

Geological Time Scale

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Component-I (B) - Description of Module

Items	Description of Module
Subject Name	Geography
Paper Name	Geomorphology
Module Name/Title	Geological Time Scale
Module Id	GEO- 3
Pre-requisites	Nature and Development of Geomorphology, Continental Drift Theory, Mountain Building
Objectives	To know about the Geological time scale and its different era like Precambrian, Palaeozoic, Mesozoic and Cenozoic.
Keywords	Geological time, Eras, Periods, Precambrian, Palaeozoic, Mesozoic, Cenozoic, Carboniferous, Cambrian , Devonian , Silurian, Quaternary Period, and Holocene

Geological Time Scale

Life on the earth did not come into being with its birth. The earth has a long history and has seen many changes on her surface through different periods. The earth cooled from its gaseous state into liquid one and transformed into solid layer on further cooling. For an instance, there was a great ocean in place of the Himalayas only 150 million years back. With one cellular organism, life began which belonged to both animal and vegetation kingdom. Later on, the animals and vegetations both evolved into more **complex life-forms**. The animals evolved into fish, reptiles, mammals and finally into human beings. The great age of the earth were based on the rate of sedimentation, age of fossils, and the rate of cooling of the earth, salinity of the oceans and the tidal force of the moon. As far as, the age of the Earth is concerned, there is a lot of difference of opinion among the scientists. On the basis of current methods of radio-metric dating, most of the modern scientists agree that the life of the Earth may range from 3 to 5 billion years.

James Hutton believed in the principle of uniformitarianism and he knew that the earth was very old but they had no method of knowing its exact age. Several methods were devised by others which were in use till about the beginning of the 20th century. **Lord Kelvin** (in 1897), a renowned physicist, had assumption that the earth was originally molten and cooled to its present condition, put the earth's age at not more than 100 million years, and perhaps much less.

THE ORIGIN OF GEOMORPHOLOGY

Origin

Ancient Medieval Beginning of Modern Period and Modern Geomorphology Recent Trends

In North America In Europe after Hutton

Modern Geomorphology and the Age of Hutton and Lyell in Europe

Hutton (1785) 'Royal Society of Edinburgh'.
Hutton proposed that land surface is evolved by slow, unremitting erosive power of moving water.
Hutton is best known for) **The present is the key to the past and , (ii) No vestige of a beginning no prospect of an end.** his two statements: (i
Thus he established the principle or doctrine of **Uniformitarianism**. His idea about the **'Theory of Earth'** or formation of earth was more popularised by **John Playfair** (1748-1819) and **Sir Charles Lyell** (1797-1875). Lyell later became the great follower of uniformitarianism in Europe. His book **'Principles of Geology'** was based on Hutton's principle of Uniformitarianism.

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Rutherford, (in 1904) for the first time took the help of radioactive substances in determining the age of the earth. For calculating the ages of rocks and minerals, the discovery of radio-activity provided a reliable means; contain radioactive isotopes (elements). This method is called radiometric dating. Till about 40 years ago the age of the earth calculated on this basis was placed at about 3,000 million years. In recent years, it has been possible to make more accurate calculations due to more precise scientific knowledge. The

relative percentage of lead isotopes in ancient rocks and meteorites has also been taken into account and the age of the earth is now placed at around **4,600 million years**. Chances of error in this calculation are very small; therefore this age is now widely accepted.

Geological History of the Earth

Though life on earth has existed only for a small fraction of her history, fossils, which are remains of extinct animals, indicate a good deal. It is possible to estimate the depth of the sea on the basis of fossils of certain marine animals like corals, where particular sediment was precipitated. Furthermore fossils provided indications of past environments. **Radiometric dating** has made possible the specific or absolute dating of rock units that represent various events in the earth's distant past. When a complete sequence of rocks representing the entire period is not available and there are breaks in the rock record, then it is known as unconformities.

The principal divisions of geological time are called eras. **Three eras are recognised- the Palaeozoic (ancient life), the Mesozoic (middle life) and the Cenozoic (recent life)**. Each of these eras is subdivided into smaller time units known as periods.

