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Subject: Anthropology

Production of Courseware
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Paper No. : 13 Research Methods and Fieldwork
Module : 19 Archaeological: River Terraces & Stratigraphy, Sediments

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Description of Module	
Subject Name	Anthropology
Paper Name	Research Methods and Field work
Module Name/Title	Archaeological: River Terraces & Stratigraphy, Sediments
Module Id	19

Contents:

1. Introduction
2. Definition
3. Identification of Terraces
4. Fluvial Terrace Morphology and Stratigraphy
5. Dating river terraces
6. Archaeology of River Terraces
7. Sediment Study of River Terrace.

Summary

Learning Outcomes:

Once you have gone through this module, you will:

- have a better understanding of what is a terrace as differentiated from other geomorphic features such as flood-plain;
- learn about the new dating techniques;
- have an overview of the possible archaeological research than can be undertaken on the river terraces; and
- have an overview of the multi-disciplinary approach to the problems of terraces.

1. Introduction

River terraces or more commonly known as fluvial terraces are important in archaeological fieldwork to understand the archaeological and geological stratigraphy of a region. This is especially true of prehistoric cultures where the only evidence comes in the form of tools discovered in the context of river terraces. Majority of river terraces developed during the Quaternary period; Pleistocene (2.5-1.75ma (ma= million years) and Holocene, approximately 10,000 yrs till present). The Quaternary is characterized by high amplitude glacial-interglacial periods and climate unsteadiness. Explorations and excavations within the river terraces have amply demonstrated the hominin-land relationship throughout the globe during the Quaternary.

2. Definition

The term 'river terrace', according to Pazzaglia, was introduced in modern physical geography in the latter part of the 19th century. Pazzaglia has defined river terraces as 'landforms underlain by alluvial deposits'. The terrace flanks the rivers in a wide range of climatic and tectonic settings and used by human groups as areas conducive for establishing settlements. The river terraces are part of alluvial environment. Alluvial environments can be said to have their own archaeology because throughout prehistory they are distinguishable from other environments in their resources and hazards (Brown 1997).

3. Identification of Terraces

'Terraces' are identified in the maps and in field as high-ground flanking a river which had been an erstwhile flood-plain before the river started flowing at a lower level due to various factors. One view holds that terraces, within a river valley are characterized by non-inundation during normal flood (Pazzaglia). This character distinguishes a terrace from a floodplain. However, the other scholars suggest that even low terraces may be inundated during normal flood cycles (Brown 1997). The individual terraces are generally numbered based on the relative height from the river bed and also the time of the deposition from the oldest to the youngest. In a matured flood plain these numberings are

replaced by surfaces and formations. Examples of such terrace surfaces are located along the river Thames in England and along the Middle Son river, in India which is included in the module as an example (Fig 2). River Terraces are also identified in topographic maps, air photographs, satellite imageries after which they are verified in the field.

4. Fluvial Terrace Morphology and Stratigraphy.

Fluvial sedimentary records worldwide have demonstrated that sediments are basically preserved in two main types

- stacks of deposits in superimposition and
- terraced sequences.

Within a river valley, terraces are fixed as geomorphic markers. A terrace and terrace alluvium are best described as allostratigraphic unit. The bounding unconformities of these units are the flat terrace surface also called 'treads', the erosional terrace; terrace base and the intervening slope connecting to a river floodplain. Terraces are commonly organized into two main categories based on their morphology and thickness of alluvial deposits; the 'strath terrace' and the 'fill terrace'. The former is an erosional terrace with thin alluvium cover while the later has a thick alluvium cover. The terraces deposits are laid down following certain stratigraphic orders. These may be interpreted as climatic signatures that influenced formation of the terraces. Therefore, terrace deposits are known to occur worldwide and they have been a response to climatic fluctuations. Bridgland and Westaway (2008) have compared the terraced sequences worldwide. In Europe, most of the major rivers display terrace sequences related to glacial, interglacial and transitional phases.

Origin of fluvial terraces

The origins of terraces, which were initially attributable to sea-level fluctuations, are presently attributable to varied and complex environmental factors such as river incision (down cutting of the river into its deposits); changes in the sediment availability; changes in catchment hydrology, tectonic activities (earthquake) and base level changes due to changes in the sea-levels. According to Brown (1997), a terrace is basically a break in slope between two high surfaces. Terraces within a single river valley may have different origins since there are changes in the catchment and drainage networks.

