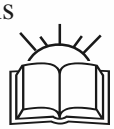
UNIT 1 TIME AND SPACE

Contents

Learning Objectives



Once you have studied this unit, you should be able to:

- understand the meaning of ice age and the climate that prevailed in the ice age;
- know about pluvial and inter-pluvial epochs that were present in the tropical region at the same time as the ice age in the temperate region; and
- learn the importance of environment for the evolution of Human being and his culture.

1.1 INTRODUCTION

It was Charles Lyell who brought forth the idea of geological time in his book, *Principles of Geology* in 1833. He was the first person to explain the relevance of geological strata for reconstruction of time. Geological strata means the layers of soil, clay, rocks and gravels which are usually found in linear order both on the surface and under surface of the earth. In fact the crust of the earth is made of such layers. Lyell's work is based on the law of superimposition of geological layers known as stratum. In an undisturbed sequence it is found that lower the stratum earlier the date of the stratum in respect to the layers lying on it. Natural history is divided into ages and eras based on this principle. Charles Darwin provided the evolutionist view and Lyell gave the background for the understanding of change and development.

Geology is a branch of science which deals with earth in historical order. Geology and geography are closely related to each other. Geography mainly studies the present day surface of the earth, which is exposed and can be seen, whereas the surface which was once exposed but now is under the present surface is mostly the subject of study of geology. Surface geology is equally important because a comparison of the undersurface condition with that of the present surface gives an idea about the conditions under which the undersurface layers were formed. In connection with surface geology major data which can be gathered are on the erosion and depositional activities. The present surface geology study, also known as, geomorphology, provides information about the land surface and the climatic

condition under which they were formed. This information helps us to reconstruct climatic condition of the earlier period. In the study of man the framework is made up of the geomorphology and environment of the area, that is the understanding of the space. It must be kept in mind that environment was not uniform throughout the time for human evolution.

Erosion and deposition are major activities in the formation of earth's surface. These are caused by elements like temperature, rainfall, wind and humidity. Surface materials are loosened by thermal activities, water and wind. The loosened materials are carried away by wind, water and by gravitation, if the surface is located on a slope. This process is called erosion. The eroded materials are carried by the elements, such as wind, water and gravitational pull and are deposited somewhere else. These two activities are going on on the surface of the earth under the influence of elements like wind, rainfall, temperature and humidity. These elements make up climates and are components of the environment.

Environment is made up of abiotic and biotic factors. Climate, soil and topography belong to the abiotic aspect of the environment. Flora and fauna belong to the biotic aspect of the environment. Man is a part of the biotic environment. Together with geology and geography comes another word, that is, ecology, which expresses the idea of interrelationships. Man evolved through Quaternary period. Therefore quaternary geography/ geology connote both environment and time. Various estimations put the date of Quaternary and about 4-2.8 millon years.

There are many approaches to the study of Quaternary geography. Following are the three basic approaches out of these (Butzer, 1964):

1) Individual Pleistocene researches by the natural sciences. These are carried out independently either in the fields or in the laboratory by geologists, geographers, soil scientists, botanists, zoologists and meteorologists. Most of the palaeoenvironmental data is obtained in this way.

2) Ecological and environmental information is gathered by collaborating with the anthropologist as also the archaeologist, especially in the field. Most common background for the study is provided by Pleistocene geology, geomorphology, palaeontology and pollen analysis.

3) Archaeological anthropologists work for a fuller understanding of human ecology of prehistoric man especially in the realm of cultural geography and economy.

1.2 GEOLOGICAL TIME-SCALE AND QUATERNARY FRAMEWORK

Of the 4,500 million and more years of the earth's existence only the last 600 million years can be traced with accuracy. Primitive forms of life must have been evolving for many millions of years before their first fossilized record is found in deposits dating from around 600million years. The earliest vertebrates did not appear for another 100 million years. Mammals date back to a little less than 250 million years. Man who is the most advanced of the mammals has only emerged within the last 2-3 million years.

Perspective of time is important for both culture historian and for the geologist. The Quaternary period is the last phase of geological history. It covers a time span of two million years and covers the total period of human history. Excepting for the last 5,000 years of recorded history, most of Quaternary represents prehistory.

> The history of the Earth is chronologically determined by the time scale which provides a base for the earth scientists, geologists, paleontologists, and other scientists to determine the age of the earth.

Geological time scale is divided into eras. The era in which we live is called Cenozoic. It is divided into two periods, the Tertiary and the Quaternary. Quaternary period is divided into two epochs, Pleistocene and the Holocene. Holocene is the recent time. It is a distinctive name for the last 10,000 years, for the sake of convenience. Pleistocene is a very unusual period in the history of the earth. It coincides with the history of man and also is a time when drastic climatic changes took place on earth. The environmental changes affected the mammalian life as well as human evolution. Throughout the greater part of earth's history world's climate was warmer and much less differentiated than it is today.

