UNIT 2 RELATIVE CHRONOLOGY

Contents

Learning Objectives

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

- understand the importance of stratigraphy, which was the outcome of different geomorphic agencies;
- 'change is the law of nature' – change in climate particularly during Pleistocene Epoch is significant in anthropological studies; and
- fossils, both animal and plant are of great help in reconstructing Pleistocene environment during which man had evolved.

2.1 INTRODUCTION

Archeological sites, depending on the cultural time range involved, may represent former houses, villages, or towns; they may pertain to temporary or seasonal camps, or to killing or butchering sites. Other sites may have little or no ecological meaning, but consist only of scattered artifactual material, possibly redeposited within a river trace. Sites dating from historical or late prehistoric times are commonly found on the surface, possibly buried under cultural debris or a little blown dust, and altered by a weak modern soil profile. Many sites belonging to different periods are found exposed at the surface. A great number of prehistoric sites, however, are found in direct geologic context, within or underneath sediments deposited by some geomorphic agency.

2.2 STRATIGRAPHY

Stratigraphy is the study of layered deposits. Stratigraphic study is based on the law of superposition, which declares that deposits, whether of natural or cultural origin, form with the oldest on the bottom of the sequence and each overlying stratum younger, or more recent, than the layer below. Once the strata have been observed from early to late, it is possible to date the artifacts and eco-facts of each layer according to Worsaae's law of association. This position states that objects, both natural and cultural, found together in the same layered deposit are of the same age. Thus the relative dating of the superpositioned deposits also dates their fossil specimens. The law of association is useful not only in the ordering of site historiographies, but also in the construction of local regional sequences.

For the archeologist a "stratified" site is one with distinct archeological horisons, with or without a geologic context. The term "surface" site might be used to describe a variety of things, such as an archeologically un-stratified surface-find or even an ancient open-air encampment now buried by a meter or two of loess or marl. From the archeologist's point of view, sites may be classified according to their cultural-ecological meaning or according to digging criteria. The earth scientist, interested in providing a stratigraphic date or a geographical-ecological meaning for a site, would naturally use different criteria of classification.

"Stratified" and "surface" sites: The most interesting kind of archeological site for the earth scientist is one found in a direct geologic context, i.e. geologically stratified or geologically in situ. This should not imply that the cultural materials have not been derived, but only that their present location is geologically circumscribed. For the sake of Convenience "Stratified" will here be used in this geologic sense only. "Surface" site will be restricted to materials found at the surface, without geologic context.

According to the basic geomorphological situation or the type of deposits involved, archeological sites can be geologically classified as follows:

a) Alluvial sites: artifacts, fossils, occupational floors and the like found within former stream deposits.

b) Lacustrine sites: archeological materials found in former lake beds, in ancient bogs, swamps, or spring deposits.

c) Aeolian sites: archeological materials found in or under wind-borne sand or loess, or found in relation to features resulting from deflation or wind scour.

d) Cave sites: archeological materials found in direct relation to erosional or depositional phenomena associated with former coastlines.

e) Costal sites: archeological materials found in caves with some form of geologic or archeological stratigraphy.

f) Surface sites:the great mass of scattered archeological materials and sites found at the surface, with little possibility of direct association with any geomorphic event**.**

Identification of the depositional medium contemporary with or subsequent to an archeological site is vital to the earth scientist. The specific relation of a cultural horison to a geomorphic event can provide direct paleo-environmental information. This local environmental setting may in turn be stratigraphically linked to regional or worldwide changes of climate.

2.3 ALLUVIAL (RIVER) DEPOSITS

The intensity and extent of alleviation in a stream valley varies in different environments. In the arctic barrens and tundra, streams are overloaded and deposit sediments along the length of their courses. In arid and semi-arid zones water loss through evaporation leads to alleviation along the river course. In the boreal forests floodplains are common while in the temperate and tropical woodlands, the rate and extent of downstream alleviation is comparatively limited. The savanna lands are somewhat exceptional through significant colluviation.

