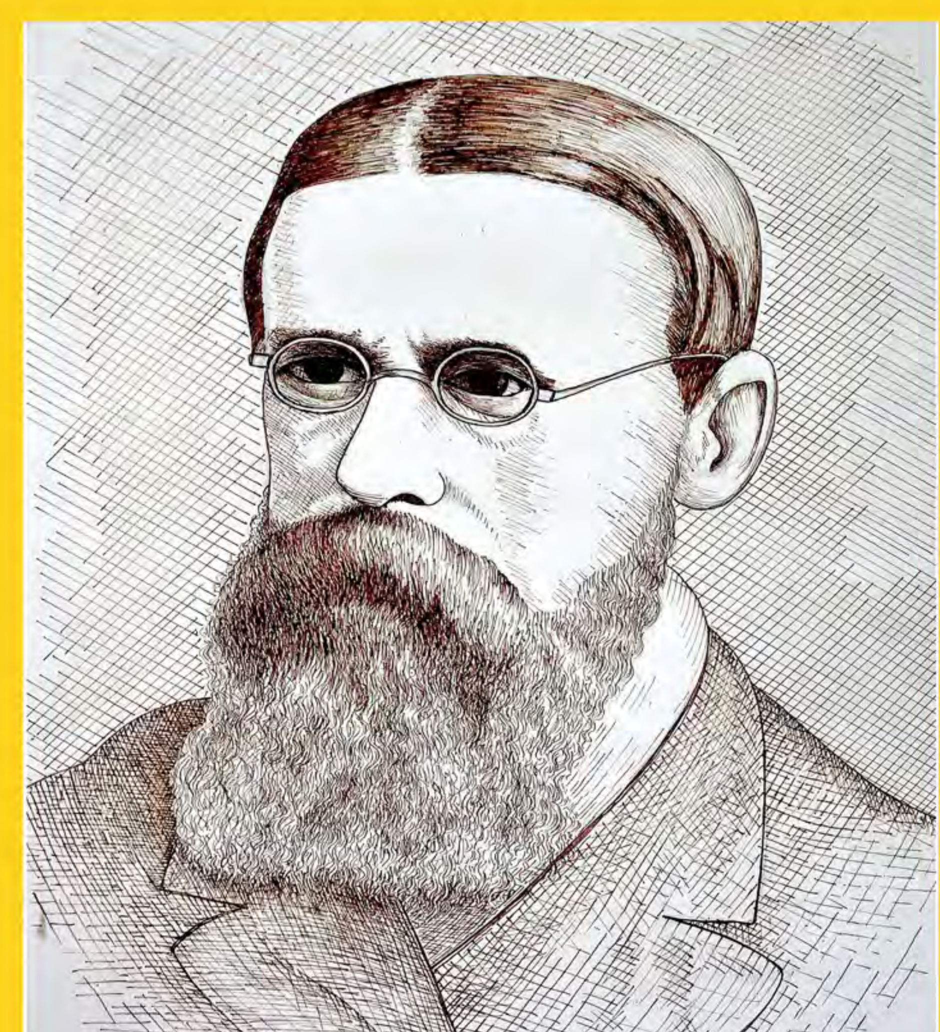
ISPQS Monograph No. 6

Recent Advances in Acheulian Culture Studies in India



Editors

K. Paddayya

Sushama G. Deo

Indian Society for Prehistoric and Quaternary Studies

Recent Advances in Acheulian Culture Studies in India

To celebrate discovery of first Palaeolithic
site at Pallavaram by Robert Bruce Foote on
30th May 1863

Editors

K. Paddayya
Sushama G. Deo

ISPQS

Indian Society for Prehistoric and Quaternary Studies
Pune, India

ISPQS Monograph No. 6

Title
Recent Advances in Acheulian Culture Studies in India

Editors
K. Paddayya and Sushama G. Deo

Publisher

Indian Society for Prehistoric and Quaternary Studies
C/o Department of Archaeology
Deccan College, Pune 411006

Year of Publication
2014

Layout and Typesetting

Aditi Typesetters
10 Sangam Apartments,
Vadagaon (Bk), Pune 411041

ISBN
978-81-938330-5-9

Cover

Sketch of Robert Bruce Foote by Mr. K.V. Ramana Rao (Courtesy: Archaeological Survey of India)

Not for Sale.
Available to Life members as e-issue from the official website
www.manandenvironment.org

Contents

Foreword

The Indian Society for Prehistoric and Quaternary Studies (ISPQS) since its establishment is engaged in promoting and organising interdisciplinary studies related to Prehistory and Quaternary Sciences. It provides a common platform for archaeologists, geomorphologists, geologists, environmentalists, anthropologists and other scientists. One of the main objectives of the Society is to encourage and organize research related to Prehistoric and Quaternary studies. Keeping this objective in mind it was felt that it is appropriate for the Society to celebrate Robert Bruce Foote's pioneering discovery of a Palaeolithic implement at Pallavaram near Chennai on 30 May 1863.

The idea of bringing out a special volume of Society's journal *Man and Environment* or a monograph dedicated to recent advances in Acheulian studies in India to mark the historic event was initiated by the Vice-Chairperson Shri S.B. Ota, and was unanimously approved by the General Body of the Society at Vadodara. Accordingly about twenty senior scholars specializing in Stone Age studies were approached to contribute research papers to this special volume. While many had appreciated the move and initially agreed to contribute, only a limited number of scholars were actually able to honour the extended deadline and send their papers. I thank all those who have contributed to this monograph.

I thank Professors K. Paddayya and Sushama G. Deo for accepting our request to edit this monograph. The monograph took a definite shape because of the constant encouragement given by Professor V.N. Misra. Further, in spite of his ill-health, he has contributed a paper to this monograph. I thank Professor Shanti Pappu for helping at various stages.

I am glad to present this monograph to all those who are interested in prehistoric past. It is freely available to anyone in e-format. I hope that this monograph will augment prehistoric research in general and Acheulian studies in particular in the Indian sub-continent.

May 2014

P.P. Joglekar
General Secretary

Editorial

Only a small gap of a year and half intervened between Alexander Cunningham's commencement of his celebrated two-decade-long surveys of historical sites of Upper India and another but unfortunately less well remembered development that took place in Indian archaeology. This other happening came up in Lower or Peninsular India and it concerns the long prelude to history, as represented by the geologist Robert Bruce Foote's recovery of a Palaeolithic implement at Pallavaram near Chennai on 30 May 1863. As with Cunningham in the case of historical archaeology, by virtue of his three-decade-long discoveries of Palaeolithic and Neolithic sites numbering over 450 and preparation of elaborate writings on these Foote laid sure foundations of Indian prehistory. It is still however a mystery why Cunningham and Foote observed 'golden silence' about each other's foundational contributions.

Foote's prolonged field discoveries and elaborate writings have three-fold significance from a historiographical point of view. First, his work has added a new and firm chapter dealing with the preliterate phase to the story of country's past. Secondly, simple and time-consuming though the intercontinental communication systems were a century and half ago, these findings in India were inspired by and came up close on the heels of the birth of prehistory itself, as represented by Joseph Prestwich's ratification before the Royal Society in London on 26 May 1859 of the findings of stone implements in association with fossil fauna in the drift gravels of France and England. No less amazing is the fact that the Palaeolithic findings from India, thanks to Foote's enthusiastic personal presentations in Europe on more than one occasion, soon made their mark in the European scientific circles – and this at a time when the now much cited East Africa and the Levant were totally unheard of.

In 2013-14 we are happily celebrating this event marking the completion of 150 years of Indian prehistory. Sharma Centre for Heritage Education, Chennai held a workshop on prehistory and lithic technology (30th May- 3rd June) and introduced R.B. Foote memorial lecture series. An exhibition-cum-display of Foote's collection was held jointly by Sharma Centre for Heritage Education and Government Museum, Chennai. On 30th May 2013 a one-day seminar was organized by Deccan College, Pune. The Indian Museum in Kolkata, in collaboration with the British Council, held a seminar on 'Footsteps of Foote' and a workshop on stone tool making from 11 to 13 September 2013. Indira Gandhi Rashtriya Manav Sangrahalay in Bhopal, in collaboration with Utkal and Sambalpur universities, held at Bhubaneswar on 8-9 November a national level seminar on the topic 'Acheulian Culture in India: Issues, Trends and Issues.' Then on 29 December Indira Gandhi Rashtriya Manav Sangrahalay sponsored a special lecture at Bhopal entitled 'Prelude to History: The Romance of the Discovery of India's Prehistoric Past' by K. Paddayya, together with a lithic workshop and an exhibition set up by Sharma Centre for Heritage Education, Chennai, to mark the 101st death anniversary of Bruce Foote. The Asiatic Society in Kolkata held an International seminar on 'A hundred and fifty years of Pre-historic Archaeological Studies in India: Homage to Robert Bruce Foote' on 31 March and 1 April 2014.

It is a matter of gratification for all workers engaged in Stone Age studies that the Indian Society for Prehistoric and Quaternary Studies (ISPQS), being the only set-up in South Asia earmarked for promoting Stone Age and Quaternary research, has thought of bringing out as part of these celebrations a special monograph exclusively devoted to Acheulian culture studies. From among the many invitations sent to scholars in India and outside, seven papers have been received and these form the contents of this issue. While three of these are in the nature of review essays, the remaining four papers deal with site- or region-based investigations.

In their joint paper dealing with the major Acheulian sites of the Deccan such as Bori, Morgaon, Chirki-Nevasa, Yedurwadi, Anagwadi and Isampur, Deo and Rajaguru adopt a landscape approach and critically examine the geomorphic and sedimentary contexts of these ancient sites. They highlight the fact that these sites occur on the erosional landscape carved out due to monsoonal activity and Neotectonics. Using this landscape-related data together with available absolute dates, they further infer that wet climate prevailed in the region in Early Pleistocene; it became semi-arid during Middle Pleistocene and, finally, distinctly arid in Late Pleistocene.

It has long been customary among prehistorians in India to divide the Acheulian culture into an early phase and a late phase but this division has been put forward on intuitive considerations of refinements in the techniques of manufacture and forms of bifacial implements. It is this inference which is supported on objective grounds by Ceri and his co-workers in their joint paper. For this purpose they have used bifacial implements forming part of early Acheulian assemblages from Isampur, Morgaon, Chirki-Nevasa and Singi Talav as one set and those from late Acheulian sites at Teggihalli II, Mudnur X, Bhimbetka III F-23 and Patpara as another set. On the basis of detailed metrical data and use of statistical techniques for recognizing patterns, they arrive at the principal conclusion that bifaces of the later phase are predominantly made on flakes and "tend to be smaller, relatively thinner and shorter, and have higher flake-scar densities".

