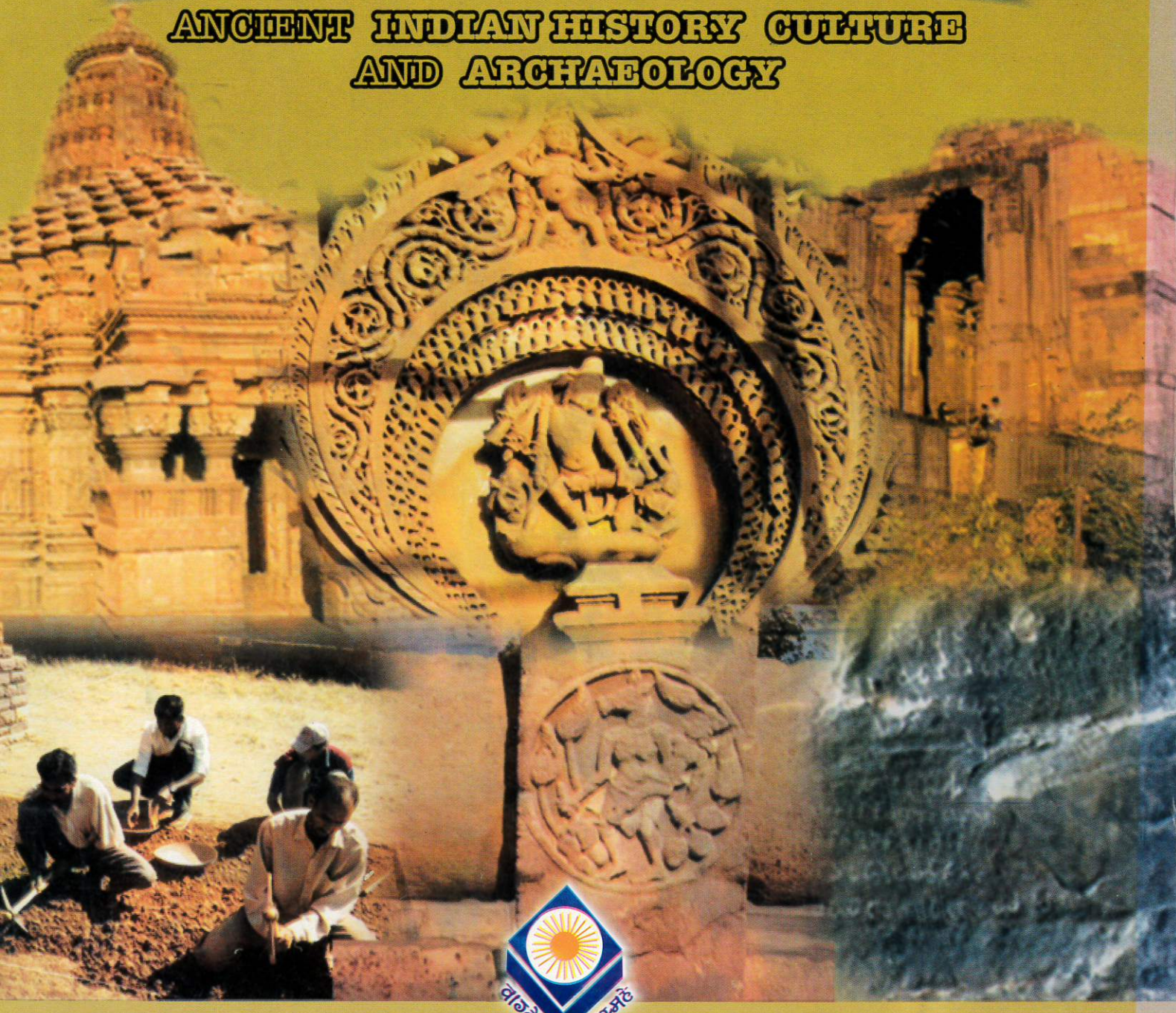
ARCHAEOLOGICAL METHODS AND TECHNIQUES

ANCIENT INDIAN HISTORY CULTURE AND ARCHAEOLOGY



DEPARTMENT OF HISTORY, ARCHEOLOGY, CULTURE & TOURISM

MADHYA PRADESH BHOJ (OPEN) UNIVERSITY

VICE CHANCELLOR'S MESSAGE

The Madhya Pradesh (M.P.) Government established the M.P. Bhoj (Open) University in 1991 under an Act of the Legislative Assembly. His Excellency, the Governor is the Chancellor of the University. A significant rapid growth and academic advancements occurred during the tenure of the then Vice Chancellor Prof. H.P. Dikshit, who is an eminent mathematician and visionary educationist and presently, he is the Vice Chancellor of IGNOU and the Chairman of the Distance Education Council, New Delhi.

I, after joining M.P. Bhoj (Open) University (MPBOU), Bhopal as Vice Chancellor on January 23, 2002, I planned and introduced over 70 new courses during 2002-05 in the areas of IT, Basic Sciences, Health Sciences, Paramedical Sciences, Archaeology and Tourism, MSW, Bioinformatics, Chemoinformatics, PG Courses, M.Phil, Ph.D. etc. The university has a national level graduate programme for B.Sc (Hons.) in Mathematics, Physics and Computer Science being conducted jointly by MPBOU and Chennai Mathematics Institute under the able guidance of Chairman Prof. C.S. Seshadri, FRS and financially supported by the Departments of Atomic Energy and Space, Govt. of India.

This university is running over 90 courses, using the existing resources and manpower of the universities and Govt. colleges of the State towards the efforts for achieving excellence in higher education. The generous support, provided by the eminent Vice Chancellors, the Govt. College Principals, the faculty members and the supporting staff is commendable; without this support the success in running the courses could not have been achieved.

The MPBOU is fully prepared to provide teaching and training to the students of Open and Distance Learning (ODL) through print media, on-line, print and on-line, and audio-video-radio for remote, rural and tribal population. The university has created a placement cell to assist the students for getting employment.

The ODL system is becoming increasingly popular because it has the capability to provide quality education to masses and disadvantaged people. This includes the people, who cannot pursue their higher education because of their jobs. Such people can join the courses along with their job and upgrade their knowledge and skill. Many women, who get married and due to motherhood or otherwise they cannot pursue higher education also get opportunity to join these courses. The girls, who are not allowed to travel long distances from their rural homes can join higher education and those persons, who have no nearby approach to study can also pursue higher studies through distance learning system.

Thus, DOL system brings the higher education at the doorsteps of the people from reach to unreach. It is also a matter of great pleasure that the University is introducing its courses at the National and International levels through study centres opened in collaboration with the reputed educational Institutions/Organizations from 2003-04 session.

We are grateful for the valuable support and guidance received from H.E. Governor and Chancellor, Honourable Chief Minister and Honourable Education Minister. I am also thankful to the Distance Education Council and its Chairman and other officials for generous financial grant. The support from the officials of the Higher Education and Finance Departments of M.P. and Chhattisgarh is highly appreciated.

I am extremely thankful to all my colleagues, particularly to Dr. Susmita Pande, Reader in Department of History, Culture and Tourism and experts of national and international repute who have provided their expertise in the preparation of the study materials, impart teaching during contact classes and conduct practical training.

I extend heartly welcome to the students, joining us, during 2004-05 and offer my best wishes for success in their career and efforts to usher the knowledge society and meet the challenges, posed by the global economy.

Our aim in launching this programme is to provide professional skill to the students who are interested in chalking out a careers in the field of Archaeology. A *Archaeological methods and techniques* in a scientifically based course. The techniques of archaeological exploration, excavation stratigraphy and the dating and conservation of artifacts involve the knowledge of the recent advancement in the various branches of science.

The course material is unique in the sense that the highly technical methods in archaeology are explained to the students in a lucid way.

(Prof. R.K. Singh)
Vice Chancellor

ARCHAEOLOGICAL METHODS AND TECHNIQUES

Ancienct Indian History, Culture and Archaeology

Course — VI

EDITED BY
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Archaeological Methods and Techniques

Edited by : Dr. Susmita Pande

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Editors Note

It is a very happy augury that study material in the distance mode for Archaeology is being structured for the first time in the country by MPBOU. The scholars involved in this effort are eminent historians and archaeologists of national and international repute.

The five blocks of course VI of M.A Final **Archaeological methods and techniques** have been integrated in one volume for the practical convenience of the students and also since the understanding of one block involves the reference of another invariably.

The volume aims to introduce to the students of History and Archaeology the process of understanding the human past through material remains of civilization. The student is also made aware of the current thinking in archaeological studies and is also exposed to the basic principles and methods employed by the archaeologists during explorations and excavations.

The *first block* deals with the conceptual framework behind Archaeology. Archaeology gathers data from different disciplines like Zoology, Physics, Geology, Botany, Anthropology, Chemistry and other branches of science. This data is used in the interpretation of human past. The scientific techniques are utilized in conducting exploration, excavations, and conservation and in determining the dates of artifacts.

Owing to the developments in science, archaeology has acquired new dimensions of knowledge. This has resulted in the expansion of different specialized branches of archaeology.

The *second block* explains in a lucid way, the various techniques of exploration, excavation and survey.

The *third block* deals with stratigraphy and record writing. It explains how the excavator, while digging understand the strategraphic relationship of each unit and how he records it by analyzing the situation of units and artifacts contained therein. The interpretation and conclusion of the excavated material depends on the accuracy of recording.

Block four deals with the dating methods-relative and chronometric. In the former a correct sequence of the units is tried to be made while in the latter the actual number of years that elapse between the event concerned and the present time is determined.

Block fifth explains the basic principles of conservations of monuments and excavated material. It explains the principle of conservation of monuments and excavated material. It explains the principle, importance and techniques of conservations to the students in a simple way.

The volume could not have seen the light of day without the support and encouragement of our Honorable Vice-Chairman Prof. R.K Singh. His academic vision includes not only the science subjects but also value based subjects in humanities and social sciences which help us to understand our present in a better way.

I must thank the eminent writers of the units-Dr. Purushottam Singh, Dr. Sunil Gupta, Dr. J.K Patnaik, Prof. J.N Pal, and J. Manuel who depite their very busy schedule completed their units.

My thanks are due to the university personel- the directors- Dr. Pravin Jain, Dr. R.P Mishra and the Registrar Dr. C.K Jain and also to the Director Hindi granth academy Dr. S.K Awasthi for their support.

I am thankful to Dr. manoj Kumar Sharma who assisted me in various ways. Shri. Bhupendra Singh Chauhan deserves my heartful thanks for preparing a neat typescript.

The volume would be helpful not only to the students of Archaeology but aslo to the scholars and the lay men who are interested in the knowledge and preservation of our rich heritage.

Susmita Pande

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BLOCK – I

GENERAL CONCEPTS & HISTORICAL DEVELOPMENT

UNIT – I

ARCHAEOLOGY - DEFINITION, SCOPE & RELATION WITH OTHER SUBJECTS

1.1 Definition & Introduction to Archaeology

The word Archaeology comes from the Greek archaia (ancient things) and logos (theory or science). Archaeology is concerned with the material past of humankind. Archaeology seeks to understand the past of humankind through study of material remain. The subject of Archaeological research is diverse prehistoric humans, early farming cultures, ancient cities, old crafts, metallurgy

etc. Field surveys, excavations and study of artefacts (especially old pottery) are at the core of the archaeological enterprise. Archaeological investigations range from prehistory to history. Prehistoric archaeology is concerned with preliterate societies, specially the activities of early man from stone Age to the beginnings of agriculture. Historical archaeology focuses upon societies which have developed writing systems, monumental architecture and organised forms of public life. Archaeology is often called the '*hand maiden of history*' because it supplies material evidences that help to frame historical perspectives.

Stratigraphy, a concept borrowed from Geology, is the most fundamental tool of archaeological interpretation. Sediments, both geological and archaeological, build up in layers, and naturally enough the higher levels are the younger ones. From this evidence we can establish a relative sequence. In geology, sequences may become complex as a result of erosion, volcanic eruptions etc. In archaeology, it is very often the quirks of human activity which make the record complicated. However, archaeological and geological stratigraphy are not necessary separate. Remains of Stone Age culture are mostly found in geological contexts.

The archaeological discipline is organized into various branches. The basic categories follow the old principle of stages of human development. The stone age, the Copper Bronze Age and the Iron Age. Each broad archaeological age has sub categories. The following schema offers a simple understanding.

Stone Age

a. Old Stone Age manifested in Palaeolithic Cultures. These are further divided into the Upper, Middle and Lower Palaeolithic Cultures. The Palaeolithic Cultures are characterized by use of large stone tools, like choppers and handaxes. The Palaeolithic lifestyle revolved around hunting and gathering of food.

b. Transitional Stage manifested in Mesolithic Cultures. The Mesolithic Cultures are characterized by use of small razor sharp blade tools. the Mesolithic people were those who were still hunter gatherers but were gradually settling down.

c. New Stone Age manifested in Neolithic Cultures. The Neolithic Culture is associated with domestication of plants and animals and beginnings of agriculture. The Neolithic tools are usually ground and polished.

Copper - Bronze Age

Copper replaced the lithic tools. In archaeological parlance, copper using societies are known as Chalcolithic Cultures. The use of bronze (alloy of copper and tin or arsenic) is associated with the

large riverine civilization like the Egyptian, Mesopotamian and the Harappan which flourished in the 3rd millennium BC.

Iron Age

The Iron Age followed the Copper Bronze Age. The Iron Age cultures are associated with large political formations, great city states, agricultural surplus and trade. The Iron Age began in most parts of the world in 1st millennium BC.

1.2. Scope of Archaeology

Since it's inception archaeology has become a complex and challenging discipline. The subject brings together the social, physical and the earth sciences, employing sophisticated scientific techniques to probe, dig and document ancient remains of habitations, stupas, temples etc. Archaeological research covers all aspects of material culture. The staple data for archaeological study are common artifacts usually present in ancient mounds. pottery, beads, terracotta figurines, mud bricks. Archaeology is called the 'hand maiden of history'. However, the subject has broader implications. Archaeology is now considered a potent tool for understanding social, cultural and technological processes in modern times. The following are the important areas in which archaeology is relevant.

1. Archaeology aims to construct a scientific form of history rather than one solely derived from traditional sources. Archaeology helps us understand the material life of ancient people, their technologies, nature of habitations, living conditions, crafts, skills, sanitation, political life, forms of entertainment etc. Therefore archaeology is called the 'hand maiden' of history.

2. Archaeological research on development of prehistoric humans has helped in understanding the critical episodes of the past when swift technological changes were taking place. Archaeology has helped establish the link between culture and biology when primates turned to bipedallism (moving on four legs to two legged gait) and when domestication of plants/animals settled to full agriculture. These episodes can become models in understanding the link between technology and culture in modern times. This aspect of archaeology applies directly to the present rather than the past.

3. Archaeology is also seen as a potent tool for the development of the third world countries. Archaeological sites are visual documents of the past and therefore attract the interest of scholars and laymen alike. Amongst the latter are school children, tourists, common village folk etc. Archaeological sites can be used to create awareness of the past and infuse a sense of national pride among the people. The creation of heritage areas, replete with site museums and well informed guides, can link archaeology with cultural tourism.

1.3 Relationship of Archaeology to other subjects

Archaeology is a multi faceted discipline. The detritus of the past unearthed in archaeological excavation is diverse, comprising of potteries, animal bones, remains of food grains, semiprecious stones etc. Archaeological finds require inputs from natural and earth sciences for complete understanding of the past. The linkages are briefly discussed below.

1.3.a Archaeology and Physics

The link between archaeology and physics is most evident in the dating techniques used in archaeological researches. Primary among these is the radiocarbon dating method. Other tools for dating are dating (TL Dating) mainly of ancient pottery, Palaeomagnetic dating, Fission Track dating and Pottasium Argon dating methods. the radio carbon dating is the most wide spread application of physics to archaeology. In India, Prof. D.P. Agrawal is the pioneer in establishing radiocarbon dating procedures and facilities. According to Prof. Agrawal 'Radiocarbon dating has made a revolutionary impact in the fields of archaeology and quaternary sciences.Though there are many dating techniques available today, there is none which provides such high accuracy and for such a recent period. The range is about 50 thousand years from present (excerpt from Dating the Human Past by D.P. Agrawal and M.G. Yadava). In his famous book *Before Civilization*, the English archaeologist Colin Renfrew says 'Radiocarbon dating came as godsend to archaeology. For the first time the prehistorian could hope to date his finds, both accurately and reliably, by a method that made no archaeological assumptions what so ever.'

1.3.b Archaeology and Chemistry

The marriage of archaeology to chemistry has yielded interesting results. Chemical analysis is used for determining trace elements in artifacts and there by creating recognizable 'signatures'. For instance, the chemical composition of coins, especially gold coins, shows the impurities present. These impurities indicate the production area or mint where the coins were made. Electron microprobe of ancient glasses also yields distinctive chemical signatures. Fluorine analysis of bones is another example of archaeological chemistry. Fluorine accumulates in ancient bones through ground water and the relative dating of bones is possible by estimating the propotion of flourine. Soil chemistry is an important focus in archaeological chemistry. Soil samples taken from archaeological contexts (layers in an excavated trench, kiln, old dumps) are analysed for content of phosphates, organic carbons, calcium carbonate etc.

1.3.c Archaeology and Botany

Archaeobotany is the study of plant remains recovered from or associated with archaeological sites. The study of these botanical remains has also been called palaeobotany. The archaeobotanist

has to do more than just identify seeds and plants from archaeological contexts. The domestication of plants is one of the watersheds in the history of humankind. The processes of domestication were complex and involved the gradual selection of wild varieties. Therefore the archaeobotanist may be involved in not only identification of ancient plant remains but also has to determine wild varieties of plants from domesticated types. There is also the study of old pollen from cores lifted from lake beds etc. This branch of botany is called palynology and indicates changes in ancient climatic pattern. For instance, the shift from aquatic pollen to that of land based plants will indicate change from wet to dry climate. The palynological indicators can then be corroborated with other criteria. Apart from pollen other plant remains like phytoliths are studied.

1.3.d Archaeo-zoology

The study of faunal remains from archaeological contexts is also called zooarchaeology or Palaeozoology. Archaeo-zoology focuses on detailed analyses of animal and human bones. Identification of animals from bone fragments can tell much about lifestyles in ancient settlements, such as the animal food eaten, the kind of animals domesticated, quantity of cattle wealth etc. The human remains are usually investigated by scientists who are called bio archaeologists or biological anthropologists. Bio archaeology is a research approach to past cultures that requires inter disciplinary co-operation between archaeologists and biological anthropologists. Bio archaeologist study human bones for disease, trauma, growth patterns, nutrition etc. A set of skeletons can say much about long dead individuals for instance the average life expectancy or the normal height of individuals. Biological Anthropology helps to reconstruct the ancient lifestyles, subsistence patterns and often the ecological contexts of ancient communities.

1.3.e Geo-archaeology

Archaeology and Geology are related Earth Sciences. Archaeological cultures are invariably to be found in geological settings. In order to fully understand the growth of archaeological cultures, it is necessary to relate them to their geological settings. Since the remains of the human past are found all over the earth, the geomorphological contexts of archaeological sites are highly varied ranging from coastal tracts, river valleys, mountain terrains and even sand dunes. Geo archaeology has its most potent application in Prehistoric Archaeology. The remains of human fossil bones and stone tools of ancient man are found in earth matrices. These earth matrices appear in the form of eroded river sections or uplifted features like the karewas in Kashmir. The study of soil types and other geophysical co-ordinates becomes critical to understanding the context of prehistoric cultures. For instance, the first stone age tool or palaeolith was discovered in India in the brick red laterite soil which prevails in the coastal regions of south India. The geochronology of the earth features is necessary to situate the prehistoric cultures in a time scale. The principle of geochronology is stated

by Dr. S.N. Rajguru in his contribution in the *Encyclopaedia of Indian Archaeology* 'Geochronology, the science of dating events in earth history, essentially involves the study of repititive superimposed features of the geological record, such as varves and sedimentary cycles.'

1.3.f Archaeology and Computer Science

The application of computer technology to archaeology is now commonplace. From inventory controls to cataloguing of artifacts, computers are necessary for any field program. Three dimensional softwares like autocad is used to reconstruct entire archaeological contexts and the virtual reality software has been used to recreate ancient cities of Egypt and Mesopotamia.

1.3.g Archaeology and Literature

Inscriptions, rendering on seals and coins and papyrus documents come within the pale of archaeological evidence and can be easily legitimised as data. Ancient textual records, on the other hand, need to be accepted as historical documents. Some would frown upon the primacy accorded to literary sources in archaeo historical constructions. However, even an insignificant material indicator may make the whole of a literary corpus interesting to the archaeo historian, creating inadvertently a powerful context for material evidence. For instance, the discovery of a seal from the 8th century B.C. contexts in Israel bearing the inscription, for the Biblical references to king Solomon's voyages to this prot. No. procedure governs the interface between classical sources and material data. This affinity has to be achieved in every case. In fact, an electic approach to the archaeo historical idea of the past would persuade us to include besides the mainstream literary records oral traditions, folk lore and even legends as potential historical resources. Phillipson, in the African Archaeology says that Herodotus' reference to phoenician mariners circumnavigation of Africa, though 'incapable of proof or disproof' should not be 'dismissed out of hand'. These words apply to all literary records used in relation to archaeology.

1.3.h Archaeology and Language

Archaeolinguistic approaches arrive from the premise that certain assemblages represent particular language speaking groups in antiquity. A progressive reduction in dates of these assemblages along a territorial spread indicates expansion and/or migration of the particular language speakers. For instance, similarities between agrarian terms in the language of the Manda tribals of eastern India and Mon Khmer speech prevalent in mainland Southeast Asia have been taken to indicate that rice cultivating Austroasiatic speakers migrated from southern China to eastern India.

1.4 Ethnoarchaeological Perspectives

The search for history in living entities and practices follows from the premise that present lifestyles reflect ancient modes of living. Isolated tribes, ethnic communities and enduring craft

traditions are the staple of ethnoarchaeological studies. The need to construct the role of traditional communities in ancient exchange networks makes the ethnographic records important. For instance, ethnographers have highlighted the role of forest tribes as likely supply of high value botanical products to the Early Historic ports in India. The Dadars for instance, a foraging tribe inhabiting the rain forests of the Malabar in south India, are in modern times the primary suppliers of herbs and resins for making of Ayurvedic medicines. A kadar folklore fragment recollects the arrival of traders seeking forest wealth like dammar and copal in exchange for gold and silver coins. The Malabar and its adjacent hinter land show the greatest concentration of Roman gold and silver coins in the subcontinent. It is not far fetched to suggest that the kadars were best positioned to participate in the international trade with the Roman World in the early centuries A.D. The point is that traditional histories of littoral communities and 'origin' legends should not be excluded from a historical discourse on the early Indian Ocean world. Ethnoarchaeological studies are relevant for gaining insights into ancient technologies that dispersed across cultural regions. Investigation into bead crafting processes in South Asia and documentation of traditional watercrafts of the Indian Ocean are some major ethnoarchaeological areas of investigation in India. Ethnographic analogies for the past may possess an element of circularity but as tools of analysis the parallelisms are important for understanding the past records.

1.5 Glossary of Important Terms in Archaeology

Acheulean : The tradition of tool making in the palaeolithic period characterized by hand axes; widespread in Europe, Africa and parts of Asia. India is included in the Acheulean tradition.

Artefact : An object made or used by man.

Assemblage : A range of objects found associated in a defined archaeological context; a layer for example or a household.

Culture : Archaeologically, a recurrent assemble of sites and artefacts.

Cuneiform : Writing system developed in Mesopotamia, using combinations of wedgeshaped impressions on clay tablets.

Dendrochronology : Dating wood by counting annual growth rings.

Diffusionism : A concept of the spread of technology or civilization through the diffusion of improvements from a single center.

Environmental : The study of any aspects of the environment of man in the past.

Archaeology : Whether biological, botanical or environmental.

Flotation : The recovery of small seeds, bones etc using a machine which agitates a sample of soil in water, causing these items to separate from heavier soil particles and to float on the surface in a frothing agent which can be skimmed off.

Fossil : A preserved organism of Pleistocene or earlier age; the original material may have been replaced by mineral matter.

Glacial : Ice Age cold periods, in which ice caps and glaciers expanded.

Harappan : The term derives from the Bronze Age site of Harappa, belonging to the Indus Valley Civilization. The term Harappan is used to refer to all artefacts, assemblages and sites of the Indus Valley Civilization.

Hieroglyphics : Literally 'sacred signs'. A formal style of ancient Egyptian writing.

Hominids : The family of man, including all species of Australopithecus and Homo.

Civilization : The Bronze Age sites on the banks of the rivers Indus in Pakistan and the dry bed of the ancient Saraswati in western India. The Saraswati is associated with the Ghagger river in Rajasthan and the Hakra in Pakistan.

Interglacial : A warm period intervening between glacial periods usually lasting for 10,000 years or more.

Interstadial : A short relatively warm period in a glacial period.

Megaliths : Tombs and other structures built from very large stones, principally during the later stone and early bronze ages. In the Indian subcontinent, the Megalithic culture is associated with the beginning of Iron Age in south India. The Megalithic Culture in India is dated from 1000 BC to early centuries AD.

Microlith : A small stone artefact, normally under 3 cm long, used in composite tools like arrow tips, sickle blades.

New Archaeology : A movement which began in America in the 1960s, aimed towards consciously scientific studies of the past, and

explanations based on carefully designed models of human behaviour.

Papyrus : A reed like plant formerly found along the Nile in Egypt from which the Egyptians made a form of paper.

Palynology : The study of pollen. Palynological studies are undertaken as part of palaeoclimatic studies, as it is presumed that wet and dry climatic cycles would be reflected in the ancient pollen profile.

Petrology : The study of ancient pottery, stone tools or rocks in thin section. Study of the thin sections with the aid of a geological microscope shows the inclusion in the clay or stone matrix. These inclusions, such as quartz, are recorded in terms of volume, size and shape and 'signatures' of the samples are developed.

Post hole : A cavity or soil filled indication of a timber upright or bamboo poles showing the position of ancient habitational structures which the uprights supported.

Potassium Argon : A techniques in which the decay of an isotope of

Dating : potassium into the gas argon is measured.

Primates : The order of mammals including man, the apes and monkeys.

Quaternary : Nominally, the fourth and most recent major system of geological time, comprising the Pleistocene and Holocene.

Radiocarbon : A technique based on the counting of decays of

Dating : Isotopes of carbon 14 in samples of charcoal or other organic materials.

Recalibration : A correction process carried out on radiocarbon dates to adjust them to calendar years, using results gained from dated tree rings.

Section : A vertical record of the stratification of a site or feature.

Seriation : A technique of relative dating by which the propotions of particular artefacts or types are compared on a site or between

everal sites, and arranged in a series so that individual types appear, flourish, and decline in an orderly manner.

Sondage : A trial excavation trench, also known as a test pit; the term is often associated with the investigation of the deep stratigraphic records in high mounds.

Strata : Layers in an excavation trench.

Stratigraphy : The sequence of superimposed layers in an archaeological excavation and the description of artefacts, assemblages, features in the sequence.

Tertiary : The geological system lasting from about 65 million years ago to the beginning of the Pleistocene.

Thermolum : A dating technique in which energy derived from radioactive.

inescence : Impurities trapped in minerals is released in a laboratory and measured. The TL technique, as it is known in short, is primary used for dating pottery.

Three Age System : The division of pre-history into three successive technological stages characterized by the use of stone, bronze and iron. At first entirely hypothetical, these divisions were confirmed by archaeological observations.

Typology : The study of changes in the form of classes of artefacts.

Varves : Annual deposits found in river and lake beds near glaciers, reflecting the fluctuation of the flow of water during periods of freezing and melting.

1.6 Summary

Archaeology seeks to understand the past of mankind through the study of material remains. Archaeological investigations range from pre-history to history. The important archaeological techniques comprise of field surveys, excavation and the study of artifacts.

Archaeology aims to construct a scientific form of history and is also a patent tool for understanding social, cultural and technological processes in modern times. Archaeological sites also create awareness of the past and infuse a sense of national pride among the people.

Archaeology is related to all the ancient and modern disciplines of study like physics, chemistry, Botany, Zoology, Literature, Archaeo-Zoology, Geo-Archaeology and computer science etc.

1.7 Check your progress -

1. Discuss the definition and scope of archaeology.
2. Discuss the relationship of archaeology with other disciplines of study.
3. Tick (✓) or (×) infront of the correct or incorrect statements.
   a. Palynology is the study of pollen.
   b. The movement of New archaeology began in Italy.
   c. Microlith is a bronze tool.
   d. Fossil is a preserved organism of pleistocene or earlier age.
   e. Cuneiform is the writing system developed in Egypt.

1.8. Activities –

1. Write a note on any archaeological site near your town/village.

   or

   Write a note on any museum near your residence.

1.9. Suggested Readings –

1. Mishra V.D. – *Some aspects of Indian Archaeology*, Allahabad 1977.
2. Pande J.N. – *Puratattva Vimarsh*, Allahabad.
3. Rajan K. – *Archaeology Principles and Methods*, 2002.

UNIT – II

HISTORY OF THE DEVELOPMENT OF ARCHAEOLOGY ESPECIALLY IN INDIA

2.1 Introduction

The History of archaeology should be traced to the beginning of the love of antiquities. Its study as a discipline began in the 18th century with the creation of society of antiquaries in London and the establishment of the Asiatic society of India.

In India the development of archaeology is linked with the creation of archaeological survey of India and the activities of the organization from 1861 to present day.

Since the mid 20th Century archaeology has taken a multidisciplinary character and many schools and disciplines of archaeology have developed since then.

2.2 Objectives -

The main objectives of this unit is to make the student aware of the history of archaeology especially in India.

The history of archaeology includes the creation of bodies like archaeological survey of India. The academic development of this field in universities, the excavations of various archaeological sites and the development of archaeological disciplines in India.

2.3 History of the Development of Archaeology especially in India -

Archaeology had its beginnings in the love of antiquities of old classical civilizations that arose in Renaissance Europe. During the time of the Renaissance the poets and writers began to look to the glories of Greek and Roman civilizations for their inspiration. The creation of the Society of Antiquaries in London in 1717 and the establishment of the Asiatic Society of India in 1784 are milestones in the study of material culture of the past. Napoleon's invasion of Egypt in 1798 was a watershed for the development of antiquarian studies in Egypt. Napoleon took with him a retinue of scholars who collected all the data they could find on the Pharaonic Age of Egypt. The great advances made in geology, especially the principle of stratigraphy influenced the nascent discipline of archaeology. The principles of stratigraphy were enunciated by Charles Lyell in his Principles of Geology (1833). In 1859 Charles Darwin published his seminal work Origin of Species. Darwin's thesis that the ancestry of humans could be traced to the great apes demolished the long held Biblical notion that human history began in 4004 BC. Other developments were also breaking this restricted idea of human history. The discoveries of Stone Age tools in Europe were especially illuminating.

The publication of John Lubbock's work Pre-historic Times in 1865 put into perspective the idea of the Stone Age and the word 'palaeolithic' was used in this book for the first time. Earlier, the 'stages' in archaeology were set forth by the Danish archaeologist C.J. Thomsen. He postulated successive technological stages in man's past and made archaeology analogous to the earth sciences like geology which had their own stages. C.J. Thomsen classified the material in Copenhagen Museum, opened to the public in 1819, on the basis of three successive ages of Stone, Bronze and Iron.

The pioneer of modern archaeology was a German businessman by the name of Heinrich Schliemann. He conducted excavations at the ancient Homeric sites of Troy and Mycaenae in the 1870s. The German Archaeological Institute was also a major archaeological force in the Mediterranean in the late 19th century. In 1822, a French scholar Jean-Francois Champollion deciphered the Egyptian hieroglyphic script. The British archaeologists started work in Egypt (Petrie Flinders expedition) and in Mesopotamia in the mid 19th century. The Englishman Henry Rawlinson deciphered the Mesopotamian cuneiform script in 1846. The beginning of excavations at the Cretan site of Knossos by Arthur Evans in 1900 heralded archaeology in the 20th century. In 1922 Howard Carter and Lord Carnarvon discovered the royal tomb of the Pharoah Tutankhamen. The discovery and excavation of the Bronze Age cities of Mohenjodaro (1921-22) and Harappa (1923) by the Archaeological Survey of India was another watershed in the development of archaeology. The royal tombs of Ur in Mesopotamia were discovered by Sir Leonard Woolley in 1926. A number of books on archaeological excavations were penned. Among the notable works are Leonard Woolley's Digging Up the Past (1930) and his later contribution Spadework (1953) and Geoffrey Bibby's Testimony of the Spade (1956).

2.4 The Archaeological Survey of India

In India, the development of archaeology is closely linked with the creation of the Archaeological Survey of India and the activities of this organization from 1861 to the present day. Before the establishment of the Survey, the principal institute for study of India's material past was the Asiatic Society founded in 1784. The famous Indologist James Prinsep was secretary of the Asiatic Society in 1830-32. The spirit behind the creation of the Archaeological Survey of India was a officer of the British-Indian army by the name of Alexander Cunningham. On his own volition, Cunningham explored large parts of northern India, documenting ancient ruins, Buddhist stupas and temples before his request for regularizing his services for the cause of history was accepted by the government. By 1848, Alexander Cunningham had gained enough experience as a surveyor because of his work in Kashmir, Ladakh and the Tibetan Frontier. Finally, in 1861 the British-Indian government created the Archaeological Survey of India and appointed General Alexander Cunningham its first head.

On becoming the Surveyor-General of the ASI in 1861, Alexander Cunningham undertook two tours, the first between 1861-65 and the second between 1871-85. He largely followed on the footsteps of the great Chinese pilgrim traveller Huntswang. He produced 23 volumes of reports of his explorations and excavations. Cunningham revealed his field interest in the report of the Archaeological Survey of India for the year 1871-72. Alexander Cunningham explained his approach to the task of recording India's material past thus: 'Archaeology is not limited to broken sculptures, old buildings and mounds of ruins, but includes everything that belonged to the world's history. From their size and number, architectural remains naturally form the most prominent branch of archaeology. This is more especially the case in India, where, save coins, ruined buildings are almost the only remains of bygone times. The study of architectural remains is therefore one of the most important objects of most Indian archaeologists. But our researches should be extended to all ancient remains whatever that will help to illustrate the manners and customs of former times.....'

James Burgess replaced Cunnigham as the chief of the Archaeological Survey till 1889. In an article titled Sketch of Arcaeological Research in India during half a century Burgess writes: 'When I left the service in 1889, Government, for a time, entrusted the work very much to the Assistants, who, in three of the circles, did excellent work. In the survey since 1889, Mr. Smith, besides his work on Fatehpur Sikri, prepared also a volume on Moghul colour decoration at Agra. In 1888, with Government sanction, the *Epigraphia Indica* was taken out as a supplementary to the *Corpus Inscriptionum Indicarum*, originated by General Sir A. Cunningham. Another important discovery in the late 19th century was the finding of Gandhara sculptures. The event is recorded by Burgess who says: 'Another branch of Buddhist art is noted in the very remarkable Buddhist sculptures found on the North-West Frontier and Kabul Valley; these were long since brought to notice by Masson and others, and their connection with Greek art was evident. Various notices of them had appeared, but no very serious treatment of them till 1889, when M. 'Emile Senart and Mr. Vincent A. Smith simultaenously published essays on the subject'.

In 1902, the Viceroy of India, Lord Curzon appointed John Marshall as the Director-General of the Survey. Lord Curzon, perhaps the most imperious of viceroys, reorganized the Archaeological Survey of India and took an active interest in the preservation of monuments, even personally supervising renovation work on the Taj Mahal. Curzon's desire to uplift Indian archaeology is reflected in his essay published in the Report of the Archaeological Survey for 1902-3. To quote: 'In the course of my recent tour, during which I visited some of the most famous sites and beautiful or historic buildings in India, I more than once remarked in reply to Municipal addresses that I regarded the conservation of ancient monuments as one of the primary obligations of Government. This obligation, which I assert and accept on behalf of the Government, is one of an even more binding

character in India than in many European countries. There, abundant private wealth is available for the acquisition or the conservation of that which is frequently private property. Corporations, Societies, Endowments, Trusts provide a vast machinery that relieves the Government of a large proportion of its obligation'. This was the beginning of a new period of research and activity with emphasis on excavation and conservation of monuments. The great Indus cities of Harappa and Mohenjodaro were discovered in the tenure of Marshall. He started the Annual Reports and the Memoir Series in the Survey. General achievements in the period of John Marshall are the excavations at Mohenjodaro, Taxila, the diggings of Ganga Valley sites of Rajagriha and Bhita. His large trench at Bhita uncovered the classic phases from the Maurya to the Gupta periods. Marshall also undertook renovation work at Sanchi stupa.

John Marshall's tenure ended upon his retirement in 1928. The years that followed were not known for any major work. The Annual Reports of the Survey were published as usual till 1935-36. H. Hargreaves succeeded Marshall and was the Director-General of the Survey from 1928 to 1931. D.R. Sahni (1931-35), J.F. Blackiston (1935-37) and K.N. Dikshit (1937-44) then followed in quick succession. In the meantime the report on the functioning of the Survey by Leonard Woolley recommended a thorough reorganization of the Survey and selection of a qualified archaeologist from abroad to head the ASI. The English archaeologist Mortimer Wheeler was chosen for the job by the Viceroy Lord Wavell.

In August 1943, Mortimer Wheeler was invited by the India Office and the Viceroy of India, Lord Wavell to undertake the total reorganization of the Archaeological Survey of India. Wheeler was on active war duty with the British Army in north Africa when the Viceroy, Lord Wavell especially requested Wheeler's services. Wheeler toured the country and chose to excavate sites in different parts of the Indian Subcontinent. Between 1944-47 Wheeler excavated the site of Bala Hissar at Taxila (North Pakistan), the great Indus city of Harappa, the Indo-Roman port of Arikamedu in south India and the Megalithic sites of Brahmagiri and Chandravalli in the Deccan Plataeu. Wheeler trained a whole generation of archaeologists in the course of excavations at Taxila. These young archaeologists came to be known as members of the 'Taxila School'. Among the trainees was B.K. Thapar, who was to become the Director-General of the Archaeological Survey of India. In the crucial years of his stewardship of the Survey, between 1944 - 47, Wheeler focused his energies on solving problems in the knowledge of the protohistory and the early history of India. In an article written in Ancient India (1949), Wheeler discussed the gaps in the history of northern and southern India. To quote: 'In the North the great hiatus between the end of the Indus valley Civilization, dated by Mesopotamian contacts in the third millennium BC, and the absorption of India into the historical Achaemenid Empire of the 6th century BCO In the South, the archaeological problem is, in a sense,

vaster still. There we have no dated contact with Mesopotamia, and no intrusive Persian Empire. Scraps of information approximating to an uncertain history begin in the time of Asoka, but it was not until the Graeco-Roman geographers of the first and second centuries AD included Indian trade within their survey that the historical map assumed something approaching a coherent outline'.

Each of Wheeler's excavations proved to be far reaching in their vision and insight. Wheeler's excavations at Harappa revealed the great mud brick fortifications of the 5000 years old city. The excavations in the Taxila region made clear the events of Alexander's invasion of north-western India. The diggings at Arikamedu brought to light the facets of India' sea trade with the Roman Empire. The excavations at Arikamedu yielded some of the best elite red wares of the Mediterranean world called the Arretine Wares. Also there were the classical wine jars or the amphorae. These ceramics could be precisely dated and therefore Wheeler was in a position to provide a chronology to the Early Historic culture of Southern India. Wheeler's excavations in the Deccan region at the sites of Brahmagiri and Chandravalli elaborated the stratigraphic perspective developed at Arikamedu.

On the whole, the periods of John Marshall and Mortimer Wheeler were quite fruitful for Indian Archaeology. The discussion on Indian Archaeology after Independence follows later.

2.5 Academic Developments

From the mid-20th century we find archaeology taking on a multi-disciplinary character. The main schools of archaeological thought are discussed in Unit III. Below, the major field events in archaeology are specified especially in the Indian context.

2.5.a Prehistory

In the last 5 million years, the homonids appear in the fossil record. Archaeology begins with the first preserved evidence of cultural activities, about 2.5 million years ago. Once stone tools appear, we have the tangible indicators of human occupation. The search for human origins is one of the most important quests in prehistoric archaeology. One of the places in the world which has yielded rich evidence of the origins of man is the great Rift Valley of eastern Africa. The Rift Valley, caused by a rupture between the continents of Africa and Asia, stretches from Ethiopia to Tanzania. Another area of great potential for finding homonids are the Sivalik foothills of the Himalayas. The Rift Valley has been called a natural laboratory for the study of early man. There is much truth in this, for it brings together sediments, exposures, sites and dating evidence in sequences that have scarely any parallel. The world famous site of Olduvai Gorge in the Rift valley (Northern Tanzania) offers the most complete archaeological sequence of the last 2 million years. The potential of Olduvai was recognized by the German geologist Hans Reck in the early part of the 20th century. However, it was Louis Leakey (1903-72) and his wife Mary Leakey who realized the archaeological potential

of Olduvai Gorge. Their prospections at Olduvai carried on for more than 30 years, in the course of which they made some famous discoveries of primates and homonid remains. In 1959, Mary Leakey discovered the bones (and tools) of the primate Australopithecus Boisei in the Olduvai Bed I. The remains were 1.8 million years old. Footprints of homonids were discovered at the Leotoli Beds site near Olduvai by Dr. Mary Leakey in 1976. These hominid footprints were about 3 million years old. Other important sites in the Rift Valley yielding hominid remains are Lake Turkana and Chesowanja. The oldest skulls of the modern man or homo sapiens have been recently discovered in Ethiopia, indicating that Africa was the genetic center of origin of humankind.

Prehistoric art is a major element of world heritage. Some of the best examples of prehistoric cave paintings is to be found in the Palaeolithic cave art in the Altimira complex (northern Spain) and the Lascaux cave paintings in southern France. In India, the earliest rock cave paintings are dated to the Mesolithic period. The best examples of such paintings occur in the Bhimbetka cave complex in Madhya Pradesh.

In India, the first stone age tool picked up by Robert Bruce Foote at Pallavaram near Chennai in 1863. Lower palaeolithic sites have been excavated at Isampur in Karnataka and Rohri Hills in Pakistan. L.A. Cammiade and M.C. Burkitt related palaeolithic tools to geological formations in the Andhra region in the 1930s. The famous Yale-Cambridge expedition led by de Terra and Paterson in 1939 undertook explorations in Kashmir, the Potwar plateau, Narmada Valley and around Madras. Their work is reported in Studies on the Ice Age in India and Associated Human Cultures (1939). H.D. Sankalia produced the first review of prehistory in the subcontinent in Prehistory and Protohistory of India and Pakistan (1963) and the revised second edition was published in 1974). In the early seventies the Cambridge-Baroda Expedition investigated the palaeoclimate and prehistory of the Thar Desert and between 1978-85 a multidisciplinary program was launched in the Didwana lake region of the Thar Desert to understand the palaeoclimate of Rajasthan. The first hominid skull belonging to advanced Homo Erectus was discovered by Arun Sonakia at Hathnora in the Narmada Valley in 1982.

The Palaeolithic Culture has shown uneven development in the Indian Subcontinent. The date for the entire palaeolithic span ranges from 600,000 BP (lower palaeolithic) in the Potwar Plataeu of Pakistan to 9000 BP (the upper palaeolithic) in the Belan Valley in Uttar Pradesh. Important Lower Palaeolithic sequences have been uncovered in Didwana Lake area of Rajasthan, Hiran Valley of Gujarat, Son Valley in Madhya Pradesh and Narmada Valley in Maharashtra.

For Middle Palaeolithic the review by Settar and Korisettar (ICHR Series on Indian Archaeology, 2002) is quite explicit: 'Until the mid-fifties the stratigraphic as well as the typological criteria for the Middle Palaeolithic in South India were not developed. Beginning with the work of

Sankalia in the Pravara Valley, a large number of Middle Palaeolithic sites have been brought to light. Among the most conspicuous early stratified sites, the following deserve notice: Nandsur-Madhmeshwar, Nevasa and Wainganga alluvial sequence in Maharashtra; Mandasor and Bhedaghat in Madhya Pradesh and in the Luni Valley in Rajasthan'. Recently, a Middle Palaeolithic section was discovered in the Yamuna Valley. Known as the Kalpi Section, the finding proves that the Gangetic Plain was occupied in Stone Age times. Middle palaeolithic sites have also been found in the Kurnool area of Andhra Pradesh, Belan Valley of Uttar Pradesh and the Chalisgaon area of Maharashtra.

The Upper Palaeolithic sequences were often followed by the Middle Palaeolithic occupation. Some of the important areas of Upper Palaeolithic culture in India are Belan Valley in Uttar Pradesh, Kurnool Caves in Andhra Pradesh, Son Valley in Madhya Pradesh and the Didwana Lake area in Rajasthan.

2.5.b Mesolithic sites.

The Palaeolithic Period was followed by the Mesolithic Period. The Mesolithic lifestyle, based on hunting and gathering ways of the palaeolithic period, had begun to orient towards sedentism. One of the earliest Mesolithic sites to be investigated in India was Langhanj in Gujarat in the late forties. Prof. Z.E. Zuener, an eminent prehistorian from UK, was invited by the Archaeological Survey of India to construct a geological based sequence for Langhanj and other sites in western India. Archaeologists from the Allahabad University discovered a number of Mesolithic sites on banks of derelict ox-bow lakes formed by the meander of the river Ganga. The important sites are Sarai Nahar Rai and Mahagara. The Mesolithic people, living on fishing and foraging on the banks of the lakes had migrated from the rocky Vindhyan ranges where they have been related to Epi-Palaeolithic settlements. The Mesolithic site of Bagor in Southern Rajasthan, discovered by V.N Mishra and excavated by him, is the largest prehistoric settlement in Rajasthan. Other Mesolithic occupations are near the river Narmada in Hoshangabad (Madya Pradesh), Adamgarh in Madhya Pradesh and Paisna in Bihar. The Mesolithic occupation in the caves of Bhimbetka in Madhya Pradesh occurs in association with world famous rock art.

2.5.c Neolithic Cultures

The first evidence for beginnings of agriculture came from West Asia where a number of Neolithic sites were discovered in Israel, Syria and Turkey. In his book, *The Archaeology of India*, D.P.Agrawal gives a summary of the major Neolithic sites in West Asia: 'Cayonu (North Syria) excavations show agriculture based on domestic emmer, wheat, einkorn, peas, lentils, and bitter vetch in c. 7000 BC. In the Levant, at Jericho, the pre-pottery Neolithic culture (c.8350 - 7350 BC)

produced two-row hulled barley and emmer wheat. In the Zagros region, Tepe Guran (c. 6000 BC) has yielded two-row hulled barley. Catal Huyuk, in Anatolia (Turkey) has produced a variety of cereals: domestic emmer, einkorn, bread wheat, six-row naked barley from c.6000 BC contexts. In Mesopotamia, from the Khuzistan plains, Tepe Sabz culture (5000 BC) also yielded evidence of early agriculture. Nearer home, in Iran from Tal-I-Iblis (Kerman) were discovered bread wheat and emmer from Early Ubaid horizons'.

In the Indian subcontinent, the beginnings of Neolithic phase has been different in time and space. The site of Mehrgarh on banks of the Bolan river in the Kacchi Plain of Baluchistan has yielded evidence for aceramic Neolithic going back to 7000 BC. The Mehrgarh Neolithic is based on cultivation of barley and wheat and domestication of cattle, goat and sheep. Mehrgarh shows the earliest occurrence of domestication of crops in the Subcontinent. The Mehrgarh evidence is comparable with the dates obtained from the early West Asian Neolithic sites. Another independent centre of cultivation, the Middle Ganga valley, saw the beginning of rice cultivation in India. The evidence of rice cultivation noticed at the site of Koldihawa near Allahabad. The evidence for early rice at Koldihawa is pegged at 5000 BC. The site of Kunjhun III in the Vindhyas have also yielded evidence for rice cultivation around 3500 BC. The excavations at Kunjhun River Face in the Son valley has also yielded evidence of the Vindhyan Neolithic. The other Neolithic sites in Eastern India are Chirand (Bihar), Kuchai (Orissa) and Golbai Sasan (Orissa). In South India the Neolithic settlements have been excavated at Kodekal, Utnur, Nagarjunakonda in Andhra Pradesh, Tekkalakota, Maski, Sangankallu, Hallur and Brahmagiri in Karnataka and Payampalli in Tamil Nadu. The Southern Neolithic Phase is bracketed between 2500 BC to 1000 BC. In the northern part of the subcontinent, the Kashmir Neolithic is represented by the sites of Burzahom and Gufkral. The time span of the Kashmir Neolithic culture is 2400 - 1500 BC.