Towards the end of the Tertiary period, around 56 million years back there was a gradual cooling of temperature mainly in the higher altitude and latitudes. In the present day temperate regions there was a southward movement of the snowline compared to what it is at present. Similar change was observed towards north in the southern hemisphere. On the higher altitudes, on the mountain tops a similar lowering of snowline was recorded. As a result glaciers were found in areas where at present none exist. The present temperate zone was displaced towards equator by some 15 degree to 20 degree of latitude. The tropical regions of the world experienced change in average annual rainfall and subsequent decrease in the same. The climatic change brought in change in the environment and in the level of flora and flora. Pleistocene and Holocene environment changes are recorded in the strata of the earth's undersurface. Geological study produces a time scale for understanding of the evolution of man and change and development of his culture. Quaternary is considered as a framework, a backdrop against which anthropological study of man may be made. The framework is of environment, space and time. Human ecology gives rise to change and development in culture.

Pleistocene is divided into three parts; lower, middle and upper. This is based on time scale, which is available through geology, palaeontology, palinology and through radiometric dating. The beginning of Pleistocene is dated at c. 1.65 million years B. P. on the basis of date found at Olduvai Gorge. In the year 2009 International Union for Geological Science (IGUS) fixed the date for the beginning of Quaternary at 2.58 million years B. P. E (Before Present Era) at the base of Matuyama, palaeomagnetic event. Middle Pleistocene starts at 0.73 million years B.P. This is based on dates found at the sea core no. V28-238 (Shackleton and Opdyke, 1973), near the Solomon plateau in the Pacific Ocean. Upper Pleistocene begins approximately at 128 thousand year B. P.

Two developments have fixed time scale for Pleistocene. These are: (i) The advent of absolute dates for the entire 2.58 Myr and (ii) the stratigraphic record obtained from cores drilled into the ocean floors. These developments have revolutionised quaternary geology. The deep sea sediments provide a continuous stratigraphic

record of Pleistocene events that can be fixed at key points by absolute dates. The uppermost section falls within the range of C14 while sediments from the core can be tested for magnetic polarity. Palaeomagnetic studies have shown that at 0.73 Myr the earth's magnetic field changed from reversed to normal polarity. The Bruhn- Matuyuma boundary is a stratigraphic marker of worldwide significance since it can be identified in ocean cores and terrestrial volcanic rocks where it has been dated by Potassium/ Argon isotope decay methods. The boundary now marks the division between the lower and middle Pleistocene (Butzer and Isaac (ed), 1975). The last interglacial/ glacial cycle correspond to the upper Pleistocene at 128 Kyr. These are estimated dates. The climatic changes are gradual processes, and they happen over a range of time (Gamble, 1986).

1.3 PLIO-PLEISTOCENE BOUNDARY AND PLEISTOCENE PERIOD

Towards the end of the Tertiary period a gradual change in climate had been observed. The last epoch of Tertiary period which precedes the Pleistocene is known as Pliocene. The boundary between Pliocene and Pleistocene is important. This period is marked not only by absolute date but also by the presence of a group of animals who are the index to Pleistocene, meaning that they are found only in Pleistocene. Thus they are called index fossils for Pleistocene. These are known as villafranchian fauna after the name of a place called Villafranca d'Asti in Itally. At this place those fossils were first identified. Villafranchian fauna are *Equus* (horse), *bos* (cattle), *elephas* (elephant) and *camelus* (camel). The first three are more common in Eurasia. Any geological layer yielding any one of these fossils may be identified as Pleistocene. The beginning of Pleistocene is also marked by the appearance of deep water foraminifera *Globorotalia truncatulinoides.*

In India work has been done by various scholars both in the sub Himalayan regions and in the peninsular regions. New techniques and extensive works point to the Plio-Pleistocene boundary in the Siwalik deposits, in Kashmir valley in the Karewas deposit and in alluvial deposits in the peninsular region. The date for this boundary goes back to 1.9 Myrs (Dennel and Rendell, 1991).

1.4 CLIMATIC EPISODES OF PLEISTOCENE PERIOD

Glacial and Interglacial Periods

The pioneer in working on the climatic episodes of Pleistocene period was Agssiz in1840. This work was taken up by Penck and Bruckner in 1909. They made a synthesis of the fragmentary evidence found in the periglacial zone in the form of moraines, glacial tills, river terraces, loess profiles, pollen sequences, molluscan faunas, beetle assemblages and animal bones, particularly of rodent species. The result led to a classic Alpine chronology of four major glaciations separated by three interglacials. The terms for the four glaciers are Günz, Mindel, Riss and Würm, named after four little streams in the Alps. These four glacial and three interglacial stages formed the framework for the Pleistocene and Palaeolithic studies.