Another long-held notion in the Indian Palaeolithic studies concerns the existence of two distinct cultural traditions – the pebble-tool based Soanian tradition of the northwestern zone and the handaxe-cleaver tradition of peninsular India. It was even suggested that the Soanians were simple food-gatherers, while the makers of handaxe-cleaver assemblages were war-like groups. Time is ripe for discarding these facile notions. In their paper Gaillard and Singh point out that as many as 20 Acheulian sites occur in the western sector of the Siwalik Hills bordering upon the Himalayan Range. These sites are located in the area between the Beas and Ghaggar rivers. Atbarapur in Hoshiarpur district of Punjab is a major site. These sites occur in the context of small streams and gullies cut into Pinjor beds forming part of the Upper Siwaliks and, on the basis of their stratigraphical contexts, are dated between 1 Ma and 0.6 Ma. The evidence from Atbarapur clearly shows that, like peninsular Indian sites, these assemblages are characterized by true bifacial implements made on flake blanks.

In his paper V.N. Misra, who inherited the mantle of doyen of Indian prehistory from H.D. Sankalia, gives a resume of his prolonged studies of Stone Age sites in the central and western parts of the country. In particular he provides a lucid account of the palaeoenvironmental and sedimentary contexts of the Acheulian localities at Singi Talav in western Rajasthan and Bhimbetka (rock-shelter III F-23) in Central India and of the techno-typological features of the excavated lithic assemblages from these two localities.

Some forty years ago the American archaeologist Jerome Jacobson alerted prehistorians in India that Palaeolithic research was much more than collecting selected stone tools from cliff-sections found along major rivers. He reported a large group of open air Acheulian sites in the sandstone hill-girt valleys in the Raisen district of Madhya Pradesh, some 30 km away from the Narmada river. Due to practical problems Jacobson could not pursue his research on these sites but he at least succeeded in highlighting the significance of these primary sites for hominin behavioural reconstruction. It is a happy development that fresh field investigations of these sites have now been initiated. Ota and Deo present in their paper preliminary results of their ongoing surface studies and small-scale excavations at two of the Acheulian localities near Tikoda village. Thanks to this work it has been possible to ascertain the sedimentary contexts of cultural levels and also highlight their importance for understanding techno-typological aspects of the lithic assemblages.

Acheulian sites are known from Orissa since the last quarter of the nineteenth century. In fact the first Acheulian site excavated in India comes from this area, viz. Kuliana in the former Mayurbhanj State excavated between 1939 and 1942 by N.K. Bose and Dharani Sen. In his paper Padhan first takes a review of the Acheulian culture studies done so far in the state and then gives results of his own study of the Acheulian sites found in the Jonk valley forming part of the upper Mahanadi basin.

In the concluding paper Paddayya seeks to place Foote’s work in the context of momentous developments taking place in the earth, biological and anthropological sciences in nineteenth-century Europe. He then reviews the results of his prolonged studies of the Acheulian sites of the Hunsgi and Baichbal valleys in Karnataka. He also draws attention to some of the major issues concerning the Acheulian culture that still await systematic investigation, particularly the need for understanding regional level organizational variability.

We would rather like to close this editorial on an interrogative note: Have we done enough to cherish Foote’s memory and his exemplary contributions, beyond calling him the Father of Indian Prehistory? Probably not. His name has no place in *The Dictionary of National Biography* published by Oxford University Press in the last century nor does it find a mention in its revised, 50-volume edition issued in 2004. Much less, no Knighthood was conferred on him. We have done no better in India, where he worked tirelessly in remote parts for decades together, chose to settle down in Madras after retirement, and breathed his last in Calcutta. Except a small prize being awarded to M.A. students at the Deccan College in Pune, there is nothing that keeps his memory alive. Instituting in his name a professorship or an annual memorial lecture or, even better, both in gratitude are worth contemplating.

K. Paddayya
Sushama G. Deo

List of Contributors

Sushama G. Deo
Department of Archaeology
Deccan College, Pune 411 006

C. Gaillard
CNRS, Departement de
Prehistoire du Museum national
d'histoire naturelle,
1 rue rene Panhard, 75013 Paris,
France

M.C. Gupta
Department of Ancient History,
Culture and Archaeology,
University of Allahabad,
Allahabad 211002

Y. Hou
Institute of Vetebrate
Paleontology and
Paleoanthropology,
Chinese Academy of Sciences,
142 Xizhimenwai Street, Beijing
100044, P.R. China

Sheila Mishra
Department of Archaeology
Deccan College, Pune 411 006

V.N. Misra
G-2, B Wing, Ganga Park
Mundhawa Road, Pune 411 036

S.B. Ota
Regional Director
Archaeological Survey of India,
Bhopal

K. Paddayya
Department of Archaeology
Deccan College, Pune 411 006

Tosabanta Padhan
Department of Archaeology
Deccan College, Pune 411 006

J.N. Pal
Department of Ancient History,
Culture and Archaeology,
University of Allahabad,
Allahabad 211002

S.N. Rajaguru
Department of Archaeology
Deccan College, Pune 411 006

N. Roseboom
Centre National de la Recherche
CNRS, Departement de
Prehistoire du Museum national
d'histoire naturelle,
1 rue rene Panhard, 75013 Paris,
France

Ceri Shipton
School of Social Science,
University of Queensland
Brisbane, QLD 4072, Australia

Mukesh Singh
Society for Archaeological and
Anthropological Research,
H. n° 1447, 160022
Chandigarh

S.G. Deo and S.N. Rajaguru, in *Recent Advances in Acheulian Culture Studies in India*
(K.Paddayya and S.G. Deo Eds.), pp. 1-22 [2014]

Early Pleistocene Environment of Acheulian Sites in the Deccan Upland: A Geomorphic Approach

Sushama G. Deo and S.N. Rajaguru
Department of Archaeology
Deccan College, Pune 411 006
E-mail: sushamadeo@yahoo.co.in

Abstract

Early Acheulian sites in the Deccan Upland occur in surficial deposits of colluvio-alluvial origin resting unconformably on denudation surface developed over rocks of Pre-Cambrian, Cambrian and Cretaceous-Eocene age. This surface has developed in response to Neogene tectonics and humid monsoon climate. Multidisciplinary studies of excavated sites like Nevasa and Chirki in the Pravara valley, Morgaon in the Karha valley, Anagwadi in the Ghataprabha valley and Isampur in the Hunsgi valley revealed interesting geomorphic features like laterite, calcrete, gruss and erosional/aggradational modes of allochthonous and autochthonous streams. From the studies of these features in the context of Acheulian sites it appears that the Early Pleistocene was wetter than the Middle Pleistocene. The Late Pleistocene was distinctly drier than the Middle Pleistocene. The Pleistocene climatic scenario of the Deccan Upland is in tune with changes in monsoon climate of the Indian subcontinent. Geomorphic and palaeoclimatic studies have helped us to date the Early Acheulian sites of Morgaon and Anagwadi to the Early Pleistocene.

Introduction

Recent advances in geochronology and earth science technology have shown that the Acheulian phase flourished in the subcontinent between 1.5 Ma and 0.15 Ma in different geomorphic and climatic settings (Paddayya *et al*. 2002; Deo *et al*. 2007a; Mishra *et al*. 1995, 2010; Pappu *et al*. 2011; Haslam *et al.* 2011). While discussing these sites it can be mentioned that the precipitation received from the southwest monsoon formed the dominant environmental parameter. It is equally clear that 20 Ma ago, the sub-continent enjoyed humid climate which turned cool and humid around 5 Ma ago and it became predominantly semi-arid in major part of India throughout the Quaternary. Tectonically, Peninsular India remained relatively stable during the Pleistocene. Naturally, landscape development was mainly due to the moderate climatic changes, in terms of weak and strong summer monsoons. Broadly speaking, Early Pleistocene (2.5 Ma to 0.8 Ma) was relatively wet, semi-arid; Middle Pleistocene (0.79 to 0.13 Ma) was semi-arid and Late Pleistocene (0.13 Ma to 0.01 Ma) was dry semi-arid. In response to these climatic changes one observes complex palaeosols like laterite/oxisol, calcrete/calcisols, black soils/vertisols either in a primary or secondary context in different parts of the sub-continent. Sediments derived from this soil-regolith are deposited in various river valleys and have preserved Acheulian artefacts in alluvial and colluvial deposits. Comparatively aeolian processes were insignificant during the early and major part of Middle Pleistocene. Aeolian processes become significant during the late Pleistocene, particularly in northwest and western India.

Absolute dating of the Early Acheulian site of Attirampakkam in northern Tamil Nadu to around 1.5 Ma has opened a new page in prehistoric research of the Indian subcontinent. This has changed the view about the origin of Acheulian culture in South Asia. A few other Acheulian sites like Isampur, Morgaon, Bori and Chirki-Nevasa in the Deccan Upland have strong potential for their inclusion in the early Pleistocene (>0.79 Ma) period. Initial attempts for dating these sites by methods like ESR, ^{39}Ar- ^{40}Ar, Th-Ur series and palaeomagnetism are encouraging, yet these need to be confirmed by further high resolution dating of sites. In the last five years we have made efforts to develop geomorphological, palaeopedological and archaeological methods to establish relative chronology of Early Acheulian sites in the Deccan Upland. Acheulian assemblages are found in abundance throughout the Deccan Upland in varying geomorphic contexts such as plough zone regolith consisting of soil-sediments, weathered bedrock and sheet wash gravel and sand, and colluvium deposited in foot slopes of hills.

Early Pleistocene in India: An Overview

The Quaternary sedimentation started in India after the closure of Tethys Sea and partial uplift of the Siwalik foreland in front of rising Himalayas and the Tibetan plateau (Waldiya 2010). Singhvi *et al*. (2012: 153) stated that "The Mio-Pliocene deposits are of marine origin and represent the continued regression of Eocene-Oligocene transgression". During the Quaternary there has been no major marine transgression in coastal region of India. Actually the main trend is regression of the sea during the Quaternary, excepting marginal transgression during the Last Interglacial (~130-125 Kyr B.P.) and the Mid Holocene (~5-4 Kyr B.P.) (Mehr 1992; Nigam and Hashimi 2002; Singhvi and Kale 2009; Deo *et al*. 2011). The regressive phase of the Last Glacial Maximum is well-recorded all along the coastline of India. On the other hand, there are a few local structural basins like the Kashmir Valley in the Himalayas, Siwalik foreland basins in the sub-Himalyas and the Central Narmada basin in Peninsular India where lacustral and fluvial deposits of the Early Pleistocene are well-documented. These deposits are briefly described below for elucidating environmental condition during the Early Pleistocene. Description of thin (less than 10 m) surficial deposits associated with Early Acheulian artefacts preserved in erosional depressions developed in rocky pediments in the Deccan Upland, are included. We have discussed the climatic and related geomorphic features of a few Acheulian sites in Peninsular India in general and in the Deccan Upland in particular.

