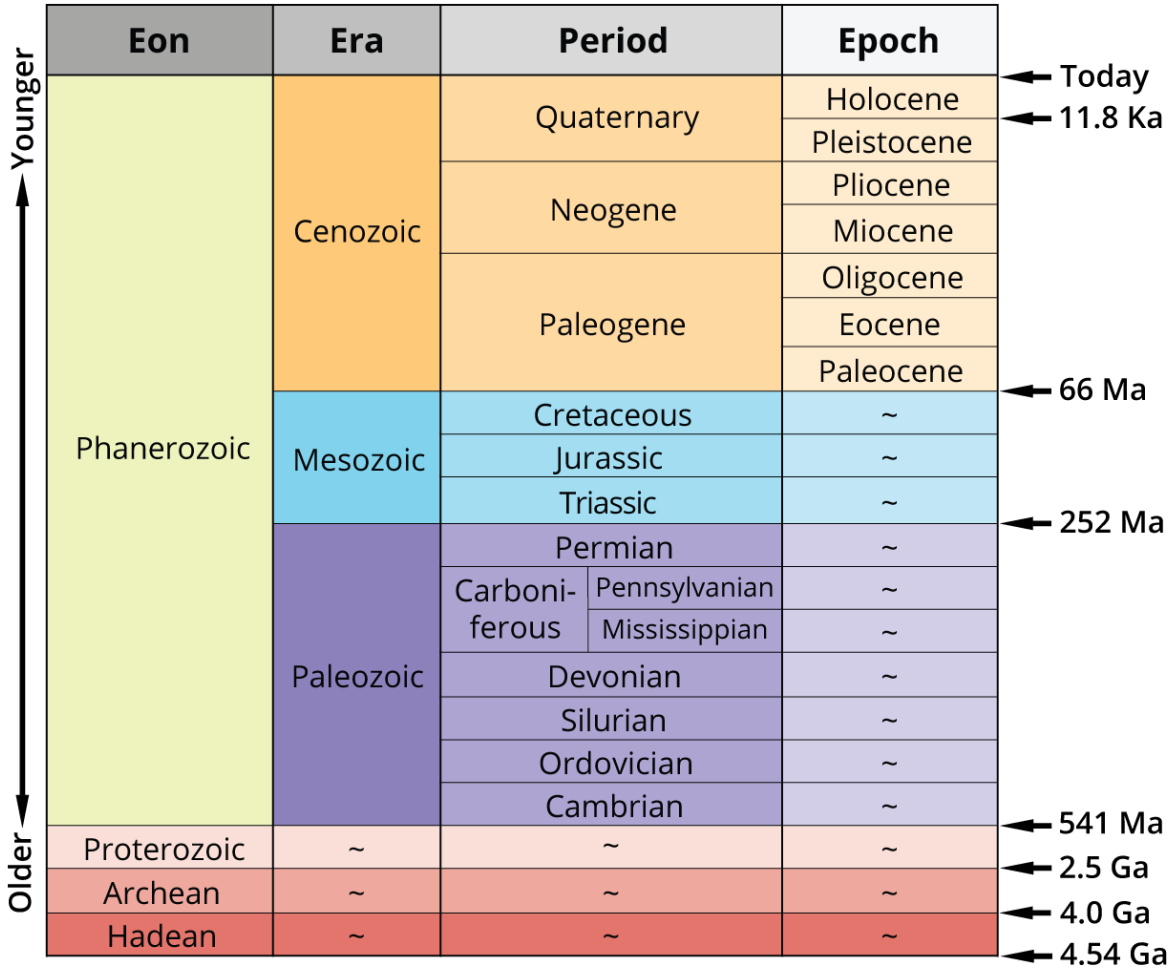
TOPIC- ENVIRONMENTAL GEOSCIENCE



The geological time scale is a reference and communication system for comparing rocks and fossils from throughout the world and is geology's equivalent of the periodic table of the elements. Most of the boundaries on the geological time scale correspond to the origination or extinction of particular kinds of fossils. Knowing when major groups of fossils first appeared or went extinct is therefore incredibly useful for determining the ages of rocks in the field. For example, if you find a rock with a trilobite fossil upon it, you will immediately know that the rock is Paleozoic in age (541 Ma to 252 Ma) and not older or younger; knowing the species of trilobite allows even greater precision.