2.5.d Proto History

The protohistoric period is alludes to societies which have achieved a reasonable level of material culture but are not yet literate. In other words, a protohistoric society is much advanced than Stone Age societies but is yet to have the classical character of the Iron Age. The first interpretation of data from prehistory and protohistory was by Stuart Piggott in Prehistoric India (1950). In India, the protohistoric record is reflected in the various copper using cultures which flourished in central parts of the country. These are the Chalcolithic societies marked by pastoral life. In fact, the Chalcolithic people were the early farmers of the Indian subcontinent and they introduced the quitessential village life which continues today. The Chacolithic period in India is bracketed between 3000 - 1000 BC. Below are listed the main Chalcolithic cultures in India, including chronology, area where these flourished. The cultures are named after the type-sites :-

Ganeshwar-Jodhpura Complex : 3000 - 2300 BC (Rajasthan): This culture flourished in Northeastern Rajasthan. The Ganeshwar-Jodhpura complex has yielded copius amounts of copper, leading to the hypothesis that it was a primary source area for supply of copper for the Bronze industries of the Harappans.

Savalda Culture: 2500 BC (Maharashtra and Gujarat) The Savalda Culture flourished along the Tapi river Valley running through parts of Maharashtra and Gujarat. The Savalda Culture was contemporaneous with the Harappan Civilization. The main Savalda Culture sites are Kaothe and Daimabad.

Kayatha Culture: 2500 - 2000 BC (Madhya Pradesh): This copper-using culture was discovered by V.S. Wakankar in 1965 in the narrow alluvial valley of Kayatha on the banks of the river Kalisindh, an affluent of the river Chambal. The Kayatha Culture is characterized by a sturdy Brown Slipped Ware, the Buff Painted Red Ware and the Combed Ware. Around 40 Kayatha Culture sites have been discovered in the Chambal Valley. The discovery of copper bangles, beads of agate and steatite indicates that the Kayathans were in contact with the Harappans. The type-site of Kayatha is the only one to be excavated so far.

Banas Culture, 2000 - 1400 BC (Madhya Pradesh): The Banas Culture flourished on the banks of the Banas river in south-east Rajasthan. The Banas Culture was concentrated in the Udaipur area. Here, within the precincts of the Udaipur city are the excavated remains of Ahar, the major Banas Culture site. Ahar was prospected by H.D. Sankalia and his associates in the sixties. Therefore the Banas Culture is also known as the Ahar Culture. Recently, another Ahar Culture site, that of Balathal was excavated by the Deccan College for seven seasons from 1994 through 2001. The excavations at Balathal yielded a rough stone fortification. The distinctive pottery of the Banas Culture is a black-and-red ware painted in white on the exterior. The Red Slipped Ware is also a common ware of the Ahar Culture.

Malwa Culture: 2000 - 1700 BC (Malwa plateau, Madhya Pradesh): The Malwa Culture which succeeded the Banas and the Kayatha Cultures, arose in western part of Madhya Pradesh. The well known sites of the Malwa Culture are Eran, Nagda and Navdatoli in Madhya Pradesh and Inamgaon in Maharashtra. Navdatoli is considered to be the type-site of the Kayatha Culture. Charred bits of rice, barley and wheat have been found at Navdatoli. The people lived in circular huts having split-bamboo screens. The Malwa Ware is distinctive. It is painted in brown with buff or orange slip.

Jorwe Culture: 1000 BC (Maharashtra): The Jorwe Culture was spread over most of Maharashtra. The type-site for the Jorwe Culture is Inamgaon. Inamgaon was excavated by the Deccan College. Here, horizontal excavations revealed a chieftains hut and also outlying seasonal agricultural

encampments at the sattelite site of Walki. The Jorwe Ware has a unique shape. It is a spouted jar with a flaring mouth and has a red matt surface painted with black designs.

2.5.e The First Urbanization / Harappan Civilization

The Indus Valley civilization falls, chronologically, in the Indian protohistoric period. However, in all its aspects the Harappan Civilization was a classic entity. It had monumental architecture in its cities (the granary at Harappa and the Great Bath at Mohenjodaro), exquisite crafts, a developed script, seals etc. The Harappan Civilization heralded the First Urbanization in the Indian Subcontinent. There are five major cities of the Harappan Civilization. These are located in five zones of the large civilizational area extending from Baluchistan to Delhi and northern Afghanistan to the Arabian Sea. The major Harappan cities are Mohenjodaro in Sind Province (Pakistan), Harappa in Punjab Province of Pakistan, Ganweriwala in the Bahawalpur area of Pakistan, Rakhigarhi in Haryana State (India) and Dholavira in Gujarat State (India). (Figure No. 01)

Except for Ganweriwala, all other major Indus sites have been subjected to excavations. The discovery of the Indus Valley Civilization took place in the twenties, in the period of John Marshall, the Director-General of the Archaeological Survey of India. Marshall's excavation of Mohenjodaro are still considered relevant. The excavations at Harappa by D.R. Sahni were followed by Wheeler in the forties and published in Ancient India, the journal of the Survey. Sir Mortimer Wheeler excavated Mohenjodaro in the fifties when he was the Director of the Archaeological Survey of Pakistan. Thereafter Mohenjodaro was excavated by a German-Italian mission. The excavations at Harappa by American archaeologists is going on. The archaeology of the Indus Civilization or the Harappan Civilization as the popular term in circulation, is a major component of research. From the days of Marshall, the archaeological interest in the Harappan Civilization remains unabated.

The growth and decline of the Harappa Civilization is divided into the Early, Mature and the Late Phases. The categories of 'pre-Harappan' and 'Early Harappan' are often confused. The former relates to material cultures which occur before the appearance of Harappan traits like pottery, script, seals, crafts etc. The Early Harappan cultures are those which exhibit the beginnings of features which flower in the Mature Harappan phase. The sites associated with Early Harappan cultures are Kot Diji (Sind), Kalibangan Phase I (Rajasthan), the Hakra Ware sites (Bahawalpur, Pakistan) and Kunal (Haryana, India). The Mature Harappan sites, the major ones are Mohenjodaro, Harappa, Dholavira, Rakhigari, Lothal etc. Interestingly, many of the Mature Harappan sites display the Early Harappan features in their early levels; the particular cases of Harappa and Dholavira are well known. The Late Harappan phase is associated with de-urbanization of the Harappan Civilization. We know that many of the Harappans migrated towards the Ganga Valley and settled mostly in the Upper Ganga Valley. Here, the major Late Harappan sites are Ambakheri, Bargaon, Hulas and


SITES WITH MATURE AND/OR LATE HARAPPAN REMAINS
AFGHANISTAN
Shortughai
PAKISTAN
INDIA
ARABIAN SEA
Manda
Jhelum
Chenab
Gumla
Pirlano Ghundai
INDUS
LAHORE
Ravi
Harappa
Sutlej
Ropar
Bara Chandigarh
Jallipur
Hulas
Balu
Bhagwanpura
Banawali
Dabar Kot
Kudwala
Lurewala
Ghaggar
Naushero
Judeiro Daro
Siswal
DELHI
Rakhigarhi
Kalibangan
Mitathal
Alamgirpur
Ganweriwala
Yamuna
Jhukar
Mohenjo Daro
Kot Diji
Ghazi Shah
Amri
Chanhu Daro
Sutkagan Dor
Sotka Koh
Bala Kot
Allahdino
KARACHI
Gharo Bhiro
Dholavira
Desalpur
Surkotada
Sabarmati
Kuntasi
Lothal
Ranpur
Nageshwar
Mahi
Narmada
Rojdi
Prabhas Patan
Padri
Tapi
Bhagatrav
Daimabad
Godavari
BOMBAY
0
200
400KM

Figure No. 01

Alamgirpur. These sites are located in western Uttar Pradesh. The Late Harappan sites show corrupted forms of the once classic Indus wares and the remnants of the script. Most of the early, mature and late Harappan sites in India have been excavated by the Archaeological Survey of India, the Deccan College and the MS University of Baroda.

2.5.f Second Urbanization / Historical Archaeology

The decline of the Harappa Civilization triggered a long phase of deurbanization which lasted nearly a millennium. From about 1500 BC to 800 BC there was hardly any city life in the Indo-Gangetic region. We find the existence of Chalcolithic communities and Late Harappan settlements subsisting on an agricultural base.

The advent of the Iron Age in the Ganga Valley in early 1st millennium BC saw the re-emergence of cities. These were in the form of city-states called mahajanapadas. Some of the important early Iron Age polites were Magadha, Kuru-Panchala, Vatsa and Avanti. The archaeological remains of their ancient capitals have been discovered. The sprawling site of Kausambi on the banks of the river Yamuna some 60 km from Allahabad was the capital of Vatsa janapada. Kausambi was excavated by Prof. G.R. Sharma of the Allahabad University in several field seasons from 1949 - 67. Likewise Pataliputra (ancient Patna) was the capital of Magadha. The Iron Age remains of Ujjain, the capital of Avanti mahajanapada have been found in western India. Most of these settlements were fortified and surrounded by deep moats. In cases, where there was no moats, the rivers formed a defensive water body.

The rise of urbanism in the Ganga Valley in the 1st millennium BC is known as the Second Urbanization. The distinctive pottery of the early Iron Age settlements in the Upper Ganga Valley is the Painted Grey Ware. In the Middle Ganga Valley, that is the region of eastern Uttar Pradesh and Bihar, the main Iron Age pottery is the Northern Black Polished Ware (NBPW). A number of high profile studies of the Second Urbanization have been carried out. B.B. Lal initiated the Archaeology of the Ramayana and Mahabharata Project in the seventies. Under this project, Prof. Lal tried to establish the antiquity of the Mahabharata and Ramayana epics. He excavated sites near place-names occurring in the Epics like Hastinapur, Ayodhya, Sringverpur and Bharadwaj Ashram. Interestingly, Prof. Lal found that sites associated with the Mahabharata have a greater antiquity than the sites associated with the Ramayana. Prof. Lal's findings go against the grain of the historical tradition which places the Ramayana chronologically before the Mahabharata.

In southern India, the Iron Age commenced after the Neolithic period. The intervening Chalcolithic phase was weak or non-existent. The Neolithic-Iron Age transition in the deep south of India, encompassing the states of Tamil Nadu, Kerala and Karnataka, took place around 1000 BC.

These transitions are indicated at the sites of Payampalli (Tamil Nadu) and Hallur (Karnataka). The Iron Age in south India is associated with two cultures: firstly the urban formations on the lines of northern India and secondly the emergence of the Megalithic Culture. The latter is represented by various grave types in the form of dolmens, cairns, barrow graves etc. The artifacts associated with the Megalithic Culture include iron implements in copious quantities. The Megalithic Culture flourished from mid 1st millennium to the early centuries AD. The Megalithic people lived side by side with the urban townships of southern India which also emerged in mid 1st millennium BC. The urban towns of south India were similar to those in the northern part of the country in terms of the use of the Brahmi script, coin types, potteries, beads etc. Some of the important Early Historic (urban) sites in south India are Kaveripattinam, Uraiyur and Alagankulam in Tamil Nadu; Chandravalli, Banavasi and Brahmagiri in Karnataka; Kodungallur in Kerala and Amaravati, Nagarjunikonda, Satanikota and Kudavelli in Andhra Pradesh. The major Megalithic sites in south India are Watgal (Karnataka), Adichallanur (Tamil Nadu) and Sotoukenny (Tamil Nadu).

2.6 Growth of Archaeological Sub-Disciplines in India

2.6.a Carbon Dating

From the mid-20th century we find archaeology taking on a multi-disciplinary character. The linkages with the natural sciences brought in revolutionary changes, the most important of these being the new absolute dating techniques. In 1948, Williard F. Libby of the University of Chicago developed the carbon dating technique. Coinciding with the centenary of the Archaeological Survey of India, a radiocarbon dating laboratory was set up at the Tata Institute of Fundamental Research in Mumbai. This was a trendsetting event. The TIFR Laboratory followed by the one installed at the Physical Research Laboratory at Ahmedabad provided scores of radiocarbon dates to samples excavated in Indian sites and also abroad. The pioneer of radiocarbon dating in India is Prof. D.P. Agrawal, who co-ordinated the archaeological carbon dating facilities at TIFR as well as at PRL. The radiocarbon dates from TIFR and PRL have been published in a number of international journals, including Radiocarbon.

2.6.b Geoarchaeology

The geoarchaeological investigations have focused on geochronology, geomorphology and recording of soil structures. In particular, geochronology involves the dating of reimposed features of the geological record through absolute dating methods like potassium-argon, uranium-thorium. S.N. Rajguru of the Deccan College has conducted extensive geoarchaeological studies on the palaeolithic contexts across India and also on sea level changes and coastal cultures. The Palaeoclimate Research Group in the Physical Research Laboratory, Ahmedabad under the direction of D.P. Agrawal

undertook geoarchaeological and palaeoclimatic investigations in Rajasthan and Kashmir. In the seventies a multidisciplinary program initiated by the Allahabad University under G.R. Sharma conducted thorough survey of the Middle Ganga region, in particular the recording of fossil rich river terraces in the Belan and Son Valley.

2.6.c Archaeobotany

The interest in botanical remains from archaeological sites was evident in the reports published in Ancient India. Just after Indepenedence, the officers from the Forest Research Institute at Dehradun studied wood and plant remains and these were reported. The towering figure in Indian archaeobotany in India was Vishnu-Mittre of the Birbal Sahni Institute of Palaeobotany at Lucknow. He began to study plant and seeds from the Chalcolithic site of Navdatoli and from Inamgaon. Vishnu-Mittre also started a palynological program in Kashmir. He was the first to attempt a synthesis of archaeobotanical data to provide perspectives to spread of agriculture in the subcontinent. After Vishnu-Mittre there was great emphasis on processual techniques to understand subsistence patterns. The flotation technique was used to recover seeds, plant remains and cereals from the soil of archaeologically defined layers. M.D. Kajale of Deccan College used this technique to good effect at Inamgaon. Flotation led to a greater identification of plant species at particular sites. There was created an opportunity to build complex pictures of resource use in ancient settlements. For instance, excavations at the Sorath Harappan settlement of Rojdi in Saurashtra have shown that the agricultural settlement doubled in size and that Rojdi grew millet varieties which had originated in Africa. The recent review of archaeobotanical studies in India by Dorian Fuller titled Fifty Years of Archaeobotanical Studies in India (2001) places the studies in time perspective. A major theme of archaeobotany has been the dispersal of botanical cultivation across large territories. The issue of the dispersal of millet cultivars from native areas in Africa to western part of the Indian subcontinent has been intensively discussed. The recent scenario presented by the American archaeobotanist Steven Weber is that millets transmitted to India in a phased time scale. Likewise, it has been argued that certain crops such as the foxtail millet and betel nut were introduced to India from Southeast Asia at some point in antiquity.

2.6.d Archaeozoology

The development of archaeozoology in India started with the publication of the first faunal reports prepared by Sewell on Mohenjodaro. Bhola Nath of the Zoological Survey of India worked intensively on the bones from Harappan and other sites. P.K. Thomas, P.P. Joglekar, G.L. Badam established archaeozoological studies in the Deccan College. U.C. Chattopadhyaya contributed as faunal analyst in the Allahabad University expeditions in the Middle Ganga Valley. Chattopadhaya not only conducted taxonomic studies but initiated a more dynamic approach focused upon seasonality

of site occupation, hunter-gatherer subsistence, site functions and pastoralism. Richard Meadows of Harvard University has earned a name for himself in the faunal analysis of e Indus Valley material.

2.6.e Ethno Archaeology

Ethnoarchaeological research rose through two impulses in India. The first was the induction of anthropologists into archaeology. The second impulse was the influence of New Archaeology which emphasized ethnoarchaeology or the present material cultural record to understand the past in dynamic terms. Several themes for ethnoarchaeological research have been taken up in India. Daniel Stiles has studied the forest tribes for their contribution as suppliers of exotic commodities to international trade networks in the Iron Age. Sunil Gupta has tried to prove that folk tales of the Kadar jungle tribe of the Malabars allude to arrival of Roman traders in early centuries AD seeking exotic herbs and medicinal plants. Alok Kanungo of the Deccan College has studied modern glass beadmaking in order to understand the beads from the archaeological record. A major ethnoarchaeological work on carnelian beadmaking was conducted by K.K. Bhan of the MS University of Baroda in the crafting area of Khambhat in Gujarat. Investigations of the catchment area of a site for pottery making, metal crafting, boat making is now a regular part in most field programs in India. Recently, there has been a strong interest in study of traditional watercraft. Two major ethnoarchaeological projects on traditional watercrafts in South Asia are currently being implemented; one by the University Grants Commission of India and the other by the South Asia Society (UK) under its 'Boats of South Asia' Project. A major edited volume on ethnoarchaeological research in India is Living Traditions: Studies in the Ethnoarchaeology of South Asia (1994) edited by Bridget Allchin.

2.6.f Marine Archaeology

Marine Archaeology is concerned with recording and excavating ancient artifacts, structures and sites under water. In India, the father of Marine Archaeology is Dr. S.R. Rao, the archaeologist who discovered and excavated the Harappan port of Lothal. In 1981, Dr. Rao launched the Dwarka Project. His was an attempt to discover the antiquity of the ancient city of Dwarka, the capital of the God-King Krishna, which the Mahabharata speaks of having been drowned in the sea. Dr. Rao formed the Marine Archaeology Unit of the National Institute of Oceanography in Goa. The Unit has now become a full-fledged Centre for Marine Archaeology. The Centre has initiated several off shore expeditions to Vijaydurg, Poompuhar, Goa and Lakshadweep.

2.7 Archaeology in post-independent India

The archaeology of post-independence India began with the search for sites of the Harappan civilization. In the words of Dr. S.R. Rao, who discovered the Indus harbour of Lothal in Gujarat:

'As a sequel to the political bifurcation of the subcontinent in 1947 and the consequent transfer of all the sites of the Indus Valley Civilization to the newly created State of Pakistan, the Archaeological Survey of India found it necessary to launch a program of exploration of the regions south and east of the Indus River for tracing Harappan sites, if any, within the present day borders of India.., The Sabarmati valley was, therefore, selected by the author for village-to-village survey and the result was the discovery of Lothal in November 1954. Further surveys of the peninsulas of Saurashtra and Kutch and the mainland of Gujarat from 1954-58 brought to light more than 50 sites representing different phases of the Harappa Civilization and thereby added a new province to the Indus Empire'. Since Independence a good number of Harappan sites have been excavated in India and Pakistan. In the fifties, the focus was upon discovering Harappan sites within Indian territory. This drive saw the excavations at the Indus port of Lothal by S.R. Rao and the settlement of Kalibangan by B.B. Lal and B.K. Thapar in western Rajasthan. J.P. Joshi launched intensive explorations in Kutch and excavated the fortified Harappan settlement of Surkotada. The advent of New Archaeology inspired archaeologists from the Deccan College and MS University Baroda to search for and excavate Harappan settlements in Gujarat. There was an emphasis on horizontal excavations in order to understand site formation processes, site function, craft specialization etc. The Harappan sites in Gujarat are strongly influenced by the local Chalcolithic Cultures which existed from before the Harappans came there. The American archaeologist Gregory Possehl gave the term 'Sorath Harappan' to explain the sites in Gujarat. The important sites excavated in Gujarat from the processual perspective were the port of Kuntasi near the Gulf of Kutch, Prabhas Patan, Padri ,Nageshwar and Bagasra. In recent times, the Archaeological Survey of India has renewed its interest in excavation of Harappan settlements. In 1989-90, the ASI began the excavations at Dholavira, a large fortified Harappan settlement in the middle of the Rann of Kutch. Dholavira is being excavated by the ASI under the direction of R.S. Bisht. Dholavira is situated on an arid 'island' in the Rann of Kutch. The settlement was fortified right from its inception. Divided into three parts: the upper town, the middle town and the lower town. There is a large open area, evidently for public meetings, just below the walls of the upper town. Dholavira was facilitated by a ingenious water harvesting system based on storm drains and a central reservoir. Another large Harappan site recently excavated in India is Rakhigrahi in the Haryana state. Rakhigarhi is being excavated under the direction of Amarendra Nath.

The School of Archaeology came into being in the sixties under the Colombo Plan. The Indian Schoolof Archaeology was to discharge training to a small number of students and prepare the, for service in the ASI. The name was later changed to the Institute of Archaeology.

2.8 University Departments

The Archaeological Survey was not the only agency to undertake archaeological field work after Independence. The growth of the University system played a major role. Other centres in the university system which came up in the fifties and sixties are the MS University of Baroda, University of Allahabad, Calcutta University and the University of Madras. All these centres initiated pioneering field projects. The Deccan College in Pune became one of the centers of excellence of archaeological research outside the Survey. Prof. H.D. Sankalia reinvigorated this institution. The Deccan College was instrumental in unearthing the Chalcolithic cultures of western India. The Chalcolithic culture was characterized by the use of copper and an agricultural way of life. The Chalcolithic people were the first farmers of the Indian subcontinent. The Deccan College fieldwworkers under the guidance of H.D. Sankalia unearthed a number of Chalcolithic cultures: the Ahar Culture near Udaipur in southern Rajasthan, the Malwa Culture and the Kayatha Culture in Central India and the Jorwe Culture in Maharashtra. Sankalia and his team also excavated important Early Historic sites like Brahmapuri, Nasik and Nevasa. These sites yielded evidence of trade between the Roman Empire and India during the 1st-2nd century AD. Like Wheeler, Sankalia created a new generation of archaeologists in the Deccan College.

The rise of the various centres of archaeology in many universities and the taking up of indepenedent projects by these universities. University of Allahabad conducted excavations at Kausambi from 1949 till about 1967. Directed by GR Shrama of the Allahabad University department, Kausambi was a long excavation. Finally four areas were excavated in huge site measuring 6.5 sq km, surrounded on three sides by mud bastions and the Yamuna river forms the fourth boundary. The Kausambi excavations established the antiquity of the Early Iron Age urban centers of northern India which went back to 1000 BC. The Allahabad University also undertook seminal investigations into the prehistory and the palaeoclimate of the Middle Ganga Valley. Excavations at Koldihawa brought to light evidence of early rice cultivation around 5000 BC. Below are some of the main university departments of archaeology and the name of the major sites excavated by these departments:

(1) Deccan College: Bagor, Bhimbetka (Mesolithic) ; Padri, Prabhas Patan, Kuntasi (Harappan) ; Inamgaon, Jorwe, Ahar, Kayatha (Chacolithic); Brahmapuri, Nevasa, Nasik (Early Historic).

(2) MS University, Baroda: Nageshwar, Bagasra (Harappan); Maheshwar, Baroda, Nagara, Dhatva (Early Historic).

(3) Calcutta University: Chandraketugarh, Tamralipti, Pandu Rajar Dhibi,

(4) Madras University: Kaveripattinam, Uraiyur, Arikamedu

(5) Patna University: Champa, Vikramshila

(6) Banaras Hindu University: Narhan, Rajghat, Aguabir.

2.9 State Departments

Then there is the emergence of the State Departments of Archaeology. These have been established in almost every state but all of them do not play the same active role. The Tamil Nadu State department has been involved in excavations of important port-sites like Alagankulam. In Uttar Pradesh, the State department of Archaeology has conducted explorations throughout the State and recorded in particular valuable rock art in Mirzapur, Allahabad and Banda districts. The department of archaeology in Kerala has of recent done pioneering excavation of watercraft in the Allepey backwater region. The department is also formulating a project to discover the ancient port of Muziris near Kodungallur. Muziris is mentioned in ancient Greek texts like the Periplus as a principal port of trade with the Roman Empire in the early centuries AD. We may aso mention some of the old archaeological for a like the Indian Archaeological Society, New Delhi; the Indian Society for Prehistoric and Quaternary Studies, Pune; the Centre for Training and Research in Archaeology, Kolkata; the Indian Rock Art Society, Agra; Indian Society for Greek and Roman Studies, Bareilly. Important journals of Indian Archaeology are the *journal of the Archaeological Survey of India, Ancient India* and *Indian Archaeology - A Review*. The Indian Archaeological Society publishes its annual journal *Purattatva*. The Indian Society for Prehistoric and Quaternary Studies brings out its journal *Man & Environment* bi-annually. The UP State Department of Archaeology brings out a journal called *Pragdhara*. The West Bengal State Department of Archaeology brings out the bulletin *Samiksha*. The Madhya Pradesh Archaeology Department publishes the journal *Puratan*.

2.10 Summary -

The history of archaeology should be traced to the beginning of the love of antiquities. The main land marks in the growth of this discipline can be traced with the establishment of society of antiquaries in London and that of the Asiatic society of India.

The establishment of archaeological survey of India and the excavation of various archaeological sites has helped in the reconstruction of pre and proto history of India.

The development of various archaeological disciplines like geoarchaeology archaeozoology, ethno archaeology and marine archaeology and the various techniques like carbon dating have established new land marks in the study of archaeology in India.

The establishment of various university departments and state departments have contributed a lot in the development of archaeology in India.

2.11. Check your progress

Q. I. Write a critical note on the history of the development of archaeology in India.

Q. II. Write short notes on -

a) Archaeological Survey of India.

b) Carbon Dating

c) The palaeolithic cultures in India.

d) Neolithic cultures of India.

e) Archaeobotany

f) Geoarchaeology

g) Ethnoarchaeology

h) Contributions of university departments to archaeology.

Q.III Write a critical note on archaeology in post independent India.

2.12. Self activity -

a. Visit any university department which conducts the course on archaeology and write a report of its various activities.

b. Visit the archaeological survey of India (Bhopal Circle) and write a note (a) On its organisation (b) on its functions.

2.13. Suggested Readings –

1. Atkinson RJC – *Field Archaeology*, London 1953
2. Pande J.N. – *Puratattva Vimarsh*, Allahabad.
3. Rajan K. – *Archaeology : Principles and Methods*. Manoo Pathippakam Thanjavur 2002

UNIT – III
NEW TRENDS IN ARCHAEOLOGY

3.1 Introduction to Modern Trends in Archaeology

Archaeology is not just about fieldwork and documentation. As an evolved discipline positioned between the social and the earth sciences, archaeology is driven by theoretical impulses. At every point of archaeological research, there are choices to be made. These choices concern selection of research themes, the conceptual orientation towards the chosen research themes and the adoption of appropriate research methodologies and techniques. In fact, these theoretical considerations influence the field operations. Ideally an archaeologist formulates an excavation project or a field survey on the basis of a broader framework of research.

In the first half of the 20th century archaeological research focused on classification, typology and documentation. The approach was event oriented and static. The meanings were inherent in the nature of the evidence and the excavation reports were considered to be conclusive. This was the time of discoveries of the first farming cultures based upon wheat cultivation. Kathleen Kenyon

excavated the neolithic site of Jericho, Robert Braidwood worked at Jarmo and James Mellaart dug evidence for early cultivation of food crops at Catal Huyuk in Anatolia. At the same time the excavations of the great Bronze Age civilizations of Egypt, Mesopotamia and the Indus continued. To all these rich material records the Australian archaeologist Gordon Childe (1892-1957) gave meaning. Childe used the term 'The Neolithic Revolution' to describe humankind's shift from hunting/ gathering lifestyle to a sedentary existence based upon cultivation of food crops and domestication of animals. Childe then elaborated his idea of agricultural surplus and the rise of urbanism. The ten criteria presented by Childe for defining civilization are (1) Increased Settlement Size and Population (2) Presence of Non-Food Producing Population (3) Divine Kingship and Taxation System (4) Monumental Buildings (5) Existence of an elaborate bureaucratic structure (6) Practice of writing (7) Development of Science (8) Flowering of Art (9) Long Distance Trade (10) Craft Specialization and social consolidation among craftsmen. The Childean idea of civilization was based upon the progression of neolithic beginnings, the creation of agricultural surplus, the rise of social classes as craft specialization took place and the rise of the early city. The ideas of Childe were all encompassing and influenced a whole generation of scholarship. Childe also postulated the theory of diffusion in which the crucial developments in European prehistory were influenced by the civilizations of the Near East / West Asia. Many of Childe's ideas were explicated in his works Man Makes Himself (1936) ;What Happened in History (1942); and The Urban Revolution (1950). In a way, the Childean discourse still goes on for new theoretical points of departure are often tested against his concepts. In Indian writings, Satyendra Kumar Jha's seminal work Beginnings of Urbanization in Early Historic India takes into account the Childe's ideas in the context of the Gangetic urbanization. Abroad, the Japanese archaeologist Yoshinori Yasuda in his recently edited volume Origins of Pottery and Agriculture postulates his theory of Eastern Civilization as a counterpoint to Childe's concepts.

3.2 New Archaeology

In the sixties there was a shift away from the Childean framework. Archaeologists in Europe and the USA began to search for new meaning in archaeology. They felt the need to break out of classificatory paradigm. The emphasis was on decribing process rather than events. This was the beginning of Processual Archaeology or New Archaeology. The new archaeologists aimed at explaining past temporal and spatial proceses in dynamics terms. Their's was an attempt to understand past cultural behaviour in relation to environment, population, technology, social organization and ideology. The interest was in use of scientific technique to precise the database and to build meaningful dynamic historical content. There was an attempt to infuse imagination into hard fact. One of the foremost theorists of New Archaeology was the American archaeologist Lewis Binford. His book, An Archaeological Perspective (1972) became popular reading in universities worldwide. Binford also visited India in 1988 on a lecture tour. Binford postulated the Middle Range Theory. It was the

notion that parameters must be created to give meaning to data and therefore the middling position between pure hypotheis and conclusion is to be achieved. To augment the endeavour to build up middle range theories, ethno-archaeology and experimental archaeology were initially utilized to provide models and hypotheses that could be tested either empirically or deductively. Binford used the technique of analogy to explicate the Middle Range Theory. According to Binford, all archaeologists offer possible links between statics and dynamics every time they put forward and interpretation of archaeological evidence. In practice archaeologists do this by making assumptions about the middle range, the space between the statics and dynamics. In the UK, New Archaeology concepts were enunciated by David Clarke and his students, notably Christopher Tilly and Ian Hodder. Clarke eninciated his ideas in his edited work Models in Archaeology (1972) and Analytical Archaeology (1978).

Mathew Johnson in his book Archaeological Theory, An Introduction. 2000. (Oxford: Blackwell) has presented the main principles upon which New Archaeology theory is based. These are:-

1. An emphasis on cultural evolution. The word 'evolution' has a series of different though related meaning stretching back to the work of Darwin in the nineteenth century. For some within New Archaeology, it meant in part that societies could be classified on a scale from simple to complex. Cultures in this view evolved from one state to another, for example from 'band' societies to 'tribal' networks to 'chiefdoms'.
2. An emphasis on systems thinking. Systems thinking allowed New Archaeologists to do two things. It firstly helped the stress on generalization. Different cultures may have different pottery styles and burial rites, but the underlying social system could be shown to have underlying similarities.
3. That culture was adaptive. The theoretical stress on the importance of the external environment led to interest in cultural materialism in which the material world is seen as more important than the mental world.
4. This theoretical attitude went hand in hand with the new scientific techniques that were developed in the postwar period: faunal analysis; carbon 14 dating, dendrochronology etc
5. Stress on the idea of culture process. New Archaeologists contrasted culture process to culture history. In the latter, traditional history described more or less random political events such as battles and births without ever explaining anything. By substituing process for history, the long term trends or processes beneath the surface of such events became the important objects of study.
6. Emphasis on problem orientation. The belief that one should survey and dig sites, or do research more generally, with clear research questions in mind.

The American approach to new archaeology was heavily influenced by anthropology. Site distributions were intergral to most research themes. The British archaeologists on the other hand drew from social theory and political economy to refine their concepts. In the field, these ideas mingled and led to fresh interpretations. Some of the basic techniques of processual archaeologists applied in the field were as follows:-

Locational Analysis: The axiom that sites are connected to each other through local exchange networks and the network is controlled by a one dominant site which is called the 'central place'. Gregory Johnson in his article Locational Analysis and the Investigation of Uruk Local Exchange Systems (1975) explicates the concept: 'Central places, or service centers, of the same functional size are equidistant from one another and when most efficiently located have a hexagonal distribution. Each center serves a surrounding, hexagonally shaped, complementary region. Smaller central places and associated complementary regions may be hierarchically nested within this system to form an intricate settlement lattice. The hexagonal distribution of central places allows immediately adjacent placement or packing of complementary regions such that no settlement remains unserviced and the average distance between a given central place and the edge of its complementary region is minimized'.

Site Catchment Analysis: The axiom that settlements are sustained by the surrounding resource areas. The resource area would typically constitute of water bodies (rivers, lakes) reachable from the settlements, fertile land for agriculture, grazing pastures, mineral yielding tracts etc. The resource area is basically the site catchment, an analogy drawn from the catchment area of a river. To get an idea of the resource area, an arbitrary circle can be drawn around the site or the potential resources within a day's walking distance of a site can be surveyed.

Site Hierarchy: Settlements are multi-scalar, differing between large cities, fortified settlements, townships and village units. Usually a large settlement, such as Mohenjodaro or Harappa, controls the smaller urban formations. Therefore a site hierarchy is established in functional terms in any given area. The large settlement is usually the Central Place in the local exchange networks.

The initiation of projects in West Asia by American and European archaeologists in the sixties and seventies opened up a new range of theoretical approaches. The challenges were on settlement patterns, resource use, trade mechanisms and state formation. Locational analysis was effectively applied to understanding of Bronze Age trade networks of the 3rd millennium BC in West Asia. In this respect the contribution of Gregory Johnson to elucidation of local networks in Uruk has been noted. A spate of studies on archaeology of Mesopotamia, Iran and the Persian Gulf and the Indus Civilization were inspired by the ideas of local exchange, urbanism, resource use and long distance trade. Philip Kohl made a sweeping review titled The Balance of Trade in Southwestern Asia in the Mid-Third Millennium B.C. (1978). C.C. Lamberg-Karlovsky excavated the proto-Elamite settlement of Tepe Yahya in the seventies and defined the production activities of the settlement in relation to

resource areas in highland Iran. Maurizio Tosi of Naples University excavated the site of Shahr - I - Sokta in Iranian Seistan and established linkages between the Indus and the Mesopotamian civilizational areas. He subsequentlly shifted his attention to Oman, where his excavations at the coastal site of Ras al Junayz yielded evidence of trade with the Harappans. Tosi began to develop a Bronze Age scenario of trade in the Indian Ocean rim. Contribution on this theme is also made by the Gregory Poesshl of the University of Pennsylvania. Possehl pointed out that certain artefacts may have been arriving in the Persian Gulf region from the east African coast. He cites the evidence of a copal pendant found at the site of Tell Asmar in the Gulf region. Preliminary studies indicate that this copal may have been sourced all the way from Maozambique. The broadening of archaeological horizons in the Indian Ocean arena characterizes recent approaches in world archaeology.

New Archaeology particularly experienced the impact of the social sciences. An interesting development was in the shift of concepts regarding the Indus Civilization. The old ideas of Harappan political-economy forwarded by Stuart Piggott (Prehistoric India, 1952) that the Indus territories were administered by formal hierarchy of kings and autocrats were challenged by those advocating a more broad based techno-cultural approach. For instance, Jim Shaffer (Harappan Culture, A Reconsideration) argues that 'a technologically advanced , urban, literate culture was achieved without the usually associated social organization based on hereditary elites, centralized political government (states, empires) and warfare'. In a critique of the Harappan polity debate, Jerome Jacobson (The Harappan Civilization: An Early State, 1986) reviews the contending positions on Harappan polity and introduces some new archaeology concepts. To quote: 'Which of these diametrically opposed interpretations more accurately reflects the nature of the political organization of the Harappan Civilization? Piggott's has been the traditional view, supported to some extent by Mortimer Wheeler (Early India and Pakistan, 1959) and still echoed by classroom texts and popular accounts. Shaffer's statement follows the precedent set by Fairservis almost a quarter century ago in challenging the earlier interpretations of Harappan society. Neither position, however, has involved examination of the range of archaeological evidence in the context of current anthropological theory in political organization. By political organization is here meant the arrangement of elements of a cultural system relating to, among other things, the exercise of power, group leadership, decision making, social control of behaviour and relations with other groups'. Among the Indian scholars, D.P. Agrawal has proposed that instead of a Harappan Empire controlled by the twin capitals of Mohenjodaro and Harappa, there were as many as five zonal 'capitals' (Harappa, Mohenjodaro, Ganweriwala, Dholavira and Rakhigarhi) controlling the far flung regions of the civilization. Shereen Ratnagar in her book Understanding Harappa (2001) speakes of the amazing standardization achieved in material culture and suggests that such techno-cultural basis over a large area could not be achieved

without some kind of political consolidation. S.P. Gupta in Indus-Saraswati Civilization (2000) has argued more for a cultural consolidation brought about by intense domestic trading networks. Gupta has defined two nuclei of the Harappan Civilization and stressed on the fact that the Vedic Saraswati, identified as the Ghaggar-Hakra seasonal beds in western India, had more Harappan sites on its banks than the Indus. The synonymity of the Harappans with the Vedic people has been the subject of the work by Bhagwan Singh called The Vedic Harappans.

Apart from civilizational perspectives, the New Archaeology also laid emphasis on studies of ancient trade. The British archaeologist Colin Renfrew has made a seminal contribution in this area. In his article Trade as Action at a Distance: Questions of Integration and Communication (1975) Renfrew considers the question of tradition and values in studies of archaeology of trade. He says that 'contemporary archaeology is faced with the problem of "getting inside" early exchange systems in the sense of understanding something of the value systems upon which they are based.' At the heart of 'structure of exchange' were the goods of trade. From a certain perspective, the commodities in circulation symbolise the basic proclivities around which any long distance trade activity revolved. This perspective is well articulated by William Schaffer who says, 'cultural determinants as to which objects are to be traded record, in a sense, the social values attached to given items.' Therefore goods of trade enter into circulation by 'selection' from a larger material corpus. This selection is determined by enduring dispositions and tastes, i.e., elements of culture. Once in circulation, the goods of trade are drawn into the dynamic of supply and demand, thus transiting from the cultural realm to the economic. The fact that disparate processes do coalesce into tangible techno-cultural traditions, contributing to the rise of sophisticated societies and polities, suggests that the attempt at archaeo-historical construction of trade in ancient socities is essentially 'civilizational' in its scholastic scope. We can perceive the the past - if not in completeness of the Childean criteria for 'civilisation' - then surely in terms of 'civilization processes'; an intensifying exchange of ideas, goods and technologies. Colin Renfrew, in his introduction to The Encyclopaedia of Ancient Civilizations points to the significance of such developments which lead to floruits: 'we seek, by comparison and generalization, insight into the more general processes which underlie the formation of civilisation. While few definative conclusions can yet be claimed, there is near unanimity that the task is worthwhile and important ...'. Viable theoretical models can only emerge through the adoption of what the English archaeologist and theoritician Ian Hodder calls the 'community of discourses model', a pluralistic regimen where syncretism of concepts, methodologies and data become possible. A seminal contribution to the concept of trade and civilization is the edited work by J.A. Sabloff and C.C. Lamberg-Karlovsky titled Ancient Civilization and Trade (1975). This book has articles by some of the best thinkers of Processual Archaeology like Karl Polyani (Traders and Trade), K.C. Chang (Ancient Trade as Economics or Ecology), Paul Wheatley (From Reciprocity to Redistribution in

Ancient Southeast Asia) and C.C. Lamberg-Karlovsky (Third Millennium Modes of Exchange and Modes of Production).

In India, the ideas of New Archaeology were first adopted by the well known archaeologist H.D. Sankalia who authored the book The New Archaeology: Its Scope and Application in India (1977). In the late seventies, the Deccan College archaeologists excavated the Chalcolithic site of Inamgaon in Maharashtra. The site was excavated according to New Archaeology principles; the deposit was horizontally exposed and documented in terms of settlement layout, craft specialization, subsistence strategies etc. In the Hungsi Valley in Karnataka, K. Padayya excavated neolithic sites and tested the results with ethnoarchaeological data. Padayya has made a seminal contribution to New Archaeology in India through his fieldwork and writings. The following titles by Padayya are basic to understanding Proccesual Archaeology in the Indian context: The Acheulian Culture of the Hunsgi Valley (Peninsula India): A Settlement System Perspective (1982); New Archaeology and Aftermath: A View from Outside the Anglo-American World (1990); A Review of Theoretical Perspectives in Indian Archaeology (2001).

However, Indian Archaeology has had its own momentum and the New Archaeology ideas formed part the broader framework of thought. In certain cases, Indian theoreticians were already employing concepts similar to processual and post-processual archaeology before the formal introductions of these precepts. Dilip Chakrabarti Colonial Indology (1997), strives to point out the bias of western scholarship. In another work, Theoretical Issues in Indian Archaeology (1988) Chakrabarti takes up the issue of external influences on Indian civilization. To quote: 'The purpose of the present study is not to raise any debate regarding diffusion verses independent invention in Indian archaeology but to underlie the fact that till recently this provided almost the only explanation of cultural change in Indian archaeology. The aspects of continuity in the regional sequence had consistently been ignored. Explanations for the changes in the material record of the successive excavated levels were sought, more often than not, in the appearance of new groups of people from outside the subcontinent'.

Recently, an ambitious project of the Centre for Studies in Civilizations (New Delhi) has sought to bring together in a series of volumes the best historical scholarship in India. Specifically, this is the Project of the History of Indian Science, Philosophy and Culture (PHISPC). Relevant from the archaeological point of view are two project volumes edited by G.C. Pande. The first volume is titled The Dawn of Civilization in India (1999). This volume contains the latest review of Prehistoric Cultures, the Early farming Cultures and the Harappan Civilization. The second volume is titled Life, Thought and Culture in India from 600 BC to AD 300 (2001). This volume begins with the review of the Iron Age in India and includes authoritative articles on Buddhism, ancient Indian trade with the Mediterranean and the political economy. The PHISPC volumes are unique in the sense that

these are guided by philosophers like D.P.Chattapadhyaya and G.C. Pande. There is a greater appreciation of the underlying essentials of Indian archaeology and a presentation of a proper philosophy of history framework. In this regard, it would be appropriate to quote from G.C. Pande's preface to the second volume:-

'One historical age, indeed, flows into another almost imperceptibly and the transitional ages tend to be gradual and indistinct. Thus the slow and locally varying succession of archaic ages is well illustrated by prehistoric archaeology. The nature of archaeological evidence, however, characterizes prehistoric ages primarily in terms of the distinctive features of their material culture. From general data about tools, industries, means of livelihood and settlement patterns one cannot determine the pattern of the inner life of a community expressed in its religious, moral and social beliefs, attitudes and institutions. Even in the case of the Indus Civilization we are unable to determine its language, beliefs and social institutions with any certainty. With the Vedic Age we face an opposite problem. The literary nature of the sources informs us about the mind and heart of the age but tells us only indirectly about its material culture.'

G.C. Pande. 2002. Introduction to Life, Thought and Culture in India 600 BC - AD 300 (2001)

3.3 Post-Processual Archaeology

Among the most recent trends in archaeological thought are the ideas of post-processual archaeologists. Nicole Boivin and Dorian Q. Fuller, in their contribution to post-processual archaeology in South Asia succintly define the concept: 'Post-processualism, as can be discerned from the term itself, is a movement within archaeology that defines itself largely in opposition to processualism. While processual archaeology generally perceived the past as something that could be objectively studied given sufficient understanding of formation processes, post-processualism questioned the foundation of such an assumption. This skepticism opened the way for a variety of new concerns within archaeology'. In essence, the post-processualists questioned the fixated notion of processualists for basing their interpretations on scientific data. The post-processualists spoke of interpretation based on individual perceptivity and therefore freed archaeological research from the scientific framework. In a way, post-processual archaeology was created by the processualists who had grown out of their own concepts. The best example of this is David Clarke of Cambridge University who is widely considered a pioneer of New Archaeology. Clarke overturned his own axioms when he he penned a critique of processual archaeology titled, Archaeology, the Loss of Innocence. Boivin and Fuller have discussed post-processual archaeological applications in South Asia. They have shown that elements of post-processual thinking existed in India before the theory became formalized. We may also mention U.C.Chattopadhyaya who has written a commentary on post-processual archaeology entitled Models, Metaphors and Archaeologies: Loss of Innocence.

The post-processual period is one of intense flux and the time when innovative ideas are being experimented with. These include the challenges presented to Childean ideas of Civilization by East Asian archaeologists, the emergence of the notion that archaeology is a potent tool for development, heritage management and global poverty reduction and the new geographical frameworks for archaeology, in particular the concept of Indian Ocean Archaeology. We will touch upon these latest trends below.

Domestication and Dispersal Processes

Dispersals of botanical and animal domesticates offer insights into early settlement processes and growth of incipient exchange networks. The spread of millets 'Out of Africa' is perhaps the most illuminating episode in this regard. The dispersal theory postulates that millet cultivars - of sorghum in particular - began to spread into West Asia from native habitats in sub-Saharan Africa in the 5th millennium B.C. The route of transmission crossed the southern Red Sea in the vicinity of the Bab el-Mandeb (straits which connect the Red Sea to the Gulf of Aden) and touched the Tihama coast of western Yemen, thence diffusing into southern Arabia/Yemen. Evidence for cultivated sorghum occurs in southwest Yemen in contexts dated to 3000 B.C.. A pottery vessel with impressions of sorghum dated to 2500 B.C. has been found in highland Yemen. The emergence of agriculture in Yemen as early as 4th millennium B.C. must have provided fertile ground for early cultivation of sorghum in southern Arabia. In Oman - the crucial link between south Arabia and India - sorghum has been recovered from contexts dated to 2330 - 2250 B.C. at Hili 8. According to Steven Weber (Out of Africa: The Initial Impact of Millets in South Asia,1998), millets of African origin entered the Indian food chain in two phases. The first phase of dispersal brought the finger millet to western India around mid- third millennium B.C. The second phase in early 2nd millennium B.C. saw infusion of the large millet (sorghum bicolor) and the pearl millet. We can envisage a 'staggered' transmission of millet domesticates from Yemen to Oman and further east into the Indian Subcontinent, the process spread out from 3000 - 2000 B.C. Here, it is important to distinguish between processes of dispersal and beginning of cultivation of sorghum along the Arabian Sea rim. The chronological range suggests that sorghum cultivation was already established in Arabia-India by mid-late 3rd millennium B.C. Allowing time for the processes of dispersal, which preceded full fledged cultivation of sorghum in Arabia, there is a lag of more than a millennium between the first dispersal of sorghum and evidence for its cultivation in the Arabian peninsula and the Indian subcontinent. The point is that early contacts along the Arabian Sea rim are associated with dispersals, in the centuries preceding the beginning of cultivation; the 4th millennium B.C. being the likely period. The significance of the 'dispersal period' is underscored by S. Cleuziou and M. Tosi (The South-Eastern Frontier of the Ancient Near East, 1989) with regard to the Omani middle ground: 'Although we assume that very

few artefacts travelled to and from Oman till the very end of the 4th millennium B.C., plants, animals and people moved around and were introduced into the country.'

The dispersal of botanical and animal domesticates points to movement of men and material in prehistory. The indicators of dispersals give a secure footing to interactive scenarios in cases where the historical record is scanty. The case of millets 'out of Africa' is just one example of long distance human interchange. Another vivid example is the finding that chromosomes of banana in eastern Africa can be traced to progenitors in Southeast Asia. This indicators suggests that banana was introduced from Southeast Asia into eastern Africa by voyagers in antiquity. Similarly, the discovery of Southeast Asian plants like the fox tail millet in Harappan contexts is suggestive of contacts between the Indian subcontinent and east Asia in 3rd-2nd millennium BC.