The Palaeozoic has seven periods, Mesozoic and Cenozoic has three and two periods respectively. Each period is characterized by its profound changes in life forms. These twelve periods are further sub-divided into epochs and epoch into ages.

It will be observed that the Palaeozoic era begins some 600 million years ago. The enormously long period of more than 4 billion years prior to the Pre-cambrian with no further subdivision, as our knowledge about those early times is very limited. This is so, because prior to the Cambrian, very simple life forms such as algae, bacteria, fungi, sponges and worms have not left adequate fossil record. On the basis of the above discussion a standard geological timescale has been prepared which is accepted throughout the world and with reference to which the geological history of the earth can be studied.

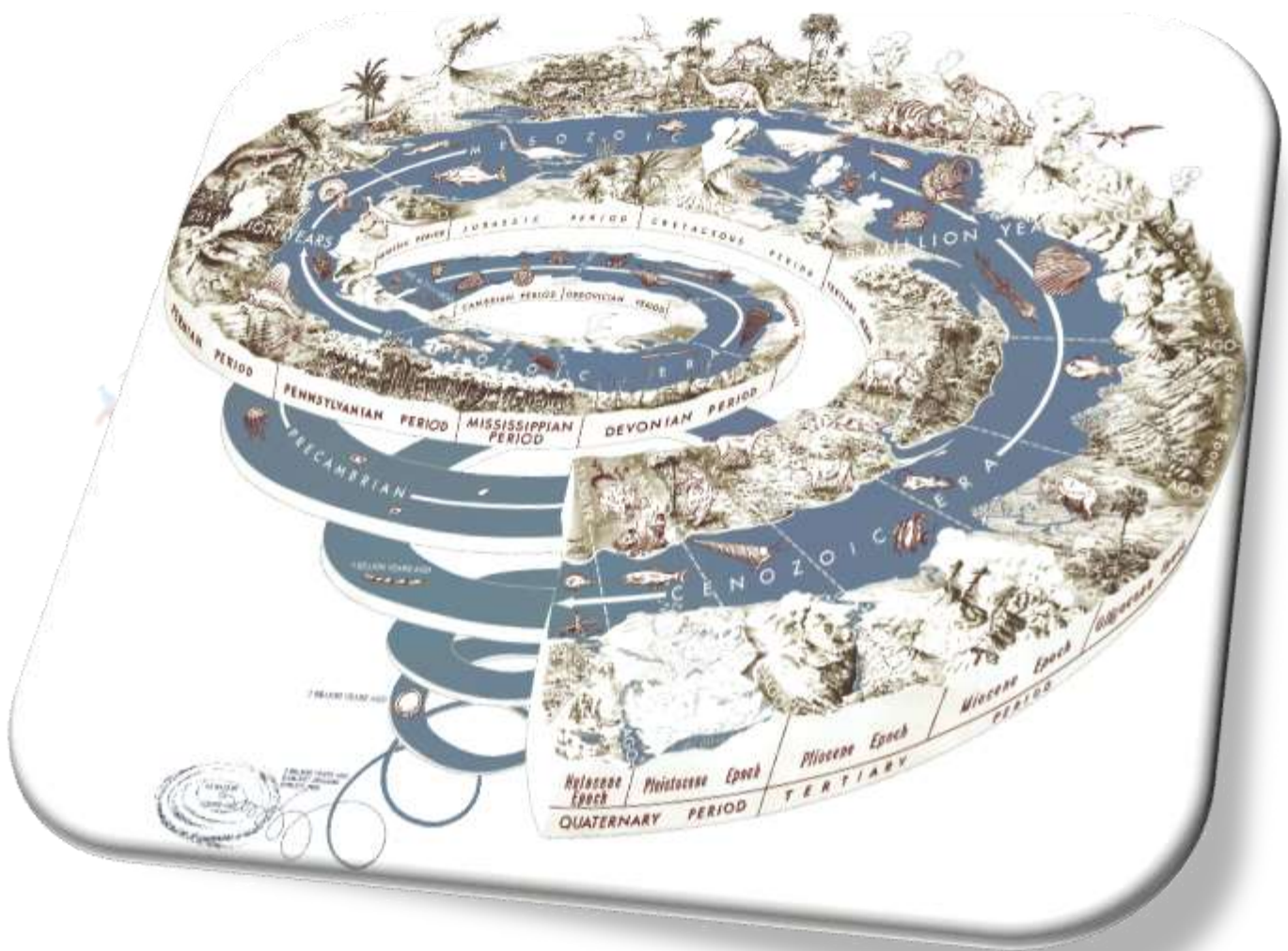
Stratigraphic Chart

Era	Period	Epoch	Million Years Age	Distinctive Life	Major Structural Episodes
Cenozoic	Quaternary	Recent/ Holocene	0.01	Ice age ends Humans are dominant	Main Alpine Episode
		Pleistocene/ more recent	2.5	Age of Man	
	Tertiary	Pliocene	12	Age of mammals- (flowering plants and broad leaved trees)	Laramide Phase
		Miocene	25		
		Oligocene	35-40		
		Eocene	60		
Paleocene	70				
Mesozoic	Cretaceous (Creta=chalk)		135	Age of reptiles (Dinosaurs) and birds	General Worldwide Elevation
	Jurassic (after Jura mountain)		180		
	Triassic (three fold division in Germany)		225		
Palaeozoic	Permian		270	Age of Amphibians	Main Hercynian Episode

	Carboniferous		350	Widespread forests	
	Devonian		440+101	Age of fishes	
	Silurian		440+10	Age of marine	
	Ordovician		500	Invertebrates	
	Cambrian		600	Abundant fossils first appear	Main Caledonian Episode
Azoic or Precambrian			Oldest rocks 3787+85		Several Mountain Building Episodes

Source: Dayal, P. "A Textbook of Geomorphology", Shukla book depot, Patna, 1994 & <https://andykh.deviantart.com/art/Geological-Timeline-Chart-283922560>