5. Dating River Terraces

The deposits river terraces can be dated based on biostratigraphic (based on fossils) and chronostratigraphic methods. Recently IRSL (infrared stimulated luminiscence) has been employed to date the Son valley terraces (Neudorf et al, 2014). The IRSL age of a sample is calculated by dividing the burial dose by the environmental dose rate integrated over the period of sample burial. The IRSL, TL (Thermoluminescence) and OSL (Optically Stimulated Luminescence) dating methods provide chronology of the terraces independent of biological remains.

6. Archaeology of the river terraces

Several of the terrace deposits coincide with the origin of modern humans and therefore these terraces are particularly attractive to archaeological fieldwork. Workers in the field have generally opined that the upper and middle terraces in the old World may contain Lower and Middle Palaeolithic artefacts, the lower terraces are the sources of Upper Palaeolithic and post-Palaeolithic artefacts (Neolithic, Chalcolithic and even historic) lying very close to the present river. A subject of particular relevance to the archaeologists is the preservation of terraces and environmental significance of terrace surfaces. The terraces are the driest part of the floodplain and therefore they have been preferentially settled by human groups.

The history of river terraces and archaeological artefacts is long. The river Thames in England, for example, has preserved patches of gravel which were the erstwhile flood-plain and now situated 100 feet above the present river. One of the famous preserved river gravel is the Swanscombe in North Kent. Thousands of Acheulian hand-axes, animal bones and parts of the skull of the 'Acheulian' hominins were found from the 'middle gravel' of the Thames, which was a cut and fill deposit into the lower or the earliest gravels. Since the gravel patches deposited by rivers such as Thames are of different ages and of different levels, the appearance of these terraces in stepped manner or the benches on which these terraces rest could therefore be relatively dated to each other and consequently the archaeological artefacts in them can be dated. However, it is important to understand the fluvial history before any attempt at a stratification can be made. Secondly, scholars have also cautioned that the

dating of archaeological artefacts must depend on the geological dating of the river deposits and not vice-versa (Pyddoke, 1961).

Reviewing the problem, Bridgland (2000) has opined that in Britain and European continent the major aggradational terraces have provided the bulk of artefactual evidence for the presence of Lower Palaeolithic hunter gatherers. These terraces have also preserved high proportion of interglacial sites. The sites are rich in vertebrate faunal remains including hominid origin such as the Swanscombe skull described above. Molluscan shells provide important biostratigraphic and palaeo-environmental information. These shells can be dated and provide excellent material for geochronology. Terraces in Northern Europe are now being looked at as archives of climatic changes during the Quaternary period and also as a response to glaciations and are records of tectonic uplifts.

Although the archaeological study of river terrace sequences have provided important inputs for stone age research archaeological settlements as young as 400 yrs B.P have been studied in association with very young terraces of less than 600 yrs B.P from New Zealand (Jones 1990).

History of Study in India

The first researchers to comment on the river deposits, Stone Age tools and climate were Cammiade and Burkitt in the 1930s, relating the river deposits to wet and dry phase in South India along the Kortallaiyar basin (Korisettar and Rajaguru 2000). In the Indian sub-continent the first detailed work on the origin of the river terraces in the North West and in the peninsular India were carried out by Yale-Cambridge expedition by Helmut de Terra and T.T Paterson and related to four-fold glacial and inter-glacial model in Northwest India relating to similar model in Europe (de Terra and Paterson 1939). Terrace I was associated with early Sohan (or Soan) industry (Lower Palaeolithic Culture identified by the occurrence of pebble tools, handaxes and cleavers. Sohan is now compared to the Acheulian culture and the initial distinction between the Sohan valley culture and the Madrasian Cultures are no longer valid in the Palaeolithic cultures of South Asia), and Terrace II was related to middle Sohan industry.

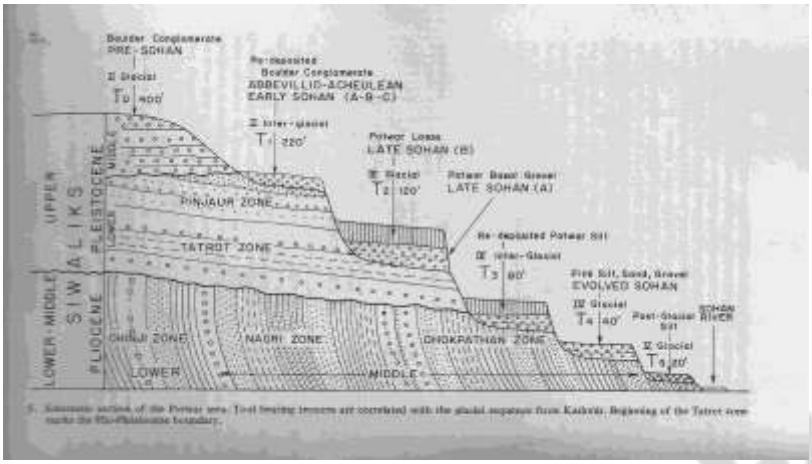

Fig 1. The four fold-terrace sequence proposed by de Terra and Paterson
(Source: Agrawal 1982)