3.4 Archaeology & Development

The present intellectual milieu in world archaeology emphasizes innovation and experimentation. Many archaeologists are now concerned with the broader implications of the practise of archaeology and associated disciplines. There is a body of opinion which seeks to make archaeology relevant to present day problems and use the discipline as a tool for development. The problems of global urbanization, poverty and the challenge of sustaining resources for an expanding population are some of the concerns of archaeologists attempting to define a modern world view. An ambitious global project launched by Swedish archaeologists under the Human Responses and Contributions to Environmental Change Program (HRAC) addresses the problem of unchecked global urbanization and the role of archaeology in stabilizing the crisis. The conceptual document produced by the Swedish group is called Global Urban Landscape Dynamics. The approach document puts the following proposal: How can a model combining research, capacity building and heritage management applied bilaterally or regionally contribute to understanding significant human problems concerning long term urban growth?

A number of significant queries are incorporated. The following concerns are at the heart of the emerging theme of Development Archaeology:-

Contextual Definition and Process Modelling: When and within which socio-cultural and biophysical contexts did transformation from pre-urban to urban settlement system occur? How important were riverine contexts?

Biophysical Parameters: To what extent are urban transformations coincident with possible global climate changes? How do sea level fluctuations contribute to coastal dynamics and urban developments?

Spatial Organization: How were the pre-urban settlements and early towns in different areas spatially and temporally structured?

Subsistence Activities: To what extent in different areas do grain cultivation, animal husbandry and hunting support urban development? How were problems of the variability of farming conditions solved in terms of water and pasture management?

Production and Exchange: What range of craft and industrial activities supported urban development? How important were metal working and ceramic technologies? How were these products distributed in local and long distance trade networks?

Communication: To what extent did events and demands in other centres cause changes in urban developments?

City & State: Is the common assumption of close links between urban development and state formation justified? How useful are currently available theoretical concepts of city-state and urban organization?

3.5 Braudelian Thought

Ferdnand Braudel was a historian of the Annales School in France. He developed the idea that there are various time-cycles in history and we can perceive processes and events in the long term, the medium term and the short term. Braudel's classic work The notion of the long term, or the longue duree, as Braudel termed it, has made a profound impact upon historical and archaeological studies. His classic work The Mediterranean and the Mediterranean World in the Age of Philip II (1973) set the framework for the histories of large geographical areas to be viewed in deep time perspective. Ian Hodder, a well known archaeological theorist has drawn upon Braudel's longue duree principle in his studies. In the Indian context, the longue duree principle has been applied to the understanding of the Indian Ocean world.

3.6 Indian Ocean Archaeology

The Indian Ocean stretches, in an extended sense, from the Red Sea to the South China Sea, incorporating the 'core' littoral regions of the Arabian Sea and Bay of Bengal. The monsoons define the environment of this maritime space. The monsoons can be broadly defined as wind systems that seasonally reverse direction. A strong monsoon system prevails over the northern Indian Ocean, manifested in steady, rain bearing winds which blow south-north from May to September (Southwest Monsoon/Southerlies) and north-south from October to April (Northeast Monsoon/Northerlies) . Recently, there has been a strong interest in the early history and archaeology of the Indian Ocean world. Writings on early exchange networks and ancient sea trade in the Indian Ocean have given emphasis to archaeo-historical evidence of contact/interchange. Data sets on ancient maritime technologies (boat building especially) are being integrated into reconstructions of early exchange networks. The adaptation of prehistoric communities to coastal environments involved, initially, the understanding of inshore arena, the lagoons, creeks and closed bays. Searches for edible shells on

inter-tidal flats and fish in near waters were crucial experiences in the process of sedentism of mobile communities seeking to inhabite sea boards. Longer ventures for maritime food resources must have gradually built up deep knowledge of coastal geomorphology, tides, shoals and currents. The genesis of the first watercraft - rafts and dugouts - is intimately associated with early near shore ventures.

While monsoon activity is strongest over Indian Ocean lands, adjoining littoral regions come within its orbit. In Egypt, the intensity of floods in the river Nile have been determined for millennia by monsoon rains over Ethiopia and Central Africa. To the east, monsoon-like conditions prevail as far as Japan, where seasonal switching of wind direction is as persistent as India. A large quantity of sediment brought down by the rivers - especially the Indus and the Ganga - is discharged into the Arabian Sea and the Bay of Bengal. Convergences between the monsoonal regime and maritime initiatives are a major focus today. For instance, the discovery of the hippalus (the Southwest monsoon wind) by the Greeks in 3rd century BC was a breakthrough for western commercial interests in the Indian Ocean. Interactive littoral regions of the Indian Ocean are situated within monsoonal contexts: the dominant SW and NE monsoon fronts and related localised wind flows, currents, tides, fluvial discharges etc. It is postulated that the greater monsoonal zone, stretching from the Red Sea region to South China Sea, emerged as a vast, interconnected maritime market by the beginning of the Christian Era.

Compared to the monumental entities of Bronze Age Egypt, Mesopotamia and the Indus, the Indian Ocean rim would seem a much less inspiring place. Childe's relegation of the Indian Ocean beyond the 'southern limit' of Old World civilizations is typical of the 'hinterland' view which stresses land to sea outreaches. However, as we have discussed, sea to land dynamics are also evident, as in contribution of 'lower Gulf' cultures to the civilisation of Mesopotamia or the desemmination of Indic culture into Southeast Asia. Adverse marine or coastal environments could not become encumbrances for wide spread exchange activity and establishment of ports from the Red Sea to the South China Sea. For instance, we find two major ports in antiquity, the Harappan harbour at Lothal and the great Early Historic entrepot of Brghukaccha (the Barygaza of Greeks) located on the edge of one of the most violent seas in the world: the Gulf of Khambhat. The sobriquet Monsoon Civilizations can be applied to all urban entities on the Indian Ocean rim which depended on seasonal rains brought by the Trade Winds: Pharaonic Egypt on the Nile floods fed by monsoons over Ethiopia, the rich farming cultures of the south Arabian highlands which received the full force of the Southerlies from the African Horn and the Indus and Gangetic zones watered by rain and snowmelt of the Indian monsoon.

3.7 On Indianization of Southeast Asia

Indianization is a concept fundamental to the history of contact between the Indian subcontinent and Southeast Asia. Most studies on the Indianization of Southeast Asia are based upon interpretations of the rich art and inscriptions of Indic polities in Southeast Asia. Typically, the historical narratives associated with Indianization commence from mid first millennium AD when sculpture and inscriptions become widespread in Southeast Asia. The theoretical connection between art and polity has created a notion that state formation in Southeast Asia happened without much precedence and was rapidly effected through enlightened migrants/traders coming from the Indian subcontinent after AD 500. The previous period has been the preserve of anthropologists and field archaeologists mainly concerned with investigating transitions from early prehistory to the metal ages of Southeast Asia. The lack of interface between the archaeological and art historical record has resulted in the idea that Indianization was rapid and late. This notion has persisted since the authoritative writings of Georges Coedès and Ramesh Chandra Majumdar firmly anchored the idea of Indianization in the historical record.

At its core, the Indianization process was marked by absorption of Indic cultural traditions (auspicious symbolisms, religious iconography, political precepts) by the rapidly transforming Iron Age communities of Southeast Asia. These borrowings began before the mid 1st millennium AD, as indicated by spread of 'mangala' symbolisms, the arrival of the first Mathura/Amaravati sculptures and references to early Indic kingdoms in Southeast Asia. The wide use of auspicious symbols in the form of the conventional mangalas (srivatsa, svastika etc) or associated auspicious signs (buddhapadas, vajra) or amulets (sakya beads) in Southeast Asia clearly points to the diffusion of aniconic modes of worship from eastern India into former region. As interactive processes across the Bay of Bengal strengthened and Southeast Asian communities grew more complex, the material initially manifest in beads, amulets and ritual pottery, gradually came to be projected through sculptural art, coinage and architecture.

3.8 Environmental Archaeology

Environmental Archaeology is based on the axiom of interaction between humankind and the surrounding environment. At the heart of the debate among environmental archaeologists is the degree of control exercised by the human agency or by environmental factors like climate, soil fertility, sea level changes etc. Prehistoric archaeology has been dominated by environmental studies. First there is the imperative to situate palaeolithic cultures within datable geological formations. Also, the role of climate is considered to be critical in the rise and fall of human cultures and civilizations. The decline of the Harappan Civilization has been related to the decline in rainfall and rise in aridity in western India in the 2nd millennium BC. The rise in aridity was determined by analysis of old pollen from the lakebed of Sambhar in Rajasthan. Though this palaeoclimatic

reconstruction, first made by Gurdip Singh of the Australian National University, has been challenged by other environmental archaeologists, the basic conceptual principle is established. A major palaeoclimatic study of the Thar Desert was carried out by the Physical Research Laboratory (PRL) in Ahmedabad with the Deccan College, Pune and other agencies. The PRL also initiated a major palaeoclimatic study of the Kashmir Valley in the eighties. The lakebeds at Mansar (Jammu) and Manasbal (Kashmir) were drilled and mud cores lifted for palynological analysis. The third major project of environmental archaeology was implemented in the Middle Ganga Valley and the Vindhyan area by an Indo-American team. J. Desmond Clark describes the collaborative project in his article Palaeoenvironments and Prehistory in **North Central India: A Preliminary Report:** 'In the winter of 1980 an interdisciplinary project was initiated in the form of a joint team study of an area in southern Uttar Pradesh and northern Madhya Pradesh embracing the eastern Vindhyas. The teams led by G.R. Sharma of the University of Allahabad and J. Desmond Clark from the University of California at Berkeleyo. The Main objectives were to establish from a study of the sedimentary sequence and geomorphology the succession of geological events represented in the fluvial and terrestrial deposits and to interpret these in terms of palaeo-environments and past climatic fluctuations; to establish the archaeological assemblages; to define and describe the nature of each industrial entity and to fit these into a chronological framework based on radiocarbon dates; to identify preferred localities for settlement and to interpret activity patterning on primary context occupation sites, thereby to understand better prehistoric use of space and how this might have changed through time;finally, to develop behavioral models for as many of the archaeological units identified as possible'.

3.9 East Asian Archaeology: New Perspectives

The recent researches in East Asia by Chinese and Japanese archaeologists need to be taken into account in this review. East Asia has seen ground breaking field activity in archaeology and some of the results are now challenging the notions of culture and civilization established in the West. In particular the recent excavations of the Chinese-Japanese teams in the Yangtze River valley are interesting. According to Yoshinori Yasuda, the leader of Japanese archaeologists from the International Research Centre for Japanese Studies (Kyoto) it is not wise to use literally the development model proposed for the West Asian region to explain the civilizational processes in the East. According to Childe's theory of the Neolithic Revolution, development of urbanization, supported by wheat cultivation and cattle breeding, took place in West Asia and later on spread into Europe and East Asia. According to Yasuda, this is the monastic concept of civilization. However, the concept of 'Agricultural Revolution' postulated by the Japanese historian and philosopher Shuntaro Ito proposes independent domestication of plants in different regions and origins of civilization in the Old World. Hence, Ito's theory advocates a pluralistic idea of civilization based upon origins of

cultivation in different parts of the world. In this regard, Yasuda proposes that the Fertile Crescent of wheat cultivation in West Asia is paralleled by the origins of rice cultivation in the Yangtze River basin in China going back to 10,000 BC. Yasuda further comments that neither Childe nor Ito investigated the processes and events leading upto the origins of food cultivation. It was generally held before that the origins of pottery and agriculture took place simultaeneously or that pottery may have appeared slightly later than agriculture. According to Yasuda, this hypothesis does not hold good any more as indicated by the evidence from East Asia. People of East Asia began making pottery much earlier than the beginning of agriculture. Recent discoveries by Chinese scholars have revealed that the origins of pottery in China goes back to about 12,000 BC. These early potteries have been found at Yuchanyan, Miaoyan and Linzhou Dalongtan Liyuzui sites in China.

3.10 Summary

The various ideologies in connection with the description of archaeology comprise of the new trends in archaeology. In the first half of the 20th Cen. archaeological research focussed on classification, typology and documentation. The approach was event oriented and static. Gordon child (1892 - 1957) was a pioner of this school of archaeology.

In the sixties there was a shift away from children framework. The new movement stressed on understanding post cultural behaviour in relation to environment, population, technology, social organization and ideology they stressed on scientific techniques and attempted to understand past cultural behaviour in relation to environment, population, technology, social organization and ideology. The American archaeologist Levis Benfond postulated the theory that para miters must be created to give meaning to data and therefore a middle position between pure hypothesis and conclusion is to be achieved. To augment this endeavour disciplines like ethno archaeology and experimental archaeology and new scientific techniques like faunal analysis, carbon 14 dating and dendro chronology were given importance.

New archaeology is based on the principles of cultural evolution, under lyijng semilaritys among the different cultures, the importance of external environment imphasis on cultural process and problem oriented study.

In India the ideas of New archaeology were adapted by M.D. Sankalia, K. Padayya etc.

Among the recent studies is archaeology the project of the Centre for studies is civilization guided by D.P. Chattopadhyaya and G.C. Pande needs to be mentioned.

Important from the archaeological point of view are its two volumes. **The dawn of civilization in India** and **Life thought and culture in India** from 600 B.C. to Ad. 300.

The most recent trend in archaeological thought is post processual archaeology. This movement Questions the foundation of the assumption that past can be studied very objectively. In fact they laid stress on enterpretation based on individual perceptivity.

The new trends in archaeology also studies domestications and dispersal process of botanical and annual remains to ditermine the movement of men in prehistory.

The scholars of archaeology use the disciptive of archaeology as a tool of development and in solving the present day problems. Other new trends in archaeology are Braudilian thought which perceives proceses and events in relation with various time cycles in history.

A new perspective has been developed in East Asia by chinese and Japanese archaeologists. According to them we should not use the development model proposed for the west Asian region to explain the civilizational process in the east eg. the origin of pottery has a different pattern in china which goes back to about 12,000 BC.

Indian ocean archaeology studies the history and archaeology of the Indian ocean world on the bases of the monsoon system, maritime technologies, coastal geomorphologies etc.

Another trend is to investigate of cultural values and artifacts of one civilization to another like the Indianization of South East China.

Environmental archaeology is also a lowest trend of archaeology of is based upon the enteraction. between humankind and the surrounding environment.

3.11 Check your progress

1. Discuss the concept of new archaeology.
2. Discuss post processeal archaeology.
3. Write short notes on
   a. Environmental archaeology
   b. Archaeology and development.
   c. Indian ocean archaeology.

3.12. Activities

Visit the archaeological survey near your residence and discuss the research methodologies adopted by their experts.

3.13. Suggested Readings –

1. Pande J.N. – *Puratattva Vimarsh*, Allahabad.
2. Rajan K. – *Archaeology : Principles and Methods*, Thanjavur 2002

BLOCK – II

METHODS OF EXCAVATION, EXPLORATION, SURVEY, DRAWING

UNIT – IV

METHODS OF EXPLORATIONS

4.1 Introduction

4.2 Objective

4.3 Types of Sites

4.4 Problems regarding exploration/Excavation

4.5 Research Design

- **4.5.a** Appraisal of the data including Historical literature, previous works, legends and local traditions.
- **4.5.b** Implementation
- **4.5.c** Data Acquisition
- **4.5.d** Data Processing
- **4.5.e** Data Analyses
- **4.5.f** Interpretation of Data
- **4.5.g** Dissemination of the results

4.6 Essential tools for exploration

4.7 Methods of explorations –

- **4.7.a** Site investigations
- **4.7.b** Sampling methods
- **4.7.c** Documentry sources
- **4.7.d** Toposheets/Maps
- **4.7.e** Test pits.

4.8 Systematic ground survey & Geophysical prospecting –

- **4.8.a** Magnetic & thermo remnant magnetic survey
- **4.8.b** Electricity resistivity survey

4.1 Introduction :

Exploration in archaeology means search or investigation, or locating an ancient site or a buried monument or an artefact in archaeological spade work. Exploration is important as well as the first step in archaeological spadework. It is a known fact that all excavations are destruction, unless the exposed remains are properly conserved and preserved. On the other hand, exploration is non-destructive, harmless and informative and in order to undertake a well planned, scientific systematic operation of digging, exploration method serves as a prelude. Whether for rescue or research or determination of the potency of site exploration, it constitutes a major preliminary step towards pre-excavation preparation. Hence, this investigation method is purely non-destructive and in Indian context, it is called as the surface exploration.

The site survey is a preliminary study of the field data available on the surface of a site or an area. The process of locating, recording and studying archaeological sites on the basis of their surface features and without recourse to excavation is known in England as "Field Archaeology". Terms like "Site survey" or reconaissance are used in the United States of America. O.G.S. Crawford in his book "*Archaeology in the Field* (1959) calls it "archaeology without digging".

Further, the recognition, description and interpretation of the traces of the past are either apparent on the surface or detectable from the surface. This is also called archaeological prospection. Largely due to its non-destructive and predictive character archaeological prospection is an important tool for the management and preservation of the buried heritage threatened by industrialization, urbanization, agricultural development, and civil engineering projects of the modern world.

4.2 Objectives

The objectives of archaeological exploration are multi-dimensional depending on nature and problems taken up by the explorer. In other words, the whole area/region is to be studied in broader perspective including the climate, topographic feature and the nature of artifacts to be collected for adaption of a strategy at large. For example, pre-historic exploration is to be organized for the study of pleistocene archaeology (Yale-Cambridge Expedition to Soan Valley) Prof. Zeuner's survey of Teri sites (T.N.) etc. Secondly in respect of proto-historic or early historic sites, instances can be cited like survey of Harappan sites and Buddhist sites respectively. Thirdly, survey for specific problems like Ramayana and Mahabharat which are problem-oriented projects under taken by B. B. Lal. Survey of ancient maritime ports etc. fall under this category. Besides, survey of any archaeological site/sites is also essential to assess their importance. In this context, it may not be out of place to say that exploration method is really called village-to-village survey of antiquarian remains. This type of survey is conducted by A.S.I., State Archaeology Departments and various Universities of the country.

4.3 Types of sites

In course of exploration different types of archaeological sites are encountered by archaeologists. Each archaeological site, large or small, has its own distinct character and problems. Based on the availability of the cultural material they are identified as single or multi cultural sites. The single cultural site is generally occupied by a single group of people whereas the multi-cultural site is continuously occupied by many people in a larger time span. These sites are classified into palaeolithic, neolithic, chalcolithic, megalithic, early historic and historic sites and sacred sited with various sub-divisions. The following are some of the subdivisions :

- Prehistoric open area sites like riverside terraces such as Sohan Valley or Kortalayaiyar valley river terraces.
- Prehistoric caves like Gudiyam and Bhimbetka.
- Neolithic sites ashmounds.
- Habitation mounds (also called nattam, tells, tepe).

- Habitation-cum-burial sites like Sanur, Kodumanal, Khapa and Brahmagiri, Karkabhat, Mahurjhara.
- Monumental sites like Harappa, Mohenjodaro, Kalibangan, Dholavira and Inamgaon.
- Sacred sites like stonehenge, temple, stupa and church.
- Underwater sites (includes submerged ports and shipwrecks) like Dwarka and Kaveripattinam, Poom Pahar.

It is quite obvious that some of the sites mentioned above sometimes must be having more than one cultural components. Each site is selected based on the objectives of the project.

Method of Exploration

The methods, the strategy and personnels depend on the objective or nature of the survey. Hence, according to the exigencies important diverse tools (requirements) to be attended for a successful prospecting.

4.4 Problems regarding exploration/Excavation

In early seventies, the problem oriented exploration and excavation received an importance in Indian archaeology. This type of research gained a momentum for over a decade. This method of approach had its merits and demerits. The problem oriented exploration/excavations are generally designed to throw light on particular problems, which are in the minds of the excavator. This single-minded approach led the field director to ignore the other valuable aspects of the site. For instance, those working on the chalcolithic/megalithic site sometimes ignore the deposits that belong to the historical period and vice-versa. In this, the excavator usually ignores the data, which are not relevant to his objective. This kind of approach would not contribute much to the nation. Archaeologists should not experiment isolated problems, since every site is unique and unpredictable. An exploration/excavation designed to answer a specific question may end up with unexpected data, which is contradictory to the expected data. The problems discussed on the committee table may not go well with the site, sometimes need a drastic modification during the excavation. Therefore one should be more flexible in his approach and always look for result-oriented data. Since every excavation is destruction, the archaeologist should be open-minded and should pay more attention to record and document all the available data. Therefore, the archaeologist should formulate a research design by keeping the above factors in mind.

4.5 Research Design

The research design is a guideline that describes the step-by-step method to be adopted in the project. A general model of a research design that outlines seven principal stages : formulation, implementation, data acquisition, data processing, analysis, interpretation and dissemination of the results.

4.5.a Formulation

Appraisal of the data including Historical literature, previous works, legends and local traditions.

The research problem or hypotheses are defined in the formulation stage. It forces the archaeologists to appraise data and dictates the choice of staff specialists, excavation tools, and methods, such as the scope and location of the excavation. Relevant background research that reviews the historical, archaeological, geological and any other studies pertinent to the problem supports these objectives. In India, historical evidences are embeded in literary works, epigraphical records, numismatic findings, foreign accounts, folklore, myths and legends. Fortunately, these materials are well preserved in India. These have to be studied and analysed properly. In preparation, the archaeologists read and survey all relevant research material and gather available informations about the site. Extensive review of early literary references, maps and illustration, archaeological and ethnological literatures and previous excavation reports are of particular importance for archaeologists. A fine example for the use of documentary sources in archaeological studies in the Schliemann's discovery of Troy in 1871 in Turkey. His firm belief in the historical accuracy of the writings of Homer and Iliad directly to the discovery. Much of the biblical archaeology stands on the documentary evidence found in old and new Testaments. In Indian context, the description of the cities found in epics helped to locate the sites like Ayodhya, Sringaverpur, Hastinapur, Kurukshetra, Kosambi and Dwarka. The locational description found in the Sangam Literature helped to locate ancient ports, trade centres and cities like Korkai, Kaveripattinam, Karur, Uriyur and Kodumanal in Tamilnadu. The pre-excavation design must be a problem-oriented within a theoretical frame work and must focus on specific topic or topics like settlement pattern, trade, technological and environmental factors, location analysis, the role of site at a given time, etc. It is always advisable to visit the area of proposed research to investigate and familiarize oneself with the local conditions. Once area is selected, then necessary follow-up actions should be taken to implement the project.

Historical Literature

Familiarity with the historical/biblical literature is indispensable for the explorer. Historical literature is in the form of ancient/medieval literature of inscriptional reference to the places, these records help in locating ancient sites as they provide valuable details regarding ancient toponyms by which city or village was known. Thus the toponyms collected from map or inventories or in the field are valuable auxillaries for the discovery of the site, whose presence is still recorded, though, changed in local topographic names.

The foreign travellers or geographers accounts help us in identifying the ancient settlements. The accounts of Greek-Roman writers like Pliny, Ptolemy and Strabo furnished valuable data

regarding ports and capitals of early historical India. The account of Huen Jsang the famous Chinese traveller of 7th century A.D. are of great use of archaeology of the Buddhist sites of India. The explorer should also acquaint himself with inscriptional/epigraphical data for helpful knowledge and interpretation of the locality/site.

Previous Works

The explorer before undertaking any exploration should go through the previous pioneer works done in the field of archaeological finding. This shall serve as a valuable guidance and help in avoiding duplication of work. The published report of the A.S.I. and State Departments of Archaeology and institutions should be consulted before commencement of the field archaeological trip.

Legends and local traditions

These are their own importance in reconstructing the history of locality. They often preserve old memories of the long forgotten facts about city/village/locality in the form of legends and folk songs would mix up with facts and fictions.

Again enquiries with elders, senior citizens, personel communication with local resourceful persons are also useful in knowing local facts.

Hence the tools mentioned above be carefully consulted or taken to recourse while conducting exploration.

4.5.b Implementation

To implement the field work, necessary permission from the government has to be obtained. The legal implications of archaeological excavation vary from country to country. It is vital that archaeologists should become familiar with the national and local legislation and should know exactly how to gain permission to excavate. In India, the Archaeological Survey of India (ASI) is the final authority to grant permission to explore/excavate site/sites under Ancient Monuments and Remains Act, 1958 and Rules 1959. However, the researcher should submit the application to the ASI routed through the Secretary of the concerned State Government. After getting the permission from the central and state authorities, the field director has to take appropriate step to get permission from the landowner or possessor in case of excavation. Generally, the owner may want the field director to refill the excavated area and to leave the site as it was originally found.

4.5.c Data Acquisition

The research design also specifies the sampling methods and techniques of data acquisition like site surface survey, field walking, aerial reconnaissance, or excavation. Sampling strategies will

vary in accordance with project goals. it is important to define the area to be investigated, its environmental or geomorphic situations. The approaches and standards to be used in excavation also should be stated explicitly. For instance, how the horizontal and vertical controls will be established and maintained throughout the project.

4.5.d Data Processing

The research design should also specify how the field data would be processed and maintained for analysis of archaeological artifacts may be processed either in the field laboratory or in a specific specialised laboratory located in different parts of the world. Preliminary analysis may be conducted on artifacts in a field lab. This laboratory process involves cleaning, sorting and labeling of the field specimens.

4.5.e Data Analysis

The results of the field data analysis are intended to provide the information sought to shed light on the research problems or hypotheses. The objectives of the analysis will vary depending upon the research design. However one always should keep ones mind and data open as it may provide unexpected results.

4.5.f Interpretation of Data

The research design should address specifically, how the data is going to be interpreted. The data generated by the field research must be synthesised and evaluated in an attempt either to test the proposed hypotheses or to investigate the problem or questions posed.

4.5.g Dissemination of the Results

The intended method of dissemination of results depend on the nature of the field work, the volume of data accumulated and the relevance of the findings in terms of broad or regional implications. The whole exercise of the research work would be lost unless the results of the work are not properly disseminated. Unreported field data that go unfinished may represent tragic losses of irreplaceable data.

4.6 Essential tools for exploration

Personnels and tool kits

For the exploration work, there should be no prescribed strength of personnels. The team may consist of one, two or more archaeologists. If it is a team work, then it should consist of photographer, draftsman, surveyor, some trainee/students along person knowing local language.

The tool kit for exploration work should be portable and consists of the minimum requirement. Following items are required.

i. Knapsack with shoulder straps for carrying equipment.

ii. Cotton pottery bags for collection of potsherds/stone implements.

iii. Antiquity envelops to collect minor/smaller antiquities like heads/coins.

iv. Measuring tapes of 15 mtrs. & 2 mtrs. (one each).

v. Excavation knife to scrap the exposed section for finding stratification.

vi. Small shovel, pick axe and geologist's hammer (one each) for emergency clearance work/ digging small scale.

vii. Few brushes for cleaning the object before photography.

viii. Navigator's compass to know direction.

ix. Portable camera with allied equipments.

x. Site note book or card to record the field data.

xi. Drawing sheet, geometry box, pencil, pen etc.

xii. Binoculars

xiii. First aid box

xiv. Motor cycle/Jeep.

Though exploration/survey work has to be done mostly on feet, the jeep may accompany the parts for transporting the camp goods/antiquities if any and shifting up of camps in different locality.

4.7. Methods of exploration

The methods, a strategy and personnels depend on the objective or nature of the survey. Hence according to the exigencies important diverse tools (requirements) to be attended for a successful prospecting.

4.7.a site investigations

As specified above, the first stage of work is to select a site and obtain necessary premission from different organisations for commencing the work. The first stage generally involves the off-site works. In the second stage, the research enters into the on-site investigation. The first part of the work is sampling of site.

Site examination and recording of data

Direct observation helps to recognise a large numbers of sites or remains from often very tenuous traces revealing themselves only to the experienced and careful observer. On the ground, even more discreete remains can be detected : ruins, random materials, topographical irregularities

etc. are the prospector's (explorer's) main interest in the course of field walking operations. The explorer has to incorporate every possible data of the site viz; name, locality, approach to the site, published reference of the site if any, archaeological significance of the spot, state of preservation, inscription data recording of antiquities. Above all he has to assess and determine about the future course of spade work there of field observation and ceramic survey etc. All the things mentioned above are to be incorporated in the "Site Card" or "Sheet". This is known as site examination.

4.7.b Sampling methods

Archaeological sampling is concerned with examining a portion of the archaeological record to derive the inference on the whole site. There are different types of sampling techniques used by archaeologists. The geographer Peter Haggett defined four basic sampling strategies namely simple, stratified, systematic and stratified systematic random sample in his classic book *Locational Analysis in Human Geography* (1965). In the sample random sampling, each unit has a statistically equal chance for selection. In systematic sampling, the first unit is selected at random. Once the first unit is established, all other units in the sample are selected at predetermined intervals from the first. In stratified sampling, the sample unit is selected from two or more sampling strata. In the systematic stratified sampling, the above said two sampling methods are integrated.

The sampling strategy can be either probabilistic (formal way of collecting sample) or non-probabilistic (informal way of collecting sample). Based on the requirement, archaeologists must decide first what kinds of archaeological data are to be collected. In the random sampling, a grid of equal-sized squares is laid out on the surface of the site and numbered in any order. The field director decides number of squares with equal probability based on the limitation of the time and space and the nature of the site. The samples from the selected squares are collected and recorded. Of course, there is no guarantee that random sampling techniques will produce representative selection of the artifacts. However, it is helpful when the archaeologists can do little more than a cursory analysis of a site. In addition to sampling method, different site survey methods are being used to judge the potentiality of the site.

4.7.c Documentary Sources

Documentary sources are great help for conducting exploration. These include Toposheet (Maps), District Gazetteers, historical literatures, archival records of the provinces, pioneer works, ancient manuscripts etc.

4.7.d Toposheets/Maps

Maps/toposheets have immense value for archaeologist and serve as true-companion for the explorer. The toposheets/Maps prepared by the Survey of India provide a mine of informations

on city, village, locality, hamlets, important railway lines, major/minor highways, district road, rural roads. It also indicates the location of rest house, Dharmasala. This helps the explorer to have his night halt at the locality etc. Again these maps are also vital for the explorer to study the physical feature of the area/region like river, mountain, lakes, spring, forests etc. Depending on the period under consideration, they make up an almost inexhaustible mine of informations, allowing the identification of concealed or even disappeared archaeological sites. Early maps and old street names are even more important in helping archaeologists work out the former plans of historic towns.

Besides, the physical features of the site including distribution of rocks, minerals, soils, flora and fauna are known from geological maps or report of District Gazetteers/Imperial Gazetteers of India. Some significant physical features taken into account in course of exploration are as follows :

Hills provide necessary raw materials for manufacturing tools in pre-historic period, knowledge about caves and cave dwellers of ancient times, tribal population etc. Similarly movement of ancient people is known from passes which served as the corridor.

Rivers are the real life line of human settlement. All the ancient cities are located on the river bank, hence study of old river terraces and gravel bed is sine-qua-non for explorer. Again river mouths are known for ancient port towns. Lakes formed another important water source. Pre-historic settlements are found around the periphery of lakes. The study of rocks, minerals and metals shall be helpful in knowing tool assemblage of pre-historic period, the architecture of the region for example, Megaliths of south India are mostly made amidst granite out crop. So by studying nature of rocks in an area, the explorer can almost anticipate the type of monument he comes across. Similarly, knowledgeof the nature of metal and minerals available in an area would be helpful to locate the bronze and iron age sites.

4.8. Systematic Ground Survey & Geophysical Prospecting

But the systematic ground survey calls for a number of other scientific parameters spread in a continuous way on the ground that must be mapped for detailed study of the site. These are to be accomplished with the help of following various scientific aids.

Geo-physical prospecting

4.8.a Magnetic and Thermo Remnant Magnetic Survey

The proton magnetic meter is highly sensitive apparatus for detecting buried irons and certain kinds of soil. Of course, this is to be used with caution.

By thermo remnant magnetic survey, existance of burnt clay artifacts, burnt brick structures and conflagration of site in past can be detected. This magnetometry is probably still the most

widely employed method. It was initially developed by one physicist Martin J. Aitkein of Oxford University in the 1950s.

4.8.b Electricity Resistivity Survey

The resistivity meter is based on the fact that the ground can conduct electricity. Different soils or rocks or sediments conduct differently. This was also first developed in the 1950 as an archaeological tool by Aitken at Oxford in 1950. It is an active method that required passing a small alternating current through the ground. Electrical conductivity of soil depends on its nature. They will show wide divergence in their restivity. This kind of survey is suitable for training the wall or a road. Negative restivity anomoly would indicate a ditch or pit, while positive anamoly shows a structure of high resistance viz; a well, floor etc.

4.8.c Metal Detector

Metal detector can be of great help to archaeologist, particularly in giving quick general result and locating modern metal objects that may lie near the surface.

4.8.d Exploration by sounding

Sometimes tapping the ground at various spots would emit differential sound. Depending upon the compactness of the soil or structure below, the sand from the natural or undisturbed soil would be different from that of the disturbed one or artificially accumulated one. This method is not always dependable.

4.8.e Stereoscopy

It involves the use of overlapping pairs of photographs, which are mounted in the plotting instrument to determine the orientation of the camera and its negatives at the time of exposure. A model on the ground is created and this model is put into scale and oriented to a datum line. That is provided by ground control points. The detail of the area and contours are transferred to the mapping sheet by the aid of the optical and mechanical linkages of the plotting instrument.

4.8.f Periscope photography

Periscope photography was developed by the Lerici Foundation in Italy to document Etruscan tombs. The device, which consists of a probe with a miniature camera and flash attachment located near its end, can be lowered into a tomb buried in the ground and rotated in an empty space of the chamber. This provides a photographic panoramic view of the chamber. This helps the excavator to select the potential tombs.

4.8.g Ground-penetrating radar

In this method, an electromagnetic pulse is released into the ground. The return time of the electromagnetic pulses varies depends upon the density and distance of the subsurface content.

This variation is measured. This method has been successfully employed in the location of buried walls, houses with highly compacted floors, foundations and any buried stone architectural column.

4.8.h Geochemical Analysis

The soil of ancient settlement often contains high concentration of phosphates from organic refuses and these organic refuses are served as fertilizer for local cultivator. On the basis of this kind of soil analysis, archaeologists were successful in defining sites.

Specialised Survey Method

4.8.i Aerial Survey/Photography

Airborne method of archaeological survey helps to have a bird's eye view of the ancient settlement as a whole, which is impossible from the ground. Again certain features which are not visible in naked eyes. Aerial photography is a non-destructive technique used in U. K. and Europe since early 20th century A.D. and in India post-independence period. This process is also known as aerial archaeology. Several ancient sites in India and Pakistan have undergone such process viz; Taxila (now in Pakistan), Sisupalgarh, more recently Sravasti in U.P. The aerial photography is done through ballon camera or from helicopter/aeroplane. Through this, layout of ancient cites, criss-cross roads, streets, alignment of houses are vividly picturised which helps the archaeologists to plan for his further spade work in the area.

New technology is also having an impact on aerial photography in other ways. The technique of transforming aerial photography into a scaled plan in an important development which helps us to get a graphic and enlarged view of the site. Further computer enhancement of pictures improves their sharpness and contrast. Digital imagery has also been introduced. Photographs are quantified in digital form. This process is called photogrammetry. This has enabled archaeologists to get rapid and accurate method of map-making. Though aerial survey is expensive, it has came to play a vital role in archaeological reconnaissance all over the world. This conventional air photography continues to be commonest and most cost effective technique of aerial reconnaissance for most archaeological purposes.

4.8.j Shadow mark

The buried structures sometimes can be detected by tracing the photographed outlines of shadows caused by different heights of vegetation growth. The vegetation grow better where soil is deep and contains greater amount of moisture; conversely, if there are underlying structures this will result in lack of soil depth and moisture. These shadow marks can be seen in the early morning or late evening lights.

4.8.k Soil mark

Soil marks of ancient structures often stand out in aerial photographs, because a decaying structure contains and collects a different type of soil than the surrounding area. This difference can be detected by a trained eye in an aerial photograph. Soil marks may show up in any area but they are usually at their best in ploughed fields. Patterns of different coloured soils will reflect what is being ploughed into the surface. These patterns may be clear, say a rectangle representing an enclosure, or very blurred as the result of long-term ploughing and mixing of the soils. Each element of an archaeological site is likely to be made up of different coloured soils. Areas of burning may show up as red or black, habitation areas could be grey or black, ditches may silt in with dark, humid soil in contrast to the plough-flattened bank which will show up the colour of the present rock, say white for chalk.

4.8.l Crop marks

Crop marks are also an important indicator of buried features and often it produces the most dramatic aerial photographs. Crop marks are basically the result of the differential speed and quality of crop growth and ripening, depending on sub-surface conditions. Crops above a ditch or moat will grow more rapidly and strongly. For instance, cereals grow shorter and turn yellow earlier when they have planted over a buried structure, but they grow taller and ripen later when planted over pits. The symmetrical difference in vegetation growth would provide information on the nature of buried structure.

Shadow marks, soil marks and crop marks all produce patterns visible to the observer flying above. But careful selection of the angle of the photograph and the type of film will make the reading easier.

4.9 Specialized Survey Method

The use of satellite imagery is now part of archaeological research. The images become more available and cheaper and their particular advantage is that they are multi-spectral and are taken all year round, may assist in discovering and monitoring sites. The satellite images can detect larger archaeological features. Palaeo channels, not visible by conventional aerial photography are just visible using enhanced satellite images. By using this, the course of dried up Saraswati river is detected. The application of these exciting new techniques to archaeology is only just beginning. It would be come cheaper and more wide spread in the near future.

4.10 SITE DATA FORM

Site Description

Site No. Site Name

Village Name Lat. Long.

Taluk District State

Topographical Sheet No. Taluk/District Map No.

Transport for access to the village/site

Local Name Historical Name

Approach to the site

Location to the site

Owner of the site

Address

Cultural Period Palaeolithic Neolithic Chalcolithic

Harappan Megalithic Early historic

Historic Others (specify)

Name of the Site Rock-shelter Burial Habitation

Habitation-cum-burial Others (specify)

Area Total Height

Condition of the site Disturbed Undisturbed Destroyed

Cause of Disturbance

Environmental Data

Ecological Zone

Climate Arid Coastal Other (specify)

Vegetation on the site

Vegetation around the site

Mean Sea Level Temperature Max Min.

Wind Direction Rainfall Max Min.

Drainage System

Water Sources River Pond Distance from the site
Well Others

Name of the River

Nature of Irrigation

Water Table

Geography

Prevailing Mountanious Hilly Flat Others
Topography

Land form at Site Hilltop Valley Ridge
Desert Others

Geology/Geomorphology

Rock Igneous Sedimentary Metamorphic

Type of Rock Granite Sandstone Schist
Limestone Laterite Others

Soil

Historical Monuments

Monument Built by
Name

Nature of Monument Temple Mosque Church
Stupa Others

Location

Survey Method

Ground Search

Method

Methods of Collection

Types of representative artifacts

Technological stage of artifacts

Antiquities

Object Material Location Remarks

Chronology

C14 Dating TL Dating

Archaeomagnetism Others

Historical Dating Epigraphical Date

Numismatics

Manuscripts Others

King's Name Dynasty Regnal Year Era Date

Reference

Probable Date

Ethnographic Data

Community Religion

Specific Social Customs

Local Industry

Folk Industry

Folk tales related to sites

Documentation

Documentation Photography Video

Drawing Others (specify)

Recommendation

General Description (This may be given on a separate sheet and attached)

Survey

Previous survey

Name Designation Institution Year Remarks

Reference

Previous Excavation (if any)

Excavator Designation Institution Date/Year Remarks

Reference

Present Survey

Name Designation Institution Date/Year Remarks

The survey information is of no use if it is not recorded properly. Hence data sheet or site inventory is to be filled in for making accessible to fellow researchers in future.

4.11 Summary :

1. Exploration is the first step in archaeological spade work. It serves as a prelude to excavation. Site survey is the process of locating recording and studying archaeological sites on the basis of their surface features.
2. Each archaeological site has a distinct character of its own. It is either a single cultural site or a multi cultural site. The former is occupied by a single people and the later by a many people over a larger time span. Sites are also classified according to the material of a particular period like pre-historical site, proto historical site.
3. While exploring a site one should not be guided by preconceived notions but should have a result oriented approach. The archaeologist should base his report on the basis of the results. He should not be biased by his hypothesis or objective before commencing the work.
4. The research oriented approach involves formulation of the problem, implementation of the field work involving data acquisition, data processing, data analysis, interpretation of data, dissemination of results.
5. The team work in exploration consists of archaeologist, photographer, draftsman, surveyor, trainees and a tool kit.
6. The investigation are of two types – on site and off site. The investigations also involve analysis of topo-sheets, district gazzeteers, historical literature, ancient manuscripts etc. The methods of exploration also include documentary sources.

A systematic ground survey needs Geo-physical prospecting. The various scientific methods of survey are Magnetic & Thermoremnant, magnetic survey, electricity resistivity survey, survey by metal detector by ground penetrating radar, aerial photography, periscope photography shadow and crop mark.

4.12 Check your Progress –

1. What do you understand by exploration? Explain its aims & Objectives.
2. Discuss the various techniques of explorations.
3. Write short notes on
   a. Toposheets
   b. Problems of explorations
   c. Aerial Photography

4.13.1 Points for discussion

4.13.2 Points for discussion

4.14 References

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UNIT – V
METHODS OF EXCAVATION

5.1 Introduction (Meaning)

Excavation is the scientific way and method of retrieving stationary features concealed by later deposits. Again when the archaeological site is discovered mapped as many as their surface and sub-surface feature as possible, but in order to check the reliability of the surface data, confirm the accuracy of the reconnaissance techniques, excavation is essential.

The archaeological excavation involves removal of superimposed layers one by one in reversal order which gradually reveals the successive stage in the history of the site.

5.2 Objective (Purpose)

Excavation retains its central role in the field work because it yields the most reliable evidence/information viz; (i) knowing human activities at a particular period in the past, (ii) change in these activities from period to period. Broadly speaking, the contemporary activities take place horizontally in space, where as changes in those activities occur vertically through time. It is this distinction between horizontal "slices of time" and vertical sequences through time that forms the basis of most excavation methodology.

The aim of the excavator is to identify, define, uncover, date and interpret each archaeological context of a site by understanding the transformation process in a given environmental condition. The reconstruction of site usually goes in reverse order. (i.e. lower most layer of trench represents earliest level and upper most the latest.)

An archaeological excavation is usually complicated and painstaking process. There are many reasons for carrying out archaeological excavations and many ways to ascertain the appropriate techniques to apply in the field. Above all the success of the excavation and many ways to ascertain the appropriate techniques to apply in the field. Above all the success of the excavation or reaching to a logical end, depends on archaeologist with flexibility and broad mindness in his approach.

5.3 Development of field techniques

It was only from the 19th century till date that a sound methodology of scientific excavation began to be generally adopted by major personalities. First among the pioneers was General Augustus Lane Fox Pitt-Rivers (1827-1900).

For much of his life a professional soldier, Pitt-river brought long experience of military methods, survey and precision into the excavation. Plans, sections and even models were made and the exact position of every object was recorded. He was a champion in his insistence on total recording basing on three dimensional measurement. It was he who brought anthropological,

and sociological approach into archaeological studies. His insistence or recording paved a new way into the archaeological excavation. His excavation report on Cranborne Chase (1877-1898) represents the highest standards of archaeological publication.

5.3.a Sir William Flinders Petrie (1853-1942)

He was an Englishman who did yeoman service to Egyptology as well as to the techniques of field archaeology. He was one of the first few to appreciate the value of pottery for chronological purposes/cross dating purpose. He devised his own technique of seriation or sequence dating, which he used to bring chronological order to the 2200 graves of Naqada cemetery in upper Egypt. This seriation could give a relative dating for materials which were entirely undated otherwise.

5.3.b Sir Mortimer Wheeler (1890-1976)

Wheeler fought in the British army in both world wars and like Pitt-Rivers brought many military precision to his excavation, notably through technique such as grid-square method or horizontal excavation. Later on, he became Director General, Archaeological Survey of India in 1944. His appointment was a great landmark in the annals of Indian archaeology. He brought to India the scientific methods or archaeological excavations which he had developed in England from earlier techniques of Petrie and Pitt-Rivers. He recognised the A.S.I. and expanded its activities in several branches. He conducted well planned and problem oriented excavation at Taxila, Harappa in North-west India and Brahmagiri, Arikamedu in South India. He introduced military discipline into archaeological camps and succeeded in projecting archaeology as a serious profession.

He introduced section, grid system, three-dimensional recording in his excavation made a sweeping change in understanding the human activities both in space and time. The introduction of cultural layer system in excavated trenches simplified the knowing various cultural level i.e. stratigraphy for understanding the chronology of site, (he adopted this method from William Stratasmith a geologist) which earlier pioneers failed to introduced into archaeology discipline.

Thus, various improved excavation techniques introduced by different scholars based on their site observation in different cultural horizons viz; palaeolithic site, rockshelter, megalithic burials, neolithic, chalcolithic, Harappan sites, historical sites etc. The advancement of science made in different disciplines further improved the techniques. Nevertheless, there is no absolute safeguard for any excavation. Therefore, the excavator has to furnish as much information as possible so that the future improvement in the technique may be applied on the published material to reinterpret or get more information on this subject.

5.4 Excavation Principles

Excavation follows exploration. Excavation is digging of the earth and removing the buried soil and in its very nature, it is a destructive and costly process. Therefore, it should never to be undertaken lightly. By its nature; archaeological excavation is a slow, systematic and planned digging to study the nature and contents of the occupation layers in reverse order in which they are laid down, gradually uncovering each successive stages in the history of the site.

The main characteristics of an archaeological excavation are – (i) it is done with great care and planning so that every artifact - be it a building or bead is laid bare and preserved, (ii) its position in relation to the layers of deposits in which it is found (stratification) and in relation to other objects (associate finds) is documented in records for verification at any time, (iii) the data relating to the environmental factors like flora, fauna, soil are recorded and studied to know the ecological setting, (iv) the record of the excavation is made known to the public through publication. Because of the methodical and scientific nature of the work involving special techniques and well tried principles, excavation should be undertaken only by the well trained and experienced archaeologists with a team of experts. The feelings and sensations can only be learned on the site. However there is a minimum common rule to be followed in excavations. The field director may alter the rule from time to time depending on the nature of the site. The followings are some of the common rules complied in the excavation.

i. Check the limit of digging area.

ii. Closely watch the content, colour and composition of soil in the trench.

iii. Excavation should be proceeded horizontally.

iv. More from one trench to another horizontally in the same level until an architectural feature is encountered.

v. Use of excavation knife, khurfi are must, while pick axe is to be used with caution.

vi. Always loosen a small amount of soil with a trowel/pick axe or other appropriate tool.

vii. Take out earth evenly through out the square.

viii. If roots, weeds are present, cut them with root clippers - don't pull at them.

ix. Use soft hair/bristle brush for cleaning the surface and use paint brush to clean the cavities.

x. Maintain the baulk/section sharply.

xi. Always scrap the section from bottom to top.

xii. If potsherd stone or any object projects out of section, it should not be pulled.

xiii. Don't trust your memory - write everything down on the field note book.

xiv. We have to leave the object found in layers there only. These can be removed only if we remove the baulkline.

xv. Each artefact, soil sample, potsherd has to be properly recorded, documented and labelled. Pottery is to be sent to pottery yard.

xvi. Potsherds are to be cleaned properly to observe painting, graffiti, script and also for mending the broken ones.

xvii. Every feature has to be drawn on a graph sheet with clear scale and direction.

xviii. Every feature has to be photographed.

xix. Carry the excavation till natural soil/bed rock is encountered. Don't stop the excavation with sterile layer. There may be some cultural deposit below the sterile layer.

xx. Baulks may be removed, when it is required to get a clear picture of the site.

5.5 Methods of Excavation

Basically there are three processes of excavation one is arbitrary, second is typological and third is the stratigraphy. Arbitrary excavation is the summary of removal of soil by any possible means. Treasure hunters still take recourse to this method. Typological method of excavation is like arbitrary excavation, in which artefacts are classified according to their forms or shape and their relative antiquity assigned on their presumption that the main criterion simple to elaborate, poorly preserved to well preserved, crude to refined is co-related with age.