This relates to a third important principle of relative age dating the principle of faunal succession. Faunal succession is the principle that different kinds of fossils characterize different intervals of time. This is because evolution and extinction are facts of nature.

The principle of faunal succession was developed by an English surveyor named William "Strata" Smith (1769-1839). As he studied layers of rocks to determine where to build canals, he noticed that he found the same ordering of fossil species from place to place; Fossil A was always found below Fossil B,

which in turn was always found below Fossil C, and so on. By documenting these sequences of fossils, Smith was able to temporally correlate rock layers (or, strata) from place to place (in other words, to establish that rock layers in two different places are equivalent in age based upon the fact that they include the same types of fossils).

The geological time scale provides a global summary of countless small-scale temporal correlations of rock layers made at local and regional scales. It is based almost entirely upon careful observations of the distributions of fossils in time and space.

Learning the geological time scale

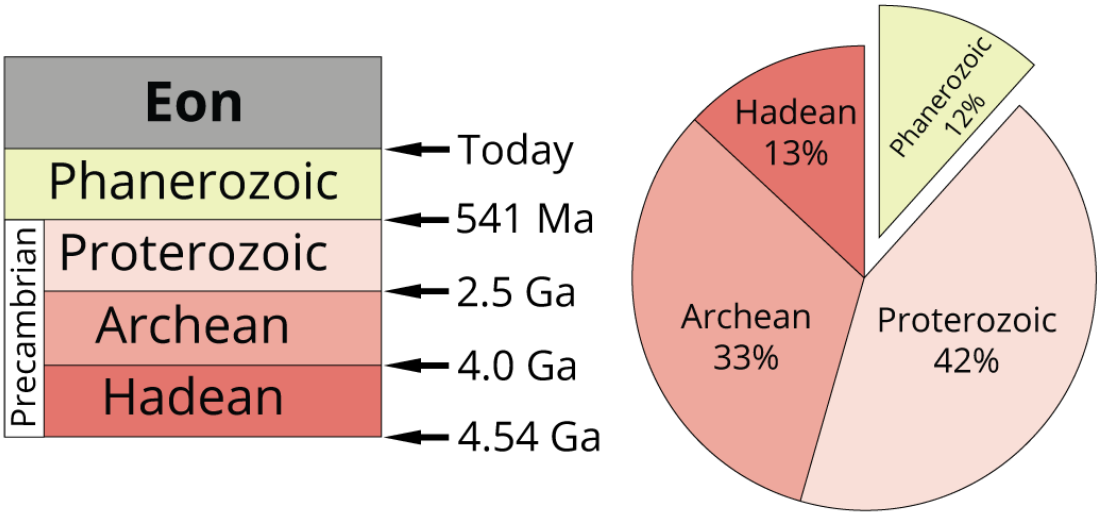
Because of its usefulness for communicating about events in Earth's history, it is important that all students of geology, paleontology, and evolutionary biology commit the geological time scale to memory. This is most easily done by first breaking the time scale into its component parts: eons, eras, periods, and epochs.

Eons

The eon is the broadest category of geological time. Earth's history is characterized by four eons; in order from oldest to youngest, these are the **Hadeon**, **Archean**, **Proterozoic**, and **Phanerozoic**. Collectively, the Hadean, Archean, and Proterozoic are sometimes informally referred to as the "**Precambrian**." (The Cambrian period defines the beginning of the Phanerozoic eon; so, all rocks older than the Cambrian are Precambrian in age.)