Important terraces from the North-West Punjab were recognized as the Potwar plains of the Sohan Rivers and the terraces of the rivers in the Himalayan foot-hills in east Punjab and Himachal Pradesh such as the Sirsa, Beas and Banganga which are rich in stone-age implements. Helmut de Terra and Patterson also correlated the Potwar Terraces with Terraces from the Narmada and those from Madras region. According to Korisettar and Rajaguru (1998), the scheme of de Terra and Patterson went unchallenged for nearly fifty years in Indian archaeology. Prof. H.D. Sankalia also highlighted importance of terrace stratigraphy in the Stone Age cultures of South Asia in his famous monograph Pre and Protohistory of India and Pakistan. However, the joint Deccan College-Berkeley team questioned de Terra and Paterson's stratigraphy and alluvial context of the sites (Mishra 1994). One of the famous terrace section identified by Sankalia was at the well-known site of Nevasa. The glacial-interglacial cycle in the Himalayan region found a counterpart in the pluvial-Interpluvial cycles for peninsular rivers such as Sabarmati and Narmada.

However, the observations of de Terra and Patterson have now been modified. Rendell's work has shown that there are possibly no terraces in the Sohan valley and the age of the Lower Palaeolithic industry in the region is 0.7-0.5 million years associated with valley fills including loess deposition and uplift (Allchin 1995). The pebble tools are 1.5 million years old associated with earlier Pinjor beds.

Similar criticisms of de Terra and Paterson's study in the south Indian rivers have made by scholars. Shanti Pappu pointed out the complex geomorphological processes operating for the Pleistocene period in the Kortalayyar basin where the famous Palaeolithic site of Attirampakkam is located (Pappu 1996). The interglacial-glacial cycles during the Quaternary based on terrace sequences have now been proved to be incomplete following studies based on continental loess or wind blown sediment and also study of oxygen isotope studies from the ocean cores.

Other than the pioneering research of de Terra and Paterson, another important scientific expedition was led by F.E. Zeuner in the pre-Independence era. Zeuner studied the formation the Pleistocene deposits in Gujarat, especially in the Sabarmati river. Zeuner was successful in proving that there were more than four wet and dry phases based on his study of the river deposits from Gujarat (Zeuner 1950). Recent researches in the peninsular India have been working on the alluvial stratigraphy of the Pleistocene period from various river basins to understand the context of archaeological artefacts. The origin of the Pleistocene terrace sequences are related to pluvial (high rainfall) and inter-pluvial phases (low-rainfall regimes).

Field researchers during the last few decades provide a good stratigraphic picture of the Central Narmada region (Korisettar and Rajaguru, 1998). Rajaguru (1969) in his review of the Peninsular River pointed out that in the central Narmada, the older alluvium deposits forms a distinct terrace at 39m above the present level of the river Upper Palaeolithic industry is placed in the Holocene terrae. The Middle Palaeolithic and Upper Palaeolithic industries are associated with the Late Pleistocene terrace T1 (lower) also known as Jhalon Formation or Nimsarya Formation. Within the Lower Palaeolithic industries, late Acheulian is dated to the middle Pleistocene errace T2 (Devakachar Formation) and early Acheulian is associated with erosional level T3 and terrace T4 (Narsinghpur Formation) again belonging to the middle Pleistocene period (Korisettar and Rajaguru, 1998).

Terraces and Stone Age artefacts have also been documented in the smaller river basins of the Deccan (Maharashtra) region. The older alluvium of the Bhima is about 12-18 m above the present level of the river. These older alluvium contain Middle Palaeolithic tools and therefore dated to the upper Pleistocene period by Rajaguru while the newer alluvium belong to the early Holocene epoch. Guzdar has documented two cut and fill terraces in the Konkan river valley, the older one being 10m and the

younger around 3 m high from the present bed level. The sediments associated with these terraces are one or more gravel conglomerates with high acidic brown silts, the upper part of the alluvium is generally silty. In the upland Deccan region the Godavari formations are the earliest Quaternary alluvial formations to be preserved as terrace gravels and middle Palaeolithic artefacts have been found from these deposits lying 6 to 35 m above the present bed of the river.

In the next section two well-defined terrace and archaeological sequences from Mediterranean region(Syria) and India, Son and Belan valley are discussed as examples.