Karewa Lake in Kashmir

One of the longest records of Quaternary environmental change is well-preserved in the fluvio-lacustrine sediment in the Karewa Lake in Kashmir. Karewa Lake was formed during the uplift of the Pir-Panjal range some 4 Ma ago. With continued uplift of the Pir Panjal during the Quaternary this lake shifted toward northeast and ultimately gave rise to the River Jhelum around 1.9 Ma ago. The total thickness of the lake sediment is about 1000 m and it has been dated by palaeomagnetic methods. A few fission track dates for volcanic ash in the area are also available. These dates range from more than 4.3 Ma to 0.5 Ma. (Basavaiah *et al*. 2010). This study shows that the valley was under the influence of a fluvio-lacustrine environment between 4.1 and 0.7 Ma, i.e. during the Plio-Pleistocene time. Sediment accumulation rate in this area was extremely slow varying from 4.6 cm per 1000 years to 23 cm per 1000 years during this period. This change in rate of sedimentation in lake is attributed to intricate interplay between climate and tectonics. On the whole the climate in the Kashmir Valley during the Plio-Pleistocene was cool and humid, and it changed to cold and dry in the Middle and Late Pleistocene. Climatically the valley was under the influence of southwestern monsoon till 1.95 Ma. After this, owing to strong uplift of the Pir Panjal range the southwestern monsoon could not enter the valley and the climate of the valley during the Pleistocene was controlled by westerlies originating in West Asia.

Siwalik-Himalyan Foothills

Like Karewa Lake sediments, the Siwalik sediments are also fluvial in origin. These are one of the most important instances of continental sequence preserved in Himalyan foreland basin. These sediments are about 5000 m thick and formed due to tectonic movements during the rise of the Himalayas in the north. Climatic reconstruction of Siwalik succession has recently been attempted (Sanyal and Sinha 2010) by investigating stable isotope composition of calcrete nodules of pedogenic origin commonly found in alluvial sediments of the Neogene age (approximately 15 Ma to 3 Ma). This study suggested that the climate during the Neogene was sub-humid to semi-arid. The climate turned cool and dry in the Pleistocene. Similarly, Patnaik and Nanda (2010) have argued that the beginning of the Pleistocene (1.8 Ma) saw an upsurge in tectonic activity all along the Himalayan foothills and this led to a change in depositional environment, slope and overall landscape.

Thar Desert

Multi-disciplinary studies carried out in the Thar Desert have shown that laterite formed during the Neogene and calcretes started forming almost all over the desert since the beginning of the Pleistocene. This drastic change in the soil formation processes reflects vagaries of southwest monsoon during the Neogene period. Further semi-arid climate continued in the Early and Middle Pleistocene as indicated by well-developed calcretised alluvial deposits over a large area of desert. The semi-arid climate changed to arid climate around 200,000 years as a result of weakening of the southwestern monsoon. After that the climate fluctuated from arid to semi-arid in the last 200,000 years. The climatic interpretation is based on geomorphological studies of palaeo-drainage and dune systems, detailed petrographic and stable isotopic studies of calcrete (Dhir *et al*. 2004; Dhir and Singhvi 2012).

Central Narmada Valley

Quaternary sediments are fairly thick and exposed to a depth of 20-30 m on the banks of the Narmada River and its tributaries. Tiwari and Bhai (1997) after mapping these sediments proposed the existence of Early Pleistocene fluvial sediments near Hoshangabad on the basis of palaeomagnetic studies. They have labelled two formations as Pilikarar Formation and Dhansi Formation, which have a reverse polarity (>0.78 Ma). The climate during the Early Pleistocene was wetter than during the Middle and Late Pleistocene in the Narmada Valley (Tiwari and Bhai 1997; Rao *et al*. 1997).

Hunsgi and Baichbal Valleys

A shallow basin carved in denudational surface occurring at 500-550 m AMSL during the Tertiary has preserved one of the richest Early Acheulian records in India (Paddayya 1982, 1993). In the light of a few Th-Ur and ESR dates, the regolith of gruss (weathered granite), travertine and spring tuffa provide an opportunity to reconstruct palaeoenvironment of Early to Middle Pleistocene period (Paddayya *et al*. 2002). The gruss formation is a relict weathering feature of a wet environment (Thomas 1994), and therefore, totally absent in the present semi-arid climate of the basin. Similarly, travertine also appears to have formed when spring discharge was significantly higher than the present one. Additionally absence of calcrete clasts in gruss and in the matrix of sites in Hunsgi and Isampur in a region of limestone, which would have easily promoted development of pedogentic calcrete in the region, suggests that Early-Middle Pleistocene was relatively wet than the present semi-arid dry climate.

Attirampakkam

The Early Acheulian site of Attrirampakkam dated to 1.5 Ma by palaeomagnetic and cosmogenic nuclide burial methods, is associated with low-energy meandering river system draining the pediment developed over shale, conglomerate and sandstone of the Cretaceous age. At present the site is 30 to 35 m AMSL and 40 km inside the Bay of Bengal coastline. The total thickness of the deposit is about 9 m out of which upper 0 to 3 m below the surface have preserved evidence of the Late Acheulian and Middle Palaeolithic cultures. The underlying layers (6 m thick) are primarily clayey with lenses of sand and gravel which have preserved one of the best evidence of Early Acheulian occupation (Pappu *et al.* 2011). Mineral magnetic and clay mineralogical studies suggest wet climate during the Early Pleistocene (Warrier *et al*. 2011).

Against this background knowledge of Quaternary environment, the following Acheulian sites in the Deccan Upland are briefly discussed in the context of local geomorphological features.

The Deccan Upland

Recently Korisettar (2012: 29) aptly described the landscape of Indian peninsula in these words: “The Precambrian tectonic framework and the geomorphic processes operating since the post-Cretaceous times in these basins have facilitated the formation of landforms carved by denudational processes resulting in a network of erosional surfaces dotted with perennial pools and ponds facilitated high water table conditions. The dominantly erosional landforms have constrained the occurrence of depositional features to narrow belts in the valley floors within the sub basins. Though the overall landscape appears senile the Quaternary landform units are recognized by the association of Palaeolithic settlements, fauna and volcanic tuff”.

The Deccan Upland (15° to 20° N; 74° to 76° E) covers south central Maharashtra and northwestern Karnataka (Fig. 1). Its landscape is dominantly erosional. The rolling Upland Plateau has developed over an ancient and relatively stable Precambrian and Cambrian metamorphic rocks like gneiss, schist, quartzite and Deccan Trap basalts of the Cretaceous-Eocene age. The southern part of the area is the tri-junction of Archaeans, Kaladgis and Deccan Trap rocks. Climatically, the region is labelled as semi-arid, with the annual rainfall varying from 1000 mm to 400 mm and is largely covered by dry deciduous to thorn and scrub forests (Rajaguru 2000). Though the major part of the area is semi-arid, there are some pockets particularly in the southern part of the study area having sub-humid to humid climate with an average rainfall of more than 3000 mm.

The landscape of the Deccan Upland is characterized by pediments with inselbergs, tors, and broad box-shaped valleys drained by autochthonous and allochthonous channels with highly seasonal discharge. Geomorphologically, the bedrock channels are ungraded as marked by presence of the prominent knick points almost up to their confluence with trunk streams. Significant erosional features of the Upland rivers are in the form of waterfalls, incised meanders and deep coalesced potholes. The foot slopes of the pediment scarps and the banks of bedrock streams are covered with regolith consisting of laterites, vertisols and colluvio-alluvial deposits. The exposed thickness of colluvio-alluvial deposits rarely exceeds 20 m on both banks of streams and their lateral extent is 1.5 to 2 km (Mishra and Rajaguru 2000). Most of the present channels are incised into older alluvium.

Geomorphic Features

The palaeoenvironment of a region is generally reconstructed on the basis of mineral characters of sediments and associated landforms, animal and plant fossils preserved in sediments, and microfossils like pollen, diatoms, microorganisms, etc. These studies are being supplemented by stable isotopic and mineral magnetic analyses of sediments. In addition, absolute chronology of sediment succession provides a firm basis for palaeoenvironmental reconstruction. In the present study, however, we have used traditional methods of field studies of geomorphic features such as laterite, calcrete and fluvial deposits to reconstruct palaeoenvironment of the study area.