The stratigraphic excavation is the removal of archaeological deposits in reverse sequence to that in which they are laid down. This method was first used by William Smith also called Strata Smith in 1816. This was adopted for archaeological investigation subsequently for effectively building up chronological frame work of the excavated site. In geology the arrangement of natural layers one above another is called stratification. William Smith was the first to use this method in 1816 and to induct it into the discipline of archaeology. Sir R. E. M. Wheeler was the pioneer who introduced stratigraphic excavation method in Indian archaeology first in the excavation at Taxila (now in Pakistan) in the year 1944.

5.6 Excavation layouts/types

Different strategies and methods have to be adopted in the excavation depending upon the aims, the area and the time available for excavation. Broadly speaking, the statigraphic excavation methods can be placed under two heads namely vertical and horizontal excavation. The vertical

excavation is subdivided into trial trenching or test pit or sondage. It is also called trench cutting, step trench cutting. The horizontal excavation is further subdivided into area/horizontal excavation and open area excavation or site grid excavation. No single method is ever going to be universally applicable. However for convenience we may classify the excavation into following heads.

5.6.a Trial trenching or sondage

Trial tenches serve as preliminary sounding before regular excavation and gives some glimpses of the nature, depth and contents of the archaeological deposit in a given site. They have to be considered as exploratory in nature and they are only means to an end and not an end themselves. The dimensions may be one meter in width for equal measure of depth. They should be laid out and oriented with the grid so that if they produce promising results the area can be extended into square excavation. Indiscriminate sondage digging should be avoided as it would effect the perspective that would be gained by a fallen area excavation. Though it serves as an index to show cultural sequence of site, it is not a substitute for more detailed excavation.

5.6.b Rectangular trenching system or vertical excavation

Vertical excavation is one of the popular methods of excavations. It is primarily to reveal the vertical or temporal dimension within archaeological deposits. Wheeler calls it as substantive trenches. This is useful when the area of dig is small and the objective is more to know the vertical sequence of culture than to have a fuller picture of each and every phase. This is also useful for cross trenching a line of fortification to correlate its stratigraphical sequence with that of the enclosure within. This method was first adopted in Harappa to establish the stratigraphical relationship between two cemeteries far away from each other.

Irrespective of the method, there are certain essential things like fixing datum point and laying grid to be followed in all excavation.

Once the site is selected it is essential to relate the excavation area and grid to permanent features in the landscape. It serves as a control point in all future excavation or it helps to relocate/relay the excavated area in future.

Generally in this system, a rectangular trench of say 2m x 3m, 1m x 2m, 3m x 6m etc. may be laid out with two parallel rows (see diagram). The pegs on one side may be numbered as O, I, II, III, IV and so on whereas the corresponding pegs on the other side as O^1, I^1, , II^2, III^3, IV^4 and so on. If in course of excavation it is felt necessary to extend the trench backward from zero, the pegs of the extended sides can be marked as A, B, C, D on one side and A', B', C', D' on the other. The pegs should be diagonally planted with a central nail at the top which marks the correct measuring point. The peg line acts as the datum line for all measurement in recording

the antiquities. The actual excavation should be done about 50cms. inside the peg line on all sides. This is done to keep the peg and peg line undisturbed throughout excavation.

Another important feature in the rectangular trenching is to leave a number of intermediary baulks at regular intervals. This helps in having proper control over digging and correlating the sections. Artefacts of the excavations are recorded through three-dimensional measurement. Hastinapur, Meerut Dist. (U.P.) is the best example of vertical excavation. (Figure No. 02)

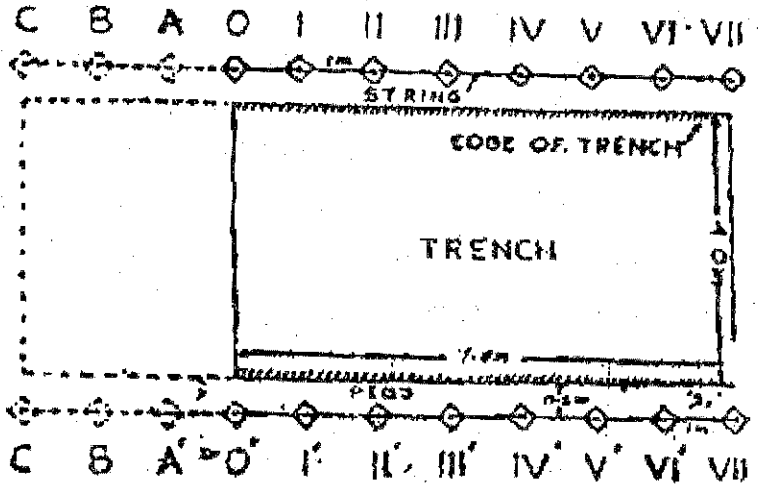

Figure No. 02 (Vertical Excavation)

Merits/Advantages

1. Vertical excavation alone provides a key to the length of occupation and cultural chronology of site.
2. It has a great advantage that within a comparatively shorter time and with less labour and expense, the excavator can obtain the vertical sequence of culture and also a few glimpse of material culture.

But is should be noted that the vertical and horizontal excavations are not mutually exclusively but complementary. The former should precede the latter. The vertical dig reveals the stratified deposits and furnishes the sequential framework, where as the horizontal dig reveals the content of the deposit.

Limitations

1. It does not lend itself for lateral expansion and the excavator's freedom is restricted.
2. It fails to give a fuller picture of material culture of a phase

5.6.c Open area excavation

It is a type of clearing excavation composed of large squares to reveal the horizontal extent of the site without maintaining baulk.

5.6.d Open stripping

Some excavators would resort to open stripping method after knowing the stratigraphy of site on the basis of the results of a series of trial digging of the various part of site. Stripping involves the removal of topsoil accumulations. This method is often employed when time is short or where there is a need for emergency excavation. But this method has to be employed with caution or else the valuable information may be lost.

5.6.e Quadrant method

The quadrant method is the modified version of the grid system. It is one of the efficient ways to investigate small mound/circular mounds such as barrows, megalithic cairn circles and stupas. Small mounds or circular burials have been successfully excavated by this method. The mound or burial is divided into 4 quarters, each of which is excavated sequentially. The quadrant method involves dividing mound into four segments and living standing baulks (50cms.) between them. Here, the baulk becomes a triangular wedge shaped strip of earth and is left standing until the last possible moment. The baulks serve as datum line for recording artefacts as well as preserving the cantour and stratigraphy of the deposit & features. Excavation of each quadrant proceeds systematically and alternately. By this careful method excavator is able to reconstruct the different stages of the burials and also the rituals that are behind them. (Figure No. 03)

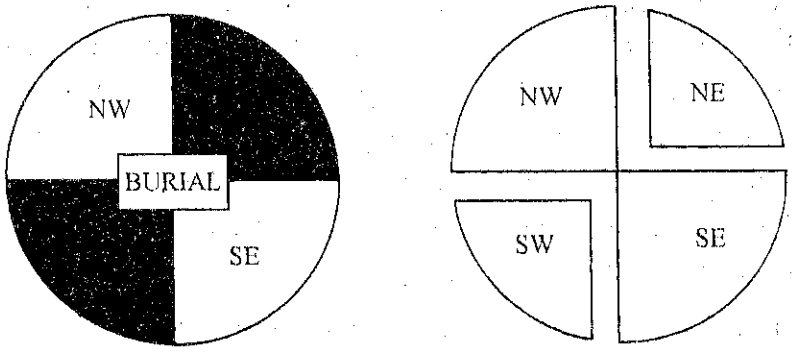

Figure No. 03 (Quadrants)

This method was introduced to India by Wheeler to excavate the megalithic burials at Brahmagiri. Buddhist stupas and other burial mounds are also excavated by means of quadrant method only.

5.6.f Horizontal excavation and grid system or area excavation

Horizontal excavation also known as area or block excavation is a type of clearing excavation composed of large squares to reveal the horizontal extent of the site while preserving a stratigraphic record in the baulks left between the trenches. This method was popularised by the British and Indian archaeologists including Wheeler, Kenyan, B. B. Lal etc.

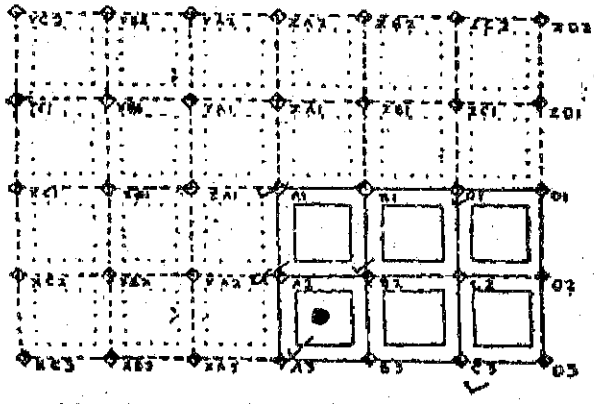

Figure No. 04 (Horizontal or Area Excavation)

The excavation grid or trench areas are to be established in check-board pattern. The grid divides the area into a series of exact squares which are parallel to the site base line (or latitude) and to datum line (longitude). The surveyor lays out the metric grid parallel to the datum line. This orientation is important because it enables the archaeologists to describe accurately any point on the site is relation to the north-south axis. The size of the square boxes will depend on the depth to be excavated site. The squares are separated by the baulk (unexcavated strip of participation) of uniform width of 50cms. or 1mtr. depending on the nature of soil. The baulks are to be retained till the end of the excavation work because these baulks must have the capacity to with stand the traffic of staff members, labourers and equipments. Another important purpose of the baulk is to establish relation between the layers and features of the vertical face of the trench and this also helps the excavator in the correlation of stratigraphy from the different part of the sites. There are two types of baulks. One is primary baulk which is 1mtr. in thick and divides two trenches while minor baulks are 50cms. and divides the quadrants of the trench. There are four quadrants in a trench. (Figure No. 04)

After the grid is laid out and the peg marking done accurately, they can be conveniently named by means of letters one in direction and number in the other. This would enable the excavator to designate and mark the square individually as A1, A2, A3 etc. or B1, B2, B3 and so on. The peg at the junction of four squares will have four different names for its four faces. A1, A2, B1 and B2. The name of trench is to be designated as (A1). Conventionally the north-west peg i.e. (A1) is the index peg and determines the name of the trench. (Figure No. 05)

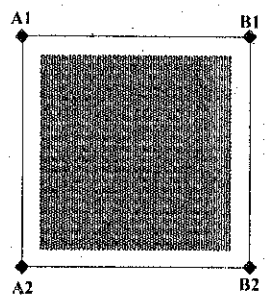

Figure No. 05 (Layout of the Trench A1)

The naming of the grid by choice of the quadrant system is outlined in the following figure. (Figure No. 06)

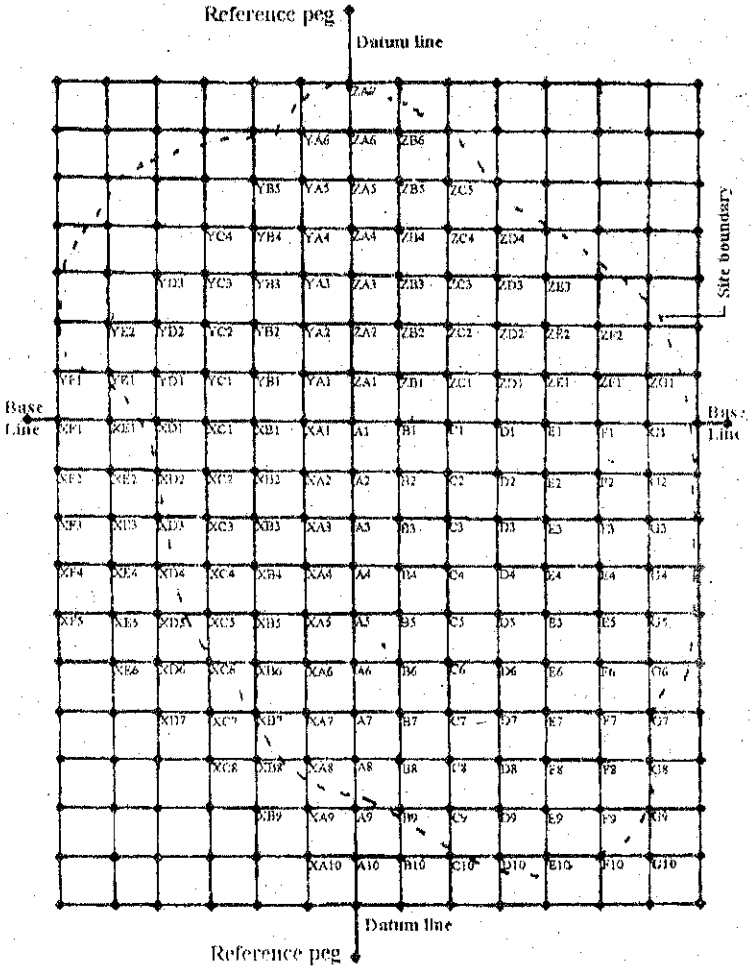

Figure No. 06 (Layout of Grids)

It is always advisable to use letters (in east-west axis) and numbers (in north-south axis). so that it is easily recognised by any staff members.

If the site is a habitation mound the site grid is divisible to four parts of quadrants and naming them AXYZ quadrants (Clockwise).

The excavation marks or numbers the trenches from the centre point of the mound. Sometimes this serves as "*Control square*" or "*Pilot trench*" f.e. (A1) is pilot trench.

If the site is a fortified wall then one has to go according to fortification system. This gives an idea about the nature of the deposit.

The greatest advantage in this grid system is that it lends itself to expansion in any direction without hampering the basic datum line in the section. Therefore, this is a very convenient system to excavate a vast area or town site and every part of it could be plotted and integrated in the overall side grid.

5.7 Stratigraphy

Accumulation of remains of human activities leave sequential layered deposits known as strata (singular stratum). Each stratum may differ below or above it in texture (the size of the soil particles), composition (types of organic or inorganic matter), or texture and composition, as well as colour, thickness, and cultural features. Stratigraphy, therefore, is the study of strata or the different layers and levels of occupation on an archaeological site and their relation to each other, and the determination of the archaeological sequence or order in which they were laid down. In summary, stratigraphy is the study and interpretation of the sequential deposit of site. Archaeologists distinguish between stratification and stratigraphy. Stratification is the existence of superimposed layers and stratigraphy is the study of stratified deposits. So stratigraphy is the archaeological evaluation of the significance of stratification to determine the temporal sequence of data within stratified deposits by using both law of superposition and context evaluations.

Some sites have a long history of occupation and have been built up over a long period of time. This may have many strata, the earliest represented by the lowermost level of the occupation and the latest represented by the topmost level of the occupation. The general rule is that the upper one is later than the lower one. Therefore, the upper stratum will contain the artifacts of later manufacture than the lower one. The archaeologists, however, must not be too hasty in equating sequential deposits with the sequential age of the materials. The context of the artifacts and their comparisons must be carefully evaluated before any conclusion can be drawn.

A stratum is dated by the latest artifacts found in the deposit. A coin or well-dated inscribed potsherd/seals are found in a particular undisturbed layer would give definite date for the layer or level. When objects of material culture are found, they can not be dated to a specific year.

Instead, archaeologist assigns a time span during which they must have in use. The time span may cover one or more centuries like 3rd century BC to 1st century B.C. The difference between the terminus ante quem (Latin word meaning limit before which - in this case 3rd c. BC) and terminus post quem (limit after which) would therefore indicate the life span of the level. These terms are used in relation to undisturbed layers. If a stratum is disturbed by layer of intrusion such as postholes, foundations, pits (storage, soil, rubbish, clay and other pits) or robber trenches (areas from which the stones or bricks of an earlier structure have been removed or robbed to be re-used in a new construction) and human or animal or natural agencies like rat hole and ditches then sealing layer of these activities are considered for dating. Therefore, archaeologists must be careful in identifying the material, formed out of primary activity or secondary activity. The erosion, earthquakes and other such activities sometimes totally reverse the cultural sequence. Therefore, stratigraphy can be understood upon prolonged observation and inference. The field director, artifact analyst, supervisor, draftsman, pottery yard analyst and other fellow members should interact frequently to identify the layers. (Figure No. 07)

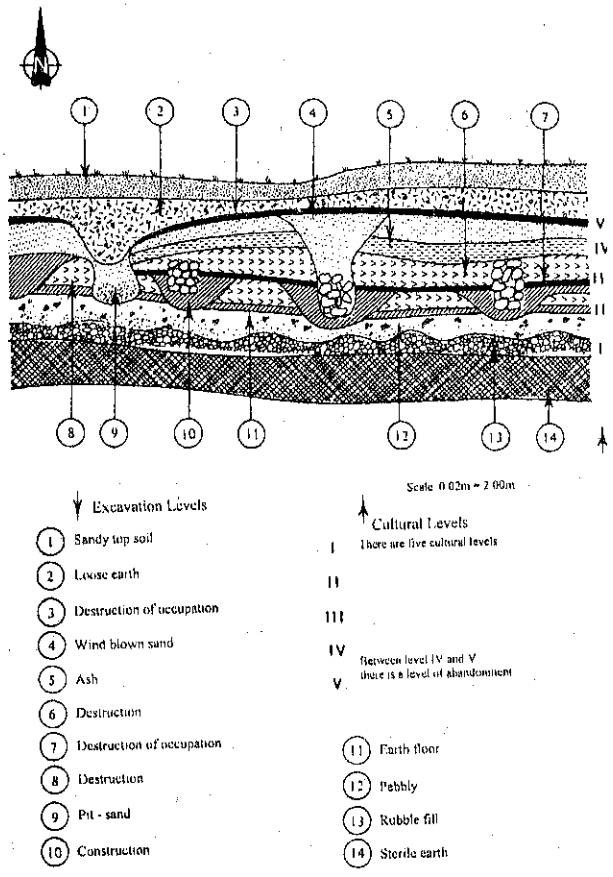

Figure No. 07 (Description of Layers)

Stratigraphy is an index to the history of the site and used as primary source of interpretation. It provides a perspective of the chronology; the geological, fauna and flora histories of the site along with the varied human activities like contemporary indutries, architectural edifices and their cultural changes. Therefore careful observation and recording of stratigraphical evidence is absolutely essential for any interpretation of a site. Without recoursing to stratigraphy an archaeological excavation is a misnomer, meaningless, and shear wastage of time, money and energy.

5.8 Pits, Post holes and robbers trench

There are many common factors which cause disturbance to the strata and they have to be recognised by the excavator are pits, post holes and robber's trenches.

Pits : Any pit dug at a time either as a refuse or storage pit or for a well, the material in the pit would be co-eval with the time when the pit was dug and not with the material found in the layers it had cut through. The antiquities found in the pit-filling should be separated from those found in the layers. Though they may be found in the same level, they belong to two different periods.

Post holes : Post holes are usually larger than the diameters of the post. They are found in the border or centre of the house plan. If the sub-soil is soft, it is usually packed with small pebbles particularly at bottom. The posts inserted into them may be removed/decomposed and replaced by soil. Dust and silt will accumulate at the top. So post holes always had filling pattern from top to bottom and differ from surrounding area by colour, texture or both.

Robber's trench : Robbers trench in excavation is a stone wall from which stones have been removed in ancient times for use/re-use. These can be detected by colour contrast between them and surrounding soil. This also causes disturbance to the earliest strata and hence theye have to be carefully isolated as a separate unit for study.

5.9 Excavation of structural remains

Structures form an important part of any site especially of the proto-historic and historical times. The structures uncovered from the excavation include mud walls, mud brick walls, floors, drains, streets, roads etc. So it is the duty of the excavator to lay bare the plan of the structure, to know the pattern of construction, to expose the successive occupation levels associated with the structures and to identify its purpose and utility.

All the architectural members like walls, floors, hearths, pits, robbers trenches should be serially numbered and labelled properly. All sorts of artefacts found from intrusion (weathering soil erosion and snakes and rodents) often carry objects from one stratum to another stratum. These should be labelled and kept separately.

5.9.a Alignment of stone brick Structures :

Systematic and deliberate arrangement of stone/brick both vertically and horizontally one above another or one after other is called structure. These are generally encountered in excavation. The duty of excavator is to know the full plan/elevation of excavated structure, whether it is circular, square or rectangular in fashion, to know the pattern of structure the materials of which they were made of, history of structure, its utility and purpose of construction. While excavating the structure one should avoid the common impulse "Find a wall and follow it".

5.9.b Floor Level :

Secondly, the floor level, an easily recognisable feature is often hard packed and generally associated with some sort of wall or ledge or post hole. It is important to interpret their composition as well as their dimension. The artifacts found in the floor level are extremely helpful in determining the cultural setting of a structure.

Thirdly walls are represented either by foundation or merely by trenches leftout by stone. Robbers (robbers trench) wall is extremely important in archaeological excavation.

What ever these may be, whether this is a floor, a wall or a structure uncovered from excavation required to be properly documented, photographed and drawing drawn.

5.9.c Section

Vertical section in an excavated trench must be cleared from the top downwards with the help of trowel and excavators knife or with specially made section trimmer. Potruding stone/ tiles should not be removed and they may be cleared around and left in the surface as it is. Section is the mirror of the excavation.

5.9.d Pottery yard

Pottery is regarded as the alphabet of archaeology. Pottery is recovered abundantly from the excavation. Due to their imperishable and ubiquituous nature, they serve as a good index of cultural continuity or diversity. It is therefore, the first and foremost task of the excavator to document ceramic evidence of the site and to segregate the pottery of each stratum of the trench as the digging precedes. This is best done by setting up a pottery yard as an important adjunct to the excavation grid. It should not be far off from the site and its layout should be just on the line of the layout of trenches. For example if there are 10 trenches taken up for digging namely, A1, B1, C1, D1, E1, F1, G1, H1, I1, J1, K1 the layout of pottery yard should also follow the same order with the division of layer. (Figure No. 08)

Trench No.

Layer No.	A	B	C	D	E	F	G
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							

(Figure No. 08) Layout of Pottery Yard

The pottery assistant is incharge of pottery yard. It is the preamble of the whole excavation.

The above are some of the procedures to be followed at the time of excavation. However, the director is the final authority on the conduct/nature of procedure to be followed during excavation. He takes final decision based on his academic/field experience.

5.10 Excavation Staff and Equipment

Excavation is an elaborate process involving time, money, labour and equipment. The services of different technical persons are needed at different stages of excavation - selection of site, setting up camp, layout of trenches, excavation, proper documentation of the evidence, sorting and transportation of the materials to the headquarters and preparation of technical reports. There should be no prescribed strength and the team consists of a Director, assisted by technical personnels, Archaeologists, trench supervisor, photographer, surveyor, draftsman, foreman or store keeper and above all labourer. The chief equipments employed for excavation camp are tents, tent equipments, (cot , bed, Tarpauline) water facilities camp, kitchen, draftsman's equipment, surveyor's equipments, photographer's equipments as required. But the excavation equipment required by archaeologists and labourers who actually execute the work at site are pick axes, excavator's knives, shavels, crow-bars, trowels, iron pans, angle measures, brushes, scissors, root clipper, tapes, pottery bags, pottery labels, cloth mounted envelopes, site note

books, quick fix, essential chemicals as preservative, first aid box etc. During the excavation work a jeep is a must for camp. The other things are as and when required to be purchased by store keeper from local market.

5.11 Summary –

Excavation can be considered as the main scientific method of knowing the human activities in different periods of time. Stratigraphy is the removal of archaeological deposits in reverse sequence to that in which they are laid down. In the reconstruction of a site the lowermost layer of the trench represents the earliest level and uppermost the latest.

The development of excavation techniques has a long history. Among the pioneers of this field are Sir Willem Handry Pettrii and Sir Mortimer Wheeler.

The various methods of excavation include trial trenching, rectangular trenching, horizontal excavations, open area excavation and quadrant method.

The archaoelogist has to have a good idea of the factors which cause disturbance to the strata like pits, post holes, robbers trench and structures. The excavator should also document ceramic evidence of the site and to seggrigate the pottery of each stratums of the trench as the digging proceeds.

5.12 Check your progress-

1. Write a critical note on the history and role of excavation methods.
2. Discuss the various scientific methods of excavation.

5.13. Suggested Readings –

1. Atkinson R.J.C. – *Field Archaeology* London, 1953
2. Dancey W.S. – *Archaeological Field Methods. An Introduction* Minneapalis, 1981
3. Drewelt L. Peter – *Field Archaeology an Introduction*, London, 1999
4. Rajan K. – *Archaeology, Principles and Methods*, Thanjavur, 2002
5. Wheeler REM – *Archaeology from the Earth*. Baltmore 1961

UNIT – VI
SURVEYING AND OTHER TECHNIQUES

6.1 Introduction (Meaning)

Archaeological excavation is a recorded destruction and waste of time, unless it is adequately recorded and well planned in the form of specialised survey method, surveying as measured drawings. Hence all archaeologists are concerned with surveying as means of planning layout of area of the excavation and keeping a record of artefacts, and structures with measured drawings. Surveying and drawing are two sides of the coins of excavation. If surveying is the first step in archaeological work, then drawings are the last step before the completion of the excavation. The survey in archaeological operation deals in macro-level measurement of the site, while drawing involves the microlevel measurement of the uncovered artefacts, objects, structures etc. It is therefore, imperative that all archaeologists should be thorough in basics of survey and drawings. They need to know how to use or read existing maps and develop their own site map.

Again, surveying is a branch of science that accurately determines the shape, area and position of a site's surface through measurement of horizontal and vertical distances. It determines the direction and relation of angles among the features.

In recent years, land surveying has been revolutionized by the introduction of Electronic Distance Measurement (EDM) equipment and the total station, together with satellite based Global Positioning System (GPS). The survey of India Cartography Division has also prepared 1 : 20 to, 1 : 500, 1 : 1000 scale maps which are immensely useful for archaeological surveyor.

6.2 Objective

Purpose of archaeological surveying :

The purpose of archaeological survey are as follows :

i. To locate the site
ii. To determine the site boundaries
iii. To complete the plot area
iv. To establish the trench or grid pattern
v. To describe the topographic nature
vi. To measure the site
vii. To locate the findspot within the site
viii. To prepare complete composite map of the area

6.3 Classes & types of Survey

There are two principal classes of survey namely plane survey and geodetic survey (Geodetic surveys are used for the study of large areas i.e. countries and continent). In archaeological survey, plane survey is needed.

In archaeology, many types of plane survey may be required depending upon site, its size and the information desired. There are three types of survey viz; (i) land survey, (ii) topographic survey and (iii) on going excavation survey.

Land Survey

Land survey is co-ordinated with the establishment of a site datum point, the datum line, the base line and the position of the overall site grid for proper planning and laying out of site.

Topographic Survey

It should be made to show the contours of the site and the natural features of the area for understanding environment of the surrounding of site. It is conducted before the excavation begins.

On going Excavation Survey

It is made at each level as the excavated area for understanding the design of ancient structure which would inturn help to determine the area to be probed.

6.4 Role of Surveyor

The above surveying works are made by the qualified surveyor. It is he who helps the director in laying out trenches for excavation, preparing general plan and contour plan of the

site, so that the relative heights of the parts of the mounds are clearly brought out. Marked, undulation depression and elevation would come off well, indicating the nature of the plan of site. He lays out the trenches and area of excavation and fixes the pegs according to the chosen measurements. Peg marks the basic datum line for all measurement and so should be accurately and firmly fixed by the surveyors. He also prepares scale drawing of the entire mound and shows the excavated trenches.

6.5 Mean & equipments of Survey

6.5.a Types of Maps & Imagery

Two types of maps and imageries which are available in India and are helpful for archaeological operation are : the topographical maps prepared by Survey of India & Remote Sensing Imageries prepared by National Remote Sensing Agency (NRSA). These are important maps for archaeologists. Before the introduction of satellite imageries, only topographical maps were used.

In topographic maps, the standardized cartographic symbols are used to represent natural cultural features like road (red), vegetation (green), water (blue), urban area (pink) and contour lines (brown). Contour lines are a cartographic device used as topographic maps to represent land form. Contour lines are imagery lines that connect equal elevation (isolines). The space between contour lines is called contour intervals. The locations of precisely determined points of elevation is called bench mark.

6.5.b Remote Sensing Imagery

Remote sensing is the process of obtaining images of earth's surface from suborbital and orbital altitudes in various wavelengths of the visible and invisible spectrum without having physical contact with the object. It provides information on vegetation, land form, waterbody, mineral zones and so on pertaining to a large area. N.R.S.A., Hyderabad through Indian Remote Sensing satellite supplies the imageries.

6.5.c Global Positioning System (GPS) & Mapping

Of late, the Global Positioning System (GPS) is a satellite system for navigation that determines nearly our exact position on earth. The importance of GPS for archaeology lies in the fact that with this positioning system one can determine the geocoordinates (latitude & longitude) and elevation. Another advantage of the GPS is that if one knows the geocoordinates of already recorded site, one can simply enter co-ordinates of the site and the handheld GPS receiver shall guide one to that location.

6.5.d Geographical Information Systems (GIS)

The systems that are collectively called Geographical Information System have developed primarily from older computer mapping system, such as system mapping and remote sensing technology. There are quite a number of GIS software available among which Arc Info Arc View and Idrisi are widely used for archaeological purpose. The former is vector based and the latter is Rastor based spetems.

6.5.e Cartographic Software

The computer aided technological development that had fallen place in the last decade revolutionised the archaeological mapping. This makes it easier to prepare high quality longlasting site maps and saves much energy and time.

6.5.f Computer Assisted Drafting (CAD)

Archaeological maps can be produced rapidly with the help of Computer Assisted Drafting (CAD) packages. These programmes allow the users to create horizontal, vertical and angled dimensions in a variety of styles.

6.5.g Surveying equipment

Following are the important equipments of the surveyor for conducting survey of archaeological site.

1. Theodolite
2. Dumpy level
3. Levelling staff
4. Prismatic compass
5. Survey level
6. Survey chain
7. Tripod stand
8. Plane table
9. Drawing board
10. Metallic tape
11. Bubble level
12. Steel tape
13. Folding scale
14. Architectural scale

15. Parallel roller
16. Protactor
17. Set square
18. T. Square
19. Drawing paper
20. Drawing pen
21. Drawing pencil
22. Iron pegs
23. Wooden pegs
24. Strings
25. Survey umbrella
26. Graph sheet
27. Indian Ink and Pen
28. Small note book
29. Nails

6.6 Terms used in Survey

In addition, there are certain terms used by the surveyors. Few such terms are given below.

Traverse : Traverse is used in measuring the length and directions of a series of connected straight lines.

Triangulations : It is based on geometric theorem that if one side and 2 angles of any triangle are known, the remaining two sides can be determined.

Bench Mark (BM) : A bench mark is a relatively permanent point of known elevation, which used to establish other elevation. It is important to check bench mark available nearer to the site.

Theodolite : Theodolite is an optical versatile instrument used for measuring angles is often employed for setting out the grids.

Datum Line : The imaginary line known as datum line is measured in north-south direction. In archaeological investigations the survey or laying a site grid begins with a permanent control point called site datum point. This serves as a reference point in all future work at the site. Once the datum point is established the excavation trenches or grid can be laid with ease. There grids usually serve as a prelude to any horizontal excavation. Its orientation is so important that it helps to locate accurately any point of the site.

Base Line : The east-west line is known as the base line. While the north-south line called meridium or datum line.

Site Map : A map showing the exact location of the excavated site, the village or town in which it is situated along with the other landmarks is the vicinity like the hills, river etc. has to be prepared by surveyor. And this can be done on the basis of the toposheet prepared by Survey of India. The survey map should show all these details and the excavated trenches set in these surroundings, This is prepared by methods like chain survey or plain table survey or level surveying.

Contour Map : The site map may also incorporate the contour line or levels of elevation of the land marks. The relative heights of the features in a given site can be brought out by the contour plan for which the usual base line is the bench mark showing the Mean Sea Level (MSL). The relative levels of the different portions of a city can abe indicated as well as a number of other factors like the height of hill or the gradient of an old dried up channel particularly in the prehistoric sites, the relative elevations of the old river terraces can be plotted in the contour map. (Figure No. 09)

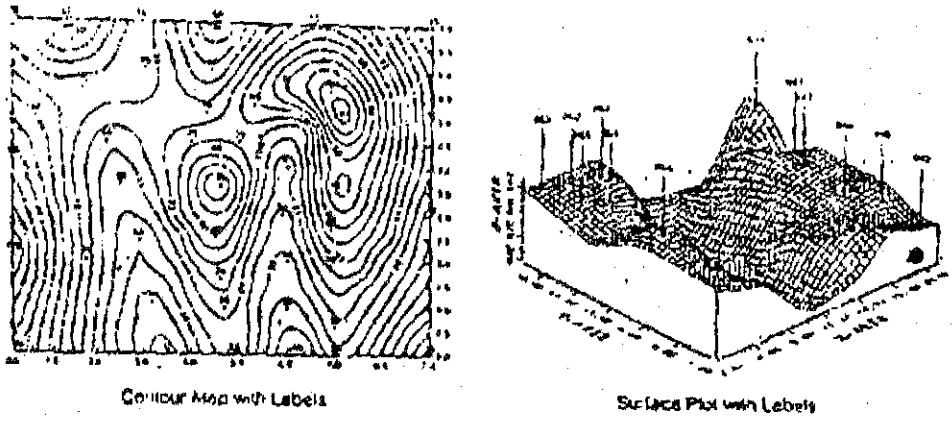

Figure No. 09 (Contour Map)

6.7 Drawings

Like surveying, drawings or graphic information in archaeology are also equally important. Drawings contribute a lot for the recording part of the excavation. As excavation is altogether meaningless, unless proper records in terms of drawings of uncovered artefact, objects, structures etc. are kept. These will prove immensely beneficial for interpretation and report writing purpose. The job is entrusted to a qualified draftsman. His work is complementary to that of photographer. His plans and drawings form the bulk of illustrations that go with publication. The following jobs are attended by the draftsman in archaeological excavation.

i. Drawings of plans sections and elevations of the excavated structure.

ii. Section drawing showing layers, pits, structure.

iii. Pottery drawings including section, elevation designs and graffit.

iv. Drawings of antiquities.

v. Preparation of models

6.7.a Draftsman's Equipments

His equipments are the same as that of a surveyor except, theodolite, dumpy level, levelling staff, prismatic compass, survey level, survey, chain etc.

6.7.b Section Drawing

Graham Webster rightly observes "Structure and features with their stratigraphical relationship are best demonstrated by drawings". Clear, neat, accurate, comprehensive sections and plan drawing are the basic forms in which the evidence is represented for better understanding, interpretation and finalizing the report. These neat and accurate section drawings illustrate the sequence of cultural deposits associated structure and disturbances to the stratification. As the digging proceeds and the layers are laid bare, they are immediately identified and labelled on the sections of the trench. The next task is to draw them on scale on the graph sheet or tracing cloth. This can be done at convenient intervals during the excavations. After the excavation is completed i.e. digging upto natural soil level is done, the entire trench (section of all four sides) is ready for a comprehensive drawing and recording to the scale.

6.8 Section & procedure for drawing section

The section is a scale measured drawing of the vertical profile of the state of the site including interrelationship of soil, trench wall, baulks and architectural features. The section should contain all details like scale, direction, position, trench number, data, name of the draftsman, plan number, level/layer depth and so on. Sections are a diagramatic renditionof the stratigraphy and represent one of the most important field operation because once baulks are drawn they may be remarked and their information goes with their removal.

6.8.a Procedure for drawing section

Section drawing may be drawn with reference to the baulks datum line with 20cms. interval so that greater amount of details can be obtained. The datum line should be checked with bubble levels to maintain absolute level. Any suitable scale for measuring can be adopted depending on the length of the section to be drawn. But a uniform scale is to be adopted for all section in a site for easy correlation. The standard scale is 5 cms., 10 cms. for 1 mtrs.

Certain conventional symbols are used to distinguish various types of earth strata in the section drawing. The diversity of the deposit like sand, clay, gravel, stone pebble, charcoal, compact soil, loose soil, debris layer can be intelligibly drawn by using such symbols (Figure No.10).

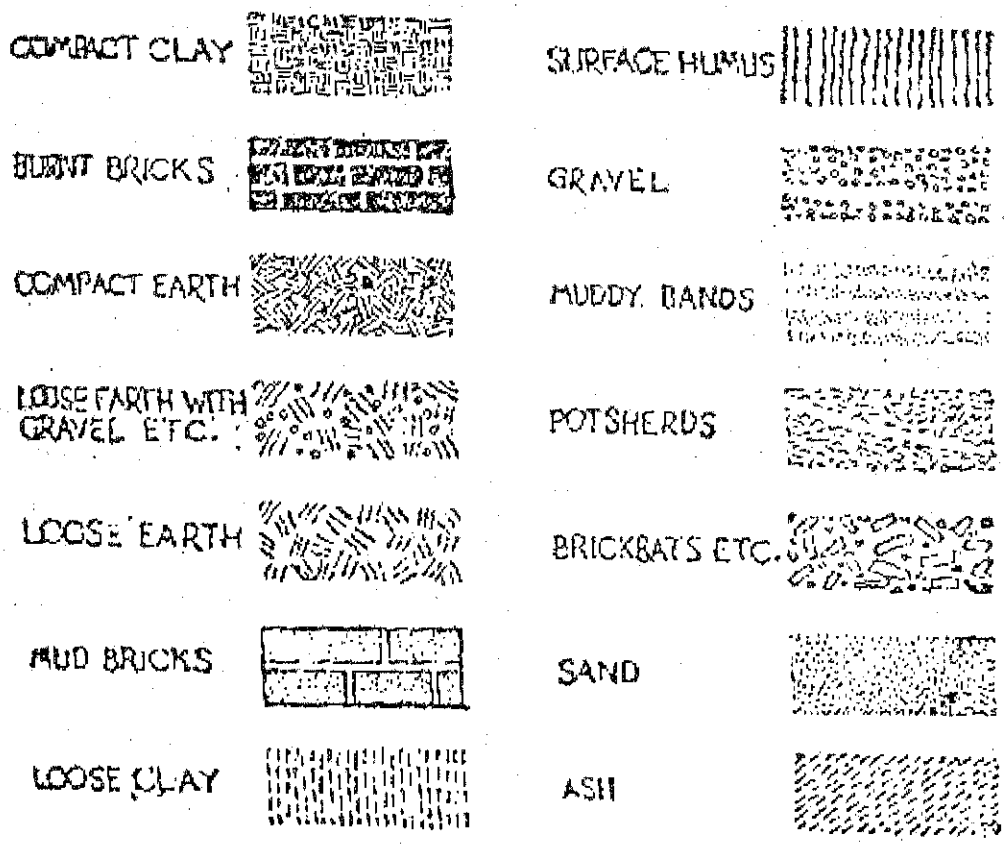

Figure No. 10 (Symbols for Section)

6.9 Plans

Plan drawing is another important constituent of the excavation records and it is indeed complementary to the section drawing. While section gives the vertical profile, the plan provides horizontal picture of the object from top. Features like room walls, flooring, hearth, soakage pit, burial, street, drainage found at a particular level, when plotted, would clearly show the overall orientation and their inter-relationship.

Apart from this, plan drawings of all the features has to be prepared to show their length and breadth. The peg points can serve as the datum point for taking measurements by triangulation method.

6.10 Elevation

The procedure for drawing elevation is almost as similar those of the section. Hence the draftsman is to draw the individual structures in trench denoting its extant height, the number of courses of brick/stone it is composed of and other minute details which can be incorporated.

6.11 Pottery Drawing

Pottery is the alphabet of archaeology and the study of pottery is very important for an archaeologist. It serve as a good indicator of prevalance and spread of an associated culture in an area. Martha Joukowsky points out that pottery probably provides the single most important yard stick for measuring technological and stylistic developments. Hence their classification and detail drawing of their representative types of different periods should be done to the scale on the drawing sheets in Indian ink by a dexterous draftsman.

The standard method of drawing pottery is to show the section and internal surface on the left hand side and the external surface on the right. The basic measurement is the rim fragment which can be guaged on a rim scale the area of which is drawn out in a series of radii. The rim is moved up and down the scale until its curves fits one of them. Once the diameter is determined, the same should be drawn horizontally and bisected by a perpendicular line. The left half is meant to show the details of the section and the right hand half shows the details of elevation. Full pot can be measured by placing it suitably against graduated horizontal and vertical rules by taking offsets from them to the pot at various points. Fragments not having rim portion but having features like painting designs, inscriptions may be drawn to the size on the sheet along with the features. Straitions and colour variations can be indicated by suitable lines or shadings as the case may be. When all selected pottery pieces are thus drawn in Indian ink, they can be serially numbered platewise and described. The description will give the details about the colour type or sub-type, the physical profile manufacturing technique, designs etc. (Figure No. 11)

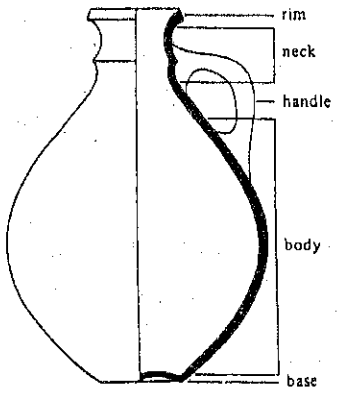

Figure No. 11 (Parts of Pottery)

All these aspects of survey and drawing are of utmost importance and the methods applied in archaeological mapping (contour plan) and graphics of site plan, elevation, section drawing, drawing of artefacts ultimately supplement and complement for the final preparation of report of excavation.

Apart from these systematic ground survey specialised survey methods highlighted already in exploration technique are also of immense importance in archaeological survey/ exploration. They are as follows.

6.12 Systematic Ground Survey

But the systematic ground survey calls for a number of other scientific parameters spread in a continuous way on the ground that must be mapped for detailed study of the site. These are to be accomplished with the help of following various scientific aids.

6.12.a Geo-physical prospecting

Magnetic and Thermo Remnant Magnetic Survey

The proton magnetic meter is highly sensitive apparatus for detecting buried irons and certain kinds of soil. Of course, this is to be used with caution.

By thermo remnant magnetic survey, existance of burnt clay artefacts, burnt brick structures and conflagration of site in past could be detected. This magnetometry is probably still the most widely employed method. It was initially developed by one physicist Martin J. Aitkein of Oxford University in the 1950s.

6.12.b Electricity Resistivity Survey

The resistivity meter is based on the fact that the ground can conduct electricity. Different soils or rocks or sediments conduct differently. This was also first developed in the 1950 as an archaeological tool by Aitken at Oxford in 1950. It is an active method that required passing a small alternating current through the ground. Electrical conductivity of soil depends on its nature. They will show wide divergence in their resistivity. This kind of survey is suitable for training the wall or a road. Negative resistivity anomoly would indicate a ditch or pit, while positive anamoly shows a structure of high resistance viz; a well, floor etc.

6.12.c Metal Detector

Metal detector can be of great help to archaeologist, particularly in giving quick general result and locating modern metal objects that may lie near the surface.

6.12.d Exploration by sounding

Sometimes tapping the ground at various spots would emit differential sound. Depending upon the compactness of the soil or structure below, the sand from the natural or undisturbed

soil would be different from that of the disturbed one or artificially accumulated one. This method is not always dependable.

6.12.e Stereoscopy

It involves the use of overlapping pairs of photographs, which are mounted in the plotting instrument to determine the orientation of the camera and its negatives at the time of exposure. A model on the ground is created and this model is put into scale and oriented to a datum line. That is provided by ground control points. The detail of the area and contours are transferred to the mapping sheet by the aid of the optical and mechanical linkages of the plotting instrument.

6.12.f Periscope photography

Periscope photography was developed by the Lerici Foundation in Italy to document Etruscan tombs. The device, which consists of a probe with a miniature camera and flash attachment located near its end, can be lowered into a tomb buried in the ground and rotated in an empty space of the chamber. This provides a photographic panoramic view of the chamber. This helps the excavator to select the potential tombs.

6.12.g Ground-penetrating radar

In this method, an electromagnetic pulse is released into the ground. The return time of the electromagnetic pulses variation depends upon the density and distance of the subsurface content. This variation is measured. This method has been successfully employed in the location of buried walls, houses with highly compact floors, foundations and any buried stone architectural column.

6.12.h Geochemical Analysis

The soil of ancient settlement often contains high concentration of phosphates from organic refuses and these organic refuses are served as fertilizer for local cultivator. On the basis of this kind of soil analysis, archaeologists were successful in defining sites.

6.13 Specialised Survey Methods

6.13.a Aerial Survey/Photography

Airborne method of archaeological survey helps to have a bird's eye view of the ancient settlement as a whole, which is impossible from the ground and certain features other which are not visible from the ground. Aerial photography is a non-destructive technique used in U. K. and Europe since early 20th century A.D. and in India post-independence period. This process is also known as aerial archaeology. Several ancient sites in India and Pakistan have undergone such process viz; Taxila (now in Pakistan), Sisupalgarh, more recently Sravasti in U.P. The aerial photography is done through ballon camera or from helicopter/aeroplane. Through this,

layout of ancient cites, criss-cross roads, streets, alignment of houses are vividly picturised which helps the archaeologists to plan for his further spade work in the area.

6.13.b Shadow marks

The buried structures can sometimes be detected by tracing the photographed outlines of shadows caused by different heights of vegetation growth. The vegetation grows better where soil is deep and contains greater amount of moisture; conversely, if there are underlying structures this will result in lack of soil depth and moisture. These shadow marks can be seen in the early morning or late evening lights.

6.13.c Soil marks

Soil marks of ancient structures often stand out in aerial photographs, because a decaying structure contains and collects a different type of soil than the surrounding area. This difference can be detected by trained eye in aerial photograph. Soil marks may show up in any area but they are usually at their best in ploughed fields. Patterns of different coloured soils will reflect what is being ploughed into the surface. These patterns may be clear, say a rectangle representing an enclosure, or very blurred as the result of long-term ploughing and mixing of the soils. Each element of an archaeological site is likely to be made up of different coloured soils. Areas of burning may show up as red or black, habitation areas could be grey or black, ditches may silt in with dark, humid soil in contrast to the plough-flattened bank which will show up the colour of the present rock, say white for chalk.

6.13.d Crop marks

Crop marks are also an important indicator of buried features and often it produces the most dramatic aerial photographs. Crop marks are basically the result of the differential speed and quality of crop growth and ripening, depending on sub-surface conditions. Crops above a ditch or moat will grow more rapidly and strongly. For instance, cereals grow shorter and turn yellow earlier when they have been planted over a buried structure, but they grow taller and ripen later when planted over pits. The symmetrical difference in vegetation growth would provide information on the nature of buried structure.

Shadow marks, soil marks and crop marks all produce patterns visible to the observer flying above. But careful selection of the angle of the photograph and the type of film will make the reading easier.

Recent development in Aerial photography and Photogrammetry

New technology is also having an impact on aerial photography in other ways. The technique of transforming aerial photography into a scaled plan in an important development which helps

us to get a graphic and enlarged view of the site. Further computer enhancement of pictures improves their sharpness and contrast. Digital imagery has also been introduced. Photographs are quantified in digital form. This process is called photogrammetry. This has enabled archaeologists to get rapid and accurate method of map-making. Though aerial survey is expensive, it has came to play a vital role in archaeological reconnaissance all over the world. This conventional air photography continues to be commonest and most cost effective technique of aerial reconnaissance for most archaeological purposes.

6.14 Remote sensing & satellite imagery

The use of satellite imagery is now part of archaeological research. As the images become more available and cheaper, their particular advantages, they are multi-spectral and are taken all year round, may assist in discovering and monitoring sites. The satellite images can detect larger archaeological features. Palaeo channels, not visible by conventional aerial photography are just visible using enhanced satellite images. By using this, the course of dried up Saraswati river is detected. The application of these exciting new techniques to archaeology is very recent. It would be come cheaper and more wide spread in the near future.

Though the specialised ground survey methods help in detecting or tracing the archaeological remains but the actual ground work are to be done manually for obtaining minute accuracy and exact dimension.

Thus survey plays a major role in archaeological field work be it in exploration of in excavation.