The deep sea core has revolutionised the idea of Pleistocene. It provides continuous stratigraphic record for the Pleistocene events. The stratigraphic record is constructed from hundreds of cores drilled into the ocean floor of the world. The coring of the ocean floor produces sediment columns, which are made up of small marine foraminifera. The foraminifera skeletons are made up of calcium carbonate and when the foraminifera were alive they had absorbed oxygen as well as its isotopes. Two types of oxygen are there, ^{16}O and ^{18}O of these ^{16}O is normal and ^{18}O is its isotope. The ratio of these two isotopes may vary because of evaporation. In case of high evaporation more of the lighter molecule of ^{16}O is taken up in the air and the heavier isotope ^{18}O is left in the oceans. At the time of ice formation, during the glacial part of the cycle the sea level falls as moisture is taken up and used to build continental ice caps. The oceans of the world then become smaller and are charged with ^{18}O. The sea cores inform us about the size of the ocean during Pleistocene and also about contemporary events that took place on the land surface (Gamble, 1986).The isotope sediments had been correlated by scholars for vegetation cycle on the basis of pollen analysis; by loess and loam cycles and by cave sediments. It became clear that oxygen isotope curve gives an indication of the changes of ice volume on land and of the oceans having consequently been slightly over 1% richer in ^{18}O at the last ice age maximum than today. Hundred thousand years scale dominates, then 40,000 years and subsequently 20,000 year of length of each fluctuation. Interglacial stages are identified by the pollen analysis. Through this time warmth loving fauna replaced the cold loving ones and deciduous mixed oak forests grew in place of coniferous ones.

Causes of Ice age

Several theories were put forth for finding out the reason for ice age. The most accepted one is the astronomical theory. It was developed by Crole and elaborated by Milankovitch. Earth's temperature would vary with periodic changes in earth's orbit and axis. Over approximately 96,000 years the shape of the earth's orbit is known to have changed from circular to elliptical and back. Axis tilts from about 21.5^0 to 24.5^0 and back over 42,000yrs. Variations in equinoxes resulted in variation in the time of the year when earth is nearest to the sun. This variation gave rise to the difference in reception of solar radiation on earth. Subsequently climatic fluctuation took place during Pleistocene.

Pluvials and inter pluvials climate

There is undoubtedly some evidence that there have been major climatic changes in the tropical region, in the lower latitude and lower altitude. There are traces of lakes in the region which are now dry; fossil soils are found which only could have been formed at a wetter and at subsequent drier periods than those prevailing today; and accumulation of windblown sand (dune) occurs under protective cover of vegetation. The relatively wet climate is known as pluvial and the relatively dry condition is known as interpluvial. There is no doubt that these climatic changes were directly or indirectly the effects of the same general cause which affected glaciation. The view that the pluvial in the low latitudes and glaciers of the high latitude were contemporaneous is still not firmly established (Oakley, 1968). Researches in East Africa have shown that there were four major pluvials with intervening interpluvials experienced in this zone. Their sequence is as follows:

4. Gamblian pluvial
   Third inter pluvial
3. Kanjeran Pluvial
   Second Interlpuvial
2. Kamasian Pluvial
   First Interpluvial
1. Kageran Pluvial

There have been two more wet phases recorded in the Post Pleistocene phase. These are:

ii) Nakuran

i) Makalian

The names for pluvial and interpluvial of east Africa are widely used in other parts of the country also to indicate similar climate and its sequences.

1.5 STRATIGRAPHIC EVIDENCES FOR CLIMATIC FLUCTUATION ON EARTH DURING PLEISTOCENE

Evidence for cold climate

Glaciers: It is a moving mass of ice. Snowline is the critical limit above which more snow falls than can melt. It is formed at a place where mean annual temperature is somewhere below freezing point (0^0c). Glaciers give important information about wind direction and moisture sources. Ice is an altered form of snow. Ice is formed due to repeated melting and over freezing of snow. Ice is capable of plastic movement. Movement of ice causes internal deformation and basal sliding over bedrock. The movement of ice leaves mark by carrying the loosened materials and also curving a deeply recessed basin known as *cirque* also termed as U shaped valley.

It is mainly stratigraphy which provides useful evidence of the Pleistocene climatic oscillation. Some of them are moraine, loess, frost soil, or solifluction, travertine, gravel deposits and certain types of flora and fauna.

Moraine: The debris material that is carried with the ice is known as moraines. Ancient moraines help in reconstruction of the past glaciers. There are various kinds of moraines, namely, lateral, end and bottom moraines. The classification is based on location of the moraine in relation to the path of the glacier. The bottom moraines are also known as till or boulder clay.

Loess: Windblown dust, which is finer than sand but coarser than clay. This is formed of rock waste of glacier climate, composed of dust which can be easily carried by wind. Loess is usually found in periglacial zone. It is pale yellowish in colour. Kukla (1975) distinguished alternating sequence of loess and loam. Loam represents warm climate. Stages of glacial and interglacial sequence on the basis of loess and loam are made in the areas where glacial ice did not reach.

Frost soil and solifluction: The area where temperature is such that subsoil remains permanently frozen is known as permafrost zone. During warm condition thawing of the soil takes place for only about a few cm to about a few mm. The zone has got certain geomorphic activities, such as solifluction, that is, soil creep of the thawed layer. In areas of annual freezing and thawing structures like ring or net work, known as stone ring and polygon soil are produced. Ice wedge is another formation. It is produced under -10 degree centigrade. Wedge shaped cracks are found due to presence of water and ice. Frost soil helps to recognise climatic feature. It is found in areas where the warmest month record below 10 degree centigrade. Such areas were too cold to allow any forest to grow.

Evidence for mild climate

Various kinds of soil are produced, namely, brown soil, black soil, due to growth of vegetation in a warmer condition.