Streams accelerate their activity in terms of erosion when there is increase in water supply due to heavy rains, the sediment loads increase and depending upon the river gradient readjustment sets in. streams reestablish a form of equilibrium related to its gradient (thalweg curve) and transport ability, and cut down its bed to a lower and smaller floodplain. The old floodplain becomes obsolete, and is separated from the new, functional floodplain by vertical escarpments forming terraces. Such alluvial terraces consists of benches, built of river deposits, remaining at the level of defunct, higher floodplains.

Terrace formation

At the start, the floodplain has a certain elevation and rate of deposition. Increased flood discharge with greater transport ability and load will lead to (a) more extensive flooding and consequently enlarging the floodplain, with undercutting of nearby hill slopes and, (b) a higher floodplain level due to accelerated deposition. The new floodplain, across which the river migrates horisontally, is broader and higher and characterised by deposition of more and larger-sized materials. When the volume and rate of deposition decreases to their original level, the stream will attempt to maintain its velocity- despite a decreasing volume by shortening its course and thereby increasing the gradient. A straighter course is adopted, usually associated with a predominance of down cutting. The new floodplain will be smaller, and will be cut out as a limited section of the greater floodplain. In this way alluvial deposits are built up at various elevations and with a distinctive morphology.

Alluvial sites rank second only to cave sites in the early history of archeological excavations. Excavations or borings in river valleys have frequently struck alluvial sands or gravels of various ages containing animal remains or human artifacts. Natural exposures in terrace faces have also revealed archeological materials. Many such sites have little more to offer than sporadic, water-rolled stone implements and possibly a little bone of dubious association. Other sites, however, may represent occupation floors with rich associations of undisturbed tools and fossils. Interpretation of such sites can, with due effort, be carried to a satisfactory stage of environmental and stratigraphic understanding (Butzer, 1971).

The periglacial stream terraces of the Old World were probably first studied by Paleolithic archeologists, and the well-known Somme River succession of northern France was established as a sequence of integrated solifluction beds, loesses, and periglacial stream deposits. Once assumed to be the framework of Paleolithic cultural stratigraphy, many of the sites in question are of limited importance since they were mainly collection of derived artifacts rather than occupation floors. The pluvial terraces of the arid zone have played a significant role archeologically in both the Old and New World, even in rather late prehistoric times. The twin sites of Torralba and Ambrona, in the Spanish province of Soria, were situated on the marshy floodplain margins of a stream valley during a moist, cold phase of the Lower Pleistocene. Swanscombe is an example of a significant site associated with downstream valley alleviation during a high, Middle Pleistocene sea level. The site was occupied on a Thames floodplain almost 30 m. above that of the present. Although not wholly undisturbed by stream redeposition, the contemporaneousness of the human and animal fossils was established by fluorine tests.

2.4 GLACIAL DEPOSITS (MORAINES)

Glaciers provide important stratigraphic data to permit identification of glacial or interglacial epochs, either locally or on much larger scale through melt water deposits and through the world-wide oscillations of sea levels. Glaciers develop in cool areas with heavy snowfall. Once formed, the glaciers create a microclimate of their own. They reflect radiation (increase *albedo*), lower the summer temperature by contact and radiative cooling, thereby lead to significant temperature inversions in the lower atmosphere, i.e. a cold skin of air underlying warmer air above. The larger is the glacier, the greater is the environmental modifications, and hence they are the markers of palaeo climate and time episodes.

Ice fields that form where snowfall exceeds annual ablation are the result of compaction and structural alteration from snow to ice. The density of fresh snow is in the order of o.15 – 0.16. after settling, removal of part of the pore space, and recrystallisation, the stage of granular snow or firn (with density of 0.5 – 0.8) is attained. Repeated melting and refreezing, aided by further compaction under pressure of overlying firn and snow leads to complete impermeability to air and densities exceeding 0.82 is defined as ice, which is capable of plastic flow. The resulting ice mass may form either mountain, valley, or piedmont glaciers in rough highland terrain, or ice caps in areas of smoother topography.