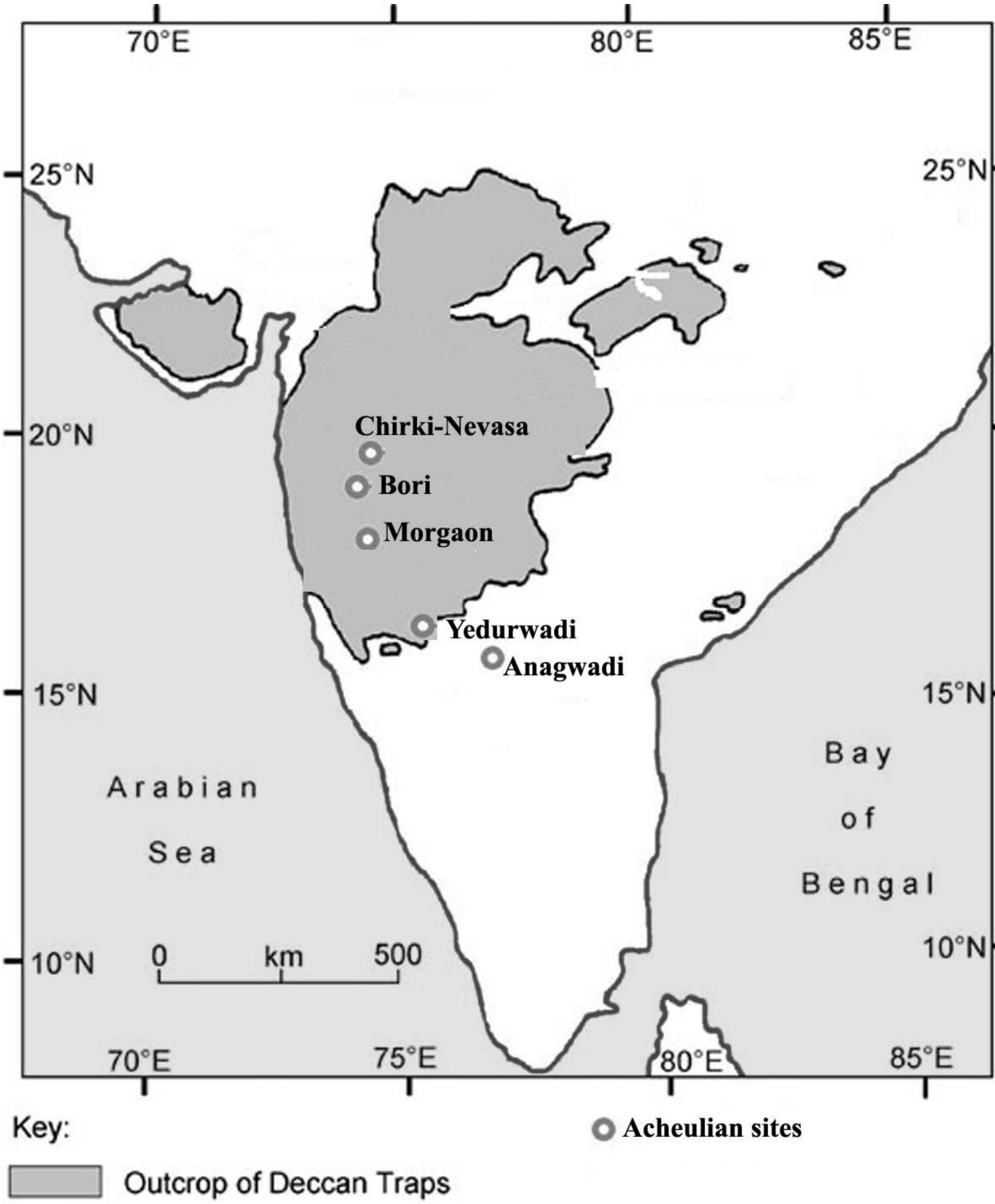


Fig. 1: Location map showing Acheulian sites in the study area

Laterite

Laterite is a brick-like hardened ferruginous soil-sediment formed during the major part of the Tertiary period in the Deccan Upland. It occurs as well-developed mesa or tableland on denudational surfaces at elevations ranging from 1500 to 1000 m AMSL in the source region of the Krishna (Fig. 2) and its tributaries like the Ghataprabha and the

Hiranyakeshi (Pappu and Rajaguru 1979, Sahasrabudhe and Rajaguru 1990, Olier and Sheth 2008). On the other hand laterites occur as thin isolated patches on lower denudational surfaces ranging in elevations from 600 to 700 m AMSL in the middle reaches of the Krishna and its tributaries. Surprisingly, there are no well-developed laterites in the Bhima and the Godavari basins. Without going into the complex genetic problem of laterite formation we believe that this formation developed in Early Tertiary (Schmid 1993) under humid tropical climate with annual rainfall of more than 1200 mm. This well-developed Tertiary regolith got eroded and re-deposited in the Pleistocene fluvial system of the Deccan Upland (Widdoson and Cox 1996).

Calcrete

It is a terrestrial material mainly composed of $CaCo_3$ and occurs in various forms--powder, pellets, nodules, hardpan, brecciated, laminated and mottled. These calcretes are both of ground water and pedogenic origin. Rhizoliths are common in upper root zones of soil sediments while hardpan bedded variety is found in fluctuating groundwater zones. These calcretes have been found to develop over varieties of rocks and soil-sediments. It is not possible to review techniques used for understanding calcretes. Some of the important methods are petrography, geochemistry and stable isotopes ($^{18}O/^{16}O$; $^{13}C/^{12}C$). Calcretes have been dated by ^{14}C, Th-Ur series and Electron Spin Resonance (ESR) methods in the last 20 years (Dhir *et al*. 2004). These have enhanced our understanding of calcretes. It has been observed that the process of calcretisation started during the Late Miocene and continued throughout the Pleistocene, particularly in the present semi-arid and arid parts of western India and the Deccan Upland. Calcretes associated with the Late Miocene sediments indicate beginning of monsoonal climate in the subcontinent (Kailath *et al*. 2000; Dhir *et al*. 2004; Achyuthan *et al*. 2007). Occurrence of calcretes, particularly of the pedogenic type, within the sediments of Pleistocene age in the present semi-arid/ arid parts, indicate that the climatic changes in this region were of degree only and not of a kind. This further indicates that the rainfall was generally ranging from 200 to 800 mm per annum; evapotranspiration was always higher than annual precipitation. In general formation of calcrete in arid or hyper-arid regions with a rainfall less than 100 mm indicates wet climate. On the other hand, it indicates dry climate in humid zone with rainfall more than 1200 mm (Thomas 1994).

Some of the well-developed hardpan type calcretes below the Acheulian artefact-bearing sediments have been observed in Hunsgi and Baichabal valleys and the Malaprabha basin. On the other hand calcretised cemented gravels (Fig. 3) are common in the Bhima, Godavari and Krishina basins. Pedogenic, powdery, pellet and concretionary types are common in the alluvial deposits of Middle and Late Pleistocene period found in the study area. Holocene alluvial deposits are generally devoid of calcretes.

Fluvial Deposits

<u>High Level Gravel (HLG)</u>

One of the important fluvial deposits is the high level gravel which was investigated for understanding the stratigraphic relationship of the Lower and Middle Palaeolithic artefacts found on the surface in the Deccan Upland (Paddayya 1971; Pappu and Rao 1983; Joshi *et al*. 1980; Korisettar 1979; Ganjoo and Achuthan 1995; Rao 1992; Mishra 1995; Korisettar and Rajaguru 1998). These high level gravels occur in the middle reaches of the Godavari and Krishna and their tributaries at elevations ranging from 20 m to 2 m above the present channel level. These gravel spreads lying in the primary context are older than the Early Middle Pleistocene and probably of the Neogene age and have been deposited during wetter climate than the present one. Their formation is also related to the Neogene tectonics.

In general HLG have not yielded any artefacts excepting in the Middle Krishna where Pappu and Rao (1983) reported Middle Palaeolithic artefacts. This gravel appears to be older than Acheulian artifact-bearing gravel at Nevasa in Maharashtra and in the Hunsgi valley, Karnataka. Textural and sedimentological characteristics of these HLG indicate deep weathering of litho components like basalt, absence of calcrete clasts and presence of cobbles and pebbles of sub-rounded to rounded chert and chalcedony with distinct patina. In most of the cases these gravels rest on underlying weathered bedrock suggesting that both the gravel as well as the bedrock have weathered after the deposition of the gravels on the rocky pediment. Their occurrence in the present landscape is a geomorphic anomaly as it is difficult to find traces of the rivers which were responsible for their deposition. They are younger than the Tertiary laterite and older than the Early Acheulian-bearing fluvial deposits. Tentatively, therefore they can be related to Neogene period (Deo *et al.* 2007b). Similar type of anomalous gravel spreads have been observed on an extensive scale in the Thar desert and have been dated to the Neogene (Misra and Rajaguru 1989).

Table 1: Aggradation-Erosion phases of the Deccan Upland rivers

Fluvial processes	Probable climatic conditions	Probable Age
High-level gravel (HLG) braided drainage	wet climate	Neogene
Incision in bedrock	tectonics and wet climate	Neogene-Early Pleistocene transition
Moderate aggradational mode	wet semi-arid	Early Pleistocene
Moderate Erosional mode	wet semi-arid	Middle Pleistocene
Strong aggradation mode	dry semi-arid	Late Pleistocene
Erosional mode	wet semi-arid	Holocene

<u>Aggradation-Erosion Processes</u>

The Deccan Upland has two major drainage systems. The first is the allochthonous drainage of the rivers Godavari, Bhima and Krishna which have catchments in humid Sahyadri mountain range. The second system, comprising the drainage of the Karha, Sina, Manjra, Hunsgi and Baichbal valleys, is autochthonous having catchments in eastern semi-arid plateaux. Geomorphological, geoarchaeological and palaeoenvironmental investigations in the last 20 years have shown that the landscape is tectonically fairly stable during the Quaternary and also unaffected by glacio-eustacy during the Quaternary (Rajaguru and Kale 1985). The major environmental factor which has affected erosional and depositional processes is monsoon climate, with a short period (4 months) of intensive summer rainfall followed by a long dry period (8 months) with strong evapo-transpiration. The fluvial system is confined to hard rocky base, with moderate scope for vertical incision as well as lateral migration. Mishra *et al* (2003) have recently documented erosional and aggradational phases of various rivers in the Deccan Upland since the Neogene times and suggested that allochthonous streams were in erosional mode during relatively wet climate and in depositional mode during relatively dry climate. On the other hand autochthonous streams responded in opposite manner. Table 1 summarizes the aggradation-erosional processes of the Deccan Upland rivers based on studies carried out by Rajaguru and Badam (1984); Rajaguru and Kale (1985); Rajaguru *et al*. (1993); Rajaguru and Mishra (1996); Deo *et al*. (2007 b).

Local Geomorphic Features of Acheulian Sites

An attempt is made here to reconstruct environment of Acheulian sites in the context of local geomorphic features mentioned earlier viz. laterite, calcrete and fluvial deposits.

Anagwadi

The Acheulian site near Anagwadi was first reported by Sankalia (1955) and later described by Banerjee (1957). Pappu (1964) excavated the site located in a nala joining the River Ghataprabha, a major tributary of the River Krishna. Acheulian artefacts were found in two geomorphic contexts -- one in channel gravel and the other on pediment surface (Deo 1991). Climatically the area is in the semi-arid zone with average rainfall of 500-600 mm. The site is surrounded by small oval shaped hills of Kaladgi formations with gently sloping pediment surface. The denudational surface (640 m) has developed on gently dipping Kaladgi formation consisting of quartzite, sandstone and limestone with chert nodules (Table 2). This surface is dotted with a cluster of hillocks of quartzite at Kovalli and of laterite at Anagwadi (Fig. 4) which grade to valley pediments up to present channel level of the Ghataprabha at 510 m AMSL.

Table 2: Anagwadi, geomorphic and other related features

Bedrock	Laterite
Archaeology	Early Acheulian
Geomorphic context (Fig. 5)	a. Kaladgi hill slope covered with sub-angular blocks and chips of quartzite, limestone and chert b. cobbly-pebbly channel gravel located about 4 km south of the Kaladgi hillock with litho clasts of quartzite, chert and laterite. It is sub-rounded, ungraded, moderately sorted with matrix of silty sand and cemented by ferruginous material
Capped by	disconformably overlain by brownish sandy silt and clay silt with varying thickness from 1 m to 10 m
Calcrete	Absent
Chronology	undated

Morgaon

The Early Acheulian site of Morgaon is on the left bank of the Karha, a tributary of the Nira which joins the trunk stream of Bhima in district Pune. The Karha is an autochthonous river flowing on the deunadational surface ranging in elevation from 800 m to 600 m. The basin is covered with Cretaceous-Eocene Deccan Trap rock. This rocky basin is situated in a semi-arid region with annual rainfall of 500 mm. This site has been excavated for several seasons since 2001 by Sheila Mishra and Sushama Deo (Mishra *et al.* 2008). This is one of the few Acheulian sites associated with tephra deposit. Early Acheulian artefacts are found in an alluvial deposit thereby indicating the riverine nature of the site. The identification of local geomorphology around the Acheulian sites is based mainly on observations of excavation trenches along with gully sections, river section and well sections around the site (Table 3). There are four cycles of sedimentary deposits separated by erosional phases (Deo and Mishra 2013).