It is clear from the above table that man is comparatively a new comer on the Earth. Even this history of the earth constitutes not more than one sixth of the life of the earth, nothing is known about 5/6th of the Earth's history.



Source: <https://abstractgeology.files.wordpress.com/2012/10/geological-time.jpeg>

Division of Geological Time into Eras

We have noticed above that geological time has been divided into four major divisions called eras-Precambrian, Palaeozoic, Mesozoic and Cainozoic or Cenozoic. The oldest and by far

the longest is Pre-Cambrian which covers 90 per cent of geological time but our knowledge about this era is too little.

PRECAMBRIAN ERA (Eozoic)

This is the oldest era of geological history. The duration of this era is from the beginning of the earth nearly 4.6 billion years or more till about 0.6 billion years ago. In other words Pre-Cambrian alone compasses 90 per cent of all geological time.

Pre-Cambrian rocks are, which are said to be the oldest one, belong to the Archaean period. **Most part of the Peninsular plateau of India is composed of Archaean rocks** which include the rocks of the Dharwar system which were originally sedimentaries. Just above the Archaean system are the Late Pre-Cambrian or Proterozoic rocks, the rocks of the Vindhya system and the Cuddapah system in India belong to this period. The rocks of the Pre-Cambrian era cover extensive areas in all the continents and usually form areas of low or moderate relief on account of the denudation of ages: These are called continental shields. In this era, Pangaea continent was born and at the end of the period the four shields had come into existence- i.e. Laurentian shield; Siberian shield; Gondwana shield; Baltic shield.

The Pre-Cambrian rocks are extremely rich in metallic minerals, and almost all the important occurrences of iron ore, gold, copper, manganese, uranium, chromium, lead, zinc and mica in the world are found in the rock of this era.