Moraines: Although permanent ice covers only 10 per cent of the world land surface today, it extended over 32 per cent at the time of maximum Pleistocene glaciation. Apart from the areal significance of glacial phenomenon, moving ice is also the most powerful agent of erosion and deposition. When snow fields persist over several years they evolve to larger ice masses, erosional niches will be created in the valley-head areas. If there is much accumulation of snow the ice basin will over deepened and broadened leading to quarrying of lateral rock faces. Such loosened rock is embedded and carried within, on top of, or below the ice. The flow passes through stream valleys by cutting deep, broad floors flanked by over-steepened cliff faces to further flow of ice. These U-shaped or trough valleys are commonly several hundred meters deep in the case of matured glaciers, and are conspicuous hallmarks of valley glaciation. Towards the terminus of the ice, debris accumulation may take the form of frontal ridges or end moraines, as sub-glacial ground-moraines, or as side or lateral moraines which extend back through much of the glacial valley. Coalescing ice tongues may also leave intermediate ridges of rock and dirt known as medial moraines. The melt water deposits of sand and gravel stream-laid a head of the ice terminus are known as outwash.

2.5 AEOLIAN DEPOSITS

Wind is one of the natural agencies had the capacity of erosion and deposition thereby modifying the topography of the earth. But, erosion by wind is limited to dry, loose, and fine-grained sediments, not protected by a plant cover. Under natural conditions wind erosion will be more or less limited to the arid zone and high arctic barrens, except for locally favourable areas: broad sand beaches, and exposed stream or lake beds during low-water. Particles in the silt or fine and medium sand size (< 0.2 mm) are carried in suspension by strong winds. Coarse sands are moved by saltation. Transport of the suspended load, consisting of silts and finer sand grades, is effected over long distances. During strong dust storms, great masses of Aeolian materials may be carried over hundreds of kilometers, only to be deposited very slowly in response to decreasing wind velocities, or more rapidly by being washed down by rain. Extensive Aeolian sedimentation of silt and fine sand may then occur well outside of those environments suitable for wind erosion. The coarser sands of the bed load can only move along the ground, migrating as sand ripples, ridges, or dunes. These materials will ordinarily be confined to the general source region, with exception of smaller dunes migrating from the coast or along other local sources of sand.

Corresponding to mode of transport of the different particle sizes, wind-borne sediments may consist of striking coarse-grained sand mounds or dunes, of smooth, extensive sheets or mantles of fine-grained materials. The morphologically conspicuous, coarse-grained types are largely confined to the world deserts and the arctic barrens, whereas the sand or dust (loess) sheets may be deposited almost anywhere, although they only retain structure and other characteristics when laid down in open country.

Sand Dunes: Dunal forms include migratory 'free' dunes, whose existence is independent of topography, and 'tied' dunes, related to some permanent wind obstruction. The free dunes include several types:

a) Longitudinal dunes occur in groups of long, parallel ridges, with many peaks and sags. They may be 100 km. long and over 100 m. high, lying parallele to the direction of strong winds. Their formation may be aided by local turbulence, leading to accumulation now on one side or on the other.

b) Crescentic dunes or *barchans,* as the name implies, are crescentic in plan, the horns and steep concave slopes facing downwind. These dunes may attain 30 m. in height and 400 m. in width and length. They develop with unidirectional effective winds.

c) Transverse dunes form irregular, wave like ridges at right angles to the effective wind direction, sometimes merging or occurring simultaneously with barchans fields.

d) Parabolic or U-shaped dunes are superficially similar to a barchan, but are more elongated and slightly asymmetrical, with the gentle, concave slope facing windward, the steeper, convex face down wind.

Specific archeological associations with Aeolian features are mainly of three kinds.

a) Occupation floors or scattered artifacts found under or on top of sand dunes;

b) Archeological materials found under, within, between or on the surface of the loess,

c) Archeological materials exposed by wind deflation or scour.

One of the best examples of an archeological site related to a complex sequence of stream and wind erosion and deposition is the Holocene San Jon site of eastern New Mexico. Most of the terminal Pleistocene Siberian cultures of the Kom, Ombo plain and Egypt, were deflated and are now partly found on yardangs scoured out of old Nile deposits. In late Pleistocene, innumerable loess sites from central and Eastern Europe are examples of occupation during or after loess sedimentation. Geomorphological investigation of aeolian sites is primarily concerned with whether aeolian activity was contemporary with occupation, and whether it preceded or followed occupation. Evidence of soil development in the stratigraphic profile are important, and other indications of sedimentary breaks may be obtained from vertical curves of particle sizes, carbonate, or humus content. With due caution, pollen studies may also be possible in the humic horisons of an aeolian profile. In general, the exact stratigraphic correlation of sediments and archeological levels can be determined, and careful examination may possibly reveal the contemporary environmental setting of the site as well as the changing environmental patterns of the period.