- **Case Studies**
  - *River Terraces, Stratigraphy and archaeology from the Orontos vallley**, Syria**.*

One of the classical stratigraphic records of river terraces during the Pliestosene period comes from the prehistoric sites in the upper Orontos valley in Syria studied by Bridgland and Westaway (Bridgeland and Westway 2008). This study seeks to relate the Palaeolithic artefacts to aggradational terraces of the Orontos. Brigland reports at least 12 terraces in the 130 m above the river. Subsequently several more terraces were found 200m above the river. The terrace stratigraphy has been explained in terms of palaeosols, gravel sands, clay alluvium. The artefact assemblage has been explained in terms of Khattabian (90+m); Middle Acheulian (50-60+m), late Acheulian (20-30m+) and Mousterian (10m+). This record was attested at Latameh, fossiferous Palaeolithic site.

  - *Middle Son Valley Terraces Sequences*.

One of the extensively researched projects on archaeology of river-terraces in India was conducted by the Allahabad University and the University of Berkeley in the middle Son valley (MSV). The project was headed by Prof G.R Sharma and J. Desmond Clarke (Sharma and Clark 1982, 1983). The objectives of the project were to evaluate the morphological succession of alluvial sediments and sequence and depositional episodes during the Quaternary and to interpret this in terms of past climate and environment and, to locate primary context sites, determine paleo-ecology. The following sequences were established (a) Sihawal formations is the oldest alluvium sediments indicating semi-arid climatic conditions and date to the middle Pleistocene. This formation contains well-developed

Acheulian deposits. The Sihawal formations are followed by Patpara formation of the upper Pleistocene with Middle Palaeolithic tools. The next formation is known as the Bagor formation belonging to the upper Pleistocene containing a large number of fossil mammal bones and an upper fine member comprising of silts and clays sealed by upper Palaeolithic tools. Early Holocene is characterized by deep down-cutting, erosion of earlier sediments and formations of erosional terraces followed by low depositional terraces (Khetauchi formation), Mesolithic artefacts are found within the erosional terraces and with the Khetauchi formation (Fig 2). Following this initial study by Sharma and Clark several researches have been undertaken on the MSV providing a rich crop of evidence with regard to the alluvial terrace chronology of the MSV. Recent dating by advanced dating methods used by Neudorf et al 2014 has demonstrated that the period of aggradation was between 39 ka and 16 ka and fluvial incision commenced after 16 ka.

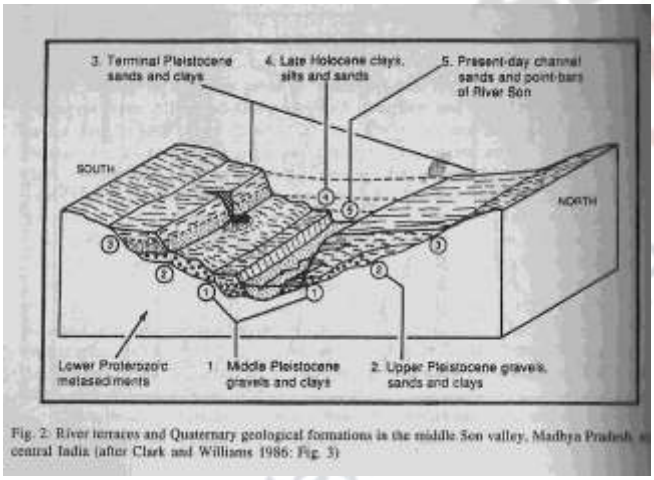

Fig. 2: River terraces and Quaternary geological formations in the middle Son valley, Madhya Pradesh, central India (after Clark and Williams 1986: Fig. 3)

Fig 2. River Terraces in the Middle Son Valley (Source: William and Clark 1995).

7. Sediment Study of the River terraces.

The stratigraphy of the river terraces as discussed above are composed of sediments which are by their very definitions are transported and deposited materials through different agencies such as water (fluvial) or wind (aeolian). Once transported from their original position to their final place of depositions, the sediments may undergo several physical and chemical alterations. Since the sediment source may vary the constituent elements within a sequence of terraces may also vary. The sedimentary

record of an archaeological site can provide critical environmental, stratigraphic and cultural information because these sediments are a mix of biological, geological and anthropogenic components. The sediments can be classified into three main groups, the clastics, the chemical deposits and thirdly organics, the decomposed materials that have been used by humans from animal and plant life and then disregarded. The clastics can be divided under several segments beginning with mud or clay followed by silt and sand and ultimately pebbles, cobbles and gravels and large sized clastics including boulders. It will be noticed that the most of river terraces discussed here contain the clastics such as silt and sand and also gravels. These clastics are used for stratigraphic reconstructions and interpretation of the depositional environment. Human made artefacts are also part of the clasts.