PALEOZOIC ERA

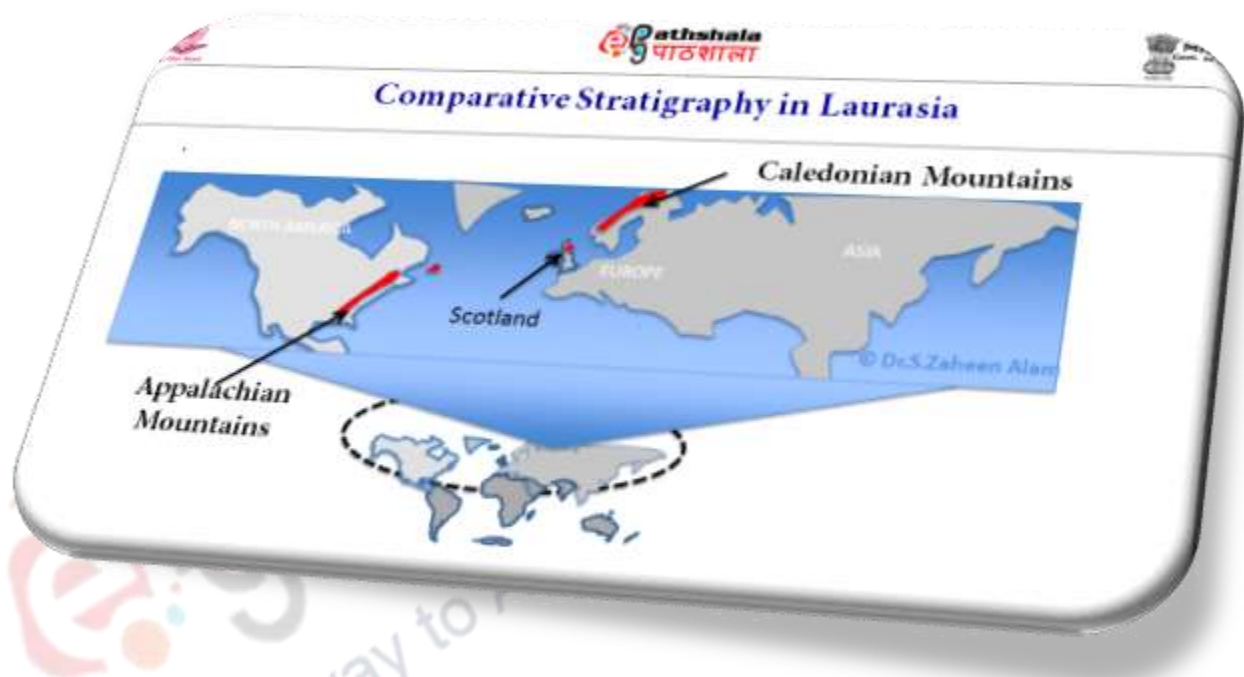
The Palaeozoic started 600 million years ago and continued till about 225 million years. Its time range is about 30 million years. The animals in the seas and oceans were invertebrate. Non-floral vegetation came into existence. The chief rocks of this period are shale, slate, hard sandstone, hard limestone, and rocks of this period are found large deposit of valuable minerals. The rocks of this period in North America abound in gold, oil, coal and iron ore while in Europe tin, copper and iron are found in the rocks of this period. This era further sub-divided into six periods of which the oldest one is the Cambrian followed by the Ordovician, Silurian, Devonian, Carboniferous and the Permian.

During this era, the South Pole was possibly somewhere in the South Atlantic Ocean and the North Pole in the North Pacific Ocean and the equator passed through South Australia, Arabian Peninsula, Middle Europe and eastern North America. In the Devonian period presence of **coral limestones** in North America, Europe and South-east Asia and Australia indicates a hot climate. On the other hand, in the Devonian and Permian periods there are evidences of relatively cold climates in South America, South Africa and India.

(i) **Cambrian Period**-This period was about 90 million year long (from 600 to 500 million years). Cambrian Period saw the transgression of sea over the land surface. Land submerged under water due to earth movement that gave rise to sedimentary rocks. It is why the rocks of this period are quite extensive. The rocks of this time have light limestone at the bottom over which are laid the layers of sandstone, shale and at the top is a thin layer of limestone again. These rocks not only contain the fossils of the oldest life but also hold the first evidence of life.