We live during the Phanerozoic, which means "visible life." This is the interval of geological time characterized by abundant, complex fossilized remains. Being the youngest eon of time, it is also very well represented by rock at Earth's surface. Because of these two factors, most paleontologists and geologists study fossils and rocks from the Phanerozoic eon.

Note in the figure below the absolute ages of the boundaries separating each eon of time.



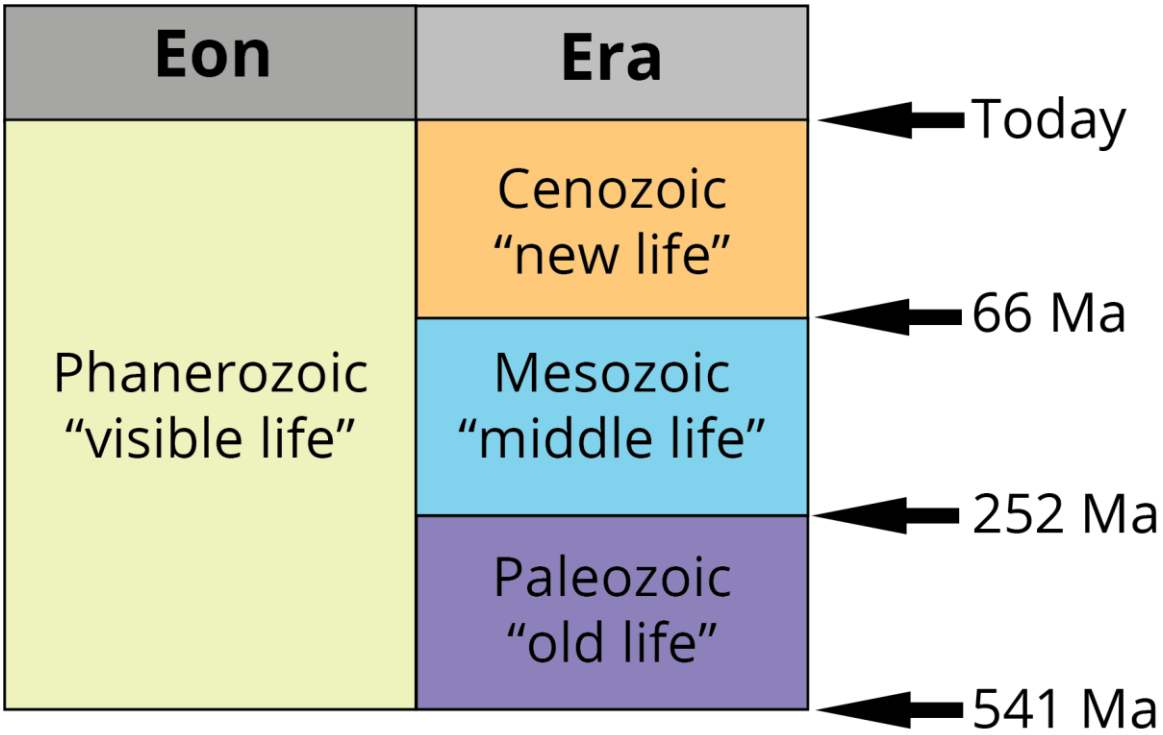
Left: the four eons of geological time. Right: the "Precambrian" eons (Hadean, Archean, and Proterozoic) represent 88% of geological time.

You have already learned that the Earth is 4.54 billion years old. The Phanerozoic eon began 541 million years ago (or, 0.541 billion years ago). Thus, the Phanerozoic eon represents a paltry 12% of Earth's history! Instead, most of Earth's history is represented by the three Precambrian eons. These older eons tell the story of Earth's beginning, life's origin, and the rise of complex life.

The Hadean and Archean are difficult eons to study, however, because they are exposed in very limited places on Earth's surface. (Since they are the oldest eons, rocks that are Hadean and Archean in age are often buried far below younger rocks at Earth's surface.) Proterozoic rocks--which span nearly 2 billion years (42% of Earth's history)--are much more accessible, but, until recently, have received significantly less attention from paleontologists than rocks from the younger, fossil-rich Phanerozoic eon. That is slowly beginning to change, however, as more clues about the origins of complex life begin to be revealed from Proterozoic-aged rocks.