Table 3: Morgaon, geomorphic and other related features

Bedrock	Basalt
Archaeology	Early Acheulian
Geomorphic context	The oldest lithological unit is represented by varied depositional facies such as rubble, cobbly-pebbly gravel with laterite, compact pink/yellow silt, tephra, black fissured clay I and II, sandy-pebbly gravel lenses within black fissured clay, and the cross bedded reddish sandy-pebbly gravel. Except black fissured clay, tephra and compact pink/yellow silt, other sub-units have yielded Early Acheulian artefacts (Fig. 6).
Capped by	Basal gravel is capped by pedogenized brownish clay. Overall, Acheulian unit is capped disconformably by calcrete rich sandy-pebbly gravel with fragmentary pieces of ostrich egg-shell, microblades and a few calcified bones of Nilgai (*Boselaphus tragocamelus*) and equid (Sathe 2007). This unit belongs to Late Pleistocene age (26 ka and 22 ka B.P.).
Calcrete	Calcrete clasts are completely absent
Chronology	Palaeomagnetic study of clays associated with the tephra, demonstrates preservation of reversed magnetic field in clays, thereby indicating Matuyama geomagnetic period (Sangode *et al.* 2007). This implies a minimum age of 800 kyr for the tephra. It is supported by recent Ar-Ar dating attempt by Westway *et al.* (2011) indicating an apparent age of 809.3 ± 51.0 ka 1043 (±2σ), similar to the age of eruption D, equivalent to OTT.
Other important features	Tephra layer sandwiched between black fissured clay. Presence of laterite cobbles in lowermost cobbly-pebbly gravel

Bori

Bori is situated on the left bank of the River Kukdi, an easterly flowing tributary of the Ghod, originating in the Western Ghats (Table 4). The Acheulian site was discovered by Kale *et al*. (1986). Subsequently Korisettar *et al*. (1989) discovered tephra bed in the Quaternary alluvial section and dated it to 1.4 Ma by K-Ar method- the first earliest date for Indian Lower Palaeolithic culture (Korisettar *et al*. 1989).

Laxmi Nala, Nevasa (Table 5)

Acheulian artefacts from around Nevasa were first discovered and studied by Sankalia (1956, 1964) and later by Mishra (1995) at Laxmi Nala, a feeder stream of the Pravara which is itself a major tributary of the Godavari River. This allochthonous river originates at an elevation of 1650 m in the Sahyadri.

Table 4: Bori, geomorphic and other related features

Bedrock	Basalt
Archaeology	Early Acheulian
Geomorphic context	Compact brown silt with lenses of gravel and is seen to cut into a small remnant of the tephra and so postdates the tephra
Capped by	Clay with lense of tephra. Overall Acheulian gravel is capped disconformably by calcrete rich sandy-pebbly gravel and yellow silt
Calcrete	rich in calcrete clast and cement
Chronology	The tephra at Bori has been dated by three different methods. Ar-Ar dating by Mishra *et al*. (1995) assigned the age of 670 ± 3 Kyr BP Subsequently, Chen *et al*. (2003) carried out chemical and isotopic studies to compare with stratigraphy of tephra layers in ODP (758) core from the Indian Ocean. By determining the degree of weathering pattern of biotite mineral using electron microscope they argued that Bori tephra is similar to Older Toba Tephra (0.8 Ma). Sangode *et al.* (2007) carried out palaeomagnetic dating of the Bori tephra which is indicating a pre-Brunches age (>0.78 Ma). Recently, Westway *et al.* (2011) have demonstrated usefulness of Ar-Ar dating technique, coupled with detailed geochemical analysis of rhyolitic glass shards from Bori and Morgaon. Based on these studies, an age of 714.0 ± 62.4 Kyr (±2σ) has been assigned for Bori tephra. This age is similar to the age of Toba eruption D, equivalent of OTT.
Other important features	A tusk (1.2 m long); Bori is one of the first places where tephra was discovered in association with Acheulian artefacts in India

Fig. 2: Well-developed laterite tableland at Panchgani, Maharashtra

Chirki-on-Pravra (Table 6)
It is located on a low order feeder of the River Pravara, 6 km downstream of Nevasa locality (Fig. 7). Corvinus (1981, 1993) discovered and excavated the Chirki locality.

Table 5: Laxmi Nala, geomorphic and other related features

Bedrock	Basalt
Archaeology	Early Acheulian
Geomorphic context	Cross-bedded and well-cemented gravel resting on bedrock
Capped by	horizontally bedded gravel and it is overlain by black fissured clay
Calcrete	Rich in calcrete clasts and cement.
Chronology	The cross-bedded and well-cemented gravel at Laxmi Nala (Fig. 8) has been dated to > 350 Kyr B.P. by Thorium-Uranium series dating method (Atkinson *et al*. 1981). Palaeomagnetic dating of the black fissured clay, which caps the Acheulian bearing Lower Pravara beds, provided evidence for reverse magnetism (>0.78 Ma B.P.) of the Matuyama period (Sangode *et al*. 2007). Thus, Early Acheulian of Nevasa belongs to the Early Pleistocene age.
Other important features	Laterites are conspicuously absent. High level gravel occurs at 12 m above the modern channel. The lithology of this gravel is dominated by compact basalt, chert, and chalcedony. Basaltic pebbles are weathered and have developed weathering rind of 0.2 mm thickness (Mishra 1995). No Acheulian artefacts have been found in this gravel so far and it is possible that it may be pre-Acheulian in age and probably of Neogene period (Corvinus 1981, 1983).

Table 6: Chirki-on-Pravra, geomorphic and other related features

Bedrock	Fluvially eroded Basalt
Archaeology	Early Acheulian
Geomorphic context	Basalt rubble resting unconformably on eroded basalt bedrock
Capped by	Cross-bedded sandy-pebbbly gravel
Calcrete	Rich in calcrete clasts and cement
Chronology	undated
Other important features	The richest horizon of artefacts is at the contact between the bedrock and rubble horizon which is also rich in mud balls.

Yedurwadi (Table 7)
This site is located on the link channel of Krishna River exposed at Yedurwadi (Fig. 9), a place 30 km south of Miraj and about 4 km east of Miraj-Belgaum highway. It is 3 km from Yedur village in Chikodi Taluk, district Belgaum, Karnataka. It was discovered by Prof. S.R. Jog (University of Pune) and subsequently investigated by Kale *et al.* (1986 a, b). The site is located between Shirguppi and Yedur villages.

Table: 7 Yedurwadi, geomorphic and other related features

Bedrock	Basalt exposed at a depth of 6 m below the bed level and capped by yellowish brown kankary silt (8.5 m thick) rich in calcium carbonate concretions
Archaeology	Late Acheulian
Geomorphic context	The silt unit is disconformably capped by sandy pebbly gravel which is moderately cemented by calcium carbonate. The gravel is cross-bedded and moderately sorted in the lower part, but it is poorly sorted and mud supported in the upper half meter. This mud supported gravel has yielded a good number of Acheulian artefacts (Kale 1986 a; Joglekar *et al*. 2011)
Capped by	Yellowish silt rich in calcium carbonate
Calcrete	Rich in calcrete clasts
Chronology	Calcretised sandy gravel has been dated to > 350 Kyr by Th/Ur method (Atkinson *et al*. 1990; Rajaguru *et al*. 1993)
Other important features	The bedrock incision is probably of Early Pleistocene age. At the surface of this silty unit one observes large number of fossil tree trunks (Fig. 10) in growth position along with well developed rhizoconcretions. Presence of groove on the calcretised silty surface (Fig. 11). Presence of elephant and hippopotamus fossils.

Fig. 3: Calcretised cemented gravel on the Krishna river at Yedurwadi

Fig. 4: Laterite hill at Anagwadi

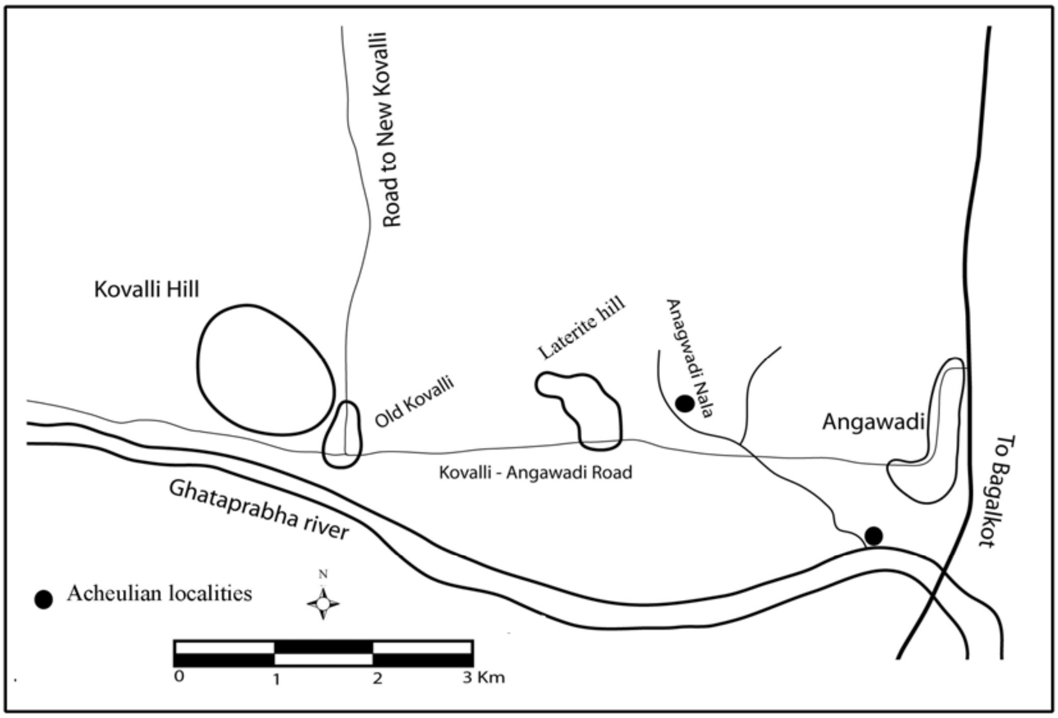


Fig. 5: Local geomorphic features around Anagwadi and location of Acheulian sites