2.6 LACUSTRINE DEPOSITS

Lake and swamps beds have been laid down in standing waters and are more generally known as lacustrine deposits. They include:

a) evaporates, usually gypsum or salts;

b) calcarious beds, including chalk;

c) marls;

d) silts and clays;

e) sands; organic deposits.

Evaporites consist mainly of gypsum (calcium sulfate) and other salts such as sodium, magnesium and potassium chlorides or sulfates. Such beds frequently indicate dessication or lake shrinkage- periodic shrinkage during the dry season or long-term reduction of a larger lake to a lagoon or salt pan (e.g. Dead Sea). Evaporates, with the exception of open coastal lagoons are indicative of some degree of aridity or at least of a high ratio of evaporation to precipitation (Butzer, 1971).

Lacustrine chalks usually indicate perennial lakes which are not subject to very great seasonal fluctuations of oxygen content. Lacustrine chalks are common in many climatic zones. In temperate Europe they may be deposited organically by pond weeds; in dry areas such as the Sahara, inorganic precipitation is more important. Plant and animal remains are more common in such beds (Butzer, 1971).

Marls are calcareous silts deposited both in lakes and swamps. The lime content may be derived through plant or inorganic agencies; the clays and silts represent soil products carried in by streams and rain-wash. Common in humid and even semiarid lands, freshwater marl sedimentation is commonly confined to comparatively small water bodies.

Silts and clays are generally carried into standing waters in suspension by local streams. They may occur wherever finer weathering products are available. Lacustrine silts and clays are however, most common in moist climates.

Sands of lacustrine deposition are most widely found in areas with limited vegetation. In lower latitudes the widespread lacustrine sands of the Sahara were largely derived from sandy wadi deposits in the course of Pleistocene. The prehistoric Chad and Fayum lakes of northern Africa are striking examples of lacustrine sands derived from direct stream influx as well as lake wave-action on local sandstone bedrock.

Organic deposits, of many different kinds and complex origins, are most common in cooler latitudes although they are not quite unknown in the tropics and subtropics. Prehistoric settlements were common around the banks of lakes. For example, the early Holocene site of Star Carr, Yorkshire, was situated next to a now extinct lake, and subsequently buried by bog depostis. In the Fayum depression of northern Egypt, high Nile floods were responsible for the creation and maintenance of several late Pleistocene and Holocene lakes. Various Paleolithic and Neolithic populations occupied the fringe vegetation of those lakes, leaving cultural and animal remains along the former shorelines or within the sand of the beaches. At the Lower Pleistocene site of Ternifine, western Algeria, a rich fauna with skeletal remains of the hominine *Atlanthroupus (Homo) mauritanicus* is exposed in clays and spring deposits of a former lacustrine basin. *Zinjanthropus* and "pre-Zinj" sites found in mixed lacustrine and volcanic ash beds of Bed I, at Olduvai Gorge, Tanganyika dating from the Basal Pleistocene. These examples are all related to pluvial climate of Pleistocene period.

In higher-latitude Europe, lacustrine beds were mainly found in poorly-drained ground moraine areas abandoned by the continental glacier. So for example, the Lower Paleolithic occupation level at Hoxne, near Ipswich, is located in clayey silts of Holstein interglacial age. The beds record a former lake within a depression in Elster till. The interesting Middle Paleolithic spear of Lehirngen, near Hannover, was found with an intact elephant skeleton in lacustrine marls of Eem interglacial age, overlying the Saale ground moraine.

Swamp and bog deposits, some of them postdating sites, have long enjoyed considerable archeological interest in northern Europe. They have produced potsherds, plowshares, house or village foundations, and even fully intact corpses.

2.7 CAVE DEPOSITS

Caves were first 'discovered' for science by archaeologists, and despite the enthusiasm of ameture cave explorers, caves and archaeology remain almost synonymous in the public mind. The earth sciences have also shown some considerable interest in caves and subterranean caverns. Various processes of groundwater solution and cave formation are a part of karst geomorphology. Practically, all true caves have developed as a result of solution in limestone, and the term "karst" refers to landscape noticeably modified through the dissolving agency of underground waters.