Travertine: It is found in the lime rich region. It is a deposit of calcium carbonate. Formation takes under a humid climate.

Glacio-fluvial terraces: Streams of melt water formed near end of the glacier join to form rivers. The debris carried by the glacier is deposited as gravel along the course of the river when water supply to the river becomes less due to dry cold condition. At a subsequent time down cutting of the deposit takes place and a step like structure is formed. These terraces are important for understanding the glacial and interglacial sequence in a periglacial zone.

The area where actual presence of glacier is found is known as glaciated area. The area where direct presence of glacier is not found but the climate is influenced by the nearby glacier is known as the periglacial region. The area where no influence of glacier is found is known as a-glaciated zone. Man did not live on top of a glacier. He preferred periglacial and a-glaciated regions to live in.

1.6 PLEISTOCENE EPOCH IN INDIA

India is basically under tropical monsoonal climatic regime. Palaeoclimate varies in the subcontinent. There are three major geomorphological zones in India. They are the Himalayan region, the Indo-gangetic plain and the Deccan land mass. Wide glaciated tract is found in the Himalayas. The sub Himalayan region, mainly the Punjab plain and Potwar plateau were under periglacial condition and the rest of India was within a-glaciated or non glaciated tract having alternating pluvial and interpluvial climates.

Siwalik formation in North West India and Kashmir valley has yielded evidences of Pleistocene glaciations. Siwalik deposit occurs as low outermost hills of the Himalayas all along from the Indus to the Brahmaputra. The Siwaliks have yielded beds belonging to both Tertiary and Quaternary periods. The beds are named as Kamlial, Chinji, Nagri, Dhok Pathan, Tatrot and Pinjor. The Neogene-Quaternary boundary is found below the Pinjor beds. Fission track dating is made of a bentonic tuff, underlying a rich Pinjor fauna near Haro river (a tributary of the Indus), in Attock district, Pakistan and is placed at 1.61 plus minus 0.10 Myr B. P. (Agrawal, 1992).

Kashmir valley was formed around 4 Myrs ago. At the beginning the climate was warm subtropical with a South Western monsoon. But it changed to cool temperate (Mediterranean type of climate with winter rain) about 2Myrs ago with the rise of the Pir Panjal range. Between 0.6 and 0.3 Myrs three long cold periods have been detected on the basis of faunal, isotopic and pollen data, with corresponding warm periods observed in the loess-palaeosol sequence in late Pleistocene. The loess-palaeosol deposit of Kashmir valley is known as karewas.

De Terra and Paterson (1939) recognised main series of four glacial and three interglacial epochs, of which the first two glaciations were more intensive than the later two, with still later oscillations or stages of retreat. Each glacial period saw intraglacial pulsations of the ice front, more evident in the late stages than in the early, because of erosion and weathering. There had been two oscillations in the second glacial phase, four advances and a retreat in the third period and four advances in the fourth period, with several retreat stages.

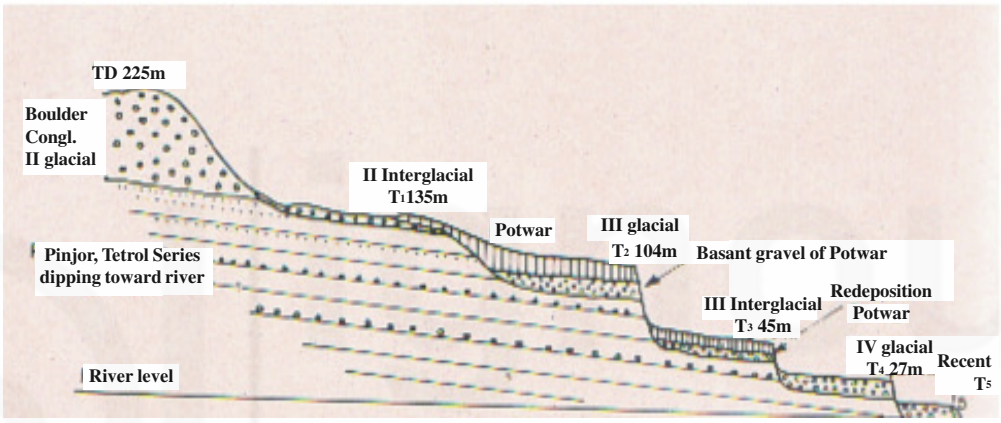


Fig. 1.1: Glacio-fluvial terraces in the sub-Himalayan region (Agrawal, 1992)

Pleistocene stratigraphy from second glacial period onward is found in the rivers of the region, such as, Jhelum, Indus, Sutlej and their tributaries. Fig. 1.1 above presents a composite picture of the stratigraphic sequence of the river terraces in relation to Siwalik formations. Owing to tectonic movement the boulder conglomerate which was deposited by second glacial period was tilted. The first rivers, Indus, Sohan etc were formed in the Potwar plateau. This started to curve away from them cutting into the boulder conglomerate giving rise to the first terrace (T1) at the second interglacial time. Second glacial terrace (TII) was formed by spreading of the gravel at first then covering it with loam. Third interglacial terrace (T III) is formed due to erosion carried out by the release of greater volume of water in the streams and rivers because of warming up of the condition and melting of glaciers at the source of the rivers. Terrace (IV) is of depositional nature belonging to fourth glacial period. The last terrace T (V) belongs to Holocene in the recent years. Large scale correction has been done for this sequencing. One of these refers to the entire glacio-fluvial succession of Potwar as belonging to late Pleistocene.