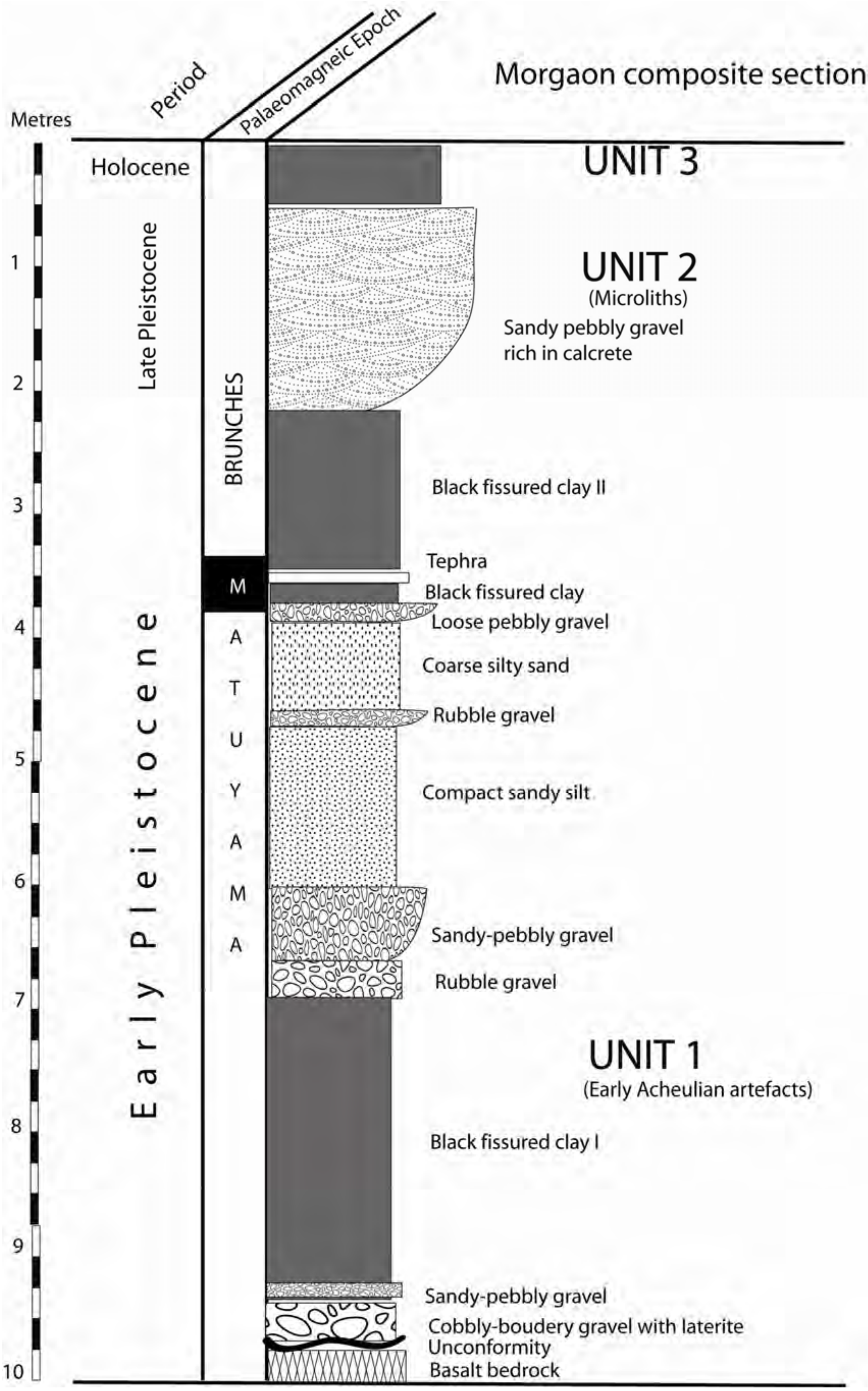


Fig. 6: Composite stratigraphy at Morgaon showing different geomorphic units

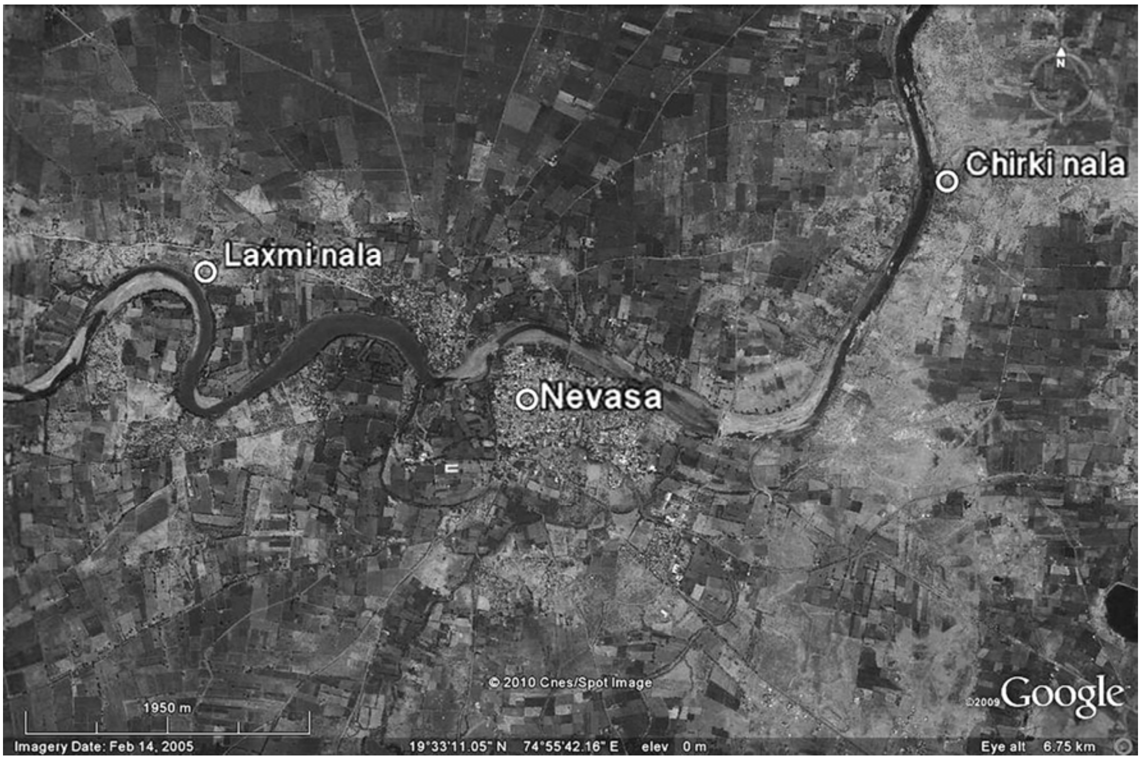


Fig. 7: Location of Laxmi Nala and Chirki sites on River Pravara

Fig. 8: Cross-bedded, well-cemented gravel at Laxmi Nala

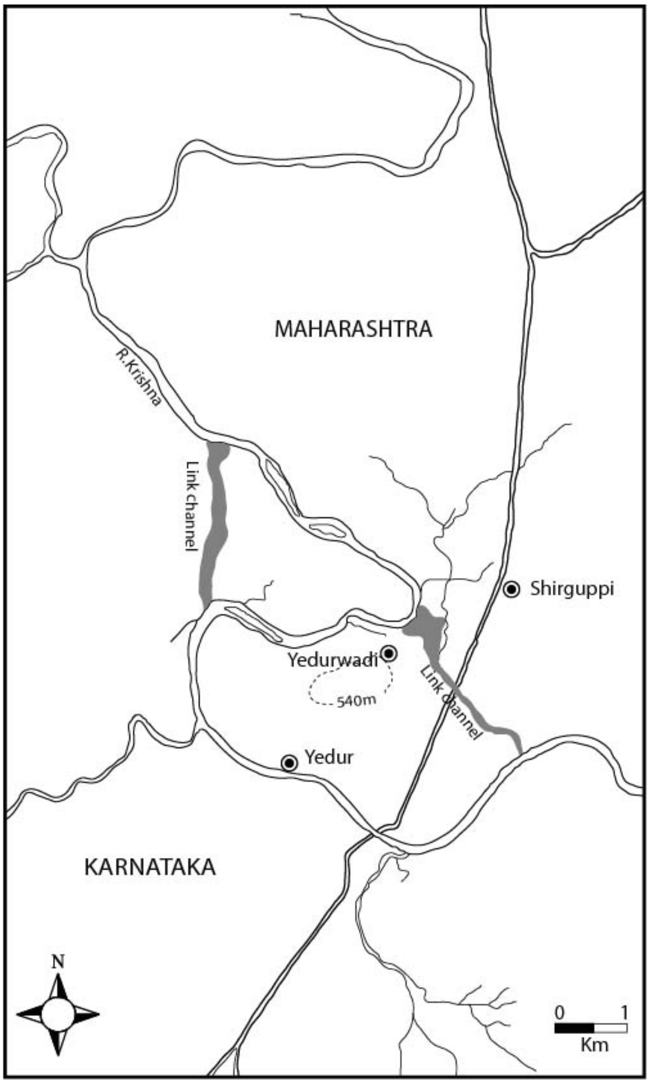


Fig. 9: Location of an Acheulian site on the link-channel of the river Krishna at Yedurwadi

Fig. 10: Yedurwadi, Fossilized tree trunks

Fig. 11: Grooves on the calcretised silt surface at Yedurwadi

Discussion

Based on geomorphological features discussed in the previous section, following inferences can be drawn on the probable climatic conditions and the landscape during the Early Pleistocene in the study area.

1. The absence of calcrete clasts and presence of detrital cobbles and pebbles of laterite in basal artefact-bearing gravel at Morgaon in the Karha valley and absence of calcrete clasts and presence of laterite clasts, ferruginous cement of artefact-bearing relict channel gravel of Anagwadi in the Ghataprabha valley suggest wet climate.
2. On the other hand the presence of calcareous cement as well as calcrete clasts in the gravels of Bori, Chirki-on-Pravara and Laxmi Nala near Nevasa indicate a semi-arid climate in the terminal part of the Early Pleistocene period (more than 0.8 Ma). Semi-aridity is also indicated by the presence of mud-balls in gravels at Laxmi Nala, Nevasa; and calcretised fossil wood pieces (around 100) in gravel at Chirki. A layer of tephra sandwiched between low energy clays deposited by a meandering Kukdi River with low discharge (Kale *et al.* 2004) strongly point towards semi-aridity.
3. The semi-arid climate continued even during the early part of Middle Pleistocene (>350 Kyr B.P.) and in later part also, as revealed by strongly calcretised overbank silts and clays and gravels deposited by the Krishna in its meander loop at Yedurwadi. Thus it is clear that the Early Pleistocene was wetter than the Middle and Late Pleistocene in the Indian sub-continent (Table 8). A more or less similar trend is observed in non-glaciated lower latitude regions.