Man and animals have sought shelter in caves since the beginnings of prehistory, and some of the most interesting cultural sequences have been derived from cave sites. The cave strata had been intensively studied and in fact these studies are basic in understanding biological evolution and geomorphic environments tied up with relative time scale. Today certain sequences of cave sediments, faunal assemblages, and pollen are as vital for Pleistocene stratigraphy as the cultural horisons are for Stone Age archaeology.

Two major kinds of caves are distinguished: exterior caves, and interior passages and caverns. The exterior type may vary from simple overhangs and shelters (rock-shelters) to shallow caves. Most of these have been dissolved or eroded near the water-mark by streams or wave-action at the coast. Sometimes they are produced by hallowing out of softer rock strata. Cave environments are highly variable. Direct sunlight is reduced or eliminated entirely. Relative humidities are high, particularly in deep, shaded caves. Except at the very entrance, temperatures are usually too low for soil development, and chemical weathering is practically limited to carbonate solution.

The stratigraphic layers found in caves are of either external origin and partly internal. The extraneous materials may be washed in by rainwash, drawn in by gravity, blown in by wind, moved in through solifluction or washed through rock joints by percolating soil and groundwater. In addition, man and beast had carried in a variety of inorganic objects and materials, deliberately or inadvertently. Due to these natural and artificial reasons the cave sediments would consists of:

1) Fossil layers: animal bones, carcasses, feces, etc;

2) Archaeological layers: the occurrence of individual proofs of human presence with or without fossil remains; and

3) Cultural layers: sediments strongly influenced by human activities such as fire and tool-making along with many imported objects such as stones, bones, shells, plant matter etc.

The only point of further interest requiring comment is the use of caves by early man. In all but the rarest cases, occupation was limited to the foreparts or entrance area of a cave. Deep interior caverns were widely use for ritualistic or artistic purposes in some areas, but such damp, lightless vaults would ethnological analogies have bearing on Paleolithic cave-dwellers, it may be mentioned that the Australian aborigines of the northern Lake Eyre area, the Shoshones of the Great Basin and the Kalahari Bushmen are all known to have occupied caves or overhangs (rock-shelters) on occasion.

Cave sites have assumed importance at many times and in many areas, ranging from the australopithencien caves of South Africa to the crevice breccias of Peking, from the Upper Paleolithic caves of southern Frnace and adjacent Spain to the terminal Pleistocene cave cultures of the southwestern U.S.A. In India too we have a very good number of rock-shelter and cave sites denoting prehistoric cultures together with relative time-scales. The Bhimbetka in Madhya Pradesh, Bethamcherla in Andhra Pradesh, Gudium in Tamil Nadu can be quoted as examples in this direction.

2.8 FOSSILISATION

Mineralised end product of an organic matter is a fossil. The organic materials are largely decomposed and carried away in solution. In this fossilised condition, the bone is characteristically light in weight, porous and brittle. Soil waters may percolate freely through fossilised bone, carrying oxides and carbonates in solution. When the soil dries out, a film of mineral precipitates is left in the pore network of the bone. Eventually these spaces are refilled, and mineral replacement of bone material by calcium carbonate, sequioxides, or silicates may take place. Dehydrated animal bone consists of about two-thirds mineral matter and one third of organic matter. The mineral component is mainly calcium phosphate with some calcium carbonate and other salts. The organic components include fat, citric acid, organic carbon, nitrogen, and amino acids which are combined in proteins and fats. Depending on the conditions of sedimentation or the chemical environment, rapid burial of bone or shell may preserve either the mineral or organic matter. Fossil bone and shell may be obtained from a number of natural and cultural sedimentary environments:

a) Stream, lake, swamp and spring beds;

b) Beach and estuarine beds;

c) Loess and volcanic ash;

d) ”fossil”, “archaeological” and “cultural” cave strata; and

e) Artificial situations such as kitchen middens, burial pits, etc.