Pleistocene formation of peninsular India has yielded evidence for alternating wet and dry conditions, similar to that of Africa's pluvial and interpluvial conditions, though the nature and types of the climatic events are quite different in India from those of Africa.

A sequence of environmental changes in the Thar Desert for the last two million years has been analysed through laboratory and field studies. There are a number of formations which have yielded evidences and a correlation of them has given a complete sequence. The sediments studied are in the form of river sections, tanks, wells etc. The formations are named after local place names. There are some important formations. *Jayal* formation is made up of cobbly gravel and is dated to late Neogene to early Pleistocene. Though unconfirmed, lying on it is the *Amarpura* formation. It is made of loam, marl and kankar. *Amarpura* formation is dated from Middle Pleistocene to Upper Pleistocene period. *Didwana* formation is constituted of Aeolian and lacustral formation. This section had been dated by several techniques. The *Didwana* profile ranges in age from Middle Pleistocene to Holocene.

Quaternary deposits in Peninsular India

Quaternary geological formations can be classified into six distinct units depending on the mode of occurrence: (1) Fluviatile deposits of river valleys, (2) Aeolian deposits, (3) Shallow marine deposits, (4) Cave deposits, (5) Laterite and (6) Thick deltaic deposits (Prasad, 1999).

1) **Fluviatile deposits of river valleys:** The Pleistocene sequence in Narmada valley is important because it has yielded the fossil partial skull of Narmada man. It is one example of fluviatile deposit mainly of sand, silt and gravel. Along Pranhita-Godavari basin rich mammalian fauna consisting of *Elephas namadicus, Equus namadicus* and *Bos sp*. are found indicating Pleistocene date for the sediment.

   In Narmada valley, in Chennai region and in the eastern part of India the Pleistocene sediment is mainly represented by fluviatile deposit in the form of alternating deposits of gravel and silt bed. The gravel beds represented wet phase. River had more water and due to greater volume and velocity of the river gravel was formed and deposited. At the time of a relatively dry phase volume and velocity of the river water was less and finer materials were deposited. On the whole two distinct cycles of wet and dry phases are noticed in most of the areas. In eastern India three cycles are identified (Ray, 1999).

2) **Aeolian deposits:** Aeolian deposits are represented by loess and windblown sand dunes. These are confined to arid and semi-arid regions. The coastal tract contains various terraces of sand dunes indicating successive positions of the shore lines.

3) **Shallow marine deposits:** Near Tuticorin a number of beds have yielded invertebrate shells belonging to late neogene/quaternary boundary. These also included *Elephas hysudricus* and *Bos sp.* The Milolite limestone known as Porbandar stone of Saurasthra, the littoral concrete of Bombay and Kathiawar coast and the shell limestone deposits along the coast lines of Kerala and Tamilnadu represent Pleistocene deposits of coastal region.

4) **Cave deposits:** The cave deposits in Kurnool, Andhra Pradesh contain numerous fossils in the stalagmite floors. These belong to Pleistocene- early Holocene date.

5) **Laterite:** Laterite is a product of weathering in a humid climate. Low lying plains of east and west coasts are covered by laterite. They also cover terraces and are associated with palaeolithic implements. In Madras and Singhbhum area secondary laterites were also deposited in the tributary river valleys in place of gravel and silt deposits.

6) **Thick deltaic deposits:** The Rivers flowing into the Arabian Sea showed comparatively slow rate of deposition along its mouth. Kutch and Cambay region is uplifted to the present height in the Quaternary time.

Human habitat and culture: As mentioned earlier the Quaternary gives a framework for the study of human adaptation, change and development of culture. A complete geographical-ecological understanding of a prehistoric community – the palaeoenvironment, its resource potential and external limitations, and man and environment relationship which is manifested in the economics are considered an important aspect in the study of Archaeological Anthropology.

The glacial periods did not have a high biomass. Man adapted to this environment by cultural innovation. Interglacial period had produced higher biomass and human adaptation with culture was more prolific in nature.

In the tropical region the oscillation between wet and dry phase was not drastic. Change and development of culture was more gradual in nature, without much drastic change. Culture that flourished during Pleistocene is known as Palaeolithic. It is subdivided into lower, middle and upper Paleolithic stages.