6.15 Summary –

- Surveying is the act of determining the relative position of points on, above or beneath the surface of earth by means of direct or indirect measurments of distance, direction and elevation.
- Is is used for fixing the boundary of an area (work area) and ascertaining its topography and including the key features.
- Using this information a plan or a site map is plotted which gives the top view of the area. The features in the plan are represented with base line as a fixed line.
- The elevation of various points are measured with respect to a fixed datum line.
- Contours are lines joining points of same elevation. A Countour map gives an ideaof relative elevations of features.
- Advanced technologies like GPS. GIS Cartographic software and CAD are used these days for mapping.

- Graphic information is very important in archaeological surveys and are noted as drawings. The jobs that require drawings are:–
  - elevations, plans and sections of excavated structures.
  - A sectional drawing represents the profile or cross section of a surface or an object. It is drawn to a scale corresponding to actual dimensions.
  - Section drawings which show layers, pits, structure.
  - Pottery drawing including, section, elevation design and graphits as pottery provides an important yardstick for measuring technological and stylistic development.
  - drawing of antiquities and preparation of models.

* A no. of scientific aids are used in ground survey viz.
  - **Magnetic and thermo remnant magnetic survey :** for detecting ions and certain kinds of soils.
  - **Electricity resistant survey :** for detecting ditches, pits or wells, floor etc.
  - **Principle :** different soils or rocks conduct differently.
  - **Metal detector :** for detecting metals.
  - **Sound detection :** for determining compactness of soils.
  - **Principle :** Sounds deflected from various soils are different.
  - **Stereoscopy :** details of area are transferred to mapping sheet using optical and mechanical linkages.
  - **Periscope photography :** to get photographic view of chamber using a probe with a camera.
  - **Ground penetrating radar :** To locate buried walls houses, compacted floors etc. by noting the time of return of electromagnetic waves.
  - **Geochemical analysis :** chemical analysis of soil.

* Besides these, some specialised survey methods are also used viz.

  Aerial survey/photography – gives birds eye view of a settlement as a whole.

  Shadow marks – detecting buried structures by tracing photographed outlines of shadows caused by different heights of vegetation growth.

  Soil Marks – different areas show different colours as per the soils.

Crop Marks – are results of differential speed and quality of crop growth and ripening depending on sub surface conditions.

* Remote sensing and satellite imagery are also used these days in discovering and monitoring sites.

6.16 Check your Progress

1. What is surveying? What are its purposes?
2. Describe briefly the various aids used in systematic ground survey.
3. Write a short note on specialised survey methods and recent developments in them.
4. Explain the importance of graphic illustrations in archaeological survey.

6.17 Suggested Readings –

1. Barker Philip – *Techniques of Archaeological Excavation*, London 1977
2. Dancey W.S. – *Archaeological field methods An Introduction*, 1981
3. Drewelt L. Peter – *Field Archaeology, An Introduction* UCL Press, London 1999
4. Hester R. Thomas, flarey and kenneth field - *Methods in Archaeology* California, 1997
5. Rajan K. – *Archaeology Principles and Methods*, Thanjavur 2002
6. Wheeler W. – *Archaeology from the earth*, Baltmore 1961.

BLOCK – III
STRATIGRAPHY AND RECORD WRITING

UNIT – VII
STRATIGRAPHY

7.1. Introduction –

The most important part of field archaeology is stratigraphy, which is the study of strata (singular stratum) or the different layers and levels of occupation on an archaeological site and their relation to each other, and the determination of the archaeological sequence or order in which they were laid down. Accumulations from and variations in human living patterns leave sequential layered deposits known as strata. Each stratum may differ from those above or below it in texture (the size of the soil particles), composition (types of organic or inorganic matter), or texture and composition, as well as colour, thickness, and cultural archaeological features. Different strata in a site are proof of changing conditions and man's unpredictable activity during the time required for their accumulation. Strata rarely have uniform characteristics, because there are always changes and variations in man' s living patterns, in the rate of accumulation and even in the collection of sterile deposits.

7.2. Objective –

Stratigraphy is a natural and cultural layering of the soil at a site. It gives information about the age of the site in case of single cultural site or the relative ages in case of multi cultural site. Hence

the object of the unit is to give the student a correct idea of gathering information and interpretation of the hypothesis regarding the history of the site as a whole, which, would result in an accurate archaeological recording.

7.3. Meaning of Stratification –

The whole archaeological investigation is based on the principle of stratification. The basic principles of stratification, borrowed from geology, are superimposition, uniformitarianism and sequence. These three principles are interrelated. The superimposition basically means that if there is no disturbance caused by natural or human agencies, the lowest stratum would be oldest and topmost stratum would be latest. This principle for the first time in geology was used by William Smith, who is known as Strata Smith. He had established the differences among the strata on the basis of fossil evidence and a sequence on the basis of evolution of fossils. Uniformitarianism is that there will always be uniformity in the formation of a stratum. The sequence is that if there is no disturbance in the deposition there will not be any disturbance in sequence.

The archaeologist distinguishes between stratification and stratigraphy. Stratification is the existence of superimposed layers and stratigraphy is the study and interpretation of stratified deposits.

Stratified deposits, as indicated earlier, are also made by natural agencies like water, wind, glaciers, etc. For the study of man, speciaJly in Pleistocene and early Holocene period, these layers formed by natural agencies are termed as geological deposits in which aI1ifacts of early man, his skeletal remains along with faunal and floral remains may be found.

7.4. Problem in Stratigraphy –

There are a large number of well-stratified mounds in the Gangetic plain, with successive deposits having evidence of building activity, as high as 30 meters. Once an ancient mud, mud-brick or burnt brick structure fell into disuse, the ancient builder leveled out the area and rebuilt on top of the earlier debris. Sometimes certain elements of the earlier structure were reused, and this, of course. presents a confusing picture to the archaeologist. A historical mound that has a long history of occupation and has been built up over a period of time may have a great many strata, the earliest represented by the lowest levels of occupation and the latest represented by the topmost levels. The general rule is that a stratum must have been deposited earlier than the one above it and later than the one below it. In other words. it is presumed that a stratum that is above another is later in time that it has been superimposed on an earlier deposit. The upper stratum will, therefore, contain artifacts of

later manufacture than the lower. or earlier level. The archaeologist, however, must not be too hasty in equating sequential deposits with the sequential age of the materials found in the superimposed layers. The context of the artifacts and their comparisons must be carefully evaluated before any judgmental conclusions can be drawn.

In Indian archaeology, it was Sir Mortimer Wheeler, who for the first time emphasized the importance of stratigraphy in excavations. A stratum is dated by latest artifacts found in its soil. Thus. the dating of a stratum is dependent on artifacts or architectural features. A coins hoard would therefore date a level easily, assuming that it was the latest object found in the level. by indicating that the level was destroyed or fell into disuse some time after the manufacture of the coins. Objects of material culture (any, by implication, the level in which they are found) usually cannot be absolutely dated- that is, to a specific year. Instead, they are assigned a time span during which they must have been in use. For example, level might be dated to the third or fourth centuries B.C. The first of these dates, 300 B.C., is considered the earliest possible date- the date before which this level could not have been is use. The second date of the span, 200 B.C., is the latest possible date- the date after which this level could not have been in use. The date of the layer above is later than every object in the sealed level. For example, if a 1947 coin is found in the construction of a floor level (not on the floor), the floor must have been laid in 1947 or after, but it does not mean that floor level below were necessari ly laid earl ier than 1947. However. the indications are that they were laid at some point around that time. unless anothc;r coin. let us say of 1935. turns up embedded in one of those levels. Should that be the case, all the floor levels above the 1935 coin could have their antiquity to later ascribed to that date.

If, however, a stratum has been disturbed by later intrusions, such as postholes. ditches. pits or robber trenches made at some later time, or even natural agencies such as the movement of earthworms or by weathering, it has to be meticulously excavated and recorded along with other stratum features. In this way the extent of disturbed soil can be distinguished from earlier soil lying adjacent to it at the same level. Thus a pit dug down into a deeper stratum must be more recent or later than the stratum into which it intrudes. Often the artifacts found at the bottom of such a pit are contemporary with the time it was dug.. In other words, the bottom of a posthole may provide an indication as to the date the post was placed in place; the material near the top of the hole as it filled up is much less useful for dating.

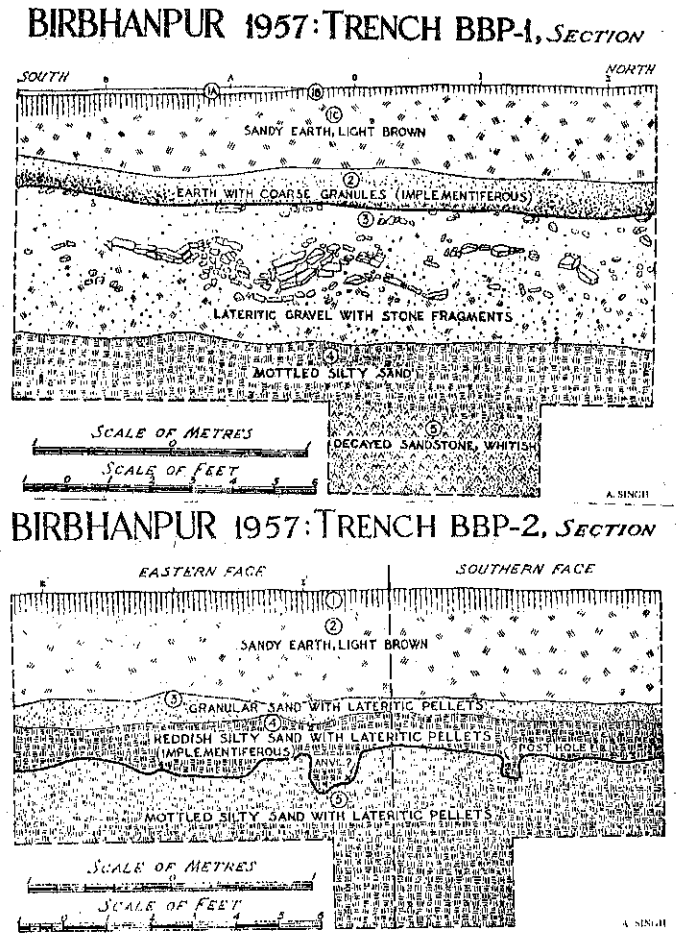

Figure No. 12 & 13 (Stratrigraphy)

Therefore, one of the first questions the archaeologist asks is whether or not the stratum is a result of undisturbed primary activity - i.e., is its preserved accumulation free from intrusions? Or is it a result of disturbed and intrusive elements. indicating that its deposit has accumulated from secondary activity? Often in multilevel sites there is a mixed deposit of primary activity that is disrupted by secondary activities; these may be human reuse of the area or may be natural processes. i.e. alluvium. Thus secondary activity may include human or natural phenomena, or both. For example. often in the complex stratigraphy of prehistoric sites. occupation surfaces are disturbed by pits or graves. Reading and evaluating the stratigraphy of such complex sites is difficult, for the archaeologist has to know how to link the activity layers so that each respective stratum and its activities can be identified and correlated. This may involve distinguishing cultural data from other cultural data. or

natural deposits from those that are cultural in context and content. The archaeologist must make both a temporal and functional assessment of the physical remains. Only then can an understandable sequence evolve for the horizontal and vertical three-dimensional reconstruction of the stratigraphy. (Figure No. 12 & 13)

Very often there are visible differences between the composition of strata, but sometimes the archaeologist is stymied. because the distinctions are unclear and strata fade into one another without any coherent reference. Thus physical stratigraphy relationships are difficult to discriminate. This is the reason why such deposits have to be segregated until their positions can be analyzed and tied in with other layers or levels.

7.5. Basic Principles of Stratification –

Stratigraphy is founded upon prolonged observation and inference. Its interpretation can only be learned by the study of exposed sections and section drawings, which are scale drawings of the stratification of a site. Only features that remain entirely within one level can be observed in relation to other levels; all else must be inferred. In fieldwork, the novice may study a stratum- the texture of . its soil, its colour. its archaeological objects. and so on, and may describe the features of each level. But in attempting to explain what happened there, when it happened. or how it happened he or she is forming inferences by interpreting visual data. The ability to observe and to infer correctly is one of the goals of field archaeology. The archaeologist is measured by his or her skill in drawing reasonable conclusions from the stratigraphic picture he or she observes.

Every archaeological stratum deserves an explanation. It may be both cultural and geological, as most are, but strata can also belong to purely geological material which may have collected when the site was abandoned. The archaeologist has to be sure that the freshly exposed section will settle the question. Stratification is by no means easy to interpret. It can be found to be inverted (a sequence of overturned level with the oldest being on the top). This is not an uncommon phenomenon, particularly in Hong Kong, where treasure seekers have dug pits in their search for antiquities and have left a reverse sequence. Erosion and earthquakes can also redeposit geological and cultural materials, which then present a confusing picture. In wet climates with a sandy soil, strata are poorly preserved and their interpretation is extremely difficult. In loose soils a heavy object, such as a coin, can move and travel downward until it rests on a hard subsoil surface. Archaeological training and experience are absolutely necessary in identifying successive strata accurately as they are uncovered, and in interpreting their time and significance.

No, site exists as an isolated phenomenon. Every site is dependent upon its surroundings, and the study of stratification depends on the correlations the archaeologist draws from his or her observation of each stratum in relation to other strata and to the surroundings of the site as whole. It is necessary to establish a hypothesis. Suppose, for instance, that an ash level is unearthed. In order to explain the origin of this stratum, the archaeologist should call to mind all possible ways in which this ash level might have been produced. To determine which is the right working hypothesis, it will be necessary to examine the surrounding objects or architectural features for other indications of a conflagration, for each working hypothesis is interrelated to a group of features and objects present in the level.

Stratigraphy, together with the study of human cultural remains, is an index to the history of the site. It is stratigraphical evidence that provides the archaeologist with a perspective of the chronology; the geological, faunal, and floral history of the site; and through the study of the cultural changes that took place within each level, the nature of the phases of settlement.

The archaeologist also uses stratigraphy as the source of primary data for the interpretation of artifact sequences. It may be assumed that all objects found in one stratum are contemporary and that when these associated data are correlated with material from other sites, a key will be provided to the understanding of contemporary industries, artifact use, and architectural features, and that (combined with non-artifactual material) will reflect shared activities of a culture. But the archaeologist cannot adequately explain the chronological patterning of objects or architectural features without having thoroughly studied and carefully interpreted what is gleaned from the site's stratification.

7.6. Process of stratification –

The process of stratification is a cycle of erosion and deposition. This process takes place on a smaller scale in archaeological sites due to climatic change or floral and faunal activity. The digging up of the earth or deposit or construction over the earth results in the making of new strata. This new strata knows the interfaces of the deposit. Archaeological stratification is composedof deposits and interfaces. These deposits can be altered or distroyed or overturned in the process. Three main factors determine the accumulation of cultural remains – The costing land surfaces. The forces of nature and the human activities. The cultural deposits or layers are classified into three –

a) Layers of material deposited one over the other horizontally.

b) Features like wall which are constructions around which layers then build up.

c) Features like pits and postholes which are constructions around which layers then build up.

d) Features like pits and postholes which are negative features which cut away the layers.

The first is related to geological deposits wheras the remaining two can be seen in archaeological context only.

7.7. Summary –

In summary, stratigraphy is the study and interpretation of the sequential deposits of a site. It is perhaps the single most important principle on which proper excavation techniques are based. Careful observation and recording of stratigraphical evidence is absolutely essential for any interpretation of a site. The greater the care with which the stratigraphy is recorded, the greater the information the site will yield. If maximum information and interpretation are to be obtained from the stratigraphy, the excavator's records and excavation techniques will be so accurate as to enable him or her to hypothetically place back in the excavated area all the walls, objects, soil types (such as burnt layers), and any other archaeological features in their exact original position in the excavation.

Stratification provides archaeologist with all the directly observable evidence for working out a hypothesis of the history of each deposit and the site as a whole. From the study of each a stratum by stratum culture evolves. The assessment of the cultural phenomena (pottery, stone tools, metalwork, etc.) typical of each stratum should provide a sequence of regional phenomena, which can be woven in to a representative culture system. This culture system forms the basis for comparison with the cultures from other sites.

7.8. Check your Progress –

1. Explain the concept and main feature of stratigraphy in archaeology.
2. Discuss the importance of stratigraphy in archaeology.
3. Discuss the problems related to stratigraphy.

7.9. Important Reference :

1. Wheeler, Sir Mortimer, 1954, *Archaeology from the Earth*, Oxford.
2. Varma, Radha Kant, 2000, *Kshetriya Puratattva*, Allahabad.
3. Atkinson, R.J.C., 1946, *Field Archaeology*, London.
4. Crawford, O.G.S., 1953, *Archaeology in the Field*, London.

Unit – VIII
EXCAVATION RECORDS

8.1. Introduction

Archaeological excavation does not only mean a collection of antiquities, artifacts, ecofacts and features. But the inter pretation of the excavated material depends on the accuracy of recording. The archaeologist should record the different groupings of artifacts and their spatial positions. Since this spatial articulation is disturbed in the proces of digging it is the responsibility of the archaeologist to make a precise recording. The field notes are permanent records of data retrieval.

8.2 Objectives -

The objective of the unit is to train the student in recording the data retrieved. The site note books, drawings, photography and the record of artifacts are permanent records which can be studied by those who have not worked at the site.

The notes should be comprehensive, legible and clearly written. Although there are no specific rules for recording since there is a great variation in sites. But still many different systems have been evolved for proper recording. The students should be trained to work on simple, logical and flexible systems.

8.3 Meaning & Purpose of excavation records -

Excavation is a destructive work by which we disturb the original nature of the site and remove the artifacts from their context. The accurate interpretation of the evidence in archaeological excavation depends upon the information recorded in the field note book. The recording includes not only the artifacts but also their archaeological context and ecological setting. Recording involves drawing, photography and writing the description in the field note book. Recording is a process, which begins before the excavation and continues during and after excavation.

Field archaeology is the base of archaeological studies. The collection of artifacts for archaeological study and new researches are based on the source material obtained from field archaeology. The archaeologist records the archaeological evidence and artifacts revealed by exploration and excavation. In a planned excavation the sites in an area are identified. The name of site on the basis of name of locality found in revenue record or village, name or any local name, which is more popular is given and recorded in the Field Note Book. A short name of three letters of the site is given; as for Kausambi the name is KSB. If there are more than one mound each mound is named as KSB-1, KSB-2, etc. The route to reach the site, distance from a known place or town, direction, latitude and longitude and location in relation to river, lake or hill should be recorded in the field note book. The general view of the site and, available section or any feature also is recorded by photograph and drawing.

8.4 Site Plan - (Figure No.. 14)

The details of site and artifacts present there are recorded in the form of following chart.

1. Name of the site code Latitude and longitude (topo sheet number)
2. Location
3. Route from main place and distance in kilometer.
4. Description of the site : Geographical and geological feature; ecology; river terrace, formation of terrace, elevation from water level; valley, nature of river; river section, deposits and nature of river section deposits.
5. Type of the site : mound, village site/ city site/burial site/rock shelter.
6. Type of artefacts : artifacts/pottery, stone/copper/iron, objects/tools, terracotta, inscription coin, etc.; structures/houses/walls/defense wall; burial
7. Method of collecting the artifacts.
8. Tentative dating
9. Sculpture (images) : length, width and thickness; iconography.

10. Architecture : Planning
11. Other
12. Stories and legends about the site
13. Importance
14. References regarding photography.
15. Name of the supervisor
16. Date

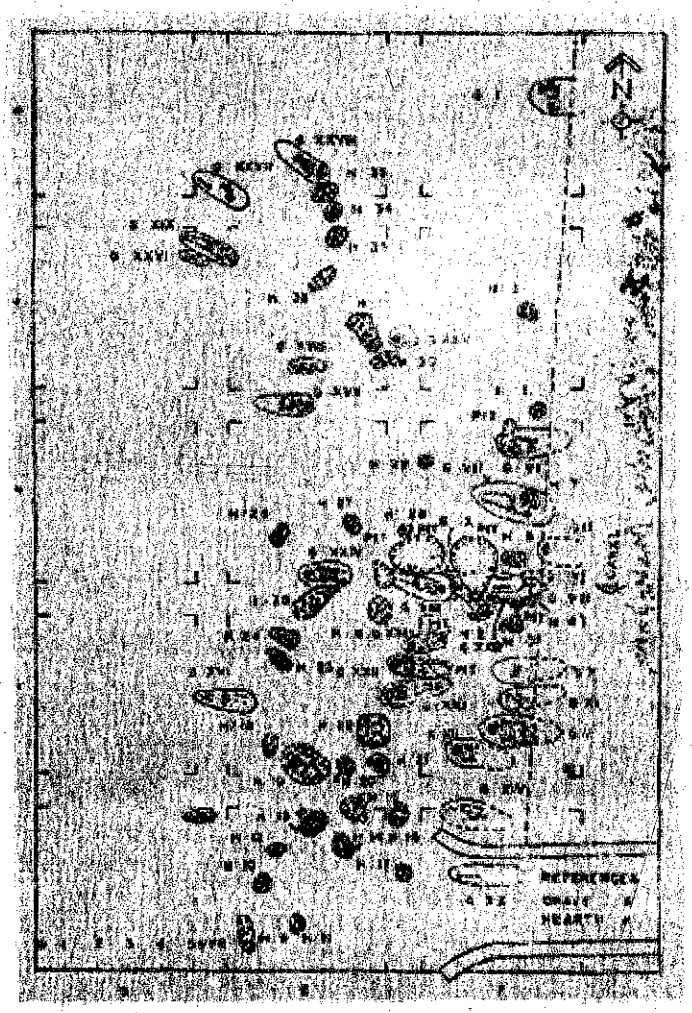

Figure No. 14 (Plan of Excavated Trenches)

8.5 Maintenance of a site note book -

The note book should contain vertical section and horizontal plan drawing of excavated trench. The drawing should be to scale on millimeter graph paper. The note book should contain lined pages for description and comments, notes on associated features and artifacts, descriptions of finds, and their provenance, interpretation and conclusions based on factual evidence, contact and other photographic prints, description relevant to the daily operation. Field notes must be logical; they are permanent written records of the excavation and they must be simple to understand and written with computer compatibility in the mind. It is essential that they are legible and comprehensive and so clearly written that they can be understood and interpreted even by those who have not worked at the site.

Standardized identification should be boldly placed on the out side cover, including the site name and number, square or trench, the year of excavation and the supervisor's name. Each square or trench should have separate notebook. A separate page should be used for each day; a new page is also begun when new level is reached.

The excavation description of the site is properly recorded by survey plan and contouring. Location map of the site gives the information about drainage system and access route to the site. The local stories and myths prevalent about the site are also noted. It may be mentioned that the artifacts include all the objects and structures, which come to light during excavation. These are recorded in two ways :

i. Three dimensional measurement and triangulation method and

ii. Recording on the plan.

8.5.a Measurement -

By the three dimensional or triangulation measurement the actual context and relationship of the artefact with other associated artifacts is established. The three dimensional measurement records the context of artefact by measuring length, width and depth in relation to the datum line in a trench. In this measurement the following equipments are used :

1. A wooden setsquare of 1 to 1.25 m size marked by centimeter and meter having inbuilt bubble level to confirm the plane level.
2. A plum bob with a strong string for measuring the depth.
3. Two tapes to measure length, width and thickness successfully. For all measurements one type of tape should be used. Generally two people are nee3ded in this type of measurement. To determine the find spot of artefact the pegs on baulk of the trench are used, which

connect the trench with master plan of the site and datum line. Therefore all measurements are generally taken from the peg of baulk.

The measurement of length in three dimensional measurement is taken from the nearest peg of the baulk by fixing the string with the help of wooden setsquare to the distance at which line the artefact lies. The measurement of width is taken on the same level from the last point of length to the place where artefact lies and the depth is also measured from the same level from the last point of width to actual artefact. Along with this measurement the layer or pit or the floor from which the artefact is found is also recorded before removing the artefact. It may be mentioned that this method of measurement is a time taking process but it is very useful to know the context of the artefact.

Besides the three dimensional method the triangulation method of recording is also used to determine the position of artefact or structure. Because this method is easier in operation, it is generally used in plotting the artifacts on plan. Some archaeologists use this method in place of three dimensional measurement. First the datum line is fixed and the horizontal distance from two walls of the baulk, to exactly above the artefact is taken. The depth of the artefact is taken after fixing the datum line on same level by bubble level. Some times this measurement is taken from the corner pegs of the trench. Two measuring tapes are used in this method. First, the tapes are fixed in the nails fixed on top of corner pegs and are extended up to the top of artefact and the distance from both the pegs is recorded. Then the depth of artefact is taken. This method is more prevalent now.

8.5.b Label Cards -

After taking the measurement either by three dimensional or triangulation method, it should also be recorded on label card, which is tied with the artefact or on the envelop or cloth bag, which contains the artefact. According to Mortimer Wheeler the serial number of artefact should be recorded in triangle and the number of layer in a circle. It is important to give a full description of the type of soil in which the artifacts were found in the field note book as well as on the tag for any artefact that requires special handling. The details on label card or envelop are written in the following form :

Name of the Department/Institution

Reg. No.

Site

Locus

Stratum

Object

Supervisor

Date

Ideally, all objects unearthed should be recorded on the plan and measured while in situ. In the excavation of a site where a large number of stone artifacts or pottery is found and the excavator wants to know the frequency, distribution and location of activity area the locus of each artefact is not recorded. Here the distribution of artifacts is plotted on graph sheet by symbols which enable to know the types of artifacts that are concentrated in particular areas of the excavated trenches.

8.5.c Section and Plans -

During excavation the exposed artifacts or structures are plotted by making the drawing of plan in a plan drawing (Fig. 15 & 16) which confirms its relation with other artifacts of the same level. This recording is done during excavation because the artefact loses its context with the progress of excavation. For the plotting the following equipments are required :

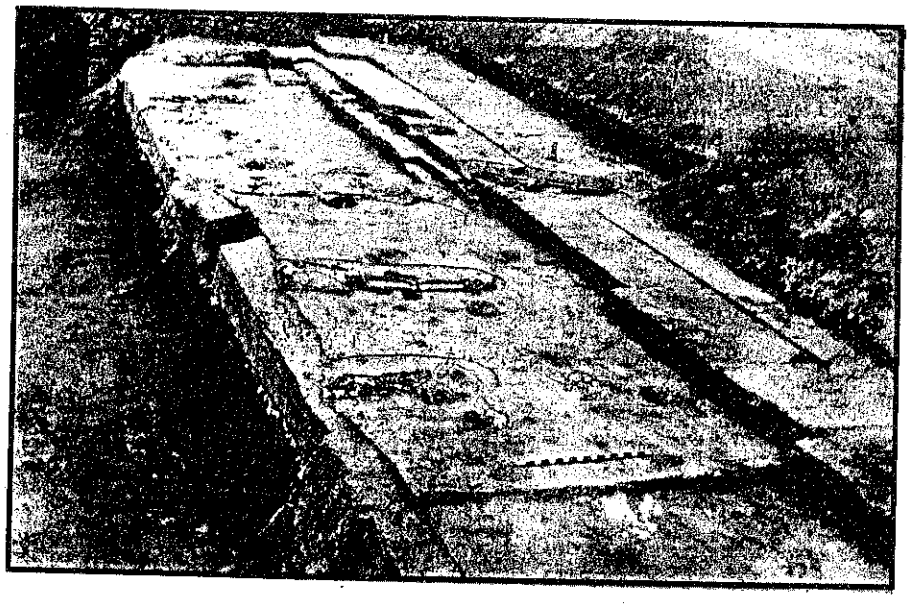

Figure No. 15 (Plan Excavated Area)

1. Drawing board with a stand.
2. Drawing Set
3. Two measuring tapes of 5 meter
4. Setsquare
5. Plum bob
6. Pencil (HB, 2H, 3H) and rubber
7. Graph sheet.

Figure No. 16 (Section of Lake Area)

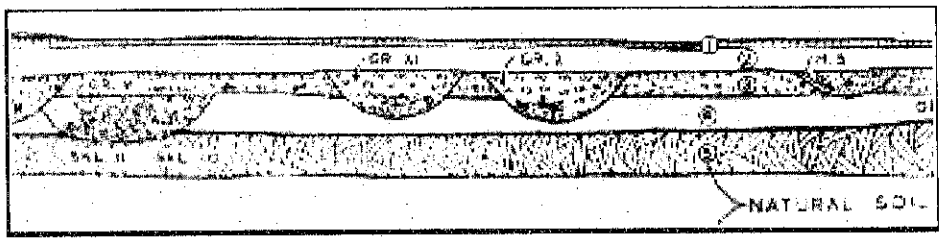

Figure No. 17 (Section Drawing)

In summer season a big umbrella is also needed to save the paper and pencil from melting in the field. In India graph sheet of butter paper is used for plotting. usually, Subsequently the plotting is traced on plane drawing paper. In western countries transparent film sheet is used which is more durable and is not affected by the bad weather. In plotting the artifacts at least three people are required, two give the measurement and one plots on the graph sheet. (See Fig. 17) It should be ensured that the measurements are given after checking the level by bubble level so that the measurement is from the horizontal plane. Before the plotting the scale is determined according to the need. As mentioned earlier the plotting of the distribution of artifacts or structure is done by triangualtion method generally.

Clear, neat, comprehensible section drawings and plans are vital for proper recording. At prehistoric sites where in a limited area a large number of artifacts are distributed or the skeleton is to be plotted in shortest possible time, a 1X1 meter frame divided in 10 cm square by nylon

string is placed on the artifacts. Here also it is necessary to check that it is placed on a horizontal plane. Each square of 10 cm is given a name on the graph sheet and it is plotted as per square. It helps in plotting easily :

Figure

As in the case of plan where horizontal distribution of artifacts or structure is recorded by plotting similarly the artifacts and structures are recorded in vertical form in a section drawing to illustrate the stratigraphic position. The section drawing of each baulk of the trench is made with its full detail; such as the direction the section faces and the direction the draftsman books on while making the section. The scale of section drawing is determined generally in 1:10 or 1:20 cm scale. When the excavation is completed a composite section running east-west and north-south of all the excavated trenches is made in which important structures are made by projection if these are not in the section. (Figure No. 18 & 19)

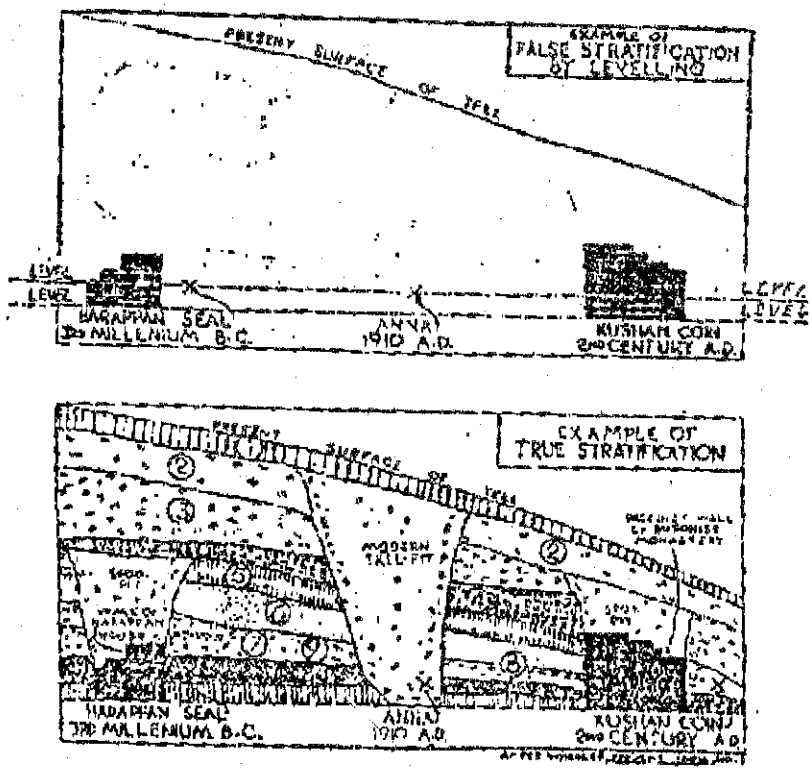

Figure No. 18 & 19 (Stratification in Excavation)

To make the section drawing, following equipments are required :

1. Drawing board with stand,
2. Two measuring tapes of 5 meter,
3. String of nylon,
4. Iron nails of 10 and 20 cm size,
5. Pencil and rubber,
6. Bubble level line,
7. Graph paper roll or sheet.

First, two nails are fixed on the two corners of baulk of the trench, the section of which is to be made, and the nylon string along with bubble line level is firmly tied in these nails. What is the position of string in relation of datum line also is determined and it is marked on the graph paper. One tape is tied along the string between the two nails and from another tape vertical measurement is taken of each line of layer at equal interval or according to the nature of layer. It is recorded on the graph sheet to the predetermined scale for section drawing. The line connecting all points of each layer should be drawn according to the line in the section. In each layer the artifacts or structure, which are looking in the section are also recorded. For recording the nature of soil and artifacts/ structure of each layer in the section drawing some symbols are traditionally used.

Loose soil
Loose soil and Gravel
Compact clay
Plastic clay
Gravel
Sand
Brickbats
Humus
Ash
Brick structure

Need less to say that artifacts are recorded in situ also by photography along with details of structure and other important features, section (Plate I) and Plan (Plate II) during the excavation and after the excavation.

8.6 Summary -

Maintenance of excavation records is imperitive in order to get a correct picture of the excavation done. Field notes are permanent records of the details of excavation. The sites of excavation very very much and there in no one system of recording yet the system should be simple, logical and flexible.

Before the onset of excavation a topographical and composite location map is proposed. This should be followed by the making of a site plan. This includes the name, area, trench, date and the strategic position of the deposits, identification of the artifact, artifact number, locus, depth and positions of the artifact, its description, its sketch, plan, sections and drawing of walls, floors and furnaces etc.

The site note book should cover each and every aspect of the excavated material. The trench number, date, locus, drawing and film roll numbers, stratigraphical position, layer, soil texture, details of artifacts should be recorded.

The objects and structures which come to light during excavations are recorded by three dimensional or triangulation measurement and attaching label cards to them. The drawing of plan is essential for a clear understanding, interpretation and finalizing of the excavation report.

8.7 Check your progress -

1. What information should be given while chalking out a site plan?
2. Giving the importance of excavation records discuss the details given in the drawing of sections and plans during excavations.
3. Explain the following -
   a. Three dimensional measurement
   b. Triangulation method.
   c. Label cards.

8.8 Activities :

Give the details of the excavation record chalked out by you on field.

8.9 Suggested Readings :

1. Wheeler, Sir Mortimer, 1954, *Archaeology from the Earth*, Oxford.
2. Varma, Radha Kant, 2000, *Kshetriya Puratattva*, Allahabad.
3. Atkinson, R.J.C., 1946, *Field Archaeology*, London.
4. Crawford, O.G.S., 1953, *Archaeology in the Field*, London.

BLOCK IV

DATING METHODS

UNIT – IX

RELATIVE DATING METHODS

9.1 Introduction

Although animals change their mode of activities as per day and night and seasonal changes it is only human beings who are endowed with a sense of passage of time. Even the most illiterate man can recall some important events in his life if not in number of years at least in relation to proximity with other major events, local or national. This helps him to recall his own life in the correct order of sequence of events and historical events of his society. He might have also heard of many actual events that had occurred in the lifetime of his parents and grand parents. These memories therefore go back to a period of, at the most, two or three generations. The events that occurred between these generations could be recounted as happened, in the words of the illiterate person "during the days of my grand father, during my fathers life time, during my life time". Herein, although we cannot get the actual number of years that have elapsed between the occurrence of the event and the present, we can give the approximate years or at least which of the event occurred first. This type of sequencing of events without mention of calender dates or the years elapsed between each does not give an absolute time frame of events. In other words these only give a relative sense of time like : recent event, old event, older event, oldest event.

Now there may be family tradition of certain legends. For example the said illiterate man claims that his parents used to tell that they belonged to a ruling dynasty of yore in Rajasthan but due to some reason they migrated to Madhya Pradesh. Even if considering the story to be true, it is not useful from the historic point of view, as the tradition does not say which dynasty he belonged to or what was the reason for their migration. Thus this story like a wooden raft on the river is of a floating nature. It could be that the story may have originated one or two hundred years or as much as one or two thousand years before now. Thus such floating stories unless clubbed with proximity of historical figures, dynasties or events, can not even give a sense of time, even in the relative context. On the other hand if the story says that this migration occurred during the sixth generations time, after Prithvi Raj Chauhan's death then the event could be ascribed to an estimated year with an accuracy of one or two decades error. Now if the migration had actually taken place within the allotted span of time it could as well be linked to other known historical events, like war, famine, epidemics that caused the migration in the first place. By such methods of cross dating even though inscriptional evidence may not be there, by reason of coherent logic also reconstruction of historical scenarios could be done with punctuations of time. However it should be remembered that there should be concurrence of several facts to reconstruct a past scenario. The tallying of legends with historical and archaeological facts should be much more than mere coincidences. All these could be linked or delinked only if the element of time is known for sure. On the other hand if no reason for migration could be accounted for in the bracket of time it was thought to have occurred, a few

confectures are possible, namely 1) The number of generations may have changed across the many generations it was carried down by word of mouth. 2) There may be other factors like political rivalry etc within the dynasty that did not find mention in history. 3) The tradition of the royal lineage of the illiterate man is false.

Historians and archaeologist abroad have been linking ancient legends of civilizations and events to sites and monuments with a mixed bag of successes and failures. At Cyrene the fallen columns of the Temple of Zeus was linked to an earthquake that occurred about AD 180. On the face of it, it appeared most possible. However on excavation at the site, an inscription was found, which stated that Jewish insurgents had caused the overturning of these columns in AD 115. On the other hand Dr. R.G.Goodchild found a coin hoard lying close to a skeleton crushed by fallen masonry at El-Beida and inferred that this event had occurred in AD 365 due to the violent earthquake mentioned in numerous literary sources. In our country also there are many oral and written traditions which have been increasingly linked with sites and monuments. Recently Dr. P.K.Mishra has on the basis of excavations at Deurkothar Distt. Rewa in M.P., linked the evidence of destruction of the Mauryan Stupa there with the persecution of the Buddhist religion by Pusya Mitra Sunga, as mentioned in the Divyavadana. According to him there are three layers of brickbats. The top most being formed due to brick robbing in the last century for building local schools. The lower one was formed due to abandonment and natural degradation. The lowest layer of brick lies directly on the flagstone flooring along with the pieces of stone railing surrounding the stupa. Now, taking an alternative view, on the basis of mere evidence of destruction by human vandalism alone, it could as well have been any time many centuries before the robbing in the last century. Moreover, not only Pushya Mitra Sunga, the Hunas and the Muhammedans are also known to have destroyed Buddhist monuments. Then how did the scholar reach such a conclusion? As it could have been destroyed by the Hunas or the Mohammedans as well. But the excavator, Dr. Mishra could demarcate the exact time bracket on the basis of the presence of broken pillars with Late Mauryan art motifs and the absence of anything of the Sunga or later period, at the site. There by indicating that the destruction had occurred during the early part of Sunga Period. *Editor's note* - The archaeological evidence is too fragile and the interpretation leans heavily on literary tradition only. Moreover the site did not lay abandoned atleast not for long before the destruction as understood by the lack of intervening soil deposits between the stone flooring and the debris layer. Evidently, to understand the intricacies of excavation and reaching conclusion regarding time one should have a good idea of stratigraphy and datable materials including dating art objects from the point of view of art history.

By the above examples one understands the importance of time in the knowledgeable handling of history.

Whereas history gives access to hundreds and perhaps in lesser number of cases to few thousand years of recorded time, it is in the realm of archaeology that the need to record time of events up to a few million years is felt. As archaeology basically deals through three types of data namely : 1) formal content (materials) 2) distribution in geographical space 3) duration in time.

In the following sections you would come to know about relative dating techniques and other aspects related to it.

9.2 Objectives

After going through this unit you would be able to know

- What are dating methods ?
- What is periodization ?
- What is relative dating ?
- What are the different techniques of relative dating ?
- What is chronometric dating in brief ?
- What is the relationship and importance of periodization, relative dating, chronometric dating ?
- What is seriation ?
- What are different types of seriation ?
- What is stratigraphy ?
- What is Geochronology ?
- What are deep sea cores ?
- What are Ice cores ?
- What is faunal dating ?
- What is linguistic dating ?
- What is cross dating ?

9.3 The Important Aspects of Relative Dating

In the following paragraph the section deals with the meaning of relative dating, the range of its usefulness in reconstructing the past archaeological scenario. The section also enumerates about periodization and the difference between relative age and chronometric age. Finally the different types of relative dating is listed in the concluding paragraph.

9.3.a Purposes of Relative Dating

Generally, by relative dating one understands that it is a method that tries to ascertain the correct order of events. Evidently, by such methods of dating the number of years that have elapsed between the event and the present year is not ascertained. Neither the exact year nor even the time bracket with an error margin of few years or decade fall in the ambit of relative dating. Unlike relative dating chronometric dating strives to provide the time in number of years. However relative dating has more use than merely giving the correct order of events relative dating techniques helps in ascertaining the relative age values of different objects in the same layer in the course of archaeological excavation. Alternatively, it also helps to establish the relative age of objects at more than one site due to the extreme similarity of art or content of these objects. This second aspect of relative dating is also known as co-relation dating or cross dating. Here it should be noted that with the help of absolutely dated (chronometrically dated) objects at a particular site, cross dating at other places with exactly same type of artifact / object would lead to absolute dates at other sites also.

9.3.b Floating Chronologies & Relative Dating

There are many calendars that are set mostly before the advent of the Christian Era. The Maya calendar in Meso America has its starting set in 3113 BC. The Egyptian genealogies also go back to 3000 BC. But the account of earlier dynasties up to 664 BC are not accurate and the margins of error may be about 200 years in the earlier part of the Egyptian history. The Greek works of literature refer their calendar from 776 BC when the first olympic games were held. In India also there are various calendars like Kaliyuga Samvat (+3101) Vikrama Samvat (+56) Saka Samvat (-78) and lesser known ones like the Newar, Kolam, Gupta era, etc. There are also many eras and genealogies of dynasties in ancient literature, which gives the reign of kings in number of years. However unless the era mentioned is not precisely correlated with the Christian calendar with its zero point in BC or AD as the case may be the genealogies referred are of a floating nature and the sense of history is not placed on the hard ground of time. That king 'A' was the grandfather of 'C' and he in turn was the grandfather of 'E' but none can say with certainty from which year to which year this dynasty had ruled. However if coins of 'A' and 'E' mentioned in the ancient literature are found at two different sites, one can say that the coin of 'A' is older than that of 'E' and the two sites was in use during the reign of this dynasty. Further it could also be said that the site with coins of King 'A' is older than the site with coins of King 'E'. However as no absolute date in years could be given on the basis of the coins or the era mentioned in the literature, the archaeology and conclusions provided in the given contexts is very limited.

Similarly, in two methods of absolute dating namely varve analysis and dendrochronological analysis the available data may not be complete. For instance there may be 2000 varves in a lake that is representative of 2000 years but if one is not able to give the actual year when the varve formation started or ended then it has no great use. Thus any number of objects trapped in between these layers could be said as differentiated by as many years as there are varves in between. Thus although one object could be said as much older or younger in years in relation to the other. Yet one cannot say the actual number of years that has elapsed since its last use and present time. In dendrochronological studies also if the tree ring data does not add up to the present times or are not corelatable in some way to the actual dates the presence of logs in ancient buildings would not be helpful in giving the year of construction of such buildings. However on the basis of comparison with available tree ring data one can give the sequence of construction of monuments in the area. Once the missing links in the tree ring reference logs has been found, these would give absolute dates in number of years up to the present.

9.3.c Periodization, Relative Dating, Absolute or Chronometric Dating

During an exploration of an area an archaeologist comes across six sites A, B, C, D, E, F. He found that

- A & D sites have iron implements and large amount of potsherds.
- C & E sites have copper implements and different types of potsherds.
- B & F sites have only stone fools.

Assuming that in a given area close by without any natural hinderances same technologies would prevail during a given time span, thus sites with same technological levels of metal, potteries and other objects could be clubbed as belonging to the same time span, in other words same period.

Thus

- A, D belongs to one period.
- C, E belongs to one period.
- B, F belongs to one period

Now as an example if one thinks for a moment that the archaeologist was doing his survey in the early part of 19th century and he is not aware of the three age classification namely : 1) stone age 2) bronze age 3) and the latest, iron age. Then how will he bring to light the correct order of development of cultures in the area? To find an answer to the vexed problem he undertakes further survey in the nearby region and discovers two other sites 'X' and 'Y'. He excavates both the sites namely 'X' and 'Y' and finds that 'A', 'D' sites type of cultural remains are fond to overlie 'C', 'E' type remains in site 'X' and in site 'Y' 'C', 'E' type remains are found to overlie 'B', 'F' sites like remains.

Thus by the geological rule of stratfication one which says that the oldest layer is the one lying lowest in the strata that means

- A D is having old material remains
- C E is having older material remains
- B F is having oldest material remains

Thus we know by the nature of archaeological remains due to systematic excavations and study of strata that

- The sites with iron implements and potteries are old (the latest).
- The sites with copper implements and potteries are older.
- The sites having only stone implements are oldest.

This is relative dating which consists of ascertaining the correct order of events. However if there are certain artifacts in few of the eight sites that can be ascribed particular number of years of being in existence before the present time then such dates are known as absolute dates (chronometric dates). The absolute dates of different objects of different periods in a site would be helpful in giving a accurate portrayal of cultural changes across different spans of time.

The relative dating of an object or a layer is obtained by several scientific procedures namely, stratigraphic excavations, Pleistocene Geology, seriation and cross dating. Thus, stratigraphy of the archaeological excavations and the geological scale in the Pleistocene times provide scope for relative dating. Seriation which involves two modes namely stylistic seriation and frequency seriation of objects, show the development and spread of the object type under study enabling the archaeologist to have an idea of the relative time bracket of the object and its context. Cross dating which has a spectrum of techniques is important for identification of the relative ages of the objects within a site and sometimes even within a layer of the site. It is also useful in other cases in providing relative dates to sites separated by large distances.

9.4 Techniques of Relative Dating

As mentioned earlier, the importance of correct stratigraphy in relative dating is obvious in archaeological and geological layers. The laws regarding stratigraphy in both the context has been outlined in the following paragraphs. Another important dating technique is by the typology of the objects also known as seriation technique of relative dating. As mentioned above it has two subtechniques namely 1) Stylistic seriation, 2) Frequency seriation.

9.4.a Stratigraphy (Archaeological)

The most simple and important law of stratigraphy is that the lower, the layer in the strata the older it is. It means that the oldest layer is that which lies lowest and the youngest being that lies on the top. During the archaeological excavation of ancient sites the different layers are demarcated largely on the basis of the materials in the layer and the colour of the layer. In fact both the aspects of the layer show the effect of ancient man or nature or both across time. As these are also markers of time these should be identified accurately. Now for example if a site has 1 to 23 layers from top to bottom and layer no. 15 yielded Punch Marked Coins and layer no. 16 yielded potteries of the Chalcolithic period. But supposing an untrained excavator could not identify the layers properly and described layers 1 to 23 as 1 to 10 layers and therefore both the layers 15 and 16 were clubbed as layer 7. What would be the conclusion. The conclusion according to this excavator would be that as the Punch Marked Coins were of say 5th, 6th century BC the potteries were also of the same period. Further supposing that neither the punch marked coins nor the time period of the pottery is known then one cannot even say that the coins are of a later period and the potteries are of an earlier period if the layer marking is not correct. The above example shows the importance of correctly identifying layers in the excavation. Moreover care should be taken that datable objects like coins and potsherds etc have not gone down into the sequence of layers by means of rat holes, tree root holes, post holes, foundation trench, robbers trench and pits.

