Introduction

Prehistoric archaeology may be defined as the science which yields information and develops theories about past human activity of the time period before the emergence of written record by means of studying ancient material remains. Numerous branches of sciences like geology, palaeontology, geography, physics, chemistry, oceanography, remote sensing, geographical information system, microbiology, metallurgy, computer and other newly emerging disciplines contribute enormously to reconstruct the human past most effectively and authentically. It has been observed that the growth of science had a direct impact on the growth of archaeology. The path breaking inventions made in different disciplines of science from time to time indirectly helped in the development of archaeological investigation.

Archaeological Science (Archaeometry)

Archaeological science is the application of scientific techniques to the analysis of archaeological materials including dating of ancient materials. It helps to reconstruct ancient human life ways in different ways; such as the physical and chemical dating methods help in building absolute and relative chronologies; environmental science provide information on the past landscapes, climates, flora, and fauna; mathematical science helps in data treatment; remote sensing and geophysical survey application helps in locating buried features at regional, micro-regional, and intra-site levels; conservation science helps in studying the decay processes and conservation of artefacts etc.

Most importantly the invention of several dating techniques such as radiocarbon (C14) invented by American chemist Willard Libby especially for dating organic materials; dendrochronology for dating trees; Thermo-luminescence (TL) for dating inorganic material including ceramics; optically stimulated luminescence (OSL) for absolutely dating and relatively profiling buried land-surfaces in vertical and horizontal stratigraphic sections; electron spin resonance (ESR), for dating teeth; potassium-argon for dating fossilized remains etc. which have contributed tremendously in building chronology of our past.
Geology

Geology is the study of the development of the earth especially as preserved in its crust formations. The first greatest contribution of geology to prehistoric archaeology is the principles of stratigraphy. Stratigraphy helps to determine the relative dating of the artifacts found in different cultural levels. The study of rocks, minerals, ores, gem stones, soil, land formations, landscape, river migration, river terrace formations, erosion, deposition, submergence of land mass, raised beaches, ancient coast lines and sea level fluctuations, all fall in the domain of geology. Geology helps to understand the factors which determine the human habitat on the earth. The artifacts recovered from particular geological formations like river terrace provide a relative dating to the site. For instance, the prehistoric tools recovered from the river terraces of different valley helps us to understand the chronological positions of the prehistoric cultures.

Archaeologists have long been using the physical and biological sciences for the resolution of archaeological problems. The earth sciences especially geology and geography have played a significant role in archaeological theory and practice for at least one and half centuries, particularly in prehistoric archaeology. In fact, it was as a result of the efforts of the geologists of the nineteenth century that the notion of human antiquity was first established in Europe. In the initial stages prehistoric research was assisted by earth scientists who helped archaeologists to understand subjects like stratigraphy, relative chronology and the palaeoenvironment of archaeological sites.

According to Fekri A. Hassan, geoarchaeology is the contribution from earth sciences to the resolution of geology related problems in archaeology. The scope of geoarchaeology encompasses:

1. locating archaeological sites
2. evaluating the geomorphic landscape for site catchment activities and site location
3. studying regional stratigraphic and microstratigraphic materials for relative dating and recognition of lateral and vertical distribution of activity areas
4. analyzing sediments for the elucidation of site formation processes and quantification of micro-archaeological remains,
5. analyzing paleoenvironments
6. studying artifacts to determine manufacturing practices, procurement range, trade, and exchange networks
7. modelling cultural/environmental interactions
8. conserving archaeological resources
Geoarchaeology is a multi-disciplinary approach which uses the techniques and subject matter of geography, geology and other earth sciences. Geoarchaeologists study the natural physical processes that affect archaeological sites such as geomorphology, the formation of sites through geological processes and the effects on buried sites and artifacts post deposition. Geoarchaeology is a recent field of research that uses the computer cartography, geographic information systems (GIS) and digital elevation models (DEM) in combination with disciplines from human and social sciences and earth sciences.

**Stratigraphy**

The concept of stratigraphy in geology had been based on the publication of the book Principles of Geology by Sir Charles Lyell in 1830. Glyn Daniel in his book *A Hundred and Fifty Years of Archaeology* published in 1975 discussed the origins and development of archaeological thought and explained the influence of geology in archaeology, particularly in stratigraphy. Stratigraphy took its root with the formulation of the principles of stratigraphy and its acceptance by the geologist and archaeologist. C.J. Thomsen advocated the Three Age System in which human passed the three technological stages namely stone, bronze and iron. Thomsen's successor J.J.A. Worsaae proved this transformation with stratigraphic validity.