The study of such materials by palaeontologists or palaeozoologists may yield data of considerable environment and stratigraphic importance, which is the prime concerned of an anthropologist or a culture historian. The study involves several steps and they are:

a) Taxonomic identification, for which purpose skull, dentition, antlers, horn cores, and long bones are particularly useful;

b) Quantitative analysis, i.e. determination of the minimum number of individuals for a species present, for which the quantity of the most frequent diagnostic skeletal part is used;

c) Age, sex, and size composition;

d) Ecological interpretation, based on comparison of the morphology, behaviour, and ecological relations for a living species, or comparative anatomical collections for an extinct species.

Animal remains, including bone and a wide range of organic refuse pertaining to dietary habits, are invariably richest in occupation sites of man or ‘sedimentary’ predators. The latter include the cave-dwelling bears, hyenas, lions and owls of European Pleistocene.

Pleistocene Fauna

The environmental significance of the European Upper Pleistocene fauna is better understood than that of any other Pleistocene fauna. Only three of the genera are extinct and two of those, the woolly mammoth and rhino, have been found more or less intact at certain localities, so that their diet and cold adaptations are well known. A half dozen further species became extinct at the close of the Pleistocene, but allied species of the same genera are still present. In all, these Upper Pleistocene faunas can be carefully evaluated in terms of their modern (or historical) environmental distributions. They are therefore an interesting case in point.

The characteristic mammalian species of the interglacial (Eem) fauna are the extinct, straight-tusked woodland elephant (*Elephas [Palaeoloxodon] antiquus),* the extinct woodland rhino (*Dicerorhinus mercki),* the African hippopotamus (*H. amphi bious major), the boar (Sus scrofa),* fallow deer (*Dama dama*), and roe deer (Capreolus *capreolus*). In mid-latitude Europe these animals are rarely found in glacial age deposits. They do however occur in the Mediterranean lands during part or all of the Wurm. In addition to these species there are a few dozen mammals of the temperate and boreal woodlands are also found in mid-latitude Europe during glacial periods. These include elk (*Alces alces*), red deer (*Cervus elaphus*), aurochs (*Bos primigenius*), the woodland horse ancestral to Equus*caballus silvestris*, lynx, wild cat (*Felis silvestris*), fox (*Vulpes vulpes*), wolf, wolverine, sable (*Martes zibellina*), and brown bear (*Ursus arctos* ssp.).

The glacial (Wurm) fauna includes temperate and boreal woodland forms consists of "typical" tundra fauna: reindeer (*Rangifer tarandus*), musk-ox (*Ovibos moschatus*), the snow shoe and arctic hares (*Lepus timidus*, L. *arcticus*), the mountain lemming (*Lemmus* [*Myodes*] *Lemmus*), and the arctic fox (*Vulpes* [*Alopex*] l*agopus*). Alpine forms such as the steppe ibex (*Capra ibex prisca*), the chamois (*Rupicapra rupicapra*), the alpine marmot (*Marmota marmota*), and alpine vole (*Microtus nivalis*) were found well outside of their high mountain haunts.

In addition to these, a cool, mid-latitude steppe fauna was also present, ranging through Hungary into southern France. They are saiga antelope (*Saiga tatarica*), the wild steppe horse of tarpana and Prezewalski type, the steppe fox (*Vulpes corsac*), the steppe polecat (*Putorius putorus eversmanni*), the steppe marmot (*Marmota bobak*), the hamster (*Citellus citellus*), and a gerbil (*Allactaga saleins*). Some of the best known "cold" elements include the wooly mammoth, wooly rhino, the steppe bison and the giant elk. The characteristic cave faunas of the European Pleistocene include the cave bear, the spotted cave hyena, and cave lion. Each of these species was cold tolerant but rather intermediate in its requirements. They are not 'cold' indicators by any means.

Pleistocene Plant Fossils- Pollen

Pollen analysis or palynology is one of the important indicators of palaeoclimate and dating in palaeo ecological studies. The basic principle of pollen analysis is that most wind-pollinated trees, shrubs, and grasses emanate pollen in great quantities. The particle size of pollen is on the order of 0.01 – 0.1 mm.' and the absolute weight less than 10^{-9} grams. Consequently, pollen grains are readily removed by wind and widely dispersed in the lower atmosphere where the grains are carried in suspension. Distances of 100-250 km. are readily crossed by traveling pollen, and grains may be found up to several kilometers in the lower atmosphere. Pollen density is greatest at elevation of 200 to 500 meters above the ground, and it remains appreciable to elevation of 2 km. Pollen accumulation in any one locality will therefore provide a regional rather than a local cross-section of the pollen-emanating plants present.