(ii) **Ordovician Period**- The period witnessed a large portion of the land surface being submerged under water and half of North America was under water. There was an expansion of oceans in this period. Several volcanic eruptions took place in this period and the eastern portion of the U.S.A. was overlaid with the volcanic ash and dust. Among the animals the greatest evolution of Trilobites took place. The sea-grass was the main vegetation with characteristic of the birth of molluscus in this period. **Slates, limestones and volcanic rocks** spread over a large area.

(iii) **Silurian Period**-It was the third period and followed the Ordovician Period and preceded the Devonian Period. This period was important for the birth of fish and land vegetation. The **Caledonian earth movement affected all the continents**. For the first time, the animals which could breathe came into existence that means animals with lungs developed. Fish came into existence. The red sandstone also came to be formed in this very period.



(iv) **Devonian Period**- It was about a million year long period. It began 440 million years ago and ended 350 million years ago. Devonian Period saw at its beginning the well-known mountain building movement i.e. Caledonian movement. The mountains of Scandinavia, North England, Scotland and Spitzbergen were formed in this period. It is called the age of fishes because the seas were full of them. In the late Devonian, the first amphibians and vertebrate colonisation of the dry land had begun. All the rocks of this system hold the fossils of fish. The chief creatures of this period were predominantly aquatic.

(v) **Carboniferous Period**- It was 80 million year long. It began 350 million years ago and ended in 270 million years ago. The importance of this period is that the coal beds of the earth came to be formed, hence it is also known as the Coal Age. Thus in course of time due to intense heat and pressure, the successive layers of decaying vegetation, entrapped in the sediment layers, were transformed into coal beds. This period also saw the beginning of such animal life which could live both on land and water.

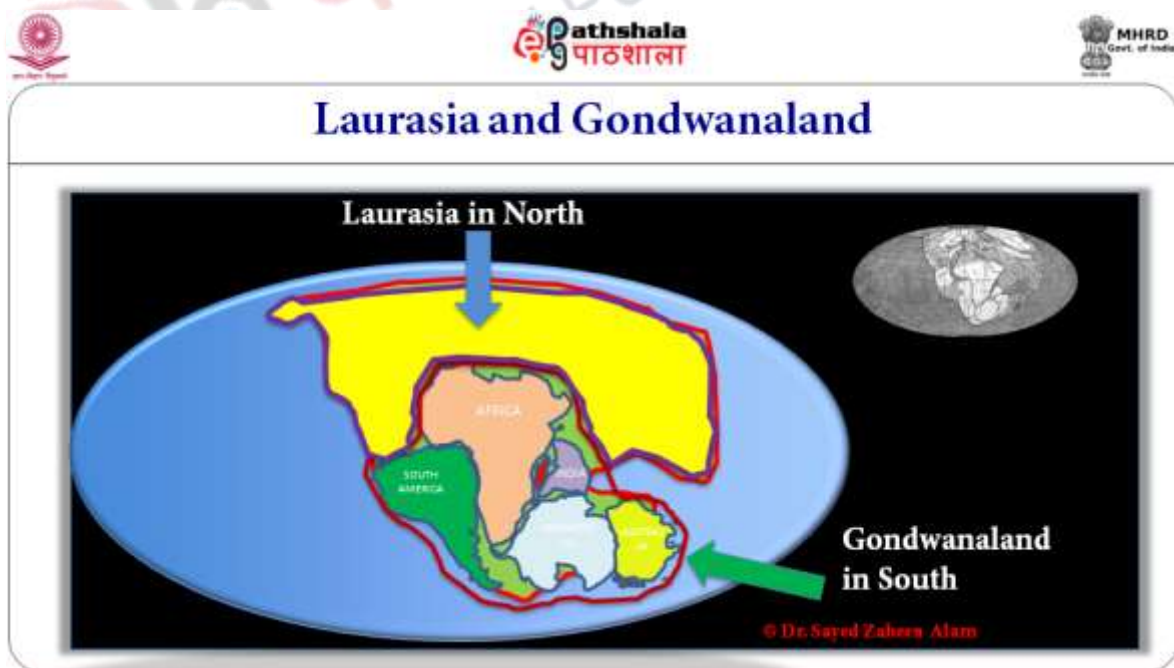
(vi) **Permian Period**-This period is 45 million years long. It began 270 million years ago and ended 225 million years ago. Permian Period was the time when the **Hercynian mountain building movement occurred**. This movement left its mark in central Europe, North America and several other places. There was a heavy deposition of red rocks and limestones in South-West U.S.A. The animals which could live both on land and sea came to evolve all the more and reptiles saw the light of day. The temperature began to rise and the climate started getting dry in this period.