Table 8: Probable climate during the Quaternary

Age	Climate	Sediments
Early Pleistocene	Relatively wet	Coarser gravel with laterite
Early Middle Pleistocene to end of Middle Pleistocene	Semi-arid with short spells of wet climate	Combination of fine and coarse sediments. Gravels with lenses of silt. This is the combination of channel and near channel flood plain deposit
Late Pleistocene aggradation	Distinctly arid with short spells of semi-arid climate	Fine to very fine predominantly silty deposit with high proportion of calcrete

Table 9: Summary of chronology and climate inferences

Site	Chronology	Climate
Morgaon	Early Acheulian (> 0.8 Ma)	wet climate
Anagwadi	Early Acheulian (undated)	wet climate
Bori	Early Acheulian (0.8 Ma)	dry climate
Laxmi nala, Nevasa	Early Acheulian (0.8 Ma)	dry climate
Chirki	Early Acheulian ((undated)	dry climate
Yedurwadi	Late Acheulian(< 0.8 Ma to ~350 Kyr)	dry climate

4. *Pre-Acheulian or Neogene Landscape*
   The landscape during the Neogene was dominated by a fairly deep regolith of laterite, weathered relict channel gravel and also underlying basaltic rocks, low-lying tors and well-developed hardpan or lithic calcrete of ground water origin. These geomorphic features indicate humid or wet monsoon climate in the region.
5. *Acheulian / Early Pleistocene Landscape*
   During the transition from the Neogene to Early Pleistocene there was a phase of moderate bedrock incision in most river valleys. This phase was followed by a moderate phase of aggradation during which channel gravel and pool clays were initially deposited along with Early Acheulian artefacts. These gravels have secondary laterite cobbles and pebbles (as at Morgaon) and ferruginous cement (as at Anagwadi). There is also development of gruss (weathered granite) matrix (as at Hunsgi). These geomorphic features and absence of calcrete clasts (as at Morgaon and Anagwadi) indicate a wet climate, probably semi-arid and drier than that of Neogene. On the other hand at Nevasa and Chirki, the presence of calcrete clasts, cement and mudballs but without the association of laterite clasts and ferruginous gravel indicate a semi-arid climate drier than what is shown in the early phase of gravel deposition at Morgaon and Anagwadi. At Morgaon, the later phase of the Acheulian is associated with an increased proportion of carbonate in gravel and development of calcrete rhizoliths. It appears that in the initial stage of Acheulian activity (~ 1 Ma B.P.), the climate was wet and it turned semi-arid around 0.8 Ma and later.

   The moderate aggradational phase of the Early Pleistocene was followed by strong incision of bedrock, reaching up to or even a couple of meters below the present bed level, during early Middle Pleistocene. The phase of incision was followed by moderate aggradation as represented by calcretised gravels and near-channel flood plain sand-silts and associated pool clays. This phase is represented at Yedurwadi. The climate was distinctly semi-arid as indicated by presence of carbonate clasts and absence of ferruginous cement.
6. *Post-Acheulian Landscape*
   The phase of moderate aggradation was followed by dominant aggradational phase of the Late Pleistocene. The climate during this phase was distinctly semi-arid to arid.

Conclusions

These observations demonstrate a trend of increasing aridity from the Neogene to Late Pleistocene in the Deccan Upland. We have not discussed sub-phases of variation in climate (wet phase in semi-arid/arid and dry phase in humid/wet climatic phases) in this paper. Our main purpose has been to show general trends in climate which help us in relative dating of Acheulian sites (Table 9).

The present hypothesis of “Early Pleistocene wet climate” in the context of Early Acheulian sites needs to be tested in other parts of India, where absolute dates are not yet available.

To conclude, we would like to quote John McNabb (2005: 301): “Although linking individual archaeological sites to specific points on the climatic seismograph is clearly impossible at the moment, advances in palaeoclimatology have begun to offer a more realistic picture of the nature and pace of long- and short-term climatic change. From an archaeological perspective it means that for the first time we suggest that individual hominins, as well as hominin groups could have been aware of major changes affecting their physical world. A goal of multidisciplinary Pleistocene studies must now surely be linking of physical and material culture-driven anthropology with climatic modelling and chronological studies. As such we approach the time when it will be possible to recognize the real factors that contributed to changes in material culture and the technology that underpinned it. On multi-period, deeply stratified sites, this would allow us to assess, for the first time, just how far external stimuli shaped hominin biotechnological evolution."

Acknowledgements

We express our sincere gratitude to Dr. R.S. Pappu, Prof. K. Paddayya, and Prof. Sheila Mishra of Deccan College, Pune for academic discussions on chronology and environmental problems of Acheulian sites in the Deccan Upland. We sincerely thank authorities of the Deccan College, Pune for the logistic support during our field work in the Deccan Upland.

References

Achyuthan, H., J. Quade, L. Roe, and C. Placzek 2007. Stable Isotopic Composition of Pedogenic Carbonates from the Eastern Margin of the Thar Desert, Rajasthan, India, *Quaternary International* 162-163:50-60.

Atkinson, T.C., P. J. Rowe, V.S. Kale and N.J. Pawar 1990. Unpublished Report Submitted to the Natural Environmental Research Council (U.K.)

Basavaiah N. E. Appel, B.V. Lakshmi, K. Deendayalan, K.V.V. Satyanarayan, Saumitra Misra, N. Juyal and M.A. Malik 2010. Revised Magnetostratigraphy and Characteristics of the Fluviolacustrine Sedimentation of the Kashmir Basin, India, during Pliocene-Pleistocene, *Journal of Geophysical Research* 115 (B08105, doi:10. 1029/2009JB006858)

Corvinus, G. 1981. *A Survey of Pravara River System in Western Maharashtra, India,* Vol. 1: *The Stratigraphy and Geomorphology of the Pravara River System*. Tuebingen: Institut fuer Urgeschichte.

Corvinus, G. 1983. *A Survey of the Pravara River System in Western Maharashtra, India, Vol 2. : The Excavations of the Acheulian Site of Chirki-on-Pravara, India*. Tuebingen: Institut fuer Urgeschichte.

Deo, Sushama, Sheila Mishra, S. N. Rajaguru, and Savita Ghate 2007a. Antiquity of Acheulian Culture in Upland Maharashtra: A Geoarchaeological Approach, in *Human Origin, Genome and People of India: Genome, Palaeontological and Archaeological Evidence,* (A. R. Sankhayn and V. R. Rao Eds.) pp. 292-308. Kolkata: Anthropological Survey of India and Allied Publishers Pvt. Limited.

Deo, Sushama , S. Mishra and S.N. Rajaguru 2007 b. Palaeoclimatic Studies at Deccan College 1940-2005: A Geoarchaeological Approach, *Bulletin of the Deccan College Postgraduate and Research Institute* 64/65: 209-228.

Deo, Sushama and Sheila Mishra 2013. Morgaon, in *Glimpses of Ancient Maharashtra Through Archaeological Excavations* (Deotare, B.C, P.S. Joshi and C.N. Parchure (Eds.), pp. 73-77. Pune: Bharatiya Itihas Sankalan Samitee & Deccan College PGRI.

Dhir, R.P., S.K. Tandon, B.K. Sareen, R. Ramesh, T.G. Rao, A.J. Kailath and N. Sharma 2004. Calcretes in the Thar Desert: Genesis, Chronology and Palaeoenvironment, *Earth and Planetary Sciences* 113: 473-514.

Dhir, R.P. and A.K. Singhvi 2012. The Thar Desert and its Antiquity, *Current Science* 102(7): 10001-1008.

Ganjoo R.K. and H. Achyuthan 1995. High Level Gravels: A Reapprisal, in *India at the Dawn of History (Shri V.D. Krishaswamy*

Commemoration Volume) (Dutta Ashok, A.K. Ghosh and C. Margbandhu Eds.) pp 9-16. New Delhi: Agam Kala Prakashan.

Goudie, A.S. 1983. Calcretes, in *Chemical Sediments and Geomorphology* (A.S. Goudie and Kenneth Pye Eds.) pp. 93-132. London: Academic Press.

Haslam, Michael, Richard G.Roberts, Ceri Shipton, J.N. Pal, Jacqueline L. Fenwick, Peter Ditchfield, Nicole Boivin, A.K. Dubey, M.C. Gupta, and Michael Petraglia 2011. Late Acheulean Hominins at the Marine Isotope Stage 6/5e Transition in North-central India, *Quaternary Research* 75(3): 670-682.

Joshi, R.V., R.S. Pappu, A.R. Marathe and R.P. Pandey 1980. Excavations at Wadoli-Waghodi : A Middle Palaeolithic Site of the High Level Gravel of the Godavari River, *Bulletin of the Deccan College Postgraduate and Research Institute* 39 : 49-89.

Kailath A.J., T.G Rao, R.P Dhir, K.S.N. Nambi, V.D. Gogate and A. Singhvi 2000. Electron Spin Resonance of Calcretes from Thar Desert for Dating Applications, *Radiation Measurements* 32:371-383.

Kale, V.S., Veena Joshi and P.S. Hire 2004. Palaeohydrological Reconstructions based on Analysis of a Palaeochannel and Toba-Ash Associated Alluvial Sediments in the Deccan Trap Region, India, *Journal of Geological Society of India* 64: 481-489.

Korisettar, R. 1979. *Prehistory and Geomorphology of the Middle Krishna, Karnataka.* Unpublished Ph.D. Dissertation, University of Poona

Korisettar R. and S.N. Rajaguru 1998. Quaternary Stratigraphy, Palaeoclimate and the Lower Palaeolithic of India, in *Early Human Behaviour in Global Context: The Rise and Diversity of the Lower Palaeolithic Record* (Petraglia M.D. and Ravi Korisettar Eds.), pp. 304-342. London: Routledge.

Korisettar R. 2012. Paradigm Shifts in the Geo-Archaeology of the Palaeolithic of the Indian Subcontinent: Building a Grand Pleistocene Cultural Sequence. *Puratattva* 42: 12-42, plates.

McNabb, John 2005. Hominins and the Early-Middle Pleistocene Transitions: Evolution, Culture and Climate in Africa and Europe, in *Early-Middle Pleistocene Transitions: The Land Ocean Evidence* (M.D. Head and P.L. Gibbard Eds.), pp 287-304. London: Geological Society Special Publications No. 247.

Merh, S.S. 1992. Quaternary Sea Level Changes along Indian Coast, *Proceedings of the Indian National Science Academy* 58: 461-472.

Mishra, S., Venkatesan, T.R., Rajaguru, S.N. and B.L.K. Somayajulu 1995. Earliest Acheulian Industry from Peninsular India, *Current Anthropology*. 36:847-851.