1.7 SUMMARY

Quaternary geo-morphology has been the backbone of prehistoric chronology for a long time. Of course this was also aided with palaeontology and palynology. However, in the recent years deep sea core oxygen isotopic analysis with palaeomagnetic reversal phases have provided a stronger and more solid support to this prehistoric calendar. Geo-morphology, and geology, as such, have been used as an aid for reconstructing past climatic features during various periods within Pleistocene. The world experienced two types of climatic events. One in the temperate regions and the other was in the tropical areas. In the former there were advance and retreat of glaciers, corresponding with cold and mild climatic phases. In the tropical areas there were alternating wet and dry conditions, corresponding with more rainfall and less amount of rainfall. Cause of ice age is predicted as a result of astronomical change in the axis and orbit of the earth around the sun and subsequent variation in the reception of solar radiation on earth. Quaternary gives a background for the study of man and his culture in the fluctuating climatic situation. India experienced glacial condition in the Himalayan and sub-Himalayan regions. Rest of India experienced pluvial and interpluvial conditions. Evidences of Quaternary climate are found in various stratigraphic evidences. In fact regional variation of climate and biosphere, within specific geological stages, was responsible for giving rise to different types of ecological condition. Paleolithic culture in India and other parts of the world was formed in response to the fluctuating climatic condition, which varied through space and time within quaternary epoch.

Suggested Reading

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Sample Questions

1) Discuss why Quaternary is considered as a framework in the study of man.
2) What are the stratigraphic evidences for cold climate in Europe.
3) What are the evidences for mild climate in temperate region.
4) What was the climatic background of Europe during Pleistocene period.
5) What kind of climatic fluctuation took place in tropical region during Pleistocene period.
6) What are the evidences of Pleistocene climate in Rajasthan
7) Write short notes on the following
    i) Moraine,
    ii) Loess,
    iii) Interglacial,
    iv) Periglacial,
    v) Karewas,
    vi) Didwana

UNIT 2 RECENT PERIOD

Contents

Learning Objectives

Once you have studied this unit, you should be able to:

- learn about Holocene, the present epoch in which we are living;
- understand the climatic change from fluctuating Pleistocene to stable Holocene or recent period;
- understand the present climatic event through various stratigraphic evidences; and
- get a brief outline of nature of adjustment made by man in the changing condition.

2.1 INTRODUCTION

Holocene is the last phase of the Quaternary. It is synonymous to the terms Recent and Post-glacial. It is convenient to maintain a distinctive name for the last 12,000 years (B.P.E.) because the climatic set up in this period was much different from its preceding period. The onset of the Holocene in Europe brought in climatic and ecological conditions similar to those of the present day. During the last 12,000 years (B.P.E.) there were numerous short term fluctuations, as well as, long term trends towards cooler or warmer, moister or drier climate. These were not significant compared to the climatic events which took place by the end of the Pleistocene. In Europe and other temperate regions the climate gradually became warmer. Previously, climate was quite cold. With the rise in the temperature snowline receded pole ward and to a higher altitude on mountain tops. As a result land form changed, patterns of vegetation changed and cold loving animals moved north wards giving way to warmth loving species.

Similar changeover of climate from the Pleistocene fluctuating condition to that of the present day stable climate has also taken place in the tropical countries like Africa and India. It is believed that the Holocene is nothing but a prelude to another glacial or pluvial time. Probably the peak of the recent interglacial/ inter pluvial epoch was reached at c. 12,000 yrs (B.P.E) and we are heading for a changed sequence in another c. 10,000 yrs. The marks of climatic change and the change in the environment are left on the surface of the earth. Geological study of different areas has confirmed that smaller climatic oscillations marked

the post Pleistocene climatic regime. It means that at the early part of Holocene there were shorter cold and warm fluctuations until the present climatic stability was reached. Man reacted to the change by adjusting to the environment with his culture. Culture of early Holocene or Post Pleistocene time period is called the Mesolithic culture. Subsequent stabilisation of climate and development of the modern man gave rise to agricultural economy, which culminated in great civilizations of the world. In fact considering the time span of human history it is the last c. 10,000 yrs that have seen very fast progress in the cultural and economic history of man.

2.2 HOLOCENE GEOMORPHOLOGY

Europe

Europe was under the influence of glaciations during Pleistocene period. Snowline marking the arctic tundra was extended up to the present temperate zone. At the end of Pleistocene period, due to change in solar radiation, Europe was gradually warming up. This led to mass scale change in geography, biology and human culture of Europe.

Deglaciation

By the end of the Pleistocene there was evidence of the retreat of glaciers towards the polar regions of the earth. First warm phase after the last glaciation, that is, würm, is known as Bölling. Then around 12,000 B. P. another interval came, which is known as Alleröd. Tundra vegetation was replaced by coniferous forests. Climate was warmer during Alleröd times than the main Würm glaciation. Overall climate became continental and on the dry side in Europe. However, there was a short cold phase after the warm phase. Glaciers readvanced in Europe and north America and world sea level dropped by another 5-10 m.

Change in the sea level

In Europe the changes in the sea level is understood in detail in the Baltic region. The evolution of Baltic region to that of the present geographical condition is summarized below:

Baltic Sea	Began c. 2000 B. C.
Littorina Sea	Began c. 5000 B. C.
Ancylus Lake	Began c. 7800 B. C.
Yoldia Sea	Began c. 8300 B. C.
Baltic Ice Lake	Began c. 9000 B. C.