The principle of stratigraphy became the mainstay of archaeological thought in 1970s. Edward Harris advocates that this geological stratigraphy cannot be applied directly on the man-made archaeological stratigraphy without any suitable modifications and revisions and he developed an archaeological stratigraphy. Edward Harris in his book *Principles of Archaeological Stratigraphy* in 1979 devised a new method in archaeological stratification which is popularly known as Harris matrix.

Accumulations of remains of human activities leave sequential layered deposits known as strata (singular stratum). Each stratum may be differentiated from one another on the basis of the texture, composition, colour, thickness, and cultural features. The colour and texture, two chief characteristics of soils, is described by using a Munsell Soil Colour Chart. Stratigraphy is the study of these strata in an archaeological site and their relation to each other, and the determination of the archaeological sequence in which they were laid down. As a whole, stratigraphy is the study and interpretation of the sequential deposit of site.

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. However, the archaeologist 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.

Stratigraphy can be considered as an index to the history of the site and used as a primary source of interpretation. It provides a perspective of the chronology; the geological, faunal and floral histories of the site along with the varied human activities like contemporary industries, architectural edifices and their cultural changes. Therefore careful observation and recording of stratigraphical evidence is absolutely essential for any interpretation of a site.

**Palaeontology**

Palaeontology is the study of fossils to determine evolution of organisms and interactions with each other and their environments and their palaeo-ecology. Fossils remain have provided new information about the earliest evolution of animals. A fossil is defined as any trace of a past life form. Thus, although wood, bones, and shells are the most common fossils, under certain conditions soft tissues, tracks and trails, and even coprolites may be preserved as fossils. Although most of the fossils that palaeontologists study are several thousands to several billions of years old, there is no absolute minimum age for a biological structure to be a fossil.

In Indian context, G.L. Badam, his colleagues and students have built up the vertebrate paleontology laboratory of the Deccan College into the only one of its kind in the country where palaeontological research in the context of prehistoric archaeology is being conducted.

In India the various subdivisions of the Pleistocene are mainly based on vertebrate paleontology and Paleolithic archaeology. Paleontology has found an important place in the study of the occupation sites of the prehistoric period. The relative dating of Stone Age cultures is now largely based on faunal evidence by undertaking fluorine analysis.

**Taphonomy**

The term taphonomy was proposed by a Russian paleontologist, J.A. Efremov in 1940 for the study of the transition of animals from the stage of biosphere to that of lithosphere. The word has a Greek origin, *taphos* means burial and *nomos* means law. Literally therefore, taphonomy means laws of burial. It is a process in which animals pass out of different parts of the biosphere, get fossilized and become part of the lithosphere. In fact during the last few years the application of taphonomy and
palaeoecology has so widened that they are now considered sister disciplines of archeology. It may be mentioned that taphonomy established itself in paleontology primarily as a sub discipline of palaeo-ecology but it has evolved into a much broader study of the ways in which preservation affects the fossil record.

Taphonomy largely helps to resolve problems in evolution, biogeography, biostratigraphy and palaeoenvironmental reconstruction, and thus to a better overall understanding of the fossil record. Taphonomy can be divided into two fields, biostratinomy and diagenesis. Biostratinomy includes the circumstances occurring between the death of an individual and its subsequent burial whereas diagenesis includes the effects upon the interred remains brought about by burial conditions and subsequent exposure until the time of discovery.

Geography

Several methods and techniques used primarily in geography are utilized by archaeologist, for example, there are several pre-excaivation techniques, namely map reading, aerial photography and ground photographic reconnaissance methods and ground search survey. A map is a scaled symbolic representation of a segment of the earth's surface as viewed from above. It is a two-dimensional representation of three-dimensional features. It is of utmost importance for the archaeologist having the basic knowledge of reading the various maps.

The topographical, hydrographic, geological and political maps published by the Geological Survey of India show elevation, vegetation, prominent manmade constructions, boundaries of sections and natural features such as mountains and rivers. The registered archaeological sites are located on the maps. These survey maps will have established network of points in the country which provide precise information on locations and elevations of important features that is the precise latitude, longitude, elevation and distances between each of these features.

A topographic survey map helps to determine or locate transit stations, prominent objects such as roads and buildings, elevations and contours showing the flatness and roughness of the terrain in three dimensions. The hydrographic map helps to identify the ancient shoreline based on average sea level, ancient water supply and palaeo-channel. This would help in turn to identify the ancient ports, trade networks and irrigation tanks.