Eras

Eons of geological time are subdivided into eras, which are the second-longest units of geological time. The Phanerozoic eon is divided into three eras: the Paleozoic, Mesozoic, and Cenozoic.



The three eras of the Phanerozoic eon..

Most of our knowledge of the fossil record comes from the three eras of the Phanerozoic eon.

- The Paleozoic ("old life") era is characterized by **trilobites**, the first four-limbed vertebrates, and the origin of land plants.

- The Mesozoic ("middle life") era represents the "age of dinosaurs," though also is noteworthy for the first appearances of mammals and flowering plants.

- Finally, the Cenozoic ("new life") era is sometimes called the "age of mammals" and is the era during which we live today.

As temporal points of reference, it is worth memorizing the ages of the boundaries that separate the three eras of the Phanerozoic eon. Long before geologists knew these absolute age dates, they realized that the boundaries **represent important events in the history of life**: mass extinctions. For example, many fossils that are commonly found in the youngest Paleozoic rocks are not found in overlying Mesozoic rocks. Similarly, dinosaur fossils found in the youngest Mesozoic rocks are never again found in the overlying Cenozoic rocks. Paleontologists and geologists used these mass extinction events to define these (and other) boundaries

within the Phanerozoic portion of the geological time scale. It is therefore no coincidence that some of the major boundaries coincide with mass extinction events!

The older Archean and Proterozoic eons are similarly divided into several eras. For example, the youngest era of the Proterozoic eon is called the Neoproterozoic. For the sake of simplicity, these older eras are not included on the time scale shown at the top of this page; they do, however, exist!

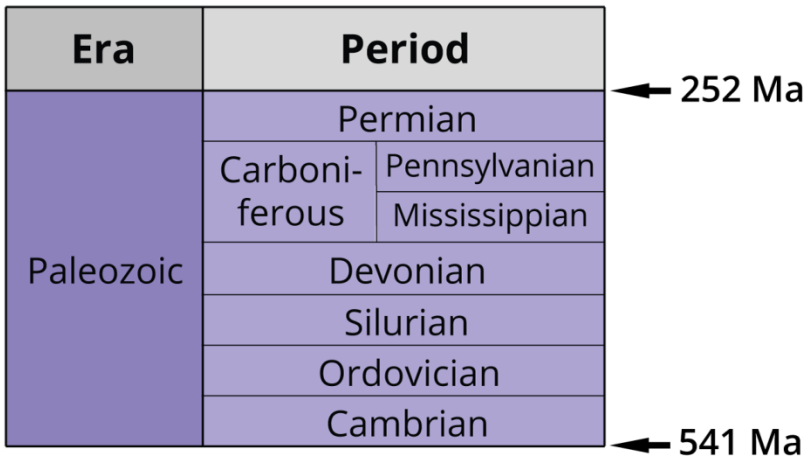
Periods

Just as eons are subdivided into eras, eras are subdivided into units of time called periods. The most well known of all geological periods is the Jurassic period of the Mesozoic era.

The Paleozoic era is divided into six periods. From oldest to youngest, these are the

- Cambrian,
- Ordovician,
- Silurian,
- Devonian,
- Carboniferous, and
- Permian.