MESOZOIC ERA

Mesozoic or secondary Eras formed of two words-*mesoi.e.* middle and *zoici.e.* life. In other words, it is the meeting time between the old and the new Eras. The Mesozoic era is of a much shorter duration than the Palaeozoic. The climate started getting warm and dry. The snow cover of Antarctica began to melt. This era is best known as the age of dinosaurs and reptiles. In this era, birds make their appearance in Jurassic and the small mammals begin to appear in the Triassic. The Tethys Sea was divided into two parts. This era consists of the following three periods:

- i. Triassic Period
- ii. Jurassic Period
- iii. Cretaceous Period.

(i) **Triassic Period**-It started 225 million years ago and ended 180 million years ago. It was about 40 million year long. During this period, one compact landmass known as Gondwanaland; South and Central Africa, Madagascar, South India and Australia were part of it.



During this period, while the northern hemisphere was having dry climate, the southern hemisphere was overlaid with an ice sheet. The **Tethys Sea** which had come into existence by the end of the Palaeozoic era, continued to exist till the Cretaceous without any significant

deformation. The places in Europe where we now find the Mediterranean Sea and the Alps mountains, there used to flow the Tethys Sea.

The shales and sandstones of the Panchet series of the Gondwana system belong to the Triassic and the sandstones and shales of the Jabalpur series belong to the Jurassic. In this period; shale, limestone, sandstone, etc. were formed. The first dinosaur was born; mammals also came into existence in the elementary form.

(ii) **Jurassic Period:** It is considered to be 45 million year long. It started 180 million years ago and ended 135 million years ago. Reptiles reach their greatest proportions in this period. They dominated the land, sea and air. The fossils of the first bird also belong to this period. A lot of deposition took place in the seas of western USA. Nevada and Laramide movements also took place in Jurassic period. Formation of Sierra Nevada Mountains was the result of these movements.

(iii) **Cretaceous Period:** It began 135 million years ago and ended 70 million years ago. It was about 60 million year long. It is well-known for its widespread deposits of chalk. The other major rocks of this period are soft sandstone, clay and limestone. Due to Laramide movement, the American Cordilleras were formed. It was during this period that deciduous trees appeared. Undoubtedly, the most dominating among the animals were the reptiles. The first birds and mammals were also appeared in this period. Huge animals (Dinosaurs) began to decay and were almost extinct by the end of the period.

CENOZOIC ERA

This latest era in the earth's geological history has began about 65 million years ago. Cenozoic is made of two words—ceno, i.e. new and zoic, i.e. life. It is an era of new life which normally divided into two periods—Tertiary and Quaternary. But there are some people who are in favour to regard the Tertiary and Quaternary as two separate eras. Tertiary period ended about one million years ago. At present we are living in the Quaternary period.

The Tertiary period is sub-divided into five epochs. These are, beginning from the oldest, - Paleocene, Eocene, Oligocene, Miocene and Pliocene. It was during this era that the vegetation increased and the apeman appeared.

(i) **Paleocene Epoch-** This epoch began 70 million years ago and ended 60 million years ago. It is considered to be about 10 million years long. The Rocky Mountains were formed under Laramide movement. Grass land area also increased in this epoch.

(ii) **Eocene Epoch-** It is considered to be 20 million years long. It started 60 million years ago and ended 40 million years ago. The land area developed many fissures which belched out lava over a big area. Mammals evolved into many branches. During this epoch plants bearing fruits and grains developed on a large scale.