Movements of the sea level, also known as eustatic movement and the land surface movement known as isostatic, took place with the end of the ice age. Sea level rose because large quantity of water was released in the sea due to melting of the ice. With the melting of the ice great mass of weight was lifted from the surface of the earth and land surface was raised upwards. This has been studied in detail in the Baltic Sea region of the Scandinavian Peninsula. Baltic was an Ice Lake by the end of the glacial period. During Pre-Boreal period with the melting of the ice, it became a sea and was known by the name Yoldia Sea. It was named after the molluscan fauna *yoldia artica*. Land surface rose during Boreal

phase and Baltic became a fresh water lake and is known as Ancylus Lake, with the characteristic presence of mollusc, *Ancylus fluviatilis.* During the subsequent Atlantis period the sea level rose again and Baltic became a sea known as Littorina Sea. This phase is identified with the presence of common periwinkle shells known as *Littorina littoria.* Several transgressions and regressions of sea took place in Atlantic period. Transgression means advance of sea and regression means retreat of the sea. Some of the transgressions are dated.

Change in vegetation pattern

The first phase of Holocene is known as Pre-Boreal (8300-7500 B. C.). Boreal means forest and pre-boreal is the period which preceded the full development of forest. At this time environment changed much more. The glaciers were reduced to their present dimensions. The retreat of glaciers was rapid. Climatic changeover from glacial to post glacial went through a gradual process producing an over-all warm condition, gradual retreat of the continental glacier and a climate ultimately warmer than that of the present day. Standard pollen zones were established. From the perspective stages of vegetation, the environmental changes of the early Holocene proceeded gradually.

K. Jessen in 1934 divided Holocene climate of Europe into nine basic zones based on pollen analysis. Pollen analysis provided a picture of forest development in north and northwest Europe. Forest in Scandinavian language is referred to as boreal. Europe was under Park Tundra condition (pollen Zone I-III) by the end of Pleistocene. With warming up of climate park tundra vegetation made way for Birch-pine pollen zone (IV) of the pre-boreal period that is a period through which forest development was taking place. The first phase of forest development is known as early boreal (pollen zone V). This phase was dominated by pine trees, but hazel and birch were also found. This is followed by late boreal (pollen zone VI). Pine and hazel trees dominated the forest, together with some elm and oak in its first phase and lime and alder at its later phase. Pollen VII (a) is known as Atlantic period because the land bridge connecting Great Britain to Europe was submerged and the climate of the area was exposed to the influence of Atlantic Ocean. The forest of this period is characterized by the presence of alder-oak-elm-lime trees. This phase continues into a period known as sub Boreal (pollen zone VII b). In it elm declines slowly and hazel increases (Table.2.1). The climate becomes such as is found today in Europe.

Table 2.1: Pollen profile of Holocene period in northwestern Europe (after Butzer, 1964. P. 407)

Zone	Date (B.C.)	Name	Dominant Vegetation	Inferred Climate
VIII	After 800	Subatlantic	Beech	Maritime
VII	3000-800	Sub-boreal	Oak-beeck	More continental
VI	5600-3000	Atlantic	Oak-elm	Warmer and maritime
V	(7500) - 5800	Boreal	Hazel-pinc oak	Warmer and continental
IV	8300 - (7500)	Preborcal	Birch pine	Warm-continental

Change in the animal world

Forest did not abruptly replace tundra at the close of the Pleistocene. Rather, forest-tundra and parklands, succeeded by open and woodlands, dotted by numerous drained tundra lowlands. The woodlands forest tundra was preferred by reindeer and bison in winter. The Pleistocene tundra fauna gradually became extinct. Large species like mammoth, wooly rhinoceros, giant elk and musk-ox gradually disappeared. The reindeer which provided most of the livelihood in Pleistocene became restricted mostly to Northeastern part of Europe. New animal spectra appeared.

Change in human adaptation

The onset of the Holocene period had a sudden and serious effect on man. The great herds of herbivorous were replaced by more solitary games, such as, deer, wild cattle, boar and similar other animals. The Mesolithic culture was considered a consequence of environmental changes. Human populations adapted themselves with the changed condition. In the Boreal period growth of forest gave rise to forest based culture represented by heavy equipments like axe and adzes, suitable for woodwork. Some of the areas in the central Europe was free from forest because of infertile loess deposits of last glacial epoch. In this area and along the Mediterranean coast microlithic culture flourished.

> The Holocene is the name specified to the ~10,000 years of the Earth's history –the moment since the end of the last major glacial epoch, or ice age.

Africa

Leakey found two wet phases intervened by a dry phase during the post pluvial condition in Africa. They are Makalian and Nakuran respectively. The Makalian is the first post pluvial wet phase. Evidence of this phase was found in the lake Nakuru and is represented by a strand line 375 ft above present day Lake Nakuru. Cultures contemporary to this climatic stage are Elmentieta, Wilton and upper Capsian, better known together as Late Stone Age culture in Africa. The Nakuran is the second of two distinct post pluvial wet phases recognised in Kenya. It is represented by a strandline 145 ft above the present Lake Nakuru. The *contemporary* cultures were Late Stone Age cultures of Africa. This phase was preceded by a very dry phase correlated with climatic optimum. That means that in between the wet phases Makalian and Nakuru represented a dry phase.