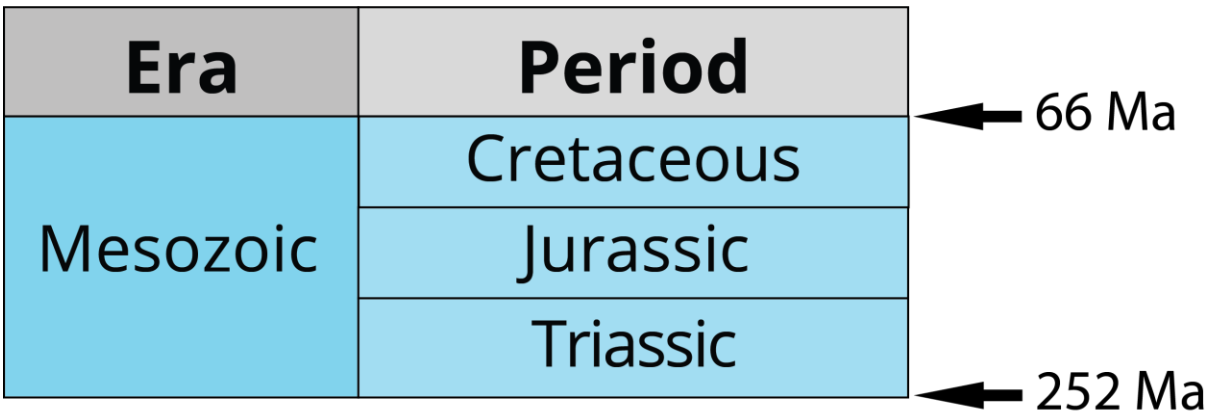
Note that in the United States, the Carboniferous is divided into two separate periods: the Mississippian and the Pennsylvanian.



The seven periods of the Paleozoic era.

The Mesozoic era is divided into the

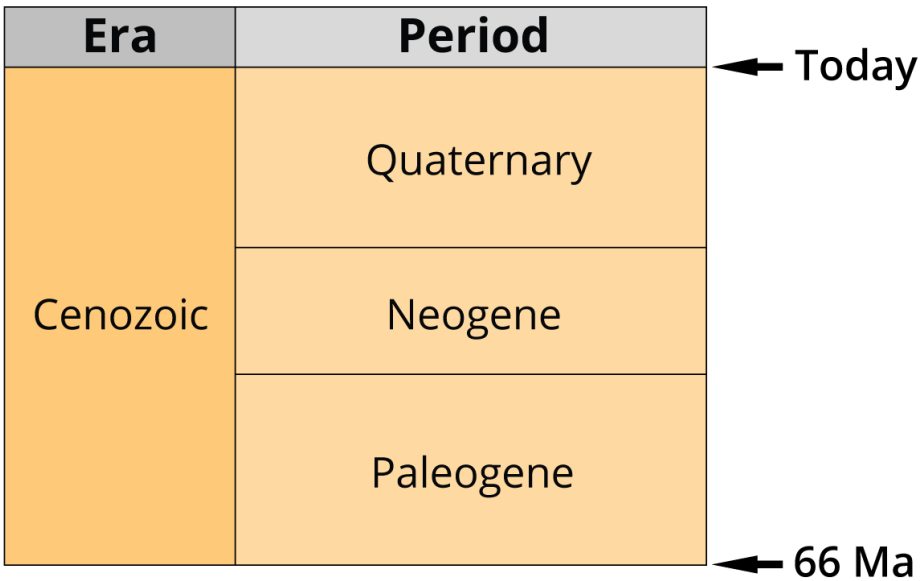
- Triassic,
- Jurassic, and
- Cretaceous periods.



The three periods of the Mesozoic era.

Finally, the Cenozoic era is divided into three periods:

- the Paleogene,
- Neogene, and
- Quaternary.



The three periods of the Cenozoic era.

Epochs and Ages

Periods of geological time are subdivided into epochs. In turn, epochs are divided into even narrower units of time called ages. For the sake of simplicity, only the epochs of the Paleogene, Neogene, and Quaternary periods are shown on the time scale at the top of this page. It is important to note, however, that all of the periods of the Phanerozoic era are subdivided into the epochs and ages.

The Paleogene period is divided into--from oldest to youngest—

- the Paleocene,
- Eocene, and
- Oligocene epochs.