(iii) **Oligocene Epoch-** It began 40 million years ago and ended 25 million years ago. It was about 15 million years long. It was the epoch of **Alpine Orogeny**. Sediment started depositing in the seas of Pacific coast. The forefather of man, Anthropoid, was born in this epoch.

(iv) **Miocene Epoch**-It was almost 13 million years long. It began 25 million years ago and ended 12 million years ago. The rivers continued to deposit sediments in the Great-Plains of U.S.A. During this epoch the Alpine folds developed in Eurasia and trended in the east-west direction. Sediment was also deposited at large scale in the Atlantic ocean and Gulf coast. The whale and monkey came into existence.

(v) **Pliocene Epoch**- This epoch was about 10 million years long. It started 12 million years ago and ended 2.5 million years ago. Due to orogenetic movement, the sediment deposited in the shallow seas rose in the form of plains. During this epoch large plains developed, the important ones are the **Northern Plains**, plains of Europe, the Po basin of Italy, the Mesopotamian plain, **Ganga and Sindh plains**. Horses, elephants and huge carnivorous animals evolved. This epoch is also considered to be the evolution of man.

(b) **Quaternary Period**:The Quaternary period started about two and a half million years ago. It is further subdivided into two epochs- Pleistocene and the Recent (or Holocene). This is the most recent of the periods of geological history. The alluvial deposits of the world were also laid in this period. The rocks of this period contain the fossils of horses, elephants, camels and several other oceanic mammals. This period saw the evolution of man and the growth of his intellect.

(i) **Pleistocene Epoch**- The Pleistocene Epoch is typically defined as the time period that began about one million years ago and lasted until about 10,000 years ago. Man appeared on this planet only towards the beginning of Pleistocene but the modern man developed in the Holocene epoch. At the beginning of this epoch, the temperature of the atmosphere became so low that the surface of the earth came under a vast ice sheet. Besides these, the Himalayas and the Alps were having small patches of ice-caps. On account of these, this era is also known as the Great Ice Age. The land masses of the Southern Hemisphere, however, remained free from ice. North Africa, North America (Canada and northern U.S.A.), Arctic and Antarctica were all covered with a thick layer of snow. The snow caps of high mountains expanded. The snow cover of North America has disappeared hardly 10,000 years ago. The snow cover had a prevalent effect upon human life. Large and violent animals were killed. Mammals had evolved very fast. Monkeys, chimpanzees and human beings increased in number at large. Man's fossils are found in rocks about one hundred thousand years old. It is, therefore, estimated that man is only one hundred thousand years old.

The snow cover was not static in this age. From a study, snow cover advanced and retreated four times. Hence this period is called ice age and divided into four ice-ages (a) Gunz (b) Mindel (c) Riss and (d) Wurm. There is no unanimity among the scientist regarding causes of ice-ages. Some of the causes have been attributed to the birth of mountains, the eruption of volcanoes, the interruptions in the receipt of solar energy, etc. The five Great Lakes of North America were formed by the retreat of the snow cover. The mountain tops of Europe and America were rounded and the river valleys developed U-shape. The landscape features of Sweden, Finland and Russia are a testimony to the work of snow cover.

(ii) **Holocene Epoch**. This epoch started 10,000 years ago. 'Man' is the most important feature of the Holocene epoch that is why Holocene can be called the age of human-evolution. However, the theory of human evolution is still in question. Man, by the development of his intellect has established his control over the flora (plants) and fauna (animals) of the world. He has accelerated some changes in the landforms and has converted the Earth into a place

for his existence. Though no large scale changes have been effected by rivers, sea waves, winds, etc., in the landforms during the Holocene, yet man has made tremendous progress in human civilization.

During his relatively short period man by his intelligence, mental ability and power of organization has greatly speeded up the pace of development. Therefore the climatic conditions in the past have played an important role in the way of human life. The effects on the life of man are visible on the type of environment creating for his comfort. Man has also been able to move out of the pull of the Earth and visited the Moon and constant efforts may make human landing on Mars.