9.4.b Stratigraphy (Geological)

When a geologist uses the term stratigraphy he means something quite different than what is meant by an archaeologist. For the geologist the layers, which are more often on a larger scale were formed by some geomorphic events, for example : sea level changes, down cutting by streams, wind erosion, retreat or advance of ice caps and glaciers, volcanic eruptions etc. In practice the human caused remains are found within layers formed by the geomorphic activities of nature. By the order of superimposition one can say which geological layer is the oldest and therefore which type of archaeological remains within these geological layers are the oldest at this site 'XYZ'. Evidently if the same layer continues few kilometers away there also the artifacts in these layer are as old as understood at the site 'XYZ'. Now if beneath the oldest layer of site 'XYZ' in the new site 'NYZ' another geological layer is observed with some archaeological remains, then obviously these remains are older than the oldest at site 'XYZ'. Thus not only by order of superimposition relative dating of archaeological materials at two sites could be established but the oldest remains among them be known by cross dating.

On the global scale particularly in Europe and America the environmental changes during the glacial period namely Gunz, Mindel, RIss, Wurm and the inter glacial periods between them are

identified as geological strata. On the basis of this stratigraphy archaeological remains within are dated relatively. In India also the expressions of the changes in the global environment in the past, was traced. This was recognized in the Himalayan region. On the other hand it was thought that the pluvial cycles in the south might be related to the glaciation in the Himalayan region. Thus in 1935 H.de Terra, T. de Chardin and T. T. Paterson under took intensive research using methods of geology, paleontology and prehistoric archaeology. The stratigraphical examination of the Pleistocene evidence, led to working out a standard sequence of geological events correlating the glacial and interglacial deposits with the late and Post Siwalik formations of the adjoining foot hills and plans lower down for dating the artifact bearing horizons in them. The stratigraphical results showed correlation of the system of terraces even in non glaciated regions in Punjab, central and south India which could be correlated with the glacial cycle in the glaciated regions. This type of stratigraphical correlation is an actual scenario albeit on a very large scale compared to the correlation of hypothetical sites 'XYZ' and 'NYZ'.

However, it should be remembered that correlation and relative dating on the basis of geological stratigraphy caused by the environmental changes in the past could be established within sites seperated by few hundred metres or even thousands of kilometers besides its use within the site itself. Frequently, fossil remains of characteristic animals and pollen concentrations found within a particular time bracket on comparisions with known tables are helpful in giving atleast a relative date to the strata and archaeological remains if absolute dates are not established by other means. The above methods are known as faunal and pollen dating respectively and are largely used as tools in cross dating. Deep sea cores retrieved from the ocean beds give an accurate temperature sequence stretching back to about 2.3 Million years which reflect climate change on a global scale and is a frame work for relative chronology for the Pleistocene. Similarly ice cores which is compacted ice of annual deposits give absolute chronology that is available for cross checking data from other branches of researches on dating and environmental studies of the past.

9.4.c Seriation Dating

This type of dating is based on the principle that "like goes with like" and has been developed to deal with association of finds, rather than the forms of single objects taken in isolation. The logical frame work of the technique involves, making artifacts to be arranged in a succession or serial order which is understood to indicate their ordering in time. There are two types of seriation namely stylistic seriation and frequency seriation. In the stylistic seriation the development of the form of the vessel or designs on it are arranged in a natural order of succession. Once this standard series is made consisting of the progression of earliest to the latest pot or design these are always available for comparison within the site or nearby sites. Thus a particular vessel or design could be

said as old, older, oldest and thereby relative age values could be ascribed to the layer in which it was found. On the other hand frequency seriation deals with the measurement in changes of the proportional abundance or frequency of a ceramic style. The logic behind such studies is that pottery styles gradually become more popular, reach a peak of popularity and then decline and secondly that at a given time period, a pot style popular at one site would similarly be popular at another nearby. The presence of similar percentages of the same type of pottery in two sites would indicate their contemporaneity whereas dissimilar percentages of pottery may suggest difference of time amidst the two sites especially if there are no other factors.

9.4.d Linguistic Dating

Although this type of dating is not obtainable on the basis of any archaeological remains yet such researches are helpful in raising questions regarding the archaeological remains and providing tentative dates about them. The basic assumption is very simple. From a homogenous group of people speaking the same language two subgroups migrate to two different parts of the globe. Even though there is no further contact between the two groups both groups will continue to speak the same language. But as the years pass by changes will occur, new words will be invented and introduced whereas other's will fall out of use. In the course of few centuries the two independent groups will no longer be speaking the language they spoke, when they had set out. Now, say after few thousand years both the groups would not be able to understand each others language. However there may be some traces of common words of basic nature for example : of family, simple numbers and simple things that were developed and in use in the early times before the migration. By statistical methods scholars have studied the degree of diversion in vocabulary from the time, when two groups were one and some have also gone to the extent of providing the number of years in centuries or millennia since their separation. Even though the reliability of the same is not universally accepted this technique has its use in archaeology namely 1) Whether two or more groups initially belonged to one group. 2) The time of the commencement of migrations on the basis of statistics of common words 3) and by comparison with common words and the assumed technical levels of the culture prior to the migration one can date the migration around the later period of the culture, so identified. This if for instance both the groups have common word for copper but not for iron, common words for numerals from 1 to 100 but not for higher numbers it would show that the migration occurred during the copper age at a time when higher numbers were not required.

9.5 Cross Dating

This is yet another type of relative dating which becomes more relevant when once a culture phase sequence has been established for a local area. Thus cross dating in the local context is the assignment of a site component to a local culture sequence. In simpler terms it means that to find

out whether the object(s) within the layer is actually contemporaneous with the layer or not. Cross dating however, is not limited to attributing relative dates to objects of a site alone. Thus cross dating term is very well applicable when on the basis of geochronological studies different sites far away are dated to the same period of Pleistocene age. Or else when well dated Egyptian objects occur at various sites in Greece, these help in cross dating.

9.5.a The Nitrogen Test

Bones of human beings and animals buried under soil are subject to a wide variety of chemical changes. These involve the loss of organic constituents and the mineralization of bones. The loss of organic constituents namely proteins and fats occur at varying rates. Whereas fats disappear very rapidly the proteins (collagen) occurs so, much slowly. Now if in an archaeological layer or a geological layer bones of several human beings or extinct animals are found and if they are of the same period these will have similar amount of nitrogen as dictated by the soil chemistry within the layer. This assumption is based on the fact that the nitrogen content of modern bone is about 4 per cent which declines with the passage of time depending on the temperature, water, chemical and bacteriological content of the soil in which the bone is buried. For all practical purposes the soil chemistry within a single layer is largely uniform and therefore loss of nitrogen from bones within this layer also would occur uniformly. This natural process allows the scientist to differentiate earlier and later bones if it happens to get mixed during the formation of the layer. The method used for determining the nitrogen content of prehistoric bone is known as the micro-Kjeldahl process.

9.5.b The Fluorine Test

Unlike nitrogen, which gets reduced with the passage of time the quantity of fluorine increases with the passage of time.

This is due to the fact that fluorine occurs in trace quantities in almost all ground waters and due to interaction of bones and water containing fluorine, bones accumulate more fluorine into itself. At the chemical level the fluorine ions replace the hydroxyl ions, transforming hydroxyapatite into fluorapatite. Once small microscopic crystals of fluorapatite are formed these are not readily dissolved out. Therefore the fluorine content of the bone increases. Thus on chemical analysis bones that have been deposited in a single event within a layer would have similar fluorine content. By this rule therefore, bone specimens of differing age, although found together through accidental re-deposition within the same layer can be differentiated by their differing percentages of fluorine. Bones which have been in soil for significantly long time also become denser and heavier due to accumulation of lime and iron oxide within itself. Broadly speaking one can therefore identify the comparatively modern bones from those obtained from prehistoric sites. The last mentioned basis for separation of bones becomes more clearly discernible in bones obtained from geological layers.

9.5.c The Uranium Test

Like fluorine the amount of uranium increases in bones with the passage of time. Bone accumulates uranium due to its contact with ground water which contains some traces of the element. The actual chemical process involves the replacement of calcium ions in the hydroxyapatite of bone by uranium. The replacement of calcium ions by uranium is a slow cumulative process. Thus the longer a bone has lain in the soil the more uranium it will have absorbed. Unlike other elements, uranium being radioactive is conveniently estimated by measuring the amount of radioactivity present, in terms of beta radiations per minute. It should be noted herein that in such type of measurement, some errors also occur due to the radioactivity of the so called daughter elements. However for the purpose of relative dating and especially to verify the intra component association within the layer the errors are not conspicuous enough to obliterate the conclusions. Moreover as all the bones found within the layer will have the same amount of radiation due to daughter elements those with very high radiation definitely could be identified as bones from earlier contexts, which got mixed in the layer concerned.

9.5.d Cross Dating and Piltdown Man Controversy

In the early 20th century some pieces of human skull an ape like jawbone and some teeth were reportedly found from a lower Palaeolithic pit in Piltdown in England. The discovery was shown as a missing link between apes and human beings. This finding was associated with other associated fossils namely extinct Pleistocene elephant besides recent fauna that included the remains of beaver and red deer. The assemblage of bones therefore indicated at the outset itself that the two faunas, one extinct and the other modern had been washed from two contrasting geological strata and re-deposited together. Besides the fact that the layer contained mixed animal remains of widely deferent time, the fact that the anthropologist could not accept the human part of skull in conjunction with part of ape like jaw bone, made the Piltdown discovery a controversial issue.

Due to the raging controversies vertebrate specimens from the Piltdown gravels were subjected to fluorine dating. The test revealed that the earlier fauna had a substantial amount of fluorine ranging between 2-3% (3.8% is the theoretical maximum). Whereas fluorine in the skull was only 0.1% and that in the jaw only 0.4%. The test done in 1949 showed clearly that neither the skull nor the jaw, were as old as the other animal bones. This led to further criticism by the scientific community. Some scholars even asserted that the skull and the jawbones were deliberately fossilized to make them appear as fossils. Again in 1953, therefore, a battery of tests were applied. By now the fluorine test had improved further. It was found that the jawbone and the tooth did not have any more fluorine than found in modern ones, whereas the fluorine test on the skull revealed that it had just enough fluorine to indicate that they were not modern. At this same time nitrogen test was also

applied which showed that the jaw had nitrogen content similar to that found in freshly dissected specimens while the skull had much lesser amount but was not absent as in the Pleistocene elephant remains from Piltdown. Later uranium test was also applied on the jaw and the skull. The jaw was recognized to be modern due to the absence of detectable amount of uranium. The skull recorded radiation of 1 PPM of uranium oxide. The Pleistocene elephant on the other hand had 610 PPM of uranium. From the three above mentioned tests, all mutually confirming with each other, it was clear that Piltdown discovery was a fake discovery. This example of Piltdown controversy also helps one to understand the importance of cross dating techniques mentioned above.

9.6 Summary

Dating is very important aspect of history and archaeology. As without the sense of time of the past, reconstruction of past history, events and human development would be muddled in confusion. Many epochs that have happened earlier could be thought to have occurred later and vice versa if they are not put in correct sequence by information regarding time. If one compares the great events of human kind as precious beads, then time is the string that binds them together. In other words there is no sense of order or purpose in study of the past without the element of time being suitably dealt with.

There are two aspects of dating namely relative dating and absolute or chronometric dating. Relative dating is a type of dating in which the correct sequence of the events is tried to be made. Thus the events in history or the cultural remains exposed during archaeological excavations are brought into a sequential frame work, in short, termed as old, older, oldest. The stratigraphic sequence of layers if correctly enumerated is progressively older as one goes down from top to bottom. Thus layer 100 is older (earlier) than layer 99. More often the objects found within these layers are contemporary to the layer. Thus supposing at a site layers 23 to 27 are identified as Mauryan layers then the objects found within are also of the Mauryan period. If supposing at that site layers 18 to 22 are identified as of Sunga period then the objects found within such layers are also of Sunga period.

In fact, it is initially the other way round, as certain objects or potteries of each layer being specifically datable are helpful in dating the period of the layers. Once the layer is given time span on the basis of a particular artifact namely a coin, for instance, other objects within the layer also could be attributed the same time bracket. Thus the identification of layers 18 to 22 and 23 to 27 as Sunga and Mauryan respectively on the basis of specifically datable objects, comes first. Then the layers could be given a time bracket and the objects that are not specifically datable could be given dates on the basis of the layers. However there are other parameters that have to be looked into before one is able to give a particular time span to a layer or set of layers. These include the re-deposition of earlier objects into later layers or intrusion of later objects in earlier layers.

Layers of geological nature are also useful in relative dating. These layers are formed by mediums of environmental change namely wind, water and glaciers. However within the sediments deposited by these agencies there may be stone tools and other objects which could be given relative dates on the basis of order of superimposition of the layers, faunal dating and pollen dating. The geological layers formed during the Pleistocene ice age are also useful in relative dating of the prehistoric sites and remains. These are also helpful in cross dating of one site with other on the basis of similarity in events and sedimentation pattern.

Artifacts are also dated on the basis of making a series based on their development. Thus if a single type of object, say a pottery shape, namely a bowl has various shapes and designs on it. Now on the basis of proximity to shape and design with some or other, these could be arranged in a series that would show the development of shapes and design on it from the earliest to the latest. Once this series has been prepared any finding of a piece of bowl in a layer could be compared with the series and the relative dates assigned to the bowl. Another type of seriation involves the study of the percentage of objects. The principle behind this method being, an object or pottery type would slowly gain popularity, then it would decline in popularity. If one looks at the percentages on a graph it will have a bow shape with the maximum percentage in the middle. The point stressed by the scholars being the similarity of percentages of a pottery type is indicative of its contemporaneity at different sites. This method is therefore helpful in cross dating.

Cross dating is another method of relative dating, it may also be done by employing the methods mentioned earlier or by similarity in objects that are atleast relatively dated at one place. Some of the cross dating methods which are specifically more useful in finding out the contemporaneity of bones in a single layer are Nitrogen Test, Fluorine Test and Uranium Test. One need not be again reminded of the utility of such tests which could enable the scientist to declare the Piltdown discovery of the supposed missing link as a fake. Lastly many of the principles employed in the establishment of relative age are also helpful in moving towards chronometric age which is the ultimate aim of the archaeological researcher. Chronometric dating techniques (described elsewhere) are dating methods which strives to provide the actual number of years that have elapsed between the event concerned and the present time, that could be translated in terms of years in BC or AD, as the case may be. However, the concept of trying to get exact number of years is the ideal situation, which is not always achievable in reality even in the case of chronometric dating. This is because of margins of error that creep up invariably due to the inherent flaws in several absolute dating systems.

9.7 Check Your Progress

- Describe the importance of time in studying the past. Give few examples.
- What do you understand by dating ?

- What is relative dating and to what extent it is useful in reconstruction of the past ?
- What is the main difference in relative and chronometric dating ?
- Describe in brief what is stratigraphy and how does it help in achieving the correct sequence of events / cultures ?
- Can stratigraphy be helpful in giving particular time span to objects ? If so how ?
- Write a brief note on the use of scientific methods of cross dating ?
- What was the Piltdown Man controversy ? How was it resolved ? What lessons can one learn from the controversy ?

9.8 Points For Clarification

- There are no hard boundaries between relative and chronometric dating.
- Several types of dating techniques for instance, stratigraphy which although useful in relative dating could as well be useful in chronometric dating once few points or the zero point in strata or varves, respectively are dated absolutely.
- On the other hand although it is assumed that strata contains objects / artifacts that are contemporaneous with the layer, in several cases earlier objects / bones could get mixed with later layer due to re-depositions.
- Similarly in layers, later artifacts also could be placed in earlier layer by means of post holes, rat holes, tree root holes, pits, inversion of layers etc.
- Due to erosion and subsequent re-deposition at a lower spot the inversion of layers is possible. Then in such cases the older objects would be found on top and comparatively younger objects are placed underneath in the inverted sequence of layers.
- Although objects are known to be popular at a particular span of time it should be remembered that the diffusion from the nucleus site to peripheral areas suffer from a time lag.

9.9 Assignment / Activity

1) Visit the local museums and enquire with the curator, if there are potteries in his collection which are having specific time span?
2) Ask the curator how he could date the sculptures and other objects of art in the museum?
3) Note down the different motifs on coins of different periods.
4) Visit an excavation site and ask the excavator.

a) To guide you regarding the demarcation of layers

b) Find out the changes in the potteries in different layers

c) Note how many objects are obtained during excavations that can be helpful in dating the layers

5) Visit a rock art site and ask the interpreter as to how the rock paintings were given dates.

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9.11 Glossory Of Technical Terms

Component — In this context component means the archaeological material that is ascribable to a particular time bracket (Period).

Deep Sea Cores — These are cores drilled out from deep sea sedimentation that provides a record of environmental changes across millions of years.

Dendrochronology — It is the measurement of time intervals by counting the annular ring of trees.

Geochronology — The measurement of time intervals by such methods like varve analysis changes during Ice ages and the astronomical effect.

Period — A particular time span that is marked by characteristics cultural materials common in the particular bracket of time.

Stratigraphy — The sequential deposition of sediments identified as different layers.

Varve — Broadly speaking the term is applied to the layer of sediment deposited in a single year.

UNIT – X
CHRONOMETRIC DATING METHODS

10.1 Introduction

In history and archaeology the time factor is quite important as one needs to know the correct sequence of events, like : a flourishing culture, migration of people, earthquakes, floods etc, which cause abandonment of a site. Imagine that in early historic times an earthquake had occurred which has been noticed as a debris layer in the strata, during the course of excavations. Now developments at the site could be said at least in terms of before earthquake and after earthquake. Thus time is segmented. Further if for example we are able to know by an inscription at a palace, that a severe earthquake occurred, in AD 180 then the sequence of events before and after the earthquake could be given. These example shows that our points of reference are those events we view as in some sense marking a change in the state of things. Thus we mark time by a succession of events. Here one should also understand that the succession of events or the changes that occurr across time need to be recognized in the scale of time as for example the inscription giving the date AD 180. One also understands that dating techniques therefore becomes important in the study of history and archaeology. There are two types of dating methods namely : Relative and chronometric dating.

Relative dating methods suggest the relative antiquity of the artifact, stratum, or site in terms of old, older, oldest but not in terms of years elapsed from the present. Chronometric dating also known as absolute dating refers to quantitative measurements of time with respect to a given scale. The scale however should be understood by all. Thus the measurement of time intervals between events or between an event and the present are expressed in number of years that have passed between the two points in time i.e. between two events or an event and the present. Events may be mentioned as have happened in any number of years in various eras in inscriptions or in case of scientific dating with reference to the term 'Before Present'. All these should be known in simple terms for example : 1000 AD or 2050 BC. Whereas when the dates go back to many thousands of years it could be mentioned as for example 22000 BP (Before Present). The reason for such differences in usage would be given further on.

10.2 Objectives

After going through this unit you would be able to know :

- Ø What is the importance of time in history and archaeology.
- Ø What are the different ancient calendars.
- Ø What is dating.
- Ø What are different types of dating.
- Ø What is the relation between relative and chronometrical dating.

- Ø How two types of dating are mutually beneficial.
- Ø What are the different methods of arriving at chronometric dating.
- Ø What is stratigraphy and periodization.
- Ø What is the importance of specifically datable objects like inscriptions and coins.
- Ø Why does the need for cross checking the context of the stratigraphy while using these materials arise.
- Ø What is the importance of correlating different eras mentioned in inscription.
- Ø How and when floating chronologies could be helpful in establishing absolute age.
- Ø What are the limits of accuracy in the scientific techniques.
- Ø How errors can happen due to the mistakes done by the excavator at the site.

10.3 Prelude to Chronometric dating

As made explicit in the earlier paragraphs many aspects are to be considered for dating to be effectively accurate. As we know archaeology deals through three types of data basically namely 1) formal content (Materials) 2) their distribution in geographical space 3) duration in time. Here it becomes obvious that the context in which the material / object that is specifying the date or is intended to be dated is found becomes very important. Another aspect include floating chronologies, calendars and correlation with the Christian calendar. Thirdly, examples of how correlation of literature could be done on the basis of coins, inscriptions and evidences of art etc in the archaeological contexts are also provided.

10.3.a Periodization and Stratigraphy

Chronometric dating is the ultimate in giving time related details of an object, soil layers in archaeological sites, or cultures as a whole. However it is not always possible that one gets objects/ artifacts that could be dated in terms of chronometric age. In such conditions it is necessary that atleast some aspect of time could be provided on the basis of periodization or relative dating to the object or layers concerned. For this it is important to know the techniques of stratigraphy which is the study of layers. Moreover stratigraphy is important to know the context of the object or layer which has been given chronometric date. This is not only important for cross checking the validity of the chronometric date if dates are available for other layers but also to give atleast some coherent dates to other layers if chronometric ages are not available for these. Thus the stratigraphical studies and allotment of periods and relative dates are complementary to chronometric dating methods as will be under stood from the following hypothetical example.

During an exploration of an area an archaeologist comes across six sites named 1) Lohapura, 2) Pathargadh, 3) Dhanpur, 4) Jankhpura, 5) Tambapur, 6) Prastargadh.

He found that :

- Ø Pathargadh and Prastargadh have only stone tools of varying shapes and sizes.
- Ø Dhanpur and Tambapur have large amount of copper implements and different type of potteries.
- Ø Lohapura and Jankhpura are two abandoned villages which yielded only iron implements and a wide variety of potsherds besides ruined brick structures. No evidence of plastic objects is noted.

Assuming that in a given area close by without any natural hindrances same technologies would prevail during a given time span, the sites with same technological levels of metal, pottery and other objects could be clubbed as belonging to the same time span in other words same period. Thus three different periods have been outlined.

- Ø Lohapura and Jankhpura belong to one period.
- Ø Dhanpur and Tambapur belong to another period.
- Ø Pathargadh and Prastargadh belong to yet another period.

Now continuing the assumptions made, if one also thinks for a moment that the archaeologist was doing his survey in the early part of 19th century and he was not aware of the three age classification namely 1) Stone Age, 2) Bronze (Copper) age, 3) and the latest iron age. Then how was he to bring to light the correct order of development of cultures in the area ? To find an answer to the vexed problem he would have undertaken further survey in the nearby region and discovered two other site-Samastpur and Samastgadh. He would have excavated both the sites and found that at Samastpur cultural remains that were found in sites Lohapura and Jankpura were found to overlie cultural deposits that were similar to those found at Dhanpur and Tambapur. Whereas at the site Samastgadh he would have found that cultural remains similar to those found at Dhanpur and Tambapur were seen to overlie the cultural remains that were similar to Pathargadh and Prastargadh.

Thus he would have inferred by geological rule of stratification which says that the oldest layer is the one lying lowest in the strata. Now between the two sites Samastagadh and Samastpur it becomes very clear that which type of sites and remains are old, older, oldest. Thus, we have relatively dated the sites.

- Ø Lohapura and Jankpura evidently are old sites as they don't have any object of plastic or any other modern object.

- Ø Dhanpura and Tambapura have older Material remains.
- Ø While the sites Pathargadh and Prastargadh have the oldest material remains.

Thus we know by the nature of archaeological remains due to systematic excavations and study of strata that

- Ø The sites with iron implements and pottery are the latest (not much old)
- Ø The sites with copper implements and pottery are older
- Ø The sites having only stone implements are the oldest

In fact the iron age, bronze (copper) age, and the stone age are universally known as old, older, oldest. But this system of finding out the correct sequence of events has been given here such that the importance of correlation by stratigraphy could be understood and these principles could be used in sites which may give problems regarding the sequence of cultures and events. This would enable one to demarcate the different periods in one or several sites on the basis of the dominant material remains of each period like on the basis of metals, or pottery types etc. One could also say which period is the oldest using the laws of stratigraphy and thereby atleast classify the periods and its antiquity on the basis of relative dating.

The semplest and the most important law of stratigraphy is that the lower the layer in the strata the older it is. It means that the oldest layer is that which lies lowest and the youngest being that lies on the top. During the archaeological excavation of ancient sites the different layers are demarcated largely on the basis of the materials in the layer and the colour of the layer. In fact both the aspects of the layer show the effect of ancient man or nature or both across time. As these are also markers of time these should be identified accurately. Now for example if a site has 1 to 30 layers from top to bottom and layer no 20 yields some punch marked Coins & NBPW and layer no 21 yields Chalcolithic pottery. But supposing the excavator could not identify the layers properly and has clubbed layers no 20 and 21 as layer no 16. What would be the conclusion ? The conclusion by this excavator would place both the Punch Marked Coins & NBPW and the Chalcolithic pottery as of one and the same period which in reality is not true. As both the type of objects namely the PM Coin and Chalcolithic pottery are separated by many centuries of time. Given that neither the dates of the PMC nor of the Chalcolithic period are / were known in this hypothetical example, if the marking of layer was done correctly then at least two things could have been said. That there are two different periods as also noticed on the basis of difference in material remains and secondly that the layer having Chalcolithic pottery is older than the layer containing PMC and NBPW. The above example shows the importance of correctly identifying layers in the excavation. Moreover care should be taken that datable objects like coins and potsherds etc have not gone down into the sequence of layers by means of rat holes, tree root holes, post holes, foundation trench, robbers trench and pits.

10.3.b Floating Chronologies, Eras and need for correlation

Suppose a year 3523 is mentioned with regard to a event that happened in the Mayan Civilization in America or say a Greek work gives a year of 1000 years after the first Olympic or say 200 years after Prophet Mohammed's departure from Mecca to Medina, how would these relate to the time scale that is commonly understood? On the other hand inscriptions obtained in our country have shown the presence of numerous eras of which many have been correlated while some have not yet been correlated. Thus imagine if we get inscriptions giving : 5000 in Kaliyuga Samvat 300 years in Gupta era 500 years in Vikram Samvat and 2000 years in Saka Samvat how could one correlate all these. Fortunately, we know the zero point of all the above mentioned calendars / eras as detailed below : 1) The Mayan Calendar commenced in 3113 BC, 2) The first olympic is believed to have been held in 776 BC, 3) Prophet Mohammed went to Medina in AD 622, 4) The Kaliyuga Samvat is reckoned as from 3101 BC, 5) The Gupta era commenced in AD 319, 6) The Vikram Samvat began in 57 BC, 7) The Saka Samvat is reckoned from AD 78. Imagine if the zero point of these were not correlated with reference to AD or BC (as the case may be) then what would have been their utility in the reconstruction of history. Then data obtained would not be of much use as the eras are not fixed, and are of floating nature. Now one wonders what is BC and AD of the Christian Calendar. By convention the year of the birth of Christ is taken as AD 1 (AD stands for Anno Domini, Latin for 'In the year of Our Lord : there is no year AD (zero)0). The years preceding the year AD1 are counted back as before Christ (BC).

In historical studies genealogies are sometimes very helpful and other times they may be even misleading. An example of Egyptian history which goes up to nearly 3000 BC makes the point partly clear. History of Egypt is classified in terms of 31 dynasties that allows for estimates of the number of years in each reign to the time of conquest of Egypt by Alexander in the year 332 BC. From this point the Egyptian dynasties can be dated backward. Although the exact number of years of every reign is not known, yet with the correlation of astronomical events mentioned by the Egyptian historical records one is able to move with reliable accuracy up to 664 BC. Then the margin of error increases. Thus in the bracket of C 1550 to 1070 BC the error may be 10 to 20 years. While the margin of error increases to about 200 years if one is dealing with the first dynasty placed around 3000 BC.

In our country there are many genealogies of dynasties with the year of events being mentioned in various different eras. However unless the era mentioned is not precisely correlated with its zero point in BC or AD as the case may be, the genealogies referred, the events mentioned are of a floating nature and the sense of history is not placed on the hard ground of time. Imagine, that in an ancient literature a King Ram is mentioned as the grand father of Shyam who in turn was the grand

father of King Ram II this genealogy cannot even impart information regarding the number of years the dynasty ruled. Now supposing that in another literature the same genealogy is provided with number of years in an era not correlated till now. Then although the number of years the dynasty ruled could be given one cannot say from which year to which year it ruled. However, if coins of King Ram and King Ram II mentioned in the ancient literature are found at two different sites, one can say that the coin of King Ram is older than that of King Ram II. And the two sites were in use during the reign of this dynasty. Further it could also be said that the site with coins of King Ram is older than the site with coins of King Ram II. However as no absolute date in years can be given on the basis of the coins or the era mentioned in the literature, the archaeology and conclusions provided in the given contexts is very limited.

Inferences due to incomplete data of scientific methods also are of a floating nature. For instance in varve analysis of the study of a lake sedimentation, it 1500 varves are counted as representatives of 1500 years it would not be of much use if one is not able to give the actual year when the varve formation started or ended. Thus any number of objects trapped in between these layers could be said as differentiated by as many varves in between. Thus although an object could be said to be much older or younger in relation to the other yet one cannot determine the actual number of years that must have elapsed since it was deposited in the lake in the context of the present time. In dendrochronological studies also if the tree ring data does not add up to the present time or is not correlatable in some way to the actual dates the presence of logs in ancient buildings would not be helpful in giving the year of construction of such buildings. However on the basis of comparison with available tree ring data one can give the sequence of construction of monuments in the area. Once the missing links in the tree ring reference logs is found or cross dated from other sequence, these would give absolute dates in number of years upto the present. In both the above examples of varve analysis and dendro-chronological analysis because the zero point (i.e. starting) or the end point is not known the utility is limited to showing the artifacts or buildings with reference to terms like old, older, oldest. Thus these are useful in relative dating. Once accurate time is known of any part of the varves or tree rings by any means of dating then the entire sequence of layers and rings becomes useful for absolute dating.

10.3.c Coins, Epigraphs, Literary Evidence in Dating of Sites

Coins are very useful as datable antiquities being identified in a particular time span on the basis of the identification of the issuer, character of the script, literary or epigraphic evidence or due to close proximity with an object of determined age. If such coins with a determined age are found in a particular stratum of a systematically excavated site all other objects within the stratum also could be placed in the same time span. Due to the presence of coins not only associated objects but

also structures and structural phases also can be given time brackets of reasonable accuracy as in the case of stupas at Devnimori (in Gujarat) and Pauni (in Maharashtra).

Similarly, palaeography and epigraphy for instance have been useful in the reconstruction of the stylistic phases of the origin, development and decline of several schools of Indian art and architecture. Here perhaps the best examples are the epigraphs of the Iksvaku Kings. Although these epigraphs are inscribed without any era being mentioned, yet these could be dated on the basis of palaeographic considerations. The epigraphs therefore not only helped in dating the material remains but were instrumental also in tracing the beginning, development and decline of the Nagarjura Konda phase of the art of Krishna valley. In other instances inscriptions on monuments are frequently helpful in providing the accurate years of the construction of temples or stupas etc.

Correlation of literary evidence and archaeological evidences at site are frequently helpful in providing specific dates to events at a site. Dr. R. G. Goodchild for instance could correlate the literary evidence of the earthquake that happened in the region around EL-Beida. He had found a hoard of coins lying close to a skeleton crushed by fallen masonry at the site. Correlating the two he dated the earthquake to AD 365 and abandonment of site, since then. Dr. S. P. Gupta on the other hand correlated the literary evidence of persecution of the Buddhists by Pusyamitra Sunga. He has dated the Lomas Rishi Cave very specifically to 187 BC on the ground that work could not be completed as Pusyamitra Sunga killed the last Mauryan ruler Brihadratha and his forces were hunting for Buddhist monks, to kill them. Dr. P. K. Mishra, also correlating the persecution of Buddhists and destruction of their shrines could specifically date the massive destruction at the Buddhist stupa at Deorkothar (Distt. Rewa) beside its abandonment to the reign of Pusyamitra Sunga.

10.4 Radiocarbon dating

Radiocarbon dating is one of the earliest methods that has been used in Archaeology. Although it had its share of controversies, yet it has been largely useful and with refinement of techniques, it has become more effective. The following paragraphs give the details of the principles, sampling techniques and refinements made besides analysina the reasons behind errors.

10.4.a The Principle of Radiocarbon dating

The technique was discovered by Williard Libby who published data regarding the first radiocarbon dates in 1949. The basis of the dating is dependent on the continuous production of carbon - 14 due to the cosmic radiation which produces high energy neutrons which in turn react with Nitrogen to produce radiocarbon. This radiocarbon is unstable due to the eight neutrons in the nucleus instead of the usual six as for ordinary carbon. Due to the instability it decays at a regular rate, earlier estimated by Libby as 5568 years for half of any amount of carbon - 14 to change to

ordinary carbon. The principle of the method is based on the fact that all plants and animals take in carbon - 14 and this intake is stopped at the death of the plant or animal. From this point of time the amount of carbon - 14 reduces and becomes half in 5730 years (the more accurate figure of half life period of carbon - 14) and becomes one fourth of the original amount in 11460 years. One eighth in 17190 years and one sixteenth in 22920 years. Now by measuring the percentage of carbon - 14 in relation to the 100% at the beginning estimate regarding the elapsed time is made.

10.4.b Sample Collection

The various precautions to be taken during the collection of samples are required to be followed, strictly

- Ø The sample collected should have carbon in it and it should not be contaminated by extraneous materials, like rootlets.
- Ø It should be packed in aluminium foils without being touched by hands.
- Ø It should be taken out from clearly marked feature namely : layer, from inside hearth, on floor etc.
- Ø The sample should have the required weight according to nature of the material which is as follows.
- Ø Approximately 5 g of pure carbon is required as per the traditional method of analysis that was in vogue. This would mean that an original sample of wood or charcoal requires about 10-20 gms of material and nearly 100-200 gms of bone is required for analysis. Recent methods, however, require only a few hundred milligrams of charcoal.

10.4.c Refinements in the Technique

One of the basic assumptions made by Libby that carbon - 14 concentrations remained constant through time turned out to be not quite correct. Now we know that Carbon - 14 content has varied due to the changes caused by the variation in the earth's magnetic field. This error was noted when carbon dates were compared with tree ring dates. Incidentally tree ring dating also provided the means of correcting the radiocarbon dates. These corrected dates are known as calibrated dates. The dates cannot be corrected on the basis of proportional adjustment as it is dependent on the varying amount of carbon - 14 produced during different periods. However for an idea of the differences between calibrated and uncalibrated dates for instance 4100 BC of uncalibrated dates would read 5000 BC on calibration. Another refinement made is the need for lesser amount of carbon required for analysis. Unlike earlier, now only few hundred milligrams charcoal for analysis is required due to the development of special equipments. The latest development in this line is

known as the atomic mass spectrometry (AMS). If the sample is being sent for radiocarbon dating to a laboratory where atomic mass spectrometry is being done then the required material is only 5-10 mg. This technique has allowed the datable material to yield much earlier dates upto nearly 80000 years from the 50000 using older methods.

10.5 Other Scientific Methods of Chronometric dating

Radiocarbon is one method which is universally known for its utility in absolute dating. However there are many other methods which are also useful in chronometric ages. These methods include : Dendrochronology, Varve analysis, Thermoluminescence dating, Optical dating, Uranium Series dating, Archaeomagnetic dating, Potassium-argon dating, Obsidian hydration dating, Fission track dating, Geomagnetic reversals besides others. In the following paragraphs a brief description of each method is given.

10.5.a Dendrochronology (Tree Ring Dating)

The technique of tree ring dating was mooted by A.E. Douglass in 1930 and subsequently developed in the same decade. Following the use of computer from the 1960s it has now become an established method that has two distinct advantages in archaeological uses. The two uses are 1) As an independent method of chronometric dating in its own right 2) For calibrating or correcting radiocarbon dates.

The principle of this method is based on the variation in the growth rings of the trees due to variations in climate. One can see the tree rings in the section of a sawn tree. As would be seen the rings do not have the same thickness. The reasons for varying thickness are intrinsic as well as extrinsic. The internal reason for the variation in thickness of tree rings is the age of the tree, as with increasing age the tree ring becomes narrower. The external reasons, however are the more important ones for absolute dating. These include : rainfall, sunlight and temperature. Thus in arid area more than average rainfall leads to greater thickness of the tree rings, on the other hand sharp cold in a particular year would cause a narrow ring.

Evidently, trees of a species in an area will have the same pattern of tree ring. Looking back in time in the same area many trees of the same type would also have the same pattern of tree rings. Now if from an archaeological structure one finds a timber this can be dated on the basis of the pattern of tree rings. This timber piece would have a particular pattern that would match with a particular part of tree ring of a living tree say 2000 years old. Supposing if the pattern of the living tree matches with the rings numbers 510 to 570 from the core to bark of the tree the timber may have been used in the architecture not earlier than 1434 years before AD 2004. (570+1434=2004). Alternatively, there may be many timber pieces in different structures that may form long master sequence. Long master sequence is explained as follows :

Suppose there is a log 'Z' which is of the most recent building built in 2002 has similar pattern in the core zone of the timber matching with the outer zone of log Y in a building that was made in 1920 AD. The pattern on the core of the log 'Y' matches with that of the outer zone of the timber piece 'X' and this process of pattern matching is seen up to log 'A'. Now in this hypothetical examples there are 26 timber pieces with matching ends that can take the tree ring dating up to hundreds or thousands of years depending upon the number of rings between two matching patterns in different logs. Now if an archaeologist of the area gets a timber log from an excavation he can compare the pattern of the timber with the logs of the master sequence of the area namely 'Z' to 'A'. Suppose his timber piece has a pattern that matches with the pattern in log 'D' he can count back the rings starting from log 'Z' to the pattern in log 'D'. This will give the number of years before which the tree was living and evidently the structure was built not before that time. Scientists have made master sequences of various areas going back many thousand years using living trees as old as 4900 years besides dead trees and wood in water logged deposits. Some of the longest sequences include those that go back to 8000 BC (Germany) 6700 BC (Arizona) 5300 BC (Ireland).

10.5.b Varve Analysis

This method of dating was first brought to use in 1878 by Swedish geologist Baron Gerard de Geer. It is a study of layers (varves in Swedish) which has been formed by the deposition of clay in lakes around the edges of Scandinavian glaciers. This deposition of clay has been a continuous phenomenon since the end of the Pleistocene epoch due to the warming up of the environment. Like tree rings the deposition of varves is also affected by climate. Thus in a warm year with increased glacial melting a thick layer is formed on the other hand in a cold year a thin layer is deposited. Like in tree ring analysis here also the overlapping matching in pattern of varves in several different lakes helps to build the master sequence. Now once a master sequence of the varves have been prepared any set of varves in the lakes in the general area can be given appropriate dates.

10.5.c Thermoluminescence and Optical Dating

Both the above techniques of dating are dependent on the radioactive decay but unlike radioactive carbon dating in which the radiation emitted is counted, here the radiation received by the object is determined. The basis of this method is as follows. The electrons in minerals and pottery on being exposed to radiation (gamma rays) from the radioactive elements within the object or in the immediate surroundings become detached from the parent nuclei and get trapped in defects within the ordering of atoms of the material. Thus the more the time elapses the more radiation it receives and more of get trapped electrons in the structure. Age is calculated as total dose received by the object divided by estimated annual dose. In the thermoluminescence method the pottery piece for instance on being heated in the archaeological past loses the stored energy and the clock is set at zero. Later

over the years the radiation received causes increasing number of trapped electrons. The total amount of dose received is known by heating the potsherd rapidly to 500°C whereupon it emits luminescence proportional to the amount of trapped electrons being evicted. The same material is heated again where upon the luminescence is lesser. This is due to the fact that the earlier greater luminescence was mostly due to the stored up energy of the radiations received. Thus the difference in the amount of luminescence in the first and second heating shows the total amount of radiation received. On finding out the annual radiation from within the pottery and surrounding soil by use of radiation counter the total dose estimated is divided by the counted annual dose to find the age of the pottery. The optical dating also known as optical stimulated luminescence is similar in principle to thermoluminesence but is used to date minerals, which have been exposed to sunlight rather than heat. Here for determining the age of the material light of a known wavelength is directed onto a sample and the resultant luminescence is measured, instead of heating used in thermoluminescence.

10.5.d Potassium Argon and Uranium Series Dating

The method of Potassium Argon dating, like radio carbon dating is based on the principle of radioactive decay. But unlike Carbon 14 the half life of Potassium is around 1.3 billion years when half of the potassium would decay to the inert gas Argon. The estimation of the trapped argon gives the age of the volcanic rock. This method has been successfully used in very old prehistoric sites like Olduvai and Hadar in Africa. However its use is also restricted to sites which are not younger than 100000 years.

The uranium series dating is also based on the radioactive decay albeit of the isotopes of Uranium. This method is useful in the estimation of age in the time bracket of 50000 to 500000 years. The principle of the method is as follows. The Uranium isotopes, U 238 and U 235 decay to Thorium and Protactinium respectively. While the isotopes of Uranium are water soluble the daughter elements namely Thorium and Protractinium are not. Thus during the formation of lime structures in lime stone cave only isotopes of Uranium are found within the lime and slowly both the daughter elements would be formed due to radioactive decay as a time dependent process. On estimating the ratio of parent and daughter elements the time elapsed is known. Modern methods of estimation of these elements have reduced the margin of error to about 1 per cent.

10.5.e Obsidian hydration and fission track dating

Both the above methods although have different principles for estimating age yet one similarity is the use of optical microscope. The obsidian hydration techniques was developed by American geologists Irving Friedman and Robert L. Smith. Obsidian is a volcanic glass used like flint to make tools. On fracture it starts absorbing water from its surroundings, forming a hydration layer that can

be measured under an optical microscope. The principle behind the method being that the layer increases in thickness and if the rate of growth and present thickness is known then one would be able to calculate the length of time, since the growth of the layer began. However as there is no universally valid rate of growth, the rate has to be established for each kind of obsidian. Moreover factors like temperature, sunlight, chemical environment around the piece of environment also have to be taken into account. It should however be remembered that a single obsidian artifact cannot be expected to give a reliable date. Therefore about 8 to 10 pieces of the obsidian objects found in the same contexts should be taken up for analysis to avoid errors that may have crept in due to extraneous factors on one or few of them. The obsidian hydration dating provides dates upto about 10000 years although dates even up to 120000 years have been accepted in the context of Middle Palaeolithic material from East Africa.

Another method that uses optical microscope is the fission track dating. The principle of this method is based on the natural fission of radioactive elements and their effects on volcanic glass and man made glass. Once a rock or a man made glass is formed it has a fixed internal arrangement of molecules. Within this arrangement there are atoms of U 238, which divide into half and move apart at high speed causing much damage to the arrangement of molecules in the vicinity. Over the years due to the spontaneous fission there is a gradual growth in the number of damaged pathways within the object. These damaged pathways known as fission tracks can be counted under an optical microscope after the polished surface has been etched to improve visibility. Once the amount of U 238 present is estimated one arrives at the date - since the formation of rock or glass - by comparing the number of spontaneously induced tracks with the quantity of U 238 in the sample. Although this type of dating is used in geological samples generally going into lakhs of years, yet it should be remembered that these have also been useful in dating pottery glazes about 2000 years old. The accuracy, however, is not high, as in favourable conditions. The error associated with this method is of the order of ± 10 percent.

10.5.f Dating based on Magnetism of the earth

There are two methods based on the magnetism of the earth, namely Archaeomagnetic dating and Geomagnetic reversal dating. The archaeomagnetic dating is based on the fact that the earth's magnetic field is constantly changing in both direction as well as intensity. Scientists have compiled the historical records and compass readings of the variation in direction upto the last 400 years in the context of Europe. Further by studying the direction and intensity of thermo remenant magnetism of baked clay (baked over 650-700°C) and correlating with dates obtained by other absolute dating techniques master sequences have been prepared in different regions of the world. For magnetic direction the master sequence have been prepared for about 2000 years in Europe and American

South West. Due to this known sequence the direction of the magnetism when the clay was last heated in the archaeological times in these areas could be compared with the master sequence of the area and reliable dates provided. Similarly in China, the magnetic intensity has been studied and a master sequence for the last 4000 years have been prepared. These obviously would be available for comparative analysis, if for instance baked clay or pottery etc are found from archaeological excavations. The intensity method of archaeomagnetic dating has however proved inherently less accurate.

In the Geomagnetic reversal dating method the phenomenon of complete magnetic reversals in the earth's magnetic field wherein magnetic north becomes magnetic south, and vice versa is recorded and compared with known sequence. A sequence of such reversals has been built up stretching back to several million years, with the aid of dating techniques like potassium - argon and other methods. Now if the sedimentation show reversed polarity it can be given the time bracket allotted for such polarity. However as the reversals were not too frequent the sequence is punctuated by large periods of normal and reverse polarity to be of much use to archaeology.

10.6 Summary

The text above describes the importance of time in the study of history. It also mentions the significance of periodization, relative age and the context of the datable objects obtained for monuments or excavation sites. In the dating techniques the context is more often outlined by stratigraphy. Thus coins, epigraphs, literary evidence acquire more significance if seen in the stratigraphic context. The enumeration also descibes in brief the principles and methods, and limitations of the main types of chronometric dating. Obviously it goes without saying that different materials obtained from archaeological monuments and excavation sites are not usually amenable to more than one type of dating. In fact, occasionally it becomes difficult to obtain even a single type of dating material that could be dated with reasonable accuracy. Thus, it is necessary that the archaeologist should take full care in outlining the context of the datable object. Moreover the object, material being collected should be recorded with maximum details. The collection of samples for different type of dating materials should be done, strictly as per specific procedures, avoiding impurities and chances of error, such that the element of error is not introduced even before it has been sent to the laboratories.

10.7 Check Your Progress

- Ø What do you understand by dating Methods ?
- Ø What are floating chronologies ?
- Ø To what extent is stratigraphy helpful in dating ?

- Ø What are the different type of dating which depends on the radioctivity of elements ?
- Ø Describe Radio Carbon dating ?
- Ø What are the time brackets upto which the different dating methods are effective ?
- Ø Describe in brief the dating methods that uses the residual effects of earths magnetic properties.
- Ø Write an essay on the importance of context in which the datable material is found.

10.8 Points for Clarification

- Ø Relative dating techniques are helpful in many ways for providing firmer foot hold to chronometric dating and in many cases is also helpful for cross checking.
- Ø It is very important to note that the context of the sample being sent for chronometric dating is without flaw.
- Ø For example if a charcoal sample of a timber burnt from an ancient architecture is found in archaeological layers it may give anamolously older dates than the layer is understood to be on stratigraphical considerations.
- Ø On the other hand dating materials may go deeper down into the layers due to rat holes etc giving younger dates to layers that are older.
- Ø Dendrochronologically dated timber was subjected to Radiocarbon dating which gave younger dates and subsequently the radiocarbon dates were corrected accordingly.
- Ø BP in radiocarbon dates means before present (Before the Present) which is taken as the year AD 1950.
- Ø The convention of providing the number of years elapsed in say 10000 ± 300 BP could be kept as such as in thousands of years 54 years difference as on 2004 hardly matters.
- Ø However in Early Historic times if a radiocarbon sample gives the date say 2000 ± 50 BP which in terms of Christian calendar would read 50 BC (not 4 AD, as on 2004) Inclusive of the error margin it falls in the time bracket 100 BC and AD1.
- Ø Dating methods in general have some inherent element of error, to avoid vast deviation more than one sample could be used for dating. If possible different types of dating methods should be employed and cross dating could also be done. In the multiplicity of dates and accurate sequence of layers anomalous dates would stand out automatically.

10.9 Assignment / Activity

1) Visit the local museums and enquire about the coins with the year of minting and the dates as well as the eras mentioned on the epigraphs.
2) Visit an excavation site and learn how demarcation of layers is done.
3) Visit a saw mill and count the tree rings in the different types of trees.
4) Make an elaborate chart with the columns. (1) Sl.No. (2) Dating Method (3) Material used for Dating (4) Age range (5) Factors causing error (6) Percentage of Error.

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10.11 Glossary of Technical Terms

Dendrochronology	:	It is the measurement of time intervals counting the annular ring of trees.
Period	:	A particular time span that is marked by characteristics cultural materials common in the particular bracket of time.
Stratigraphy	:	The sequential enumeration of different layers.
Thermoluminescence	:	The radiation emmitted by an object on being heated.
Varve	:	Broadly speaking the term is applied to the layer of sediment deposited in a lake in a single year.