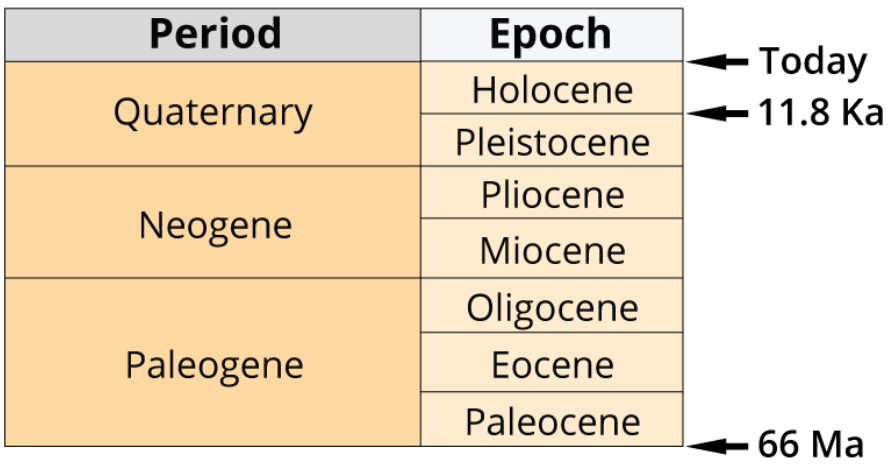
The Neogene is divided into the

- Miocene and
- Pliocene epochs.

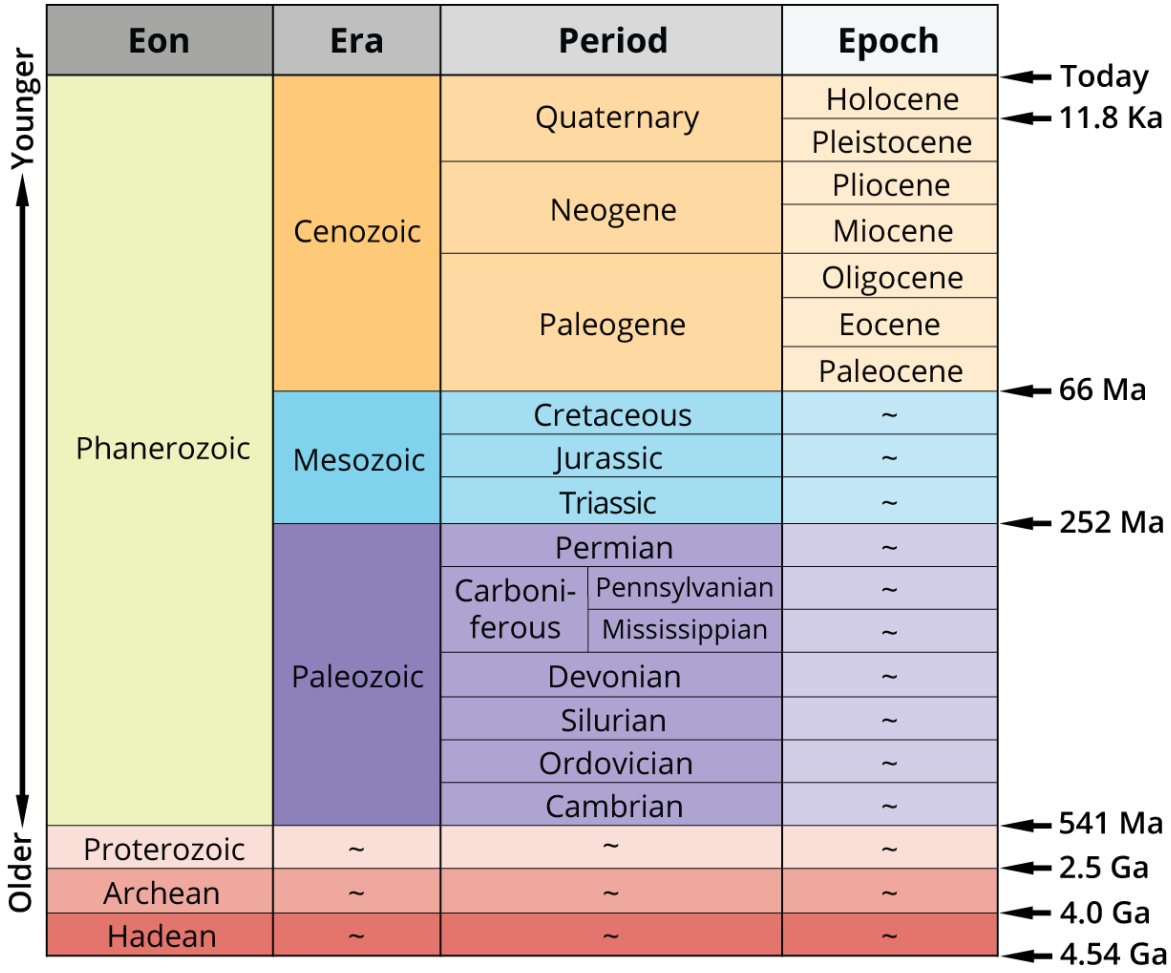
Finally, the Quaternary is divided into the