The annual pollen 'rain' in a vegetated area amounts to several thousand grains per square centimeter. A part of this pollen may be preserved indefinitely if oxidation is limited or absent, particularly in dense, poorly aerated sediments or in acidic environments such as provided by bogs or many lake beds. Year after year stratified laminae of sediments, including a small cross-section of the year's pollen that is preserved, may be laid down under various conditions at a number of localities. Each of these sediments, then, preserves its own chronological and environmental record (Butzer, 1971).

Application of pollen analysis

Pollen analysis may be applied to a broad range of palaeo-environmental problems.

a) *Reconstruction of local vegetation*: Careful interpretation of contemporary pollen spectra from neighbouring sites may provide a good picture of local vegetation and ecology. Certain floral elements are characteristics of certain environments, although most genera are distributed rather than more broadly. If species identification is possible and supported by some macro-botanical evidence reconstruction of forest type is possible.

b) *Regional pollen maps*: Plotting of data of approximately contemporary pollen spectra over wider areas can be made.

c) *Climate change*: Although with considerable qualification, it may be said that specific changes in pollen spectra with time may indicate climate or ecological change at a locality.

d) *Stratigraphic dating*: Characteristic pollen diagrams have been described for certain interglacial periods or for the Holocene period in temperate Europe. Such standard profiles are frequently used as dating tools, either within the span of a certain diagram, or as fossil assemblages referring to a particular interglacial interval. Artifactual materials in bog can occasionally be dated according to their position within pollen profiles.

e) *Prehistoric settlement*: Forest clearance, burnings, and agricultural colonisation are dramatically recorded in pollen profiles by sudden abundance of NAP, appearance of weed or cereal pollen, and the like. In fact the earliest agricultural settlements in temperate Europe frequently have been first recognised by pollen diagrams, as in the case of Denmark.

2.9 SUMMARY

The 'stratigraphy'– the descriptive account of sequence of layers formed due to the geomorphic agencies is the main source of data system used in relative dating ever since the chronological understanding of events. Natural agencies like wind, water, ice etc. had the high energy capacities to erode materials during dynamic conditions, while in low energy conditions remain as depositing agents. Due to these dynamic conditions the rivers, lakes, seas, oceans, glaciers etc, the surface of the earth has been subjected to topographical changes, which can be learned through the geomorphology. A wind range of deposits (alluvial, aeolian, morainic, lacustrineare, karst etc.) are systematically brought out in understanding chronological ordering of events.

Since the Pleistocene Period embraces the human emergence and initial development, the dynamic nature of depositing agencies were presented in this unit. The fauna and flora are sensitive to climatic change, thereby the faunal and floral variation in given time frame were of great significance in relative chronology besides the palaeoclimatic inferences. The geomorphological studies together with biological remains in the form of fossils (both macro and micro) go a long way in understanding the environmental changes that had taken place during the Pleistocene Period.

Suggested Reading

Brothwell, D and E. Higgins. 1970. *Science in Archaeology*. New York: Praeger.

Butzer, K.W. 1971. *Environment and Archaeology*. Chicago: Aldine-Atherton.

Cornwall, I.W. 1958. *Soils for the Archaeologist*. London: Phoenix House.

Michels, J.W. 1973. *Dating Methods in Archaeology*. New York: Seminar Press.

Zeuner, F.E. 1958. *Dating the Past*. London: Methuen.

Sample Questions

1) Discuss various kinds of Glacio-Pluviation climatic events that had taken place during Pleistocene Period.

2) Describe the process of formation of river terraces and bring out how the terrace formations are useful in relative chronology.

3) What is palaeontology? Discuss the importance of paleontology in understanding palaeo-climate.

4) Write short notes on the following

   i) Moraines

   ii) Cave deposits

   iii) aeolian sands iv.lacustrine deposits

5) Write an essay on integrating the Pleistocene climatic sequence against the geomorphological events and the fossil fauna- floral evidences.