UNIT – XI
BASIC PRINCIPLES OF CONSERVATION OF MONUMENTS

11.1 Introduction

India is a vast country with a rich cultural heritage of remote past. This heritage comprises temples, monoliths, stupas, monasteries, mosques, church, forts, fortifications, palaces, tombs, Sarais, bazaars etc. besides pre-historic and proto-historic sites and megalithic monuments. The pre-historic

remains consist of stones (generally roughly dressed or crude), arranged in crude forms. They comprise Stone-Age implements, ash-mounds, cave paintings, megalithic burials etc. but when we deal with historical sites we come across stupas, rock-cut monuments, brick and stone temples, dry stone masonry, Prakaras, Toranas, Gateways, Gopura Dwaras and the like. Among the Indo-Islamic monuments one comes across mosques, tombs, palaces, forts, gateways, minars, etc. The pre-dominant feature of the Islamic architecture is the arch and dome, which are totally absent in the native Hindu architecture. The forts comprise rampart or fortification, bastions and towers, moats, gateways, pathways secret passages and other structures.

11.2 Objective – The study of the principles of conservation is important because –

a) These monumental edifices of the past are located all over the country in different climatic zones viz. snow-bound; humid; arid and semi-arid; coastal and fertile alluvial valleys and as such need a specific treatment for preservation. Being vestiges of the past, they have to be protected and preserved to be handed down to the posterity in reasonably well-preserved condition.

b) The conservation of monument requires highly specialized techniques involving different engineering and scientific methods combined with knowledge of archaeology, including ancient art and architecture, materials, techniques etc. Most of the monuments are embellished with intricately decorated stone and terracotta work, rich sculptures, paintings, stuccos, glazed tiles, inlays etc. The problems of conservation therefore, are manifold and need to tackled by highly skilled conservators, after understanding the structure and studying the causes of decay in the field as well as in the laboratory.

c) In India conservation and preservation of monuments/remains of national importance numbering about 5000 is carried out by the Archaeological Survey of India and another large number of monuments of local and regional significance are looked after by the State Departments of Archaeology and other agencies. Eighteen of the national monuments of India have been included in the World Heritage List (Joshi, 2001: 516). Hence looking at the vast treasure of heritage monuments a training in their conservation is essential.

11.3 Definition and Principles of Conservation

Although the word 'Conservation' came into use in preservation of cultural property in the seventeenth and eighteenth centuries, its application to ancient monuments, with a particular meaning has been prevalent in England since 1855. Sheldon says that conservation covers the immediate intervention or repair work and also long range upkeep and maintenance of the monuments, and the term restoration conveys a restricted meaning of a temporary operation with a begining and end, and

completed when the structure has been restored as nearly as circumstances permit, to what is considered, the original physical and aesthetic state.

B.M. Fieldin opines that conservation is an action to prevent decay. It embraces all acts that prolong the life of natural and cultural heritage. The minimum effective action is always the best. If possible, the action shall be reversible and should not prejudice possible intervention.

In India the word 'Conservation' is being used for the preservation work of ancient monuments since 1885. Preservation of ancient structures with a modern spirit, basing on the archaeological and architectural values, was initiated in India by the British from the first decades of the nineteenth century. The preservation work of Taj Mahal for the first time was taken up in 1808 and for Qutub Minar in 1826. Though Archaeology Department has been existing in India since 1861, the conservation work of the monuments was brought under its purview only in 1886. By the time Sir John Marshall came to India, a rational approach to conservation was evolved and found acceptance in England, and the same was introduced by Marshall in India. The principles of preservation of ancient monuments followed in India, are embodied in the 'Conservation Manual' prepared by John Marshall in 1907 (revised in 1924). According to Marshall "the repair of ancient architecture, howsoever humble, is a work to be entered upon with a totally different feeling from a new work or from the repairs of a modern building. Although there are many ancient buildings whose state of disrepair suggests at first sight, a renewal, it should never be forgotten that historical value is gone, when their authenticity is destroyed, and that our first duty is not to revive them but to preserve them. When, therefore, repairs are carried out, no effort should be spared to save as many parts of the original as possible, since it is the authenticity of old parts that practically all the interest attaching to the new, will owe itself. Broken or half decayed original work is infinitely of more value than the smartest and most perfect new work."

The principle of conservation, therefore, suggests that in whatever condition of disrepair the monument may be, the renewal or restoration is not to be resorted to. No effort should be spared to save as many parts of the original as possible, as its aim is preservation without alteration.

The sole aim of archaeological conservation is to prevent a monument from further decay. Damages caused to it due to water or other natural agencies have to be properly attended to. Growth of micro-organisms have to be stopped. Proper drainage has to be provided to prevent stagnation of water and rank vegetation and fungi is to be periodically removed and chemically treated whenever necessary. During the last four decades preservation of cultural property has become a matter of great concern to all countries of the world to the extent that some of the monuments are now to be considered as parts of the World Heritage, belonging to mankind as a whole. UNESCO itself has been actively deliberating on this subject and has passed various resolutions, recommendations and conventions to this effect (Joshi, 2001: 519).

Some of the principles of conservation as followed by the Archaeological Survey of India are as follows:

The treatment of a monument aims at (1) its preservation without disfigurement or alteration of its character; (2) its maintenance in a proper and attractive condition; (3) the complete examination of its remains and documentary evidence concerning it; and (4) the preparation of monographs, guide-books and reports, so that its historical and artistic interest may be brought home to the scholar and the visitor and may rouse general interest in the past relics of the country.

Much ingenuity, care and patience are needed for the successful preservation of monuments. This will be readily admitted if one goes round India and looks at the variety of the monuments ranging from the prehistoric burials, early stupas and temples down to mosques, forts and mahals of the eighteenth century (Ramachandran, 1953: 173).

K. Lakshmana Murthy (1997: 81) defines the principles of conservation as follows:

1. Historical value is gone, when the ancient monument's authenticity is destroyed. Broken or half decayed original work is of infinitely more value than the smartest and most perfect new work.
2. Every original member of a building should be preserved intact, and demolition and construction should be undertaken only if the structure could not be otherwise maintained.
3. Annual repairs are indispensable in case of archaeological monuments.
4. Hypothetical restoration can be done, only if they are essential to the stability of the monument.

With the practical experience gained after attending the conservation work for about five decades (from 1902 to 1952), the aims of treatment of a monument, as stated by one of the senior officers of the Archaeological Survey of India are as follows:

(i) Its preservation without disfigurement or alteration of the character.

(ii) Its maintenance in a proper and attractive condition.

(iii) The complete examination of the remains and documentary evidence concerning it.

(iv) The preparation of monographs, guide books and reports, so that its historical and artistic interest may be brought home to scholars and the visitors, which may rouse general interest in the ancient monuments of the country.

11.4 Restoration

Restoration is generally needed when a monument has reached an advanced stage of deterioration. The object of restoration is to bring an ancient building back to its original condition

in appearance by faithfully and minutely reproducing all that has been lost or destroyed by making the new work with new material to resemble the old as nearly as possible. New work should match the adjacent or original work but it must be distinguishable when closely observed so as not to falsify the archaeological or historical evidence.

Restoration becomes all the more necessary when the monument is in use. The lost or missing parts of the monument have to be replaced or restored for the safety of the devotees, if the monument happens to be a religious one. Restoration is also necessary when tops of roofs are leaking and to check penetration of water, a fresh mortar or concrete is to be laid after demolishing the dead or loose concrete. N.L. Batra (1996: 19) suggests that the following steps may be followed while carrying out restoration work:

1. While carrying out plaster work, the thickness of original plaster, its composition and finish should be investigated properly. At times the new plaster may be toned or stained to match with the adjacent colour and/or texture.
2. Similarly, while replacing stones, the thickness of the original facing stones, thickness of joints, their colour and the quarry from which originally brought be properly investigated. Even the mortar used for binding should be got analysed before resorting to restoration work. The material used therefore should conform to original specification.

   However, sculptural work need not be restored, the repairs of human figures need not be restored, only carving or geometrical pattern may be restored if necessary, to harmonise and to match with the original. The broken limbs of the images with the old pieces may be joined together. In case the missing limbs are to be restored with new material, the new work need not be carved to imitate the original.
3. While restoring the rubble stone masonry or ashlar stone masonry, care be taken that the courses as per original character are maintained.
4. For woodwork, efforts should be made to preserve the existing woodwork by eradication of the causes of decay in the wood, sterlisation of the material and by consolidation of the loose fibre and texture of the wood additional permanent material may be used side by side to bear the superimposed load or the existing woodwork may be strengthened with reinforcement.
5. In case of pavement with stone or brick, the character of the original workmanship be studied thoroughly and the restoration work done accordingly.
6. While repairing an old building with bricks the size of the bricks used in the building be investigated and for new work, the old bricks of the same size and texture be procured

and used. The bricks be laid in the same bond and the mortar should be of same thickness and toned to the same colour as in the old work. Where desirable, the mortar used for pointing should be recessed about 75 mm or 125 mm from the face of the wall. Modern bricks on no account be used on the front face. However, due to non-availability of old bricks, modern bricks on the core are sometime permitted.

7. For inlay work, the missing precious stones may be restored with semi-precious stones. However, the shape and size of the stones to be used for restoration be maintained as per original.

11.5 Causes of Decay

The rich heritage in the form of stone buildings and other types of monuments handed over to us by our ancestors have suffered due to a variety of reasons. These can be broadly divided into two categories: A. Natural Causes, B. Man-Made Causes

11.5a Natural

(I) Extreme Weather Conditions

The eastern half of India and its west coast have thick vegetation brought on by tropical rainfall; Assam have been world's record for heavy rainfall. Monuments located in the extreme rainfall zone require annual repair in the manner of jungle clearance after monsoons, resetting of stones and other materials loosened by the rains or by the sprouting of tree-roots. The heavy rainfall also produces moss of lichen enough to disfigure a monument. Monuments which are located on sea-shores or near the sea like the Sun Temple of Konark in Orissa or the Rathas of Mahabalipuram, are badly affected by salt-action, as the salt-laden air penetrates into the surfaces and wears them out. In the interior of India, particularly in the north-west, where salt peter of the soil, in the absence of plant life, wears out brick monument and reduces the bricks to dust. The excavated brick structural remains at Mohenjodaro (Sind) and Nalanda (Bihar) were found to become powdery due to salt crystallization. Climatic deterioration depends on the degree or intensity of climatic agents and also on the nature of material.

(II) Earthquakes

Another natural cause, which fortunately is not normal, is the occurrence of earthquakes in the lower Himalayan region of India as also other parts of the country. For example, the Kangra earthquake 1905 brought down the Nagarkot monuments in Kangra (Himachal Pradesh). The Assam earthquakes of 1918, 1945 and 1950 brought down a number of monuments in Sibsagar district, including the Sibdol temple at Sibsagar. The Bihar earthquake of 1934 was another occurrence of sufficient intensity that caused injury to some monuments of Bihar.

Other natural causes of decay of monuments have been listed by S.L. Nagar (1993: 33-35) as follows:

(III) Environmental pollution also contributes massively to the decay of monuments. This is of two types, viz. natural as well as man-made. In the natural environmental decay, sea breeze plays considerable havoc to structures, particularly those made of stone. The Shore temple at Mahabalipuram and the Sun temple at Konark, could be quoted as examples. These structures are being threatened due to sea breezes, and could be saved because of extensive preservation works undertaken there for the past many decades.

(IV) Sub-soil water or saltpeter action is also responsible for gradual decay of monuments in some parts of the country. The structures close to the sea shore, river banks, reservoirs or tanks are particularly damaged by sub-soil water.

(V) Tornados or hailstorms due to different atmospheric pressures in the weather system, are responsible for extensive damage to the monuments. The coastal areas are particularly prone to such cyclonic gales which have devastating effects.

(VI) Natural calamities like earthquakes cause extensive damage to ancient structures. It is on record that the temple of Vajresvari at Kangra was completely ruined in the earthquake of 1905, and a new structure was erected there subsequently.

(VII) Floods in the rivers, streams, etc. also account for the damage to structures, together with lightning. It is on record that the wooden post in the compound of the Bijli Mahadeva temple in Kulu, is damaged by the lightning quite often.

(VIII) Wild growth: Ivy, creepers and other forms of plant life cause considerable damage if allowed to grow freely. In the Indian climatic conditions wild growth at the monuments is commonly found and persistent and sustained efforts are needed to have them eliminated in order to save the structure, because their unchecked growth could damage the very foundations of the structures.

(IX) Birds are also sometimes the cause of damage to monuments, wherein they make nests at some soft sports, sometimes by digging holes. Bats are indeed a nuisance at the monuments. Though they do not cause severe damaged to the structures, but their very presence at a monument has a sickening effect. Beehives are also commonly found at certain monuments in India. Though they do not cause much damage to structure, but cause nuisance to the workers and the visitors.

(X) Bacteria and lichen can also cause decay of building materially by producing acids which react chemically with the structural material. The growth of bacteria and lichen was widespread at the temples at Khajuraho, which was removed by extensive and prolonged chemical action.

(XI) Insects and other pests are also responsible for destruction of wood work in a structure. These insects cause great amount of damage by weakening structural timbers.

(XII) When the sub-soil water in summer or in draught goes considerably down, cracks are bound to appear on the surface of the structure.

11.5b Man made Causes

(I) Destruction and Vandalism

Another destructive factor is human agency. Religious bigotry of one community often led to the disfiguring of monuments of its rivals. The vandalism of some of the invaders from the north-west is too often recorded by historians to need any repetition and the fact remains that several monuments have suffered as a result of iconoclastic zeal, fad, fancy and frenzy of the invaders (Ramachandran, 1953: 171). Within the country, wars and changes of fortune of the ruling dynasties brought much destruction to the forts and inside structures. Kakatiya Pratapa Rudra invaded Kanchipuram and burnt the fort gates, but it seems he did not do any damage to the temples. Sikandar Lodi (15th Century A.D.) spared only five mosques and destroyed all the structures in Jaunpur. Aurangazeb destroyed the palaces and administrative buildings of Qutub Sahis (1687), after capture of Hyderabad, leaving the religious structures intact. The English razed to ground several forts captured by them in Maharashtra.

Religious structures like temples, stupas etc., suffered much from vandalism and despoliations. Vandalism means willfully or ignorantly destroying works of art or the like. Despoliation means to take away structural materials by force or to rifle a structure. Though vandalism and despoliation are different in spirit, their contribution to ancient structures from present day view point is the same i.e. their destruction.

It is mentioned that the Buddhist structures of Gandhara region suffered from iconoclasm of Huns and Muslim invaders. Mihiragula (5th century A.D.) destroyed 1600 stupas in Gandhara region alone. Buddhist establishments that survived as educational centres like Nalanda (Bihar), were turned into heaps of rubble by invading Muslim armies in 13th century A.D. The Buddhist sculptured panels, found used in the Hindu temples at Amarvati, Ghantasala, and Chandavaram. Jain temples in some places likes Kulpak (Nalgonda dist.) also suffered in the hands of Vira Saivite zealots.

Beginning with the invasion of Mohd. Ghazni in 11th century A.D. Hindu temples became targets of vandalism. Though Prof. Habib says that Islam never sanctioned vandalism or plundering of Hindu temples, Muslim rulers beginning with the 1st ruler Qutubuddin (1206 A.D.) made it a state policy to destroy Hindu temples. According to Volwashean, 'There could be no more testimony to the Muslim victory over the pagan, than the use of parts of Hindu temples, in the prayer hall of

True Faith'. In Gujarat, in early Muslim structures (1300-1459), the pillars of the mosques are as a rule Hindu. In this way, vandalism and despoliation were combined by Muslim rulers in India. The destruction of Hindu temples in this way went on with some interruptions upto the death of Aurangazeb (1707 A.D.). Though temples of South India also suffered in the expeditions of Malik Kafur (early 14th century A.D.) and also later, the temples beyond the river Krishna survived to a great extent due to the rise of Vijayanagara kingdom. Among the Europeans, Portuguese caused damaged to the temples in Goa. The British, it seems, on the whole kept aloof from temples, even prior to the proclamation by Queen Victoria (1858), of the policy of non-interference in the religious life of Indian people (Lakshmana Murthy, 1997: 53-54).

(II) Abandonment

A structure that does not serve any purpose will be abandoned. When there were no devotees to take care, and monks to pray, the Buddhist monuments lost their worth. Yuan Chwang, the Chinese traveler who passed through India (7th century A.D.) found that a greater part of Buddhist monasteries were deserted and ruined. By about the 12th century A.D. Buddhism vanished from India and from then onwards, the Buddhist monuments were abandoned. With the passage of time, (more than seven centuries) the ruins got covered by debris and the flowing silt or loose earth, so that the sites turned into mounds (Lakshmana Murthy, 1997: 55).

(III) Despoliation

Among the present-day human actions, despoliation is the most important. Despoliation of ancient structures on a large scale began from the 19th century A.D. for building materials. The bricks of ancient sites at Harappa, and Kalibangan were used for laying railway lines. The bricks of stupas of Gandhara region and Sarnath, were utilized for building construction and road laying. A bridge was constructed with the stones of a ruined temples at Ratanpur (M.P.). The Asokan pillar at Sanchi was cut to pieces for utilization as a cane press.

(IV) Encroachments

The unauthorised occupation of the protected monuments is generally considered as encroachment. Large scale encroachments on protected monuments particularly prehistoric sites, ancient sites and forts had been going on in the last four decades for agricultural, industrial and housing purposes. While the excavation site at Rajahmundry has become a public urinal, the temple complex at Kondaparthi (Khammam Dist. A.P.) has become a public toilet (Lakshmana Murthy, 1997: 59).

(V) Urbanization and Pollution

Large scale structural activity is going on in all Indian cities covering every inch of open space. A visitor has to search for the first mosque of Hyderabad city near Charminar as it is closely encircled by modern structures. In industrial areas, oxides of nitrogen occur in atmosphere, usually through burning of coal. The presence of nitric oxide leads to formation of nitric acid which is highly corrosive and causes fast deterioration of structural material. Industrialization also increases the sulphur content of the atmosphere. Sulphates play a very important role in weathering as they convert carbonates into sulphates, which are more soluble. Acid rain water erodes carbonate stones (marble and lime stones) at an accelerated rate. It was found that the erosion rate will be about 1 mm in 25 years.

Agra, Delhi, Hyderabad and other cities containing a good number of ancient monuments have become big industrial centers, emitting pollutants in the atmosphere. The Pollution Control Board has specified 30 Mg/Cum. of sulphur dioxide, as the level beyond which the danger of degradation of historical monuments exists. The cities of Hyderabad (31 Mg/Cum.) and Delhi (34 Mg/Cum.) have just crossed the safe limit, causing concern regarding the safety of the monuments at these places. In Agra, the sulphur dioxide level recorded in normal times (10-15 Mg/Cum.) is within limits, but higher amounts (40-45 Mg/Cum.) were recorded when hazy and fogy conditions prevailed (Lakshmana Murthy, 1997: 60).

(VI) Damage by Visitors

Another problem is wear and tear due to movement of visitors in large numbers. Some delicate parts of monuments are found damaged by visitors as observed in Siddi Mosque (Ahmedabad), where the shaking of the minars by the visitors has worn out the basal stone of the minars. Graffiti or engraving on structures is a hobby that disfigures the monuments, and a greater part of the monuments are found with Graffiti. In Bala Hisar of Golconda Fort, visitors engrave their names with penknives, causing much damage to plaster work (Lakshmana Murthy, 1997: 61).

11.6 Methodological study of monuments

Before any conservation project is taken in hand, it is necessary to make an analytical study of the monument. Inspection notes and conservation points are drawn to illustrate the works to be carried out. A skilled conservator before attempting the conservation work must study the aesthetic aspects, architecture of monument and investigate the purpose of original construction and all subsequent additions.

A conservator is primarily guided by the character and aim of the original building, and the purpose for which it was originally constructed. The need for careful historical ,technological and structural research is a 'must' (Batra, 1996: 43).

Commenting on the importance of this topic, N.L. Batra writes that a full report may be worked out by stages as follows:

1. **Note** – Name of the monument, district and the State
2. **Summary** – The report should start with a summary stating the purpose of inspection.
3. **Location** – Distance from nearby town, direction of the site where it is located, latitude, longitude, etc. to locate the position while in office, transport facilities available to reach the site, if the monument is located in a remote area and availability of conveyance, etc. should be incorporated.
4. **Equipment** – It includes writing pad, pen or pencil, a torch, penknife, measuring tape, magnifying glass, hammer for testing masonry and camera.
5. **Description** – Description of the complex or the monument includes structural and material condition: different phases of the construction of building and later interventions; any peculiarities and environmental context of the surroundings; general features of the monument including constructional features and the material used; and limit of protection, encroachments, etc.
6. **Brief History** – The study should deal with political, social and economical aspects, the period in which the structure was built and should give chronological sequence of vicissitudes in the life of the building. The name, the character of the actual creator should be recorded, if known.
7. **Conservation Problems** – This is the most important part of the inspection note. Each nook and corner of the monument is to be inspected and details of any damages caused to the monument recorded. Causes of damages, deterioration and decay should be thoroughly studied and remedial measures suggested item-wise; expert advice to tackle the problem sought, if necessary; repairs of immediate necessity and future conservation and restoration be elaborated.

   The monuments are to be inspected frequently and before that the earlier reports be also studied for drawing the inspection reports. Illustrated examples of analytical and methodological study based on the inspection reports on some of the important buildings belonging to different periods and regions are given to enable the readers to get an idea of writing inspection reports. Inspection notes will not only serve as guideline for the executive staff for framing detailed project reports or technical estimates, maintenance plan, etc. but also help the succeeding officer to assess the extent of work done on the monument by his predecessor.

8. **General Assessment** – Administrative problems such as security, watch and ward, scarcity of water, lights, toilet facilities, watchmen's quarter, improvement of pavements or roads and provision of notice boards or protection boards should be incorporated (Batra, 1996: 43-44).

11.7 Example of a model Inspection note.

Tomb of Mohammad Ghaus

This tomb is situated about 1 km east of the Gwalior gate. The tomb is dedicated to the preceptor of Emperor Akbar. It is square in plan having a domical roof supported on eighty pillars, which takes a usual shape of octagon, over which are laid architraves and then corbelling tiers in circular shape to support the dome.

In the center is the grave of the saint, enclosed in an enclosure of white marble perforated screens. The tomb is surrounded on all sides by corridors, having flat roof, with side walls filled with beautiful stone screens of geometrical pattern. It is entered through a porch in its south.

Conservation

1. Plaster of the intrados of the main dome is peeled off and therefore needs to be replastered.
2. The walls are plastered with shell powder. It should be stabilized by edging the portion wherever it is intact.
3. The marble screen provided in the enclosures of the saint's grave is to be cleaned with lukewarm plain water and rubbed with soft brush.
4. Flat roof of the corridors is plastered and its border painted. The plaster at some places is worn out. Therefore, wherever it is loose, it may be fixed with its base by injecting fine powered mortar and then filleted.
5. On the eastern corridor, three stone jalis were broken and the gaps created were temporarily filled with bricks. This looked very ugly. New jalis are to be provided here, for which there is already an estimate. On the other walls of corridors, some more jalis are broken and need to be replaced.
6. One beam in the western verandah is broken and needs to be changed. This would be only possible if the roofing slabs of the verandah are fully supported below by brick masonry pillars and a strong scaffolding would be required.
7. In this complex are some other monuments like Tansen's grave, a mosque and some graves belonging to nobles. Area in the south and west is therefore not demarcated properly as the rear façade of some private houses falls in the protected area. As a result, water

from these houses flows into monument area. It is therefore suggested that the existing compound wall be extended further along the line of houses and a drain be constructed to drive out the water falling from these houses (Batra, 1996: 72-73).

11.8 Techniques of Structural Conservation

To maintain the stability of a structure and also to maintain the internal and external shape of the structure without change, the various parts of a structure like walls, beams and pillars, etc., should be in a condition to bear and transmit the load of upper parts to basement. The basement and foundation shall be able to transmit the load of the structure to the ground without any problems of overloading or unequal loading.

Some of the important techniques of structural conservation are briefly discussed below:

a) Tell-Tales

'Tell-Tales' fixed on cracks can be considered as investigative study carried out on monuments in the past. Glass or plaster tell-tales are fixed on cracks, to find out whether the cracks seen on the structural phases are live or not. Breakages of tell-tales denote the movement in the structure. If the tell-tales are of cement mortar, these may be formed in oval pats, the size depending upon the width of the crack but generally 3 to 6 inches long by 1 inch wide and 1/8 to ¼ inch thick.

The glass tell-tales should be of crown glass about 1" wide and 6" long secured at either end with a pat of cement leaving the middle clear. The tell-tales shall break if the cracks develop further. This movement is to be watched frequently.

b) Shoring, Centering and scaffolding

Whether repair work is taken up immediately or not, the parts of the monuments that are in dangerous condition or ready to collapse, require to be given temporary support before permanent measures are taken up. When repair work in structural parts like arches involve taking them down and rebuilding, temporary supports to carry the load carried by the arch has to be provided, before taking down the arch. The entire operation of providing temporary supports to carry the structural loads and keeping the structure intact, is termed as 'Shoring'. Wooden posts, steel joists and rods are generally used for shoring work. The load of any structure acts through specific points and accurate analysis is necessary to provide the shores from the points.

The temporary frame work provided for re-erecting the missing or collapsed arches etc., is known as centering. The temporary frame work provided attached to a structure from where artisans attend to repair work is termed as a scaffolding. The centering and scaffolding are formed with ballies (teak, sal or jungle wood), bamboos, wooden planks, rolled steel joists, steel plates, and tubular steel. Tubular scaffolding is strong and also safe (Lakshmana Murthy, 1997: 84-85).

c) Underpinning

In case of disturbance or defects in the foundations of a structure, it is not possible to carry out repair work without removing the upper parts that rest on the foundations. The technique of repairing at foundation level, without disturbing the upper parts is termed as 'Underpinning'. By this technique, if it becomes necessary, the existing foundation layer can be replaced, piece by piece with new and stronger material (Lakshmana Murthy, 1997: 85).

d) Mending Out-of-plumb Walls

In some monuments walls are found slightly inclined outwards, or out-of-plumb. Marshall feels that no repair is required for such out-of-plumb walls. Buttresses were built in the past to arrest further movement. Buttress feels Fieldin, is not an effective solution to the problem. He says that adding a buttress alters the appearance of the structure, and therefore, should not be undertaken until all other methods are considered and rejected (Lakshmana Murthy, 1997: 86).

e) Grouting

When the condition of the brick or stone is good, and there is no change in the shape of the structure as a whole, the voids found inside the wall etc., can be consolidated by injecting lime or cement mortar slurry inside, and this technique of consolidation is termed as 'grouting' and is extensively used in conservation work of monuments. The cement or lime mortar injected inside, in liquid condition, is known as 'grout'.

Thin walls can be grouted by hand grouting, with a nozzle through which liquid grout is poured into the crevices or it can be injected by a hand operated pump. The grout reaches the void space by gravitation. For thicker walls, where huge quantity of grout has to be injected, grouting machine can be used. If the wall is not solid, while undertaking machine grouting, the grout shall be injected inside by gravity principle only. If the walls are solid enough to withstand pressure, the voids can be filled by pressure grouting or cementation process (Lakshmana Murthy, 1997: 87-88).

f) Cracks and Fractures

Narrow cracks in walls can be filled with lime or cement grout. Wider fissures can be filled with lime or cement concrete. The mortar or concrete is filled in the crevices, leaving a recess of 6 mm to 12 mm, from the wall surface and finished to match the adjoining surface. Very fine cracks in piers are filled with epoxy resins combined with stainless steel dowel pins. In the mortar used for filling cracks on roofs, water proofing compounds are also added (Lakshmana Murthy, 1997: 88).

g) Pointing

The finishing work done to joints of the masonry, is termed as pointing, and consists of providing a thin finishing band along the exposed edge of the joints of the masonry, generally with a rich

mortar. Finishing of the joints and flushing the wall surface is called 'Flush Pointing'. When the finishing is done by recessing the joints deep inside (by about 12 mm to 20 mm) from the wall surface, it is called' Recess Pointing. Recess Pointing is found in a greater number of ancient structures. The type of pointing found in a structure shall be maintained while undertaking repointing work. In structures in which pointing was existing originally, if it is now found lost, repointing is to be done as a part of strengthening the structure (Lakshmana Murthy, 1997: 90).

h) Plastering

Marshall says that the old plaster found on top of terraces, roofs, domes etc., require to be maintained to keep them watertight, and the new plaster requires to be coloured as nearly as possible to the old work. He suggests a mortar containing Kankar lime (10 parts), cement (1 part), black slag from kilns ground roughly (3 parts), Jaggery (1/2 part), hemp (1/2 part), and also a small quantity of black oxide for the plaster work.

The plastering laid in three coats in modern days may not generally exceed 25 mm. in thickness. But, the plaster on ancient structures is found to be very thick and 10 cm. thick plasters are very common in Qutub Shahi structures. The thickness of lime plaster over Golgumbaz (Bijapur) varied from 10 to 15 cm and was laid in layers, and the layers were bonded with broken tiles. The same technique was adopted in repairing to patches found on the dome, and for additional strength, iron nails were fixed and the ara covered with galvanized wire netting (Lakshmana Murthy, 1997: 91).

i) Guniting

It is the technique of ejecting cement, sand and water with force, on a surface and forming a hard, impervious coat. As a cement gun is used, the technique came to be known as guniting and was successfully used in rock-cut monuments at Elephanta, Golgumbaz etc.

The sand and cement are mixed almost dry and the necessary water is added to it to mix, issues from the gun. But the material fed is not totally dry. The mixture ejects at a pressure of about 20 to 28 tonnes/1 sqm. and the nozzle of the gun is kept at about 1 m from the surface to be treated. The surface of the area to be gunited shall be cleaned carefully, using compressed air or water or both, before undertaking the operation (Lakshmana Murthy, 1997: 92).

j) Wall Tops

Wall-tops should be waterproofed to prevent percolation of moisture into the heart of the wall. The upper course of stone, which are usually loose with the mortar disintegrated should be lifted, cleaned and re-bedded. The joints between the stones should be finished, so that water does not stand on the wall-top. If the wall-top presents an uneven sky-line, it is good for the wall and should be preserved, but pockets which may hold water must be avoided.

British experts advise in certain circumstances the provision of small cess-pools at the lowest points of the wall-top. A rain-water pipe of lead, say 2 in. in diameter, can be embedded in the heart of the wall. This is best done by withdrawing the face-stones, putting the pipe in position and then replacing the face. The pipe should be cleaned out both at the top and at the bottom. The provision of galvanized wire-guards will prevent choking with leaves, etc.

In order to ensure waterproofing of the wall-top, the mortar should be of lime gauged with cement in the proportion of 1part cement to 4 or 5 parts of lime. Or, if the stone is of a hard texture, cement-mortar may be used, the mixture being in the proportion of 1:4 (1 part cement to 4 parts of sand) (Ramachandran, 1953: 176-77).

k) Displaced Masonry

Masonry face-work which has bulged should be taken down and the stones rebedded in their original position. The stones should be numbered for subsequent identification. Stone dressings to opening, when displaced by vegetation or other causes, may be similarly treated.

Clamps or ties should be of non-corrosive metal. In no circumstances should iron or steel be used except as reinforcement for concrete.

Walls with pronounced 'bow' can be made strong by the internal insertion of reinforced concrete beams. A trench is formed in the wall-head to receive the beam, which is concealed in the core-work. In high walls additional beams are inserted at a lower level by withdrawing the face-work, cutting recesses for the beam in short lengths and replacing the face-stones when the concrete has set. Provision should in such cases be made for the appropriate connexion of the reinforcements uniting each section.

Underpinning is necessary where a structure is in danger through settlement. This is usually done in reinforced concrete in short sections. When lateral support is required for a wall which leans from the perpendicular, vertical reinforcement is inserted in preference to external buttressing, but this is effected in conjunction with underpinning. Vertical reinforcement may be inserted in a manner similar to that described for horizontal reinforcement except that it can be done in long lengths (Ramachandran, 1953: 177).

11.9 Outstanding conservation work undertaken by Archaeological Survey of India.

11.9a Elephanta

The main cave at Elephanta, a small island off Bombay, is distinguished by the exceptional quality of its sculptures, of which that of Mahesa is well-known. The main axis of the excavation is parallel to the length of the rock. Its plan consists of a large mandapa supported by twenty pillars on

its periphery, eight each on the longer sides and two between the corner-pillars on each of the shorter ones, which have the flights of steps leading from the courts in front and behind. These courts are formed by cuttings which more or less isolate the section of the rock with the excavation from the rest of the mass. In front of the eastern entrance on the floor of the court is a circular pedestal, perhaps for a nandi. On the northern side of the main mandapa is cut a porch-like ardha-mandapa with two pillars and pilasters on its façade, and behind it a rectangular mukha-mandapa, longer than the porch by the addition of one more bay at either end. These two are in design the northern lateral extensions of the main maha-mandapa with an entrance on the open side. The corresponding lateral extension of the same type on the south into the hill contains the niches of the Mahesa and another sculptures. Towards the distal end of the maha-mandapa is cut a chatur-mukha shrine, square in section and with doors on all the four sides framed by simple over doors. Inside the shrine is a rock-cut linga-pedestal, with a spout at its north on top, the linga being a separate insertion. In front of the shrine is formed an inner or ranga-mandapa, between two linear rows of four pillars, and leaving a circumambulatory bay in front of the shrine as on the other three sides. A cutting into the rock, on the east beyond the northern portico, leads to the eastern forecourt and the main entrance to the temple. On the southern side of this court is a smaller cave-temple dedicated to Durga. A similar cutting at the western end, beyond the northern portico, leads to the court behind the main temple on the western wall of which is cut a smaller Siva cave-temple consisting of a square shrine and mandapa in front.

The rock-cut temples on the island of Elephanta present some acute problems of conservation, all of which have their genesis in the disintegration of the rock caused by the presence of injurious salts in the atmosphere and the percolation of water into the caves. In 1935 three fragments of appreciable size fell off from the Mahesa figure. Following the report of a Committee of Experts, extensive measures of conservation have been carried out here. All earth and vegetation have been removed from the top of the cave. Visible cracks have been grouted and the entire rock-surface covered with a coat of gunite. Thirty holes, each 2 in. in diameter, ranging in depth from 40 to 70 ft. and spaced 6 ft. apart, have been bored in the southern fringe of the rock-roof and filled up with cement-grout. Another group of about fifty suitably-spaced holes have been made and filled up in the entire surface of the roof-rock. To prevent rain-water from finding its way into the main cave a deep trench with an angular flank on either side has been sunk behind it and filled with an impervious cement-barrier by the Francois cementation-process. In one of the caves columns of plain ashlar-masonry have been constructed to hold the ceiling. The loose or cracked parts of all sculptures have been internally secured with non-rusting metal dowels and cracks in the panels have been neatly filled up with suitably coloured mortar. A constant vigilance is maintained over this monument (Ramachandran, 1953: 194-95).

11.9b Gol gumbad, Bijapur

The Gol Gumbad at Bijapur, which entombs the mortal remains of king Muhammad Adil Shah (1626-57), has been one of the major items of conservation of outstanding interest. The Department has been repairing it from time to time and maintaining it in a sound state of preservation. The dome-masonry developed early a number of cracks, and patches of plaster from the inner side of the dome began to give way. This interfered with the well-known acoustic properties of the monument and called for attention. In 1937 the exterior of the dome was rendered watertight by a shell of gunite.

A further development in regard to the stability of the dome proved to be a great concern to the Department. Loose patches of plaster from the intrados of the dome began to fall down at intervals, and wide transverse cracks appeared in the brick shell, impairing the structural stability of the monument. The retention of the acoustic properties also depended on the condition of the intrados of the dome, and hence it was decided to institute inquiries as to whether the whispering properties of the dome, which constitute its chief attraction, would in any way be adversely affected if the intrados of the dome were to be stripped of all plaster and gunited all over the stabilize it.

After obtaining expert opinion of scientists, engineers and architects, who were unanimous as regards the replastering of the dome for the stability of the structure and retention of its acoustic properties, the Department proposed to provide a 412 in. thick reinforced gunite shell below and against the intrados of the dome. The thickness of the gunite was to be doubled at the base to a height of 2 ft. resting on a reinforced circular beam at the base. The reinforcement was proposed to be dovetailed with the brick core by means of dowels at 3 ft. centers either way, grouted in the masonry of the dome. (In actual execution stainless steel dowels were used in the portion above the cylindrical portion of the dome with a view to eliminating the factor of rusting and consequent damage.) The gunite was to be composed of one part of Portland cement and three and one-half parts of sand, and standard 'gunite' practice was to be followed in all the gunite-operations. The surface of the gunite was to be covered with a new plaster, quite smooth and uniform and follwing the contour and the colour of the existing dome. These proposals were intended to ensure the stability of the structure, the retention of the acoustic properties and its ancient appearance. The work of repairs lasted from March 1949 to July 1951.

Interesting details came to light when the intrados of the dome were stripped of the plaster. The exposed brickwork of the intrados above the plane of rupture was remarkably free from cracks, as expected. The lime-mortar between the bricks was found to be decayed to some extent. Square and round holes, 4 to 5 in. in diameter and about 4 to 5 ft. in length, containing wooden stakes decayed to the core, were found dotted over the intrados. The holes were cleaned of all wood and filled with plain gunite before covering them with reinforced gunite.

After the completion of the repairs it was deemed proper to undertake mechanical recording of the acoustical properties of the dome. The important conclusions arrived at in this respect by Dr. Tawde of the Institute of Science, Bombay, are :- (i) the whispering effect may be due to the cylindrical wall and the dome, the latter making the major contribution in the ratio of 5:1; (ii) corresponding to a point in the gallery there is focus at the diametrically opposite end in the gallery and at about the same distance from the wall; (iii) the cylindrical wall and the dome contribute about equally to the multiple-echo effect, the contribution by the cylindrical wall being of a more certain type due to the support it receives from the hard gallery-floor; (iv) the maximum number of distinct echoes heard has been found to be twelve, giving a better multiple-echo effect than that recorded by earlier investigators, which may be attributed to the improvement brought about by repairs to the intrados; (v) the sharper the note the better is the echo-effect (vi) a very loud explosive sound persists for about twenty seconds; and (vii) the reverberation-time of twenty second for note used is in reasonable accord with the theoretical estimates from Sabine's formula. The report has established beyond any doubt the efficacy of the repairs undertaken by the Department (Ramachandran, 1953: 191-94).

11.9c Jagannath Temple, Puri

The Jagannath Temple at Puri, Orissa, was constructed at the time of Raja Anaga Bhima Deva in the eleventh century A.D. and it enjoyed the royal patronage of the Gajapati Kings of Orissa who were the guardians of this temple

The Jagannath Temple has four gates and two compound walls. The main temple was erected on a raised plateform. The duel of this temple rises to a height of about 65 meters, thus making it the tallest in Orissa. It is the duplicate of the Lingaraj Temple at Bhubaneswar. The sculpture on the walls are covered over with protective coats of heavy lime plaster.

The general condition of the main temple at the time protection was far from satisfactory. The ancient records show that in order to protect the stones from the action of salt and rain water, with temple was plastered four times between sixteenth and eighteenth centuries, as a result the thickness of the plaster covering the original damaged stones increased to about 30 cms.

As per the recommendations of the Expert Committee appointed by the Government of India, the Archaeological Survey of India took up the conservation of this temple complex in 1974. The conservation policy of this temple was formulated by Shri M.N. Deshpande, the then director General of the Archaeological Survey of India and during the last two decades a major portion of this temple has been repaired.

For the conservation of the main temple, a broad analysis of the cracks in exposed temple structure were worked out. (Dikshit, 1991: 726-27).

(i) Vertical cracks which may cause slipping of a portion of the structure;

(ii) Vertical cracks which are not very deep but at the same time dangerous;

(iii) Horizontal or vertical cracks which are not structural in nature but should be repaired in the interest of strengthening the structure; and

(iv) Cracks of local nature which are not dangerous but should be closed to prevent further deterioration.

In respect of category (i), epoxy resin grouting together with the use of copper dowels for stitching the masonry was suggested, whereas for category (ii) the suggested treatment was grouting with conventional materials for the interior preparation and resin grouting on the periphery and sealing of joints or cracks by resin putty. For category (iii), grouting with conventional material with resin pointing was suggested. For the last category (iv), resin coupled with copper dowels would suffice. The removal of plaster alone could undertake remedial measures to the fabric of the temple structure.

In the main temple removal of old plaster was taken up first to find out the nature and extent of damages and the causes of flaking of stones. The dead load of the plaster was adding to the total load of the structure causing additional strain on it. The plaster has lost its binding property and has become porous. During the rainy season with the absorption of moisture containing salt, the dead weight of plaster increases considerably.

In the main temple, a portion at the junction of the mukhshala and the vimana was found leaking in the rainy season. The dead plaster was removed and cracks and fissures were carefully grouted by conventional material and watertightened with suitable mortar mixed with a water proofing compound. It was felt necessary to remove the plaster along the vertical side of the junction of the vimana and the kukhshala so as to study in what way the two parts of the structure were integrated. The slope of the covering plaster was so aligned as to facilitate easy drainage of water away from the joints.

The stone masonry which was covered with thick lime plaster all over the walls of bada-deul was badly shattered. The deplastering work was limited to the springing level of spire. It was taken up at the corners first and then extended towards the middle portion. After major portion of the deplastering work was done, consolidation of the northern side was taken up first. This portion was thoroughly stabilized by grouting fissures and voids, resetting broken and dislodged members and replacing missing members. The process of consolidation upto the end of upper jangha was continued and the eastern, northern and western sides were consolidated. All the projecting members were further reinforced by inserting stainless steel round bars with resin mortar. At this point, measures

were taken to arrest future decay of the recently exposed and consolidated stone masonry by means of chemical or other stone preservatives.

Apart from the main shrine, subsidiary shrines like muktimandapa which was in danger has been consolidated by strengthening the weathered columns and broken stone beams, after grouting all fissures and voids with resin mortar. Capitals of all columns were also strengthened by epoxy resin, duly strengthened by inserting non-corrosive metal pins and the missing stones were replaced with new ones. The western and northern parts of Kurmabeda were also attended for structural repairs (Dikshit, 1991: 727).

11.10 Summary

Conservation of a monument involves preservations and restoration. Preservation includes those techniques which prevent and protect a monument from deterioration and restoration involves the treatment of a deteriorated ancient building to bring it back to its original form.

Conservation of a monument requires highly specialized techniques involving different engineering and scientific methods.

The greatest principle of conservation is that minimum restoration work should be resorted to the aim should be preservation without alteration.

The causes of decay should be understood as natural causes and man made causes. The natural causes are earth quakes and other natural calameties environmental pollution subsocial or soltpeter action plant growth, birds, bacteria, insects and pests. Man made causes are destruction and Vandalism, abandonment of a monument, despoliation, incroachments, urbanization and pollution, damage by visitors. Before embarking on a conservation project one should be aware of its location its detailed discription, its brief history, its conservation problems and the equipment and material needed to for its conservation.

11.1 Check your Progress

1) Discuss the difinition and principles of conservation.

2) Write short notes on –

   a) Convervation, Preservation and Restoration.

   b) Causes of deterioration of monuments.

11.12 Activities

Write a report on the suggested conservation work of a nearby historical monument.

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UNIT – XII
BASIC PRINCIPLES OF CONSERVATION OF EXCAVATED MATERIAL

12.1 Introduction

Excavation is described as a way of eliciting evidence from the site by destroying it. Even by refilling the excavated earth, it is not possible to restore the stratigraphy of the site. The remains of the structure are the only undisturbed evidence, hence their preservation is of prime importance. According to Arthur Evans 'the adequate record for an archaeological excavation comprises not only of reports, photographs, drawings and objects removed to museum, but the site and buildings conserved as far as possible.' Hence such sites and buildings are to be conserved and preserved at all costs.

12.2 Objective

Conservation of excavated sites basically aims to preserve the structures and objects from disintegrating once they have been exposed to the atmosphere and to discover the true nature of the original artifact. Thus conservation is part and parcel of Archaeology; without it much archaeological information is lost or left unexploited. Problems related to conservation of excavated sites can be divided into the following sub-heads:

1. Pre-excavation considerations
2. On-site conservation
3. Laboratory conservation
4. Long-term conservation by control of environment

12.3 Pre-excavation Considerations

- Even before the site is excavated, it is important to consider the conservation requirements likely in order to ensure that adequate facilities and funds are available. The level of requirement will depend on the nature of the site. Without due thought being given to conservation before excavation, disaster can occur on site when unpredictable material and conditions are found and there is no equipment or personnel available to deal with them. This is especially true on excavation at some distance from a town. In India, unfortunately no guidelines so far have been formulated with the result that most of the excavated sites have been left unconserved without evolving any viable method for their protection (Batra, 1996: 179).

12.4 On-site Conservation

On-site conservation is perhaps the most crucial stage of all. Most of the materials are jeopardy when first exposed to the atmosphere after many centuries of burial. They begins to dry out and shrink, react with the air, or crumble as they lose the support of the surrounding soil. Thus on-site conservation begins from the moment of exposure.

First then, for materials at risk, it may be necessary to retain dampness while an artifact is still in situ; just occasionally, as for soft pottery, it may be the reverse, and drying out in situ is important. Next the artifacts must be lifted from the deposit without damaging them or introducing unnecessary adhering supporting materials which are later difficult to remove or which actually harm the finds. In the vast majority of cases no special techniques are necessary, thought and dexterity alone being required. However, fragile objects may need support and where possible, this is given by very simple techniques; but in the case of a crumbling mass, such as a totally corroded iron sword in a gravel deposit, more elaborate techniques are necessary.

Once lifted, either by hand or with supports, materials are preserved by good packaging and where necessary, controlling their environment. Bad handling/packaging is responsible for a great deal of harm to objects which unfortunately are often much more fragile than they appear. The decorated surface of a waterlogged timber may decay in ten minutes or a copper alloy coin may begin to disintegrate within twenty-four hours if they are not stored correctly (Cronyn, 1990: 5).

12.5 Laboratory Conservation

The real examination of the excavated material begins in the laboratory. This involves investigative cleaning in which artifacts are fully inspected by using microscope as the obscuring debris is removed. After this, attempts are made to preserve the artifact/antiquity by bringing materials into equilibrium with their surroundings. Preservation is achieved either passively by continued control of the environment and supportive packing or else actively, when chemicals are removed from or introduced into the artifact. These processes are known as stabilization. Whether investigative cleaning is required and/or stabilizer is necessary, or even possible, will depend both on the condition of the material and the archaeological questions it can answer.

A third aspect of laboratory conservation is that of getting material ready for display. Such objects require a greater degree of cleaning and/or stabilization than that described above.

12.6 Long-term Conservation by Control of Environment

This is the prophylactic or preventive aspect of conservation. Material which is stable only as a result of the exact control of environment must be closely monitored in perpetuity after excavation. Its condition and the variable in the atmosphere surrounding it have to be checked and maintained. Whether this is a matter of weeks or decades will depend on the material and the environment. Since it is not possible totally to adapt archaeological material to post-excavation environments, it must be the environment which is modified. Thus conservation must continue as long as it is decided that the excavated archive is to be retained (Cronyn, 1990: 8).

In India preservation of archaeological sites after excavation becomes a major problem, because the structures which remained covered for centuries by debris suddenly get exposed to sun, rain and other natural or man-made causes. Conservation of excavated sites poses considerable problems particularly due to lowering of the ground levels. Hence steps need to be taken to deal with rain and rain water which might destroy all the evidence being laboriously acquired. Adequate arrangements are therefore to be made for proper drainage of rain water.

12.7 Classification of sites for conservation

S.L. Nagar (1993: 43-46) has divided the excavated sites of India in the following four categories:

(i) Sites having stone structures,

(ii) Sites having structures of burnt bricks,

(iii) Sites having structures of mud-bricks or clay,

(iv) Excavated sites near sea shore

In so far as the sites with stone structures are concerned, these may not pose much of a problem in their preservation. But even in such structures adequate arrangements have to be made after excavation for providing proper outlets for rain water and making the structure water-tight in order to protect it from seepage of water through the joints or cracks, which need be properly treated. Special attention has to be paid to prevent rain water from stagnating within or around the excavated structure, as this could prove harmful to the structure.