- Pleistocene and
- Holocene epochs.

Some geologists now think that--since humans are having such a notable impact on the Earth and its life--a new, youngest epoch should be added to the Quaternary: the Anthropocene. There is still considerable discussion in the geological community about whether this epoch should be added, as well as debate about what characteristics should define its beginning.



Epochs of the Paleogene, Neogene, and Quaternary periods.



The geological time scale. .

The geological time scale is a result of hundreds of years of investigation and remains very much a work in progress.

Most of the names of time intervals on the modern geological time scale have been stable for many years. The absolute ages associated with the boundaries that separate these time intervals continue to be refined as new evidence becomes available. For example, the modern absolute age associated with the Proterozoic-Phanerozoic boundary (equivalent to the beginning of the Cambrian period) is 541 Ma. In 2009, this age was 542 Ma; in 1999, it was 543 Ma; and in 1983, it was 570 Ma.

Events associated with the geological time scale

PRECAMBRIAN

1. Hadean (Age – 4.6 *billion years)*

- Indirect photosynthesis evidence of precambrian life.
- Oldest known mineral. i.e ZIRCON
- Crust was thin in the 1st stage of Earth's history.
- Composition of atmosphere was- vapour, methane, Co2, Nitrogen, Hydrogen, Inert gases and acidic fumes.
- Hydrogen and Helium was later dissipated into universe.
- Free Oxygen was 1st formed from the disintegration of H2o and Co2 under the influence of Sun rays in the upper layer of the earth's atmosphere.
- Proportion of Oxygen in the atmosphere increased to its present level.
- Formation of hydrosphere and atmosphere lead to intensive erosion and deposition of sedimentary rocks intercalated with volcanic rocks.

2. Archean (Age – 400 my to 2500 my)

- Oldest Microfossil was of this era.
- First known Oxygen producing bacteria.
- Hydrosphere contained dissolved gaseous product of volcanism such as HCl , HF, Basic Acid, H2S, Co2, CH4, Highly acidic water with silica in dissolved state.
- Extensive volcanism and unusual composition of atmosphere are reflected in the chemical composition of rocks making them distinct from younger rock formations.

3. Proterozoic (Age 2500 my to 541 my)

- It begins with tectonic zonation of earth surface.
- Composition of Hydrosphere and atmosphere underwent very little change during the transition period of Archean and Proterozoic eras.
- Carbon Dioxide content in hydrosphere declined.
- Volcanic products such as Sulphur and H2S of hydrosphere were converted into sulphates in the presence of Oxygen which insure deposited in the sedimentary succession of the time.
- Deposition of carbonate rocks(limestone and Dolomite)
- Early forms were not having hard parts so could not preserved as fossils.
- Imprints of Algal life preserved in the form of Stromatolites commonly observed in proterozoic succession.