Mishra, Sheila 1995. Prehistoric and Quaternary Studies at Nevasa: The Last 40 Years, in *Quaternary Environment and Geoarcheaology of India* (Wadia S., R.Korisetter and V.S.Kale Eds.), pp. 324-332. Bangalore: Geological Society of India.

Mishra, S., S. Deo, R. Abbas, S. Naik, G. Shete, N. Agrawal and S. Rajaguru 2008. Excavations at the Early Acheulian Site of Morgaon, Maharashtra (2000–2007), in *Recent Research Trends in South Asian Archaeology* (Paddayya K., P. P. Joglekar, K. K. Basa and R. Sawant Eds.), pp. 121-137. Pune: Deccan College Postgraduate and Research Institute.

Misra, V.N. and S.N. Rajaguru 1989. Palaeoenvironment and Prehistory of the Thar Desert, Rajasthan, India, in *South Asian Archaeology* 1985 (Sorensen, P. and K .Frifellt Eds), pp 296-320. Copenhagen: Scandenvian Institute of Asian Studies.

Nigam, R. and N.H. Hashimi 2002. Has Sea Level Fluctuation Modulated Human Settlements in Gulf of Khambhat, *Journal of Geological Society of India* 59(6): 583-584.

Ollier, C. D. and H. C. Sheth 2008. The High Deccan Duricrusts of India and Their Significance for the 'Laterite' Issue, *Journal of Earth System Science* 117(5): 537-553.

Paddayya, K. 1971. High-Level Gravels and Related Palaeolithic Sites of the Shorapur Doab, Peninsular India, *Quartar* 22: 95-110.

Paddayya, K. 1982. *The Acheulian Culture of Hunsgi Valley (Peninsular India: A Settlement System Perspective*. Pune: Deccan College.

Paddayya, K. and M. D. Petraglia 1993. Formation Processes of Acheulean Localities in the Hunsgi and Baichbal Valleys, Peninsular India, in *Formation Processes in Archaeological Context*. P. Goldberg, D. J. Nash and M. D. Petraglia Eds), pp 61-82. Madison, Prehistory Press.

Paddayya, K., B. Blackwell, R. Jhaldiyal, M. Petraglia, S. Fevrier, D.A. Chaderton II, I.I.B. Blickstein and A.R. Skinner 2002. Recent Findings on the Acheulian of the Hunsgi and Baichbal Valleys, Karnataka, with Special Reference to the Isampur Excavation and Its Dating, *Current Science* 83(5): 101-107.

Pappu, R.S. and S.N. Rajaguru 1979. Early Quaternary Laterite at Anagwadi, District Bijapur, *Bulletin of Earth Sciences* 7: 41-43.

Pappu, R.S. and J.V.P. Rao 1983. On the Problem of the Age and Origin of High Level Gravels around Moravakonda, District Kurnool, Andhra Pradesh, *Bulletin of the Deccan College Research Institute* 42 : 119-130.

Pappu, Shanti, Yanni Gunnell, Kumar Akhilesh, Régis Braucher, Maurice Taieb, François Demory and Nicolas Thouveny 2011. Early Pleistocene Presence of Acheulian Hominins in South India, *Science* 331: 1596-1600.

Patnaik, Rajeev and Avinash C. Nanda 2010. Early Pleistocene Mammalian Faunas of India and Evidence of Connections with Other Parts of the World, in *Out of Africa I* (John G. Fleagle, John J Shea, Frederick E. Grine, Andrea Baden and Richard E. Leakey Eds.), pp. 129-143. Springer: Netherlands.

Rajaguru, S.N. and G.L. Badam 1984. Litho and Biostratigrahy of Quaternary Formations Central Godavari Valley, Maharashtra, *Geological Survey of India, Special Publication* 14 (89-96).

Rajaguru, S.N. and V.S. Kale 1985. Changes in the Fluvial Regime of Western Maharashtra Upland Rivers during the Late Quaternary, *Journal of the Geological Society of India* 26 16-27.

Rajaguru, S.N., V.S. Kale and G.L. Badam 1993. Quaternary Fluvial Systems in Upland Maharashtra Rivers during the Late Quaternary, *Current Science* 64 (11&12): 817-822.

Rajaguru, S.N. and S. Mishra 1996. Quaternary Climatic Changes in India: A Geoarchaeological Approach, *Bulletin of the Indo Pacific Prehistory Association* 16: 27-32.

Rajaguru S.N. 2000. Quaternary Palaeoclimate of Northern Deccan, in *Deccan Heritage*, (H.K. Gupta, Aloka Parashar-Sen and O. Balsubramanian Eds.), pp. 157-167. Indian National Science Academy University Press.

Rajaguru, S.N. Sushama Deo, Sheila Mishra, Savita Ghate, Sonali Naik and Prabodh Shirvalkar 2004. Geoarchaeological Significance of the Detrital Laterite Discovery in the Karha Basin, Pune District, Maharashtra, *Man and Environment* XXIX (1):1-6.

Rao, J.V.P. 1992. *Prehistoric Environment and Archeaology of the Krishna-Tungabhadra Doab,Andhra Pradesh*. Ph.D. Dissertation. Pune: University of Poona.

Rao, Venkata, S. Chakraborty, K.J. Rao, M.S.V. Rajmani, S.D. Marathe and B.F. Borkar 1997. Magnetostratigraphy of the Quaternary Fluvial Sediments and Tephra of Narmada Valley, Central India, *Special Publication of Geological Survey of India* 46: 65-78.

Sahasrabudhe, Y.S. and S.N. Rajaguru 1990. The Laterites of the Maharashtra State, *Bulletin of the Deccan College Postgraduate and Research Institute* 49: 357-374.

Sanyal, P. and R. Sinha 2010. Evolution of the Indian Summer Monsoon: Synthesis of Continental Records, in *Monsoon Evolution and Tectonics–Climate Linkage in Asia*, (P. Clift, R. Tada and H. Zheng Eds.), pp. 153-183. London: Geological Society of London, Special Publications 342**.**

Sathe, V. 2008. Discovery of large mammalian fossils at Morgaon, District Pune, Maharashtra, India, *Quaternary International*: 192: 52-61.

Schmidt, P.W., V. Prasal and P.K. Raman 1983. Magnetic Ages of Some Indian Laterites, *Palaeogeography, Palaeoclimate and Palaeoecology* 44: 185-202.

Singhvi, A.K. Nilesh Bhatt, K.W. Glennie and P. Srivastava 2012. India, Arabia and Adjacent Regions, in *Quaternary Environmental Change in Tropics* (Sarah E. Mecalfe and David J. Nash Eds.) pp. 151-200. John Wiley and Sons.

Thomas, Michael F. 1994. *Geomorphology in the Tropics*. New York: John Willey and Sons.

Tiwari, M.P. and H.Y. Bhai 1997. Quaternary Stratigraphy of the Narmada Valley, *Special Publication of Geological Survey of India* 46: 33-63.

Warrier, Anish K.,K. Sandeepa,B.G. Harshavardhanaa, R. Shankara, Shanti Pappu, Kumar Akhilesh, C.N. Prabhua, Y. Gunnell 2011. A Rock Magnetic Record of Pleistocene Rainfall Variations at the Palaeolithic Site of Attirampakkam, Southeastern India, *Journal of Archaeological Science* 38 (2011) 3681-3693.

Widdowson, M. and K.G. Cox 1996. Uplift and Erosional History of the Deccan Traps, India: Evidence from Laterites and Drainage Patterns of the Western Ghats and Konkan Coast, *Earth and Planetary Science Letters* 137: 57-69.

C. Shipton *et al*., in *Recent Advances in Acheulian Culture Studies in India*
(K.Paddayya and S.G. Deo Eds.), pp. 23-36 [2014]

Empirical Differences between the Earlier and Later Acheulian in India

Ceri Shipton,.S. Mishra[1], K. Paddayya[1], Sushama G. Deo[1], J.N. Pal[2], N. Roseboom[3], C. Gaillard[3], M.C. Gupta[2] and Y. Hou[4]

School of Social Science
University of Queensland
Brisbane, QLD 4072, Australia
E-mail: c.shipton@uq.edu.au

1. Department of Archaeology, Deccan College, Pune 411006, India

2. Department of Ancient History, Culture and Archaeology, University of Allahabad, Allahabad 211002, India

3. Centre National de la Recherche Scientifique, Departement de Prehistoire du Museum national d'histoire naturelle, 1 rue rene Panhard, 75013 Paris, France

4. Institute of Vetebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, 142 Xizhimenwai Street, Beijing 100044, P.R. China

Abstract

The Indian Acheulian is now known to have endured for around one and a half million years. Several authors have identified temporal patterns in behaviour, particularly in relation to shaped bifaces, which may be discerned over this vast timescale. These chronological trends include a decrease in mean biface size; an increase in the relative thinness of bifaces; a decrease in the elongation of bifaces; an increase in biface flake scar density; a decrease in the shape variation of bifaces; an increase in the size variation of bifaces; a decrease in the proportion of bifaces in an assemblage; an increase in the use of flake blanks; and an increase in the use of cryptocrystalline materials. Here we statistically test these patterns by comparing a series of four earlier Acheulian assemblages from Isampur, Morgaon, Chirki-on-Pravara and Singi Talav with a series of four later Acheulian assemblages from Teggihalli II,Mudnur X, Bhimbetka IIIF-23, and Patpara. Our results indicate that many of the proposed patterns are real, and we offer some interpretations as to what they represent for the evolution of hominin behaviour and cognition.

Introduction

Since Robert Bruce Foote's discovery of Acheulian bifaces at Pallavaram and Attirampakkam 150 years ago, hundreds of Acheulian sites have been found across India (Mishra 1994). In the last 25 years the advancement of dating techniques has allowed for the upper and lower time limits of the Indian Acheulian to be ascertained in absolute years. Firstly, Uranium-Thorium dating of calcrete in association with artefacts at several sites pushed the age of the Acheulian back beyond 350 thousand years (Mishra 1995). Argon-Argon dating of Toba tephra associated with heavy duty picks at Bori increased the age to 670 thousand years (Mishra *et al.* 1995). Electron Spin Resonance (ESR) dating of bovid teeth from Acheulian levels at Isampur produced a date of 1.27 Ma (Blackwell *et al.* 2001). Most recently, cosmogeneic dating of the deep levels at Attirampakkam yielded some of the oldest dates for the Acheulian in the world, with a mean age of 1.51 Ma (Pappu *et al.* 2011), but possibly as old as 1.77 Ma. At the other end of the spectrum three Acheulian sites in the Son Valley have been dated with Optically Stimulated Luminescence (OSL) to just 140-131 Kyr making them among the