The chemical constituents of the sediments are also important; the sediments may be rich in organic matter. The sediments may be calcareous or non-calcareous in nature. One of the commonest minerals precipitated in the sediments is Calcium Carbonate (CACO3). Other chemical constituents that evaporate such as calcite, gypsum, and halite are indicator of mineral precipation sequence in a stratigraphic profile. This may be used as indicators of evaporating conditions and changing water chemistry within the basin. Presence of Iron oxides, Manganese, phospates, etc is also indicators of past environment (Rapp and Hill 2006).

Considering the wide variety of climatic zones, geology, geomorphology of the quaternary terrace sediments worldwide, a complicated sedimentary record is preserved entailing advanced sedimentological analyses. River Thames has been extensively studied for palaeo-environment during the Pleistocene period (Schreve et al, 2002) including clast lithology, palynology, (study of pollen grains), vertebrate and other organic remains for biostratigraphic correlations). The river deposits such as the *Purfleet deposits,* clearly demonstrates the importance of detailed sedimentalogical analysis of Pleistocene terrace deposits at a global scale.

The deep cores from the ocean can now be correlated with the sediments from fluvial terrace. The glacial-interglacial contrasts from the northern Indian Ocean offers encouraging support for reconstructing late Quaternary changes in the river flow and sediment load in the Son and Belan valleys of India (William and Clark, 1995). Inputs from sediment studies from different sources, including terrace deposits of the Son and Belan valleys points that during climate during 18kyr B.P

over much of India was drier, windier, with less summer and stronger winter monsoon than present. During the early Holocene South-West monsoon became stronger with the result that the river valleys of the India including those from Central India became less seasonal. The terrace sediment profile also provides good evidence of chronostratigraphic events such as the deposition of the Toba ash from volcanic eruptions at 75kyr. The ash deposits from the terrace sediments in the middle Son Valley from were analyzed and diagnosed to be volcanic in origin lying below the Bagor formation. One very important aspect of the study of alluvial stratigraphy and sediments from the Son valley formations is minute observations of the soil colour using Munsel colour chart since even the minor variations can prove to be diagnostic.

Sediment profiling from river terraces therefore has the potential of interpreting climatic signatures during the Quaternary where they have been preserved and is an excellent archive of past human adaptations from the lower Palaeolithic till late medieval period (approx 150-200 yrs B.P) world wide.

Summary

River Terraces are archives of archaeological and sedimentological data during the quaternary period. River terraces are landforms underlain by alluvial deposits. River terraces normally lie above the normal flood level and are numbered accordingly. The numbers are at times replaced by surface or formations/ Formations. The older archaeological deposits are associated with the oldest river terrace.

The terraces originate due to various factors such as climatic, base-level change, uplift. The terraces can be generally two types, Strath Terrace and Fill Terraces. Archaeological sites are associated with both types of terraces. Terraces are now dated by radio-metric methods if organic materials are available from them. Terrace sediments can also be dated through various luminescence methods. Many of the important drainage basins have preserved terraces that originated during the Pleistocene period. One of the well studied terrace is that of Thames in England which has also yielded archaeological artefacts. The Stone Age artefacts (Palaeolithic and Mesolithic) within Pleistocene terraces allow evaluation of past environmental and cultural records. Neolithic Chalcolithic cultures are associated with relatively older river terraces. Historical period sites are also associated with younger river Terraces of the Holocene period.

In South Asia, Helmut de Terra and Paterson (1939) provided the first ever model of fluvial terraces related to the four fold model of glacial and inter-glacial cycles based on their observations of the Sohan valley in the Potwar region of Punjab. This model also attempted to situate the 'Sohanian' and other Stone Age cultures to the glacial-interglacial cycles based on their observation of tools within the terrace deposits. Another important research on Indian rivers, especially, the Sabarmati and Narmada was studied by F.E. Zeuner (1950). In the post-Independence period, the Palaeolithic industry was divided into the Lower, Middle and Upper and related to the terrace sequences of the rivers in Northern and Peninsular India.

Many of the observations of de Terra and Paterson have been modified or rejected by subsequent workers in the field. Important multi-disciplinary researches on river terrace stratigraphy and hominin culture have been conducted throughout the World such as the Orontos river stratigraphy in Syria. In India, Multi-disciplinary researches including detailed sedimentary researches have been conducted in the Middle Son Valley by University of Allahabad and University of Berkeley.