PHANEROZOIC

Precambrian is divided into 3 Era

- Paleozoic
- Mesozoic
- Cenozoic

Paleozoic (Age 541 my to 262 my)

Paleozoic is divided into 6 Periods

1. Cambrian (Age 541 my to 485 my)

- Major diversification of life in cambrian explosion.
- Numerous fossils, most modern phyla appeared.
- 1st C*hordates appeared.*
- Trilobites, Sponges, Inarticulate sponges brachiopods and various other animals appeared.
- Gondwana Emerged.
- Climate was mild.

2.Ordovician (Age 485 my to 443 my)

- Invertebrates diversified into many new types.
- Early Corals, Bivalves and many types of Echinoids were common.
- Conodonts (early planktonic vertebrate) appeared.
- First green plant and fungi on land appeared.
- Ice age at the end of the period

3.Silurian (Age 443 my to 419 my)

- First vesicular plant appeared.
- First fishes appeared as well as many armoured jawless fishes populated the seas.
- Brachiopods and Crinoids were abundant.
- Trilobites and Mollusks diversified.

4.Devonian (Age 419 my to 358 my)

- 1st Club mosses and ferns appeared, as do the first seed bearing plant.
- Trilobites declined while jawless fishes and Sharks ruled the sea.
- 1st Amphibian still aquatic.
- Mountains of North America and Appalachian mountains of North America were seen.

5.Carboniferous (Age 358 my to 298 my)

- First reptiles
- Highest ever atmospheric Oxygen levels.
- First land Vertebrate.
- Rhizodonts were dominate big freshwater predators.
- In Ocean early sharks are common and quite diverse.

6.Permian (Age 298 my to 262 my)

- Landmasses units into supercontinent Pangea, creating the Appalachians.
- Reptiles become plentiful while amphibians remain common.
- Marine life flourished in warm shallow reefs.
- Triassic extinction event occurred 257 mya: 95% of life on earth become extinct.

MESOZOIC (Age 262 my to 66 my)

Mesozoic is divided into 3 Periods

1.Triassic (Age 262 my to 201 my)

- Archosaurs dominated on land as Dinosaurs, and in air as Pterosaurs.

- 1st mammal and Crocodile appeared.
- Modern Corals and fish appeared.
- Andean orogeny in South America.

2.Jurassic (Age 201 my to 145 my)

- Gymnosperms, Conifers and ferns were common.
- Many types of Dinosaurs evolved.
- Mammals were common but small.
- 1st Bird and lizard appeared.
- Sea Urchins were common.
- Carbon Dioxide levels in atmosphere were 4-5 times more than the present day.
- Breakup of Pangea into Gondwana and Laurasia.

3.Cretaceous (Age 145 my to 66 my)

- Flowering plant along with new type of insects evolved.
- Ammonoidea, Belemnites, Bivalves, Echinoids were common.
- New type of Dinosaur appeared on land and modern snake in sea,
- Atmospheric Co2 close to present day levels.

CENOZOIC (Age 66 my to Recent)

Cenozoic is divided into 3 Periods.

1.Paleogene (Age 66 my to 23 my)

- Dinosaurs became extinct in the junction of cretaceous and paleogene epoch.
- Climate was warm.
- Rapid evolution and diversification of fauna.
- Appearance of several " Modern" mammal families.
- Primitive Whales appeared and diversified.
- First Grass.
- Modern plant appeared.
- Mammals diversified into numbers of primitive lineages following the extinction of dinosaurs.

2.Neogene (Age 23 my to 2.5 my)

- Widespread forests slowly draw in massive amounts of Co2, lowering the level of atmospheric Co2.
- First APE appeared.
- Horses and Mastodons diversified.
- Modern mammals and bird families become recognizable.
- Moderate climate, punctuated by Iceage.
- Orogeny in Northern Hemisphere.

3.Quaternary (Age 2.5 my to Recent)

- Human Stone age culture with increasing technical relative to previous Ice age culture in Pleistocene.

- Agriculture begins in Holocene.
- Flourishing and then extinction of many large mammals