The old maps may also be helpful for determining the site in its setting. There may be perceptible change in the geomorphology at the site from the date of
preparation and to the present day. The pattern of erosion and weathering may be different from present ones, owing to climatic changes. A river may have changed its course; waves may have undermined shore cliffs, and wind corrosion may have brought about changes in earth surfaces, particularly in areas located near desert margins. So, map reading would give valuable information on the various physical features of the prehistoric site.

Applications of Geographic Information Systems in Prehistoric Archaeology

Geographic Information Systems (GIS) has been an important tool in archaeology. The GIS has strengthened the archaeological investigations, since archaeology often involves the study of the spatial dimension of human behaviour over time. Since archaeology looks at the unfolding of historical events through geography, time and culture, the results of archaeological studies are rich in spatial information. GIS is adept at processing these large volumes of data, especially that which is geographically referenced. It is a cost effective, accurate and fast tool. The tools made available through GIS help in data collection, its storage and retrieval, its manipulation for customized circumstances and, finally, the display of the data so that it is visually comprehensible by the user.

The most important aspect of GIS in archaeology lies, however, not in its use as a pure map-making tool, but in its capability to merge and analyse different types of data in order to create new information. The use of GIS in archaeology has changed not only the way archaeologists acquire and visualise data, but also the way in which archaeologists think about space itself. GIS has therefore become more of a science than an objective tool.

Archaeo-information science attempts to uncover and explore spatial and temporal patterns and properties in archaeology. Research towards a uniquely archaeological approach to information processing produces quantitative methods and computer software specifically geared towards archaeological problem solving and understanding.

Site Formation Process Studies

Past natural processes and human activity, and present natural processes along with modern activities contribute to the formation of an archaeological site. The recognition and interpretation of the diverse processes is one of the most important aspects of modern archaeological research. Archaeologists refer to this as site formation processes. The development of the concept of site formation processes in archaeological studies has been dealt with extensively by L. Binford, M.B. Schiffer etc.
Site formation process analysis provides a basis for interpreting the duration of human occupation, the continuity or intermittence of occupation, intensity of occupation, rate of site formation, post-depositional alternations and the effects of erosion on the preservation of cultural remains.

In India, K. Paddayya have made an attempt to study site formation processes in the Hunsgi-Baichbal valleys, Karnataka who discusses in detail various natural and cultural processes that have contributed in the formation and preservation of Acheulian sites in the Hunsgi-Baichbal valleys. S.M.K. Ahsan made a study of site formation processes of sub-humid environment of the Narmada valley with special reference to the Middle Paleolithic site at Samnapur.

**Settlement Pattern Studies**

For the reconstruction of man-land relationships, the study of settlement patterns as well as the geomorphic context of settlements is essential. The concept of settlement patterns was first applied in archaeological studies by G.R. Willey in 1953 in the Viru valley, Peru. K.C. Chang in his book *Settlement Archaeology* in 1968 defined settlement pattern as the manner in which human social systems are distributed over the landscape in relation to the environment. The analysis of settlement patterns comprises the location of sites, their distribution and densities, and their relationship with ecology. Locational analysis is a study of the physical location and distribution of human activities across the landscape.

In recent years, the concept of settlement patterns has been applied with great success to Neolithic, Harappan, Chalcolithic, Megalithic and Early Historic sites. However, this concept has not been widely applied to the study of Paleolithic cultures. A few attempts in this direction have been made by K. Paddayya in Hunsgi-Baichbal valleys, R. Ray in Eastern India, and D.R. Raju in Cuddapah region of Southeast India.

R.S. Pappu and S.G. Deo have used the techniques and methods of geomorphology to understand the settlement pattern and man-land relationships in the Kaladgi Basin, Karnataka.

**Site Catchments Analysis**

The explicit realization that human groups procure resources from the regions immediately surrounding their settlements led to the introduction, in the late 1960s, of the analytical method of site catchment analysis. This method was first introduced by C. Vita-Finzi and E.S. Higgs in 1970 in their study of the prehistoric economy of the Mount Carmel area in Palestine. According to them, site catchment analysis is the study of the relationship between technology and the natural resources lying within the economic range of individual sites. The catchment area is that from which resources are taken to support human populations and occur within reasonable walking distance from a site.
Site catchments analysis is thus concerned with the exploitation of plant, animal, mineral and other resources by human groups in a particular territory and encompasses both the theory and method of assessing the resource potential of any archaeological site. Studies of modern hunting-gathering and agricultural economies have shown that the territory exploited from a site tends to lie within certain well defined limits.