Sites having burnt brick structures from earliest times are available in the country. The structures at Sanchi, Nalanda, Paharpur, Bhumra come under this category. The conservation of such sites may not pose any particular problem, but bricks themselves are quite open to gradual decay or deterioration. Such structures have to be saved from rain or dampness. To achieve this objective these structures have to be kept free from moisture and fungus growth besides dampness. Outlets for rain water through adequate drainage is essential. In addition, periodical coating of the preservatives would add to the stability of these structures. Whenever decayed bricks have to be replaced, the standard modern bricks should not be used for the purpose; instead bricks made specially of the same size, strength and composition as the original ones are to be used.

Aging and decay of pointing are the most common defects in brick work. Besides individual bricks also decay due to frost action and often develop vertical and diagonal cracks, particularly through the arches of windows and walls above lintels and below sills. Rain water enters into the structure through these cracks and weakens the walls resulting into final disintegration of parts.

Vertical cracks can be repaired by putting in new matching brick work or, if the coursing is out of alignment, it can be restored with pieces of matching roof tiles. It is essential that the bricks used

in the repairs or restoration should match with the old ones in colour and size and strength and while restoring, the old form of bonding and jointing should be followed. Equally important is the colour of the mortar and the profile and texture of pointing. For re-pointing, brick work should be raked out to minimum depth of about 20 mm and pointing should be inserted with a special trowel.

The cavities in walls caused by the deterioration of bricks need not be covered by cement. In case the face of a wall is required to be renewed, it is best to tie the new brick work back to the old as in the cavity wall construction and the gap between the old and the new bricks may be grouted in order to prevent the seepage of water and frost action.

The preservation of structures of mud bricks or those plastered with clay pose a complex problem, because such structures are likely to decay rapidly and cannot face excessive rains. Attempts in such cases have to be made to preserve them by erection of tin sheds, but they hardly serve the purpose, because these sheds cannot withstand strong winds or storms and they mar the very aesthetic sense of the environment. Moreover such sheds can be of some use at small sites, but cannot be useful at large sites. The approach for the protection of mud walls should be such as to save them from excessive rains, which could be done by placing some straw mixed with mud over the tops of walls as is done in any village in India. But this method could only serve for a season or so, and cannot secure the structure permanently. Alternatively, the tops of the walls could be covered with alkathin sheets under expert advice.

The methodology to be adopted for the making of mud bricks for replacement of the damaged bricks and other repairs to mud brick walls could be as follows:

(1) The local clay soil as originally used for the manufacture of mud bricks should be taken and mixed with sufficient water and kept immersed in water for a week. The wet soil is then mixed to form a slurry consisting of 8 parts of water to 1 part of sand and one part of Portland cement. Chopped straw is added to improve the mechanical properties of the mix which is then set to dry in moulds resting on sand, which gives a rough texture. The bricks should have a wet net covering for about a week and be turned over after three days to ensure even drying. After a week they are to be dried up in the sun.

(2) The top of the mud brick walls, if not roofed over, needs special attention. A sloping rendering of mud-cement mortar made like mud bricks but without the addition of straw, cannot be of much use, because it develops cracks after setting, even if done with two coats. Mud cement mortar is however useful for grouting cracks in walls, because it is not subjected to rapid drying.

(3) Treatment of mud brick walls can also be carried out by the use of ethyl silicate 40.

(4) Mud brick walls can be repaired by the removal of the defective bumps and insertion of new bricks of almost the same size and strength with are then plastered over and lime washed to match the old surface.

Indeed, archaeological excavations pose considerable problems of maintenance primarily due to lowering of the ground level. Steps have therefore to be taken effectively to deal with rain and rain water which might destroy all the evidence being laboriously acquired. Adequate arrangements are therefore to be made for proper drainage of the rain water etc.

Another method adopted by the archaeologist to preserve the excavated sites is to fill up the trenches with earth after the excavated material is taken out and the report on the excavation is prepared. This method has some inherent deficiencies in as much as that the trenches or the excavated sites permanently get out of the reach of the future scholars. Because of the total separation of conservation from excavation, even where an attempt is made to preserve the excavated sites, little care is taken by the conservation staff to provide proper treatment to the newly exposed structure. In the fitness of things, better results could be achieved if the work of initial conservation of the archaeological site is left to the excavators, who perhaps could do more justice to the task of its preservation.

The excavated sites at sea-shore pose the biggest challenge in the field of preservation because of the sea breeze as well as the underground water level. The prime example of this type is the Lothal site, which is in disarray after the excavations.

12.8 On-Site Conservation of Some Important Sites in India

As stated earlier, no guidelines so far have been formulated for the conservation of excavated sites in India. However, the Archaeological Survey of India, the premier institution for conservation work in this country has devised some methods of conservation and used them on selected excavated sites. These methods were employed in the conservation of the following excavated sites:

a) Dholavira

The Harappan site of Dholavira is located in the Bhachau Taluka of Kutch district in Gujarat State. This site has been under excavation since January 1990 under the direction of Dr. R.S. Bisht of the Archaeological Survey of India. The ancient settlement extends over an area 800 meters east-west and 650 meters north-south. The excavated remains were inspected by Shri N.L. Batra, Superintending Archaeological Engineer in the Archaeological Survey of India in February 1992 who recommended the following measures for the preservation of the excavated remains (Batra, 1996: 179-191).

During the inspections it was noticed that the digging work was in progress simultaneously at several places, may be a citadel. Bailey Middle town, Lower town, city wall to establish and link the salient features of the structures, to evolve a clear pictures of the different settlements of different townships, the lay out of the houses, streets, water channels, drainage systems, storage of water, etc. A stage has therefore reached when the spade work is to be stopped and the entire remains and their antiquities recorded by way of photography, illustrative maps and drawings and preparing a text report for future reference. The area is to be marked for preservation of the remains in situ or to be reburied for total protection after recording. The following conservation measures are suggested for the excavated remains which have been dug out till date:

The gateway and the structures within the Acropolis prior to its digging and exposing must have been protected well by the debris laid over, it, since centuries ago. But after laying the structures beneath the debris by cutting, making a trench of about 5 metres deep has laid bare the remains and now structures are exposed to the open atmosphere and have to withstand the vagaries of atmosphere and rains. Luckily for structures, the rainfall as witnessed for the last so many years is found to be scanty and the damage caused to the gateway was more through vandalism than structural as the vital parts of the highly polished pillars of chambers or guard rooms flanking the passage were missing. The only damage caused to the gateway was perhaps due to an earthquake which occurred in 1819. The traces of the havoc caused by earthquake are visible everywhere. The stones of the masonry wall were found to be disturbed at several places and a few portions of the wall were titled. Due to ageing the mortar of the masonry has turned dead and become weaker to hold the masonry stones together. Another problem to counter in protecting the gateway would be drainage of water during rainy season which is active from June to August.

1. For draining out water which is likely to be collected in the passage, being at the lowest level of the gateway, after making a cutting into the inner blocked door, the water be collected in a sump to be made near the north-western corner of the outer threshold and be drained out through an R.C.C. pipe concealed and laid to gradual slope or cutting out a channel to a slope to carry out the water to the ground. There are indications of stone pavement of the floor or passage, which can be restored with new flag stones after confirming the traces of the original work.
2. Loose stones on the top, three or four courses, be removed and reset with the fresh mortar.
3. The out-of-plumb sections, masonry stones are to be taken out and reset in plumb with fresh mortar.
4. The entire exposed surface of all the walls of the guard rooms, internal fortification wall and external fortification wall which is in stone masonry, the dead mortar of the joints be

racked out, joints cleaned with water and repointed in recess with fresh mortar to render the surface watertight and to stabilize the stone masonry.

5. All the steps in stone masonry be consolidated and rendered watertight from the top as well from the vertical section by repointing with fresh mortar.

6. The inscription of 9 letters be covered suitably by constructing a box-like structure in stone masonry plastered with mud mortar and covered with a lid made of Perspex sheet of stone slab, fine dressed and sliding like a shutter.

7. The loose dressed stones lying in the chamber of the gateway may be restored to their original place. Possibly they belong to the sill of the door jambs of inner threshold.

8. The buried structures after exposing from the northern gate towards the north-east corner probably served double purpose to serve as a buttress to counteract the thrust of the retaining fortification wall and to function as living apartment.

   These structures after recording the finds can be refilled with the earth already removed after protecting the structures with alkathin sheets. Fefilling of these structures will serve to counteract the thrust as well as to drain out the water from its surface to the ground level.

9. The north-eastern bastions in square shape, may be retained and strengthened by racking out the joints to take out loose mortar and recess pointing with fresh mortar of composition (Batra, 1996: 186-187).

b) Agroha

The ancient mound of Agroha is situated about 24 kms. north-west of Hissar (Haryana) on the Delhi-Sirsa Road. The ancient mound covers an area of about 650 acres and it was excavated by the Department of Archaeology, Haryana during 1978-80. This excavation has revealed five cultural periods from circa 3rd-4th century B.C. to 12th-13th century A.D. The excavation has also revealed too ancient shrines, the one is Buddhist Stupa and the other is a Hindu temple.

Conservation of the ancient excavated remains was done by the Archaeological Survey of India under the direction of Phanikanta Mishra (1999: 115-119) who gives the following account of the conservation work:

The excavated site had certain causes of degradation in the following way:

1. Mechanical degradation of bricks by alternate heating by (sun) and cooling by rain water, frost.

2. Extensive chemical and biological degradation of bricks by rain water, and

3. Cryptogamic growth with ultimate formation of Limonite, Kaolin and Silicas.

Three to five percent liquid Ammonia was poured and brushing on the bricks was done very gently to eradicate the moss, lichen, algae etc. by mechanical means. In 3 to 5 percent liquid Ammonia 1 to 2 percent aqueous zinc silica fluoride was also applied. This method was applied to only those parts which were not replaced but were reset.

Adequate steps were taken to prevent flow of water into the excavated trenches by providing drainage along the trenches coupled with provision of bunds. The drains built to avert flow of water into excavated trenches were provided brick lining. The bunds, raised on the sides of the excavated trenches were turfed. Turfing was very essential, because it has prevented their erosion and consequent damage.

The most important task which was done to conserve this important site was to water tighten the exposed tops of the excavated structures by dismantling. In this process the complete layers of the brick required water tightening. The courses from the bottom were first documented by drawing and photographs. Thereafter it was dismantled gradually but very carefully. After dismantling, the resetting process was started. The resetting of these structures was followed strictly as per the original and with archaeological norms. The resetting was done in toned lime surkhi-cement mortar. In this the cement was used at less points and mostly the use of mortar was done identical to the original. In this it was tried to produce a combination of finally sieved clay, lime, surkhi and at some instances fly-ash also was used. This was used after full care was taken that the impurities were removed and bricks were rendered to use for making surkhi salt-free. This was possible here by thoroughly washing the bricks from the site which were grounded into powder.

It was also necessary that this salt-free mortar attracts saline encrustation faster than the infected bricks. This was done here during conservation but it is a continuous process and the affected mortar will have to be periodically raked and redone. V-cut recess pointing was done of the joints in order allow greater evaporation.

After watertightening the tops of the exposed structures, the joints of the structures were nicely pointed. The filling was done to the cavities and underpinning was also done very carefully.

The area adjoining the trenches was turfed. This has made the area or surrounding more beautiful and it has also checked the flow of water and top soil into the excavated area (Mishra, 1999: 118-19).

c) The Stupa at Sanghol

Sanghol is a sprawling village in tehsil Khamano of district Fatehgarh Sahib (Punjab) and situated about 40 kms. west of Chandigarh on the main Chandigarh-Ludhiana road. This site has

revealed rich cultural assemblage beginning from Harappan (Bara) to late medieval times. It was a rich and prosperous town during the Kushana Period. This site was excavated by the Department of Archaeology and Museum, Government of Punjab during 1968-73 and 1978-80 and large-scale excavations were carried out by the Archaeological Survey of India from the year 1985-86 to 1989-90. This site has yielded 117 beautiful red sandstone sculptures. During the course of excavations different types of structure of Kushana and Gupta periods were found. Besides, a cylindrical brick stupa of 16 mtrs. diameter, built over a raised platform and monastery complex-both datable to the Kushana period, were excavated.

The architectural plan of the stupa is like the Dharmachakra or spoked wheel of three concentric rings of brick masonry with intervening spaces divided by radiating spokes of similar brick masonry at regular intervals.

Basically there may be two main problems for consideration for decay of the monument:

1. Human Vandalism: include the vigorous attacks and destruction by humans and at later times the locals from time to time and negligence for several decades, and
2. Natural: include weathering conditions, heavy rains, atmospheric pollution etc.

Before commencement of the conservation work proper documentation was done to maintain the originality as per archaeological norms. Removal of the scattered material and debris on the surface of the area around the stupa and scientific clearance was done neatly and systematically and proper alignment was kept since the slope of the ground was moving from north-east to south-west before taking the conservation work to preserve the structures.

The excavated remains of a stupa with monastic complex to the north-east, the votive stupa to the east, a brick-paved pathway on both sides leading to the western side and other contiguous structures like entrance to the stupa, brick-lined drains, brick floors and pathways etc., were taken up for repairs and resetting. The missing (robbed) and damaged existing portions of concentric ring walls, many connecting brick-spokes were replaced and resetted by raising to 4-5 courses with the available brick, brick-bats and clods and consolidated at base with fresh lime cement mortar. The core brick structures were also strengthened and plastered. The dome was filled with mortar in the cavities.

In the same way the exposed and damaged main walls of the monastery with a central courtyard and a brick-built drain was strengthened by raising the required height of the structures and missing portions were resetted with available bricks as per original pattern with lime cement mortar. Pointing was done neatly with utmost care. Before pointing was done, the joints of the bricks were made naked and cleaned by removing loose dust particles and old mortar. In order to consolidate the area

within the monastery the corner of the floor was strengthened at the lower level by an invisible concrete bed in lime cement.

The votive stupa and floors unearthed to the east to the stupa were also strengthened by lime base and edged with mortar. Proper drains by laying out P.V.C. below the structures were provided in between the spokes and concentric walls of the stupa for smooth flow and flush-out the rain water.

Barbed wire fencing with iron angular rods all around the complex and a turn-style gate towards the west, facing the approach road was provided to check the mis-use of the monument ((Mishra, 1999: 122).

12.9 Reconstruction and Transplantation –

12.9a Reconstruction

Reconstruction of ancient monumental edifices by using new materials could be necessitated by disasters, or other natural calamities. For example, the massive wall of the Purana Qila monument at Delhi, gave way during rains, some times back and had to be reconstructed to save the monument from further decay (Nagar, 1993: 46). The reconstruction of a monument should be based on the initial documentation of the materials it is built with. But in cases where no prior documentation is possible because of the sudden collapse of a structure, efforts for its reconstruction should be based on the original pattern of the edifice.

12.9b Transplantation

This amounts to moving of the entire structure piece by piece to new sites. Though it entails the loss of essential cultural values and generation of new environmental risks, but still this type of work might be taken up because of over-riding national interest. One of the best known example of the transplant of this type was taken up in Egypt when the temple complex of Abu Simbel (XIX Dynasty) was moved to a safer site to prevent its submergence the reservoir then coming up of the Aswan High Dam on the river Nile.

In India, however, which is a developing country, with several of the development projects in progress, including the building of dams and reservoirs, some monuments are likely to be threatened with extinction. One of the earliest such work of transplantation was taken up at Nagarjunakonda, where the ancient site was to be submerged in the reservoir of the Nagarjunasagar Dam in Andhra Pradesh. The ancient monuments scattered in the valley of the Krishna river were shifted to the top of the Nagarjuna Hill site and transplanted there. (this was a gigantic task which was accomplished successfully by a team of experts of the Archaeological Survey of India, under the guidance of late Dr. R. Subhramanyam.

Another transplantation of monuments was taken up also in Andhra Pradesh, where the Papanasi group of temples at Alampur in Mehbubnagar district were dismantled from their original locations and transplanted to the newly acquired site consequent to the coming up of the Srisailam Hydro-Electric Project. Similar transplantation of the Sri Sangmesvara temple, Kudavalli, was also taken up in Andhra Pradesh.

Both these works were carried out by the Archaeological Survey of India while the transplantation of Bhattiprolu temples was under-taken by the Department of Archaeology and Museums, Government of Andhra Pradesh.

The transplantation of ancient structure devolves a great responsibility on the conservators as well as the workers in the field, particularly in view of the fact that:

(i) these structures are centuries old, and are often damaged. Among the structurally unsound portions some could be visible to the naked eye, while others could be invisible and so are more dangerous while handling,

(ii) the architecture of such structures was developed in the ancient past and the same expertise might not be available locally and the required skilled artisans might have to be brought from far off places,

(iii) even the brick or stone masonry, which outwardly may seem to be sound, may not be so; while in actual handling, some of it might cave in and cause heavy damage,

(iv) since these are ancient structures, they cannot be dismantled with heavy machinery, the dismantling has to be done so by manual labour very carefully, preserving every bit of archaeological evidence available for use during reconstruction work.

However, in the case of actual transplantation of monuments, the task has to be accomplished at different stages, which are described hereunder (Nagar, 1993: 48):

(i) Documentation

The first measure to be adopted in the process is the complete documentation of the edifice. A detailed structural drawing should be prepared. In case the structure is made of stone, each and every stone on the outer and inner surface has to be numbered carefully and shown in its exact place on the drawing. By indicating the stone thus in the drawing one could easily locate the same while re-erecting the same structure. Besides, the photo documentation of each and every part of the structure should be done extensively, which shall serve as a practical guide to the experts in the field, who are responsible for the transplantation of the edifice. As soon as the complete documentation, i.e. drawing and photographs is over and each and every stone is suitably numbered, the dismantling of the structure has to be taken up.

(ii) Dismantling of Structures

This is the second stage of the work. The dismantling of the structure should start from the top and each dismantled piece or object should be properly stored, after providing the actual documentation number on it. For heavy pieces chain pulley and could be used. As far as practicable the pieces of outer structure and the inner structure may be stored separately in order to avoid subsequent confusion.

It may not be difficult to properly document the stones up to the foundation level. But while digging for the foundation stones, extra care has to be taken for the photographic as well as architectural documentation. In case there be paintings on the walls of the structures, the same should be removed with the help of the scientists and carefully stored.

(iii) Transportation

The transportation of the dismantled material from the old to the new site is also an important stage. Since some of the stone objects are likely to get damaged in the process of handling and transportation, adequate arrangements for careful handling of the objects have to be made. During actual transportation, sufficient padding or cushions may be provided in the vehicles engaged on the job.

(iv) Stackyard

The dismantled objects should be stored in the godown in a most systematic manner because even a slight lapse in the proper storage of art objects is likely to create insurmountable difficulties in the re-creation of the edifice.

(v) Reconstruction

The reconstruction of the edifice should be done as per the original plan and orientation of the structure and in case of frescoes or wall paintings, they could be rearranged in the new structure with the advice and help of the experts in the field.

The transplantation of stone structures is comparatively easier than transplanting a brick structure, particularly in view of the fact that in ancient brick structures small bricks are invariably used with lime mortar and these bricks are so numerous that it is practically impossible to document them or assign them documentation numbers. Even photographic documentation in such cases, will be of no avail. Moreover, the brick structures invariably have thick plaster of lime mortar, which once removed, is not fit for re-use. Indeed the bricks if used in arches, domes or in sikharas of temples would pose a massive problem and the methodology used in the transplantation of stone structures could be of little avail in the case of brick structures. In the latter case the following courses can be considered for implementation of the proposal for the transplantation:

(1) To lift the entire structure by means of foreign technology from the original site to the new abode, using the latest machinery and expertise involving primarily horizontal boarding.

(2) To dismantle the original structure in blocks and to re-assemble them at new site.

(3) To dismantle the structure brick by brick and then re-erect it at the new site.

The shifting of wooden structures may not pose much of a problem because dismantling of a wooden structure is comparatively easy than brick or stone structures. Lastly, the site chosen for reconstruction should be, as far as possible, identical to the original site. For instance a temple on a site situated at the confluence of two rivers should be reconstructed only at such a site where two rivers meet. This is a very important aspect of reconstruction and on no account is to be neglected.

12.10 Conservation of Excavated Objects

12.10a Ceramics

Ceramics forms the largest quantity of artifactual material recovered from the excavation of proto-historic and historical sites. Sometimes potsherds are found in thousands. These potsherds are very valuable for the archaeologist as they provide an index for understanding various cultures. It is therefore, not far off the mark to say that pottery is the alphabet of Archaeology.

Ceramics are made of fired clay; their precise composition will depend upon the initial mineral content and the conditions and duration of firing. A thin coat of diluted fluid clay, a slip, is generally applied to the surface of the parts for decorative purposes. By the use of a particular clay, usually based on iron-rich illites a red or black gloss (not a glaze) which is highly lustrous, is produced.

Underfired earthen ware gradually rehydrates in a damp soil, becoming softened and liable to crumble, especially fare the fabric is coarse and porous. Excavated pottery requires cleaning and there is great danger in overcleaning Ceramics; excessive use of mechanical methods leads to abrasion and excessive use of chemicals may weaken and alter the fabric and extract traces of decayed food etc. Therefore, water with gentle brushing is normally the best cleaning method and is used before adhering soil begins to harden and shrink. In case of poorly fired Ceramics and painted or poorly glazed surfaces, deep swabbing or even swabbing with alcohol is preferable. Washed sherds may be air-dried, out of direct sunlight or artificial heat sources. Packing for storage and transport must incorporate adequate padding to prevent abrasion, caused by sherds rubbing against each other and crushing (Cronyn, 1990: 148).

12.10b Conservation of Metal Objects

Metals form a heterogeneous though well-define group of materials. When metals are buried in the ground, the rate of corrosion is intensified according to the acidity of the soil, its porosity and

presence of naturally occurring soluble salts. The individual metals of antiquity are few in number¾gold, silver, copper, lead, tin and iron. Electrum (an alloy of gold and silver) is much more common than pure gold, and ancient silver almost invariably contains copper. Copper and tin were alloyed intentionally to make the more useful metal called bronze.

i) Gold

Gold (melting point 1063o C) is found in nature in the metallic condition as a rich yellow, soft metal, commonly associated with quartz and certain sand. It does not corrode, it is not dissolved under natural condition, but is often found alloyed with the baser metals silver and copper.

Gold is the most malleable of all metals used in antiquity, and without annealing it can be hammered into sheets only 0.2 micrometres thick. It is easily cast and can be joined by cold welding (Cronyn, 1990: 235).

Gold in artifacts is seldom pure. One cause of this is impurities from the raw material, which, since gold is extremely noble, is in the form of metal, not ore. An important naturally occurring alloy is electrum, or white gold, which has a silver content of more than 20 per cent.

Gold can be extremely weak and brittle and must be handled with care. Gold is never cleaned, however gently, without a microscope; the danger of abrasion of a surface-enriched layer or of scratching the soft metal is too great. Care must be taken, then, in the field, to prevent hands, rubbing the surface of object. Even in the laboratory, mechanical cleaning is kept to a minimum. Gold should not be polished 'bright' on site; gentle washing alone is permissible. Packaging must ensure abrasion is prevented. Gold alloys encrusted with copper corrosion products also should have no on-site cleaning and are treated as for copper alloys (Cronyn, 1990: 237).

Plenderleith (1956: 207) suggests that incrustation of lime can be removed from the gold by applying dilute nitric acid (1 per cent) locally with a match-stick, a small brush, or a capillary glass tube. Siliceous or muddy incrustations on gold may be removed by soaking in a 2 per cent, solution of a surface-active agent such as Lissapol. Organic remains are softened by immersion for a few minutes in caustic soda (2 per cent) and removed with a match-stick. If incrustations resist these attentions, they may sometimes be disintegrated by using a fine jet of stream. When gold is present in reserve ornament on silver, special care is required in cleaning because the gold is thin and the surface soft, and the gold reserves could be easily damaged by the cleaning materials used to remove tarnish from the surrounding silver.

Crushed Gold Objects

Objects of gold are often found in a distorted condition when they are dug from the ground, and there may be a strong temptation to try to fold the metal back into shape. This must be resisted

as it is not the easy task that it appears to be. Pure gold is readily malleable, but when it is alloyed, as it usually is to some extent, the metal becomes brittle on ageing, and mechanical manipulation should only be undertaken after scientific examination has shown that the metal is of such a composition that reshaping can be considered a reasonably safe procedure in the hands of an expert.

Many examples of the restoration of crushed golden objects, by careful annealing and tooling back to shape, are provided by the material excavated at Ur of the Chaldees by Sir Leonard Woolley. One of the finest specimens is the wig-helmet of Mes-Kalam-Shar, made from a single plate of 15 carat gold, and weighing 2 lb. 4½ oz. A more intricate reconstruction was that of the gold bull's head forming the frontal ornament of a lyre. This was brought to the Laboratory as a complex, held together by wax and bandages, so that the relative position of the various pieces could be studied at leisure. The gold mask, ears, and horns were first recovered, and as the gold, though badly crushed, was much thinner than that of the helmet it was correspondingly easier to manipulate. The original shape of the animal's head was re-established, and having done this is was possible to reset the eyes and resemble the various pieces for carved lapis lazuli forming the beard.

The special tools used for such work are metal and wooden stakes, levers of various kinds, mallets of box-wood, hide and horn, and shaped sand-bags of leather (Plenderleith, 1956. 210-11).

ii) Silver

Silver (melting point 960.5o C.) is a soft white lustrous metal it often contains up to 5 per cent of impurities such as copper, lead, and even iron, but is also commonly alloyed deliberately, to harden or debase it. Sterling silver is at least 92.5 per cent silver, whilst crude silver may be only 80 per cent pure; very base alloys containing less than 50 per cent silver are termed billon (Cronyn, 1990: 230).

Both horn silver and silver bromide darken on exposure to light; they can change from white to pink, grey, or black within seconds of excavation. Brittle ancient silver is liable to shatter with poor handling. Even though silver is a noble metal, when excavated, it can be in a delicate and badly corroded state, worse even than base lead. On site it must be handled with great care and given adequate packing. An original surface may be retained within a corrosion crust, and thus cleaning is carried out only in a laboratory. Since silver is a soft but noble metal, where the metal is to be exposed, chemical cleaning is preferred over mechanical methods.

On exposure to city atmosphere, silver is readily tarnished by the formation of a thin surface film of silver sulphide, and for this reason polished silver requires regular cleaning. Tarnish is early removed with plate powder, or rouge cloths, but for antique silver which requires regular cleaning such abrasives are not recommended as they would tend in time to cause damage by wearing down

stamp marks and fine ornament. The same applies to Sheffield plate or silver-plated ware, where drastic cleaning or the use of chemicals might result in exposing the underlying base metal. In these cases it is safer to confine routine cleaning to rubbing with a soft cloth and a little French chalk, moistened to a paste, if desired, with methylated spirit containing a few drops of ammonia (Plenderleith, 1956. 213).

For silver that has been neglected and is heavily tarnished, the following simple electro-chemical method of treatment may be used. Place the silver in contact with aluminium, over it with a dilute solution of caustic soda or sodium carbonate (washing soda)-a solution of 5 per cent, strength is ample-and allow it to remain until the stain has disappeared. It can then be washed in running water and polished with a soft cloth or cotton-wool. Alternatively a chemical solvent for tarnish is available called Silver Dip, and this gives excellent results provided the silver is not left in the solution longer than necessary and is washed thoroughly afterwards (Plenderleith, 1956. 214).

Cleaning Silver Coins

Old silver coins that have been found in the ground provide examples of decay which will vary according to the quality of the alloy and the nature of the soil.

Identification of the coins is a primary requirements, and treatment is carried out with a view to making the ornament distinct and the inscription, if any, readable. It is sometimes the case, however, that an inscription is more legible in the corroded state, and for this reason it should be studied before treatment. After such preliminary study, a hoard of coins is assorted into groups according to the different forms of treatment required. In some cases corrosion may have proceeded in such a manner that the surface of the coin is black and wax-like, and very little metal remains. This is characteristic of a sulphide incrustation, and such coins had best be treated only by washing and drying. When the surface is cracked or the coin is very porous it may be reinforced by impregnation with a nitrocellulose solution.

More usually, a preponderance of metal remains, and the incrustation is due to silver chloride; but silver coins are generally debased and the incrustation will be found to be mixed with the products of the corrosion of the copper present in the silver alloy. The coins may then be adhering firmly together in masses. A conglomerate of this nature may be broken down by formic acid treatment or by soaking in 5 per cent citric acid, although sometimes the individual coins are more easily released by reducing the mass with zinc and caustic soda. The alkaline Rochelle salt process has advantages where the silver is greatly debased with copper, but in this case the coins must be carefully brushed from time to time since the cuprite which cements them together is dissolved by the Rochelle salt exceedingly slowly and then only in the presence of air (Plenderleith, 1956. 224).

iii) Copper

Copper derives its name from Cyprus which was the Roman source of the metal, aes cyprium being the 'bronze from Cyprus'. It is however, an element, and it occurs in nature in the metallic condition as well as in the form of many minerals, chief of which are cuprite (cuprous oxide), chalcocite (cuprous sulphide), chalcopyrite (copper pyrites), and the basic carbonates, malachite and azurite or chessylite.

Metallic copper resembles silver in being sensitive to sulphur which causes it to become covered with a film of tarnish consisting of copper sulphide. It differs from silver, however, in being sensitive also to oxygen; pure copper oxidizes very readily when exposed to moist air, whereas, under similar conditions in air that is free from sulphur compounds, silver remains unstained (Plenderleith, 1956. 232).

The restoration of the metallic condition is not, however, a major problem as the thinly oxidized metal may be cleaned with metal polish or by immersing the object for some hours in dilute sulphuric acid (5-10 per cent), washing afterwards, in each case, drying, and rubbing up with a soft cloth. But the brilliancy is soon lost and to preserve a burnished surface, even under museum conditions, it is usually necessary to cover it with an impervious film of lacquer.

When buried in damp soil, copper soon loses its metallic appearance. The oxide layer increases in thickness, and cuprous oxide becomes compacted into the purplish-red mineral known as cuprite; this, in turn, may become encrusted with basic carbonates that are green or sometimes blue in colour and that correspond to the minerals malachite and azurite. Such incrustations are stable when free from chloride and they protect the underlying metal from further corrosion.

It was noted in the case of silver that when this is buried in salty ground it tends to become covered with an insoluble shell of stable silver chloride. In the case of copper and its alloys, however, the presence of chlorides in the incrustation presents an acute problem from the point of view of conservation because an unstable cuprous chloride is formed; this cuprous chloride continues to react and there is progressive corrosion, even under museum conditions, with the result that the surface becomes powdery and spotty. So common are these features in corroding bronzes that the appearance of characteristic pale green powdery spots is referred to as 'bronze disease' whether occurring upon copper or on any of its alloys (Plenderleith, 1956. 233).

The choice of a method of conservation depends upon the physical and chemical condition of the specimen, the amount of chloride present, and the nature of the incrustation-its thickness, stratification, and porosity. If it is essential that the patina should be save, it is clear that the operation may be a lengthy one, and the results inevitably fraught with some uncertainty.

Deterioration after excavation

Upon excavation it seems that many patinated and crusted copper/copper alloys are stable, with corrosion of any remaining metal only occurring at an RH greater than 80 per cent. This figure is lower in polluted air, especially if contaminated by chlorides. In marine artifacts, corrosion by chlorides is particularly noticeable locally where these are trapped in calcareous and ferrous concretions. However, if nantokite (CuCi) is present within any patina or crust, an extremely destructive type of decay known as 'bronze disease' can occur at RH as low as 35-50 per cent. Nantokite is stable so long as both oxygen and water are absent and thus it can exist sealed beneath layers of compact corrosion without causing any damage. If water is present, it slowly reacts to give cuprite. But if there is plentiful oxygen as well as water present, it reacts extremely quickly to give, amongst other products, the basic copper (II) chloride, paratacamite. This appears as small, bulky, loose-fitting, pale-green crystals which are a component of 'bronze disease' (Cronyn, 1990: 226).

Freshly excavated material may develop 'bronze disease' in a matter of hours, as a result of the drying out of a wet or damp crust. As the water recedes and/or the crust shrinks, air, and thus oxygen, enters, and when it penetrates to the nantokite, deterioration ensues. However, even if nantokite is present, a crust, and more especially a compact patina, may remain stable for many years after excavation, since the entry of oxygen and water is blocked by the denseness of the overlying minerals. But if for some reason the crust loses its seal, perhaps as a result of being cracked by handling, cleaning, or continual temperature fluctuation, 'bronze disease' could develop if the ambient relative humidity is over 40 per cent.

Other types of post-excavation deterioration involve the formation of white deposits of lead carbonate on heavily leaded bronzes from corrosion by organic acid vapours, and the appearance of brown or black hairy crystals on copper alloys, but these are far less common than 'bronze disease' (Cronyn, 1990: 227).

Important tips on the conservation of objects of copper and its alloys

Copper and its alloys corrode in such a way that it is highly likely that the level and topography of an original surface will be retained, either by the outermost patina or within the corrosion crust. Patinas and crusts are often more fragile than they appear, and causal cleaning, even brushing or rubbing with a thumb, can destroy important information. This is especially true of coins. Cleaning should thus be restricted to the laboratory. Here stripping techniques are avoided, mechanical methods being preferred. Deterioration of copper and its alloys can usually be achieved by desiccation, which should be carried out within forty-eight hours of excavation; but there are notable exceptions. For long-term stabilization, BTA has been found to be highly effective but even when treated thus,

extremely high RH and fluctuating temperatures (especially for enamels), have to be avoided. Bright metal, and objects treated with BTA, should be handled only in gloves (Cronyn, 1990: 229-230)

iv) Iron and Steel

Iron is seldom pure and minor levels of other constituents can introduce very different properties into the resultant alloy. Phosphorus usefully hardens and strengthens iron but makes it brittle when cold worked; sulphur detrimentally introduces brittleness alone. The alloying element of greatest interest, however, is carbon, which in concentrations ranging from 0 to 5 per cent greatly affects the properties of the different alloys formed. The most common phases found are soft ferrite (pure iron), hard brittle cementite (the compound iron carbide), pearlite (laminations of ferrite and cementite), and graphite (pure carbon).

Iron formed by primitive smelting is a spongy mass or 'bloom' which can be consolidated into a solid lump by forging. When the bloom is heated in a reducing atmosphere in contact with carbon, as may happen during smelting, the iron on the surface becomes alloyed with carbon. When the lump is worked, the alloy areas become distributed throughout the object, resulting in a metal with an extremely heterogeneous composition, but with an average of 0.1 per cent carbon. To raise deliberately the carbon content of an entire bloom by heating in this manner, called carburization, is an extremely slow and expensive process requiring large amounts of charcoal. Thus in antiquity a tool or knife may have been fashioned from wrought iron and then only the working edges hardened by raising their content of carbon to about 0.3 per cent through carbonization, producing a zone of steel (Cronyn, 1990: 176).

Iron occurs in the metallic condition in meteorites where it is associated with small quantities of nickel, cobalt, copper & c., and the oldest iron objects that have been subjected to chemical analysis have been shown by the presence of these trace elements to be of meteoric origin. Terrestrial iron is of rare occurrence as the metal is so readily oxidized and converted to minerals, and these are abundantly distributed throughout the earth's crust.

Objects of iron and steel provide some of the most intractable problems for the conservator, because of the variety and complexity of their corrosion products. Iron corrodes easily, the corrosion products are unsightly, and the swelling and deformation of the objects may be severe.

Iron is readily attacked by oxygen in presence of moisture to form rust-a name derived from the characteristic orange and red compounds that appear as the first products of corrosion. These consist at first of a mixture of ferrous and ferric hydroxides, but on further oxidation the rust becomes substantially a hydrated ferric oxide, in which some carbonate is usually present as well (Plenderleith, 1956: 271)

Preliminary Examination

When an iron object comes to the laboratory for treatment, a careful examination is necessary to determine the condition of the specimen before a course of action can be decided upon. If a massive incrustation of dry rust is free from chloride, it may be stable under museum conditions, or if rusting has proceeded to the limit and no metal core remains, even if the oxide is swollen and fissured, the specimen will also have reached a stage of stability and no treatment will be essential. On the other hand, if corrosion is still taking place, some process for the removal of chlorides will have to be employed in order to preserve the object. Therefore the first question to decide is whether there are any signs of chemical activity (Plenderleith, 1956: 273).

For assessing the internal condition of an iron or steel object, the method of X-radiography is particularly useful. Iron oxides are relatively much more transparent to X-rays than the solid metal, and X-radiographs reveal the distribution and extent of oxidation more certainly and directly than any other method; they enable one to estimate the depth of pitting, and hence to decide on the best method of treatment.

But only in rare cases can radiographic methods of examination be considered an essential and their application in any case is limited by the thickness of the metal. Whether facilities are available for X-radiography or not, a careful examination is always carried out, first with a magnet in order to determine the extent of the metal core, and then by a needle or metal probe, used with the aid of a lens, in order to reveal the extent and condition of the rust layers and discover, if possible, the existence of any decoration hidden beneath the incrustation. Other tests are made instinctively, e.g. the balance of a rusty blade as an indication of the regularity or otherwise of the corrosion, and an estimate of weight for bulk (relative density) which, with the magnet test, should help in determining the extent of oxidation (Plenderleith, 1956: 274)

Treatment of Iron Objects

Where a substantial core of metal remains in the heart of the rust, reduction methods can be employed without the cleaned object being mechanically weakened, but if, as in the case of a thin and heavily rusted blade, the metallic core is discontinuous, reduction methods are best avoided.

When a small object no longer has a metallic core it is very brittle, and as any treatment would be likely to weaken the specimen still further, objects in this category are best left alone. Sometimes interesting ornament may be hidden in a mass of rust, and can never be revealed by cleaning because of the frailty of the specimen. In such cases photographic evidence may be made available by radiographic methods, using X-rays or radio-isotopes (Plenderleith, 1956: 275).

Reduction

The standard practice with iron objects is to apply reduction methods whenever possible, i.e. when a good continuous core of metal remains, and there are no complications in the way of inlays or non-metallic attachments. In cases where the surface is not much pitted, electrolytic reduction may be applied forthwith, but when pitting is at all extensive it is advantageous to start with electro chemical reduction, using zinc and caustic soda, as this treatment is more likely to get at the deep-seated corrosion in the pits and cracks; but a final electrolytic reduction is always worth while, as it has been found to remove most of the residual chloride, and thus cut short the time necessary for washing. This is clearly an advantage in dealing with metals that rust (Plenderleith, 1956: 276).

Protective finishes

Whatever chemical method is adopted in cleaning iron and steel, the subsequent washing is likely to be accompanied by a certain amount of rust discoloration, and when the metal is dry this is removed by brushing, but if washing has not been prolonged, the rust discoloration can be avoided by a final bath in acetone with removes the surface film of water. There then arises the question of what type of protective finish is likely to be most suitable. Choice may be made from a wide range of materials: there are sealing agents, such as oils and fats, waxes or lacquers: there are also chemical inhibitors, one of the most effective of which is sodium benzoate. This may be applied in either a water or glycerine solution of 1.5 per cent, strength for keeping steel bright in moist surroundings (Plenderleith, 1956: 279).

Important tips on the conservationof iron and steel objects –

Ironwork, especially wrought iron and artifacts from the sea, is perhaps the most problematic, in terms of both investigative cleaning and stabilization, of all material excavated. Research being carried out will, it is hoped, point to means of developing more satisfactory conservation techniques than are available at present.

On site, the only treatment given to iron should be that of careful handling and passive stabilization, and this should begin as soon as possible after exposure. Since the technique of stabilizing ironwork from land sites varies between conservation laboratories, it is essential that liaison with the laboratory which is to treat the iron is established before excavation, to determine the method of passive stabilization required. Where there has been a failure to liaise with a laboratory before excavation, an indefinite delay in the treatment of the material is likely; in this case it is suggested that the ironwork be desiccated, a process which should begin within forty-eight hours of exposure. The opposite is correct for marine ironwork: it must be kept wet from the moment of removal from the sea. Again, advice is essential.

Adequate publication of ironwork cannot take place without radiography; without this, much evidence is missed or misinterpreted. Investigative cleaning, likewise, is essential for competent assessment of a site and cannot be performed without the use of radiographs. Illustration of ironwork should be carried out with reference both to the artefact and to its radiogaph: if the artefact is used alone, corrosion crusts may be misinterpreted; and if radiographs are used alone, distortion occurs and a third dimension of morphology is lost. It cannot be said too often that for publication and display of ironwork liaison between excavator, conservator, and curator is essential.

In the absence of satisfactory methods of active stabilization of iron, control of the storage and display environment is indispensable. As ironwork is a sensitive material, its condition has to be monitored regularly and indefinitely (Cronyn. 1990: 201-202).

12.11 Conservation in Present-day India

During the past three to four decades, many conservation laboratories have been set up but they still remain under the minimum need level. In many of them, only a few hands are available, with inadequate facilities at their disposal. Further, the Conservation Scientist or Restorer continues to get third rate importance in the hierarchy of institutions (Bisht, 2003: 146). Presently the following institutions/individuals are engaged in saving the monuments and artifacts by practical conservation:

The Chemistry Branch of the Archaeological Survey of India, with its headquarters at Dehradun, the Regional Laboratories at Hyderabad, Dhar and Bhubaneswar or Zonal Laboratories at Delhi, Chandigarh, Vadodara, Agra, Aurangabad, Ajanta, Mysore, Jaipur, Madras and Patna continue to serve in the monumental task of saving our monuments by practical conservation.

The National Research Laboratory at Lucknow has a beautiful building of its own now and is well equipped as regards staff and equipment to do useful research work which is helping other institutions of the country. It has opened a regional Laboratory at Mysore to look after the needs of the southern part of the country. However, facilities for actual conservation need to be augmented manifolds even in this laboratory.

The Conservation Laboratory of the National Museum continues to contribute its share to conservation of antiquities. It is helping the NMI in its two year Degree course in Art Conservation to freshers and is conducting a three month training course for in-service personnel of the country. It is also helping institutions of neighboring countries. National Museum Institute (A deemed University of Art History, Conservation and Museology) has produced ten batches of Conservators/ Restorers since 1989.

The laboratories of the National Archives continue to serve the cause of conservation of archival materials of the country. They have centers at Bhopal and Pondicherry which are doing good work taking into consideration the facilities at their command. The States Archives are also doing their part.

There are other laboratories which are contributing to meet the challenge of conservation, namely the laboratories of the Indian Museum, Calcutta, the Salarjang Museum, Hyderabad, the Government Museum, Madras, the Baroda Museum and Picture Gallery, Vadodara, the Directorate of Archaeology and Museums, Rajasthan, Jaipur, the Regional Conservation Laboratory of Archaeology, Trivandrum, Department of Archaeology and Museum, Patiala, the government Museum & Art Gallery, Chandigarh, the Bharat Kala Bhavan, Varanasi, the National Library, Calcutta and the Victoria Memorial Hall, Calcutta. All other laboratories have a single man outfit. Such laboratories are not many and they continue to work in isolation.

Studies in Archaeological Chemistry made by late Prof. K.T.M. Hegde of M.S. University, Baroda and Dr. H.C. Bhardwaj of the Banaras Hindu University, Varanasi need a special mention. Both of them have done commendable work in their respective fields (Bisht, 2003: 146-47).

12.12 Summary

Conservation of excavated material involves four basic consideration –

a) Pre excavation conservations

b) On site conservations

c) Laboratory conservations

d) Long term conservation by control of environment.

Pre excavation consideration involves the estimation of conservation requirements for a particular site. On sight conservation involves lifting them from the deposits without harming them giving them adquate environment and packing them skilfully.

Laboratory conservation involves the conservation in the laboratory. Attempts are made to control the environment in accordance with the artifacts or to introduce new chemicals to preserve the artifact and also in getting material ready for display.

Long term conservation involves control of environment, conservation of excavated sites, adaptation of archaeological material to post excavation environment.

Proper conservation needs the under standing of various sites which deserve different types of conservation. These are devided into four categories – (a) sites having stone structures, (b) sites having structures of burnt bricks, (c) sites having structures of mud bricks or clay, (d) excavated sites near sea shore.

The Archaeological survey of India has devised some methods of conservation of some of the important excavated sites eg. Dholavira, in Gujrat, Agroha in Haryana, Sanghol in Punjab.

Sometime reconstruction and transplatation work becomes essential for conservation eg. the wall of the Purana Qila monument at Delhi. Transplantation involves moving of the entire structure piece by piece to new sites.

In India this type of work was taken up at Nagarjunakonda is Andhra Pradesh. The Papanasi group of temples at Alampur in Mehbub Nagar district were also transplanted to a newly acquired site.

The methodical execution of the above process requires a complete documentation of the edifire, a scientific dismantlingof the structure, careful transportation, proper storage and reconstruction.

The excavated objects which need conservations are of various types – ceramics and metal objects like that of gold, silver, copper and iron. Different chemical methods are prescribed for the conservations of different metals.

The various prestigious institutes which conduct conservation are as following –

The Chemistry branch of Archaeological Survey of India with its headquarters at Dehradun, Laboratories at Hyderabad, Dhar and Bhuvaneshwar zonal laboratories at Delhi, Chandigarh, Vadodara, Agra, Aurangabad, Ajanta, Mysore, Jaipur, Madras and Patna.

The other prestigious laboratories are National Research Laboratory at Lucknow, Conservation Laboratory of the National Museum, Laboratories of National Archives which are also centred at Bhopal and Pondicherry.

Other laboratories engaged is doing significant work in this field are laboratories of National Museum, Calcutta, Solarjung Museum Hyderabad, Government Museum Chennai, Baroda Museum, Vadodara, Directorate of Archaeology and Museum Rajasthan, Jaipur the regional conservation laboratory of Archaeology Trivandrum, Department of Archaeology and Museums Patiala, Government Museum and Art gallery Chandigarh, Bharata Kala Bhawan, Varanasi. The National Library Calcutta. The Victoria memorial hall Calcutta.

12.13 Check your Progress

a) Discuss the different types of excavated sites for conservation.

b) Discuss the conservation work done in any two of the important sites in India.

c) Write short notes on –

   i) Reconstruction

   ii) Transplantation

   iii) Documentation

   iv) Conservation of gold objects.

   v) Conservation of silver objects.

   vi) Conservation of copper objects.

12.14 Activities

Visit a nearly conservation lab and a note of their activities.

12.15 References for further reading

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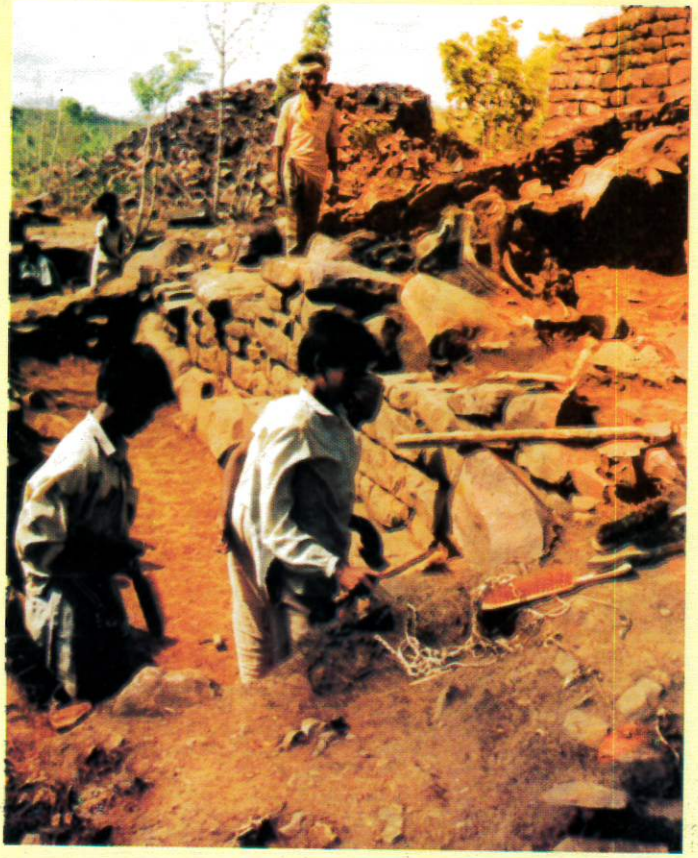

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