Holocene in India

Similar to Pleistocene, Holocene geological formations can also be classified into six distinct units depending on the mode of occurrence: (1) Fluviatile deposits of river valleys, (2) Aeolian deposits, (3) Shallow marine deposits, (4) Cave deposits, (5) Laterite and (6) Thick deltaic deposits (Prasad, 1999).

1) Fluviatile deposits of river valleys

In the Kashmir valley the palaeosol developed at 18Kyrs is considered to be the first phase of deglaciation of the valley. Climatic amelioration was suggested by Agrawal (1992) around 18Kyrs, 6-5 Kyrs and 1 Kyrs B. P. This is also correlated with increase in human settlement in Kashmir valley.

In the Potwar region of the Siwaliks last terrace in the rivers of the area, the terrace T (V) belongs to the Holocene period. Even in the peninsular region, wherever identifiable, the last terrace near the river bed belongs to the Holocene.

2.2.1 Sea level Changes

3) **Shallow marine deposits**

Work in the ocean floor sediments of Arabian Sea and Bay of Bengal suggested a weak monsoon around 20,000 B. P. during the last Pleistocene epoch. Evidence from the Arabian Sea core has shown that there were three cold and arid phases approximately at 18kyrs, 7 kyrs and 2 Kyrs. At Tuticorin bay Zeuner had identified fossil dunes and present day dune along the coast. His study has shown that sea level changed from higher to lower level by early Holocene time. The fossilized dunes were formed at the time of higher sea level. Sea was higher by 20-30 ft at the end of the Pleistocene. Worldwide dry climatic phase led to the formation of dunes and also to lagoons along the coast. These are locally known as *teris*. The Mesolithic people lived on the ancient dunes and exploited the marine resources.

Afterwards the climate changed and weathering occurred. This made the dunes get fixed. They became reddish and cemented. In the next phase wind activity restarted and fresh *teris* and lagoons began to be formed.

2.2.2 Deltas

6) **Thick deltaic deposits**

The delta regions have shown mainly the sea level changes and also the changes that had taken place due to tectonic movement by the early Holocene period. This is mainly observed in Kutch, the deltas of Arabian Sea.

2.2.3 Deserts

2) **Aeolian deposits**

In the deserts of Thar the lacustrine formation of Didwana sediment yielded interesting results. The alternating evaporate and non evaporate suggest fluctuating hydrology in response to the slight amelioration of the arid climate of the terminal Pleistocene and the early Holocene (13,000-6000 B. P.). Organic rich clays and domination of *Artemisia* pollens suggest sub-humid climate between c. 6000 and 4000 B. P.

Dunes were formed during late to early Holocene period in the arid areas of Gujarat, especially at the Mesolithic sites of Langhnaj. The dunes were formed after a short wet phase. The low areas around the dunes were inundated and formed lakes. Mesolithic people lived along the lake shores. Their habitation also coincided with gradual desiccation and formation of the dunes.

5) **Laterite**

In Deccan plateau and other areas the Holocene deposit consisted of red colluviums soil made of pelletic laterite. There are loose kankary deposits found over the gravel of last wet phase.

Special mention may be made of a calcareous deposit known as *ghutin* lying on top of the silt bed or alluvium deposit of late Pleistocene. Geologists found that the *ghutin*layer always suggested Post Pleistocene deposition.

2.3 SUMMARY

Worldwide Holocene heralded the beginning of recent climatic condition. Recent or Holocene is considered as a period of climatic stabilisation. It could very well be another interglacial age. However, this period had experienced a gradual changeover from fluctuating climate of Pleistocene to stable climate of Holocene. Evidences from geography, geology, palinology and palaeontology have clearly shown the dynamicity of climatic change over and subsequent cultural adaptation of man to the changed climatic condition in Europe.

Holocene deposit in India had shown that there were smaller climatic oscillations before the present day condition was reached. In the glaciated and periglaciated regions small advances of cold phases gradually led to the present day condition. This is noticed in the Karewa deposits and in the terrace sequence of Kashmir valley and Siwaliks, respectively. In the Desert area the pollen study had shown alternating short spells of semi-arid condition until the present day arid condition set in. This is also recorded in pollen analysis from lakes in Rajasthan and measuring of the alternation of salinity and fresh condition of the water of the lakes. In the coastal region fossil dunes were formed. In the plateau area kankary lateritic pellets and calcareous ghutin were formed because of the onset of dry condition after a short wet phase.

India is a land of diverse geomorphological features. Similar diversity was maintained in the Holocene period. Man settled in diverse environmental zones and adjusted with his culture in the varied condition and formed ecological niche. In India the culture of early Holocene is known as Mesolithic or Microlithic. In later part of Holocene agriculture developed in river valleys. Hunting-gathering way of life continued in hills and jungles.

Suggested Reading

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Sample Questions

1) Define the geological period known as Holocene.
2) What are the stratigraphic evidences for the onset of Holocene in Northwest Europe?
3) What kind of climatic changes took place in Europe during Holocene.
4) Write short notes on:
   i) Teris in Coastal region in South India
   ii) Ghutin in the plateau area
   iii) History of Baltic Sea
   iv) Pollen sequence of Post Pleistocene in Europe
   v) Holocene sequence in Didwana formation