This concept was introduced for the first time in India at the Chalcolithic site of Inamgaon by R.S. Pappu. Since then this method has been successfully employed at a number of Chalcolithic, Neolithic, Harappan and Megalithic sites in the Peninsula.

Geophysical Methods

The geophysical methods provide a board picture on the potential of the site. It is a non-destructive method of site investigation. Geophysical survey is of greater use in planning the area and size for conducting excavation. Geophysical prospecting gives better picture of the cultural deposit. The sites with deep stratification would be confused because many deep structures sometimes escape detection. Scientists are trying to rectify these deficiencies by refining the techniques and instruments. Resistivity surveying remains perhaps the most important technique available to archaeologists, closely followed by magnetometry. Other techniques like ground penetrating radar, acoustic reflection and thermal sensing are also used occasionally.

Physics

The application of physical methods in archaeology are various such as it helps analysis of the location based on resistivity, magnetic and electromagnetic survey methods, analysis of artefacts based on x-ray fluorescence, neutron activation etc. and dating the strata or the artefacts by radiocarbon, thermo-remenant magnetism and thermo-luminescent techniques, potassium-argon dating, uranium series dating including ionium dating, fission track dating and dating by chemical change including hydration of obsidian and weathering layers on glass.

One of the greatest contributions of physics is the dating method particularly radio carbon dating. The various dating methods like Radiocarbon dating, TL dating, Archaeomagnetic dating, Potassium-Argon dating, Fission track dating and others are the contribution of physics to archaeology. The absolute dating methods have revolutionized the archaeological interpretation. The series of radiocarbon dating collected from different sites of Neolithic, Chalcolithic, Harappan and later period culture help to determine the chronology of these cultures. Among the sciences, physics has contributed significantly in getting an absolute date for archaeological materials.
Radiocarbon dating, applicable to wood and some other organic remains, is predominant in this field and forms the basis of most prehistoric chronologies. Its techniques of measurement are now well established and the main research emphasis is concerned with the fluctuations in the radiocarbon content of the atmosphere that have been inferred from small systematic errors shown up in the dating of known-age samples.

Archaeomagnetism, which is based on the magnetization fossilized in clay when it is fired, also provides data on the past secular variation of the geomagnetic direction and to a limited extent this can be used for dating; the geophysical interpretation of the data is also of interest. Thermo-luminescence is a fairly recently developed method and the main research emphasis is still concerned with various complications of technique. It is important because it is directly applicable to pottery and pottery styles are the ‘grammar’ of most archaeological chronologies.

Potassium-argon dating is a well developed geological technique and is notable in the present context for its dating of volcanic material associated with early hominid remains. Uranium series dating has the possibility of being applicable to bone and shell of the Palaeolithic period, this being too early to be reached by radiocarbon. Fission track dating is primarily a geological technique but it holds promise for archaeology, particularly in early periods. Obsidian dating and glass layer counting are based on the hydration caused by weathering.

Chemistry

Chemistry plays an important role in archaeological studies as it forms a new and distinctly interdisciplinary subject, Archaeological Chemistry, dealing with the chemical study of ancient materials. The composition, structure and properties of materials can be studied with the help of archaeological chemistry. The essence of this science rests in its ability to provide information about the properties of matter that is completely closed to visual observations. It therefore helps the archaeologist to seek that stored information which is beyond the scope of visual observations and is buried with the ancient material in the form of minerals and chemical elements.

Chemistry plays a crucial role in the conservation of antiquities and archaeological monuments. The chemical deterioration takes place once the buried object is disturbed from its microenvironment. Therefore, cleaning, repairing and stabilizing the artifacts falls in the hands of conservationists. The application of various chemicals particularly preservatives are works of the chemists. The dating methods like Amino-acid racemization, nitrogen and fluorine tests are determined based on the chemical properties found in the archaeological material. The preservation of rock paintings, fresco paintings, palm leaf manuscripts, rare paper manuscripts, bronze objects, cleaning of monuments, etc are being carried out at the advice of
conservationist. Therefore, the contribution of chemistry in the preservation of various historical documents can not be underestimated.

Archaeological chemistry is a subject of great importance to the study and methodology of archaeology. F. Gobel was the first to suggest that the results of chemical analysis of archaeological materials could be of service to archaeology.

Conclusion

In recent years, it has been observed that archaeologists and scientists have been working together with particular interests in advancing the development and application of scientific techniques and methodologies to all areas of archaeology. It is helping in developing and applying scientific methods through improving the quality and reliability of scientific information derived from archaeological research. It is strengthening our knowledge of our past, through the application of a wide range of techniques derived from the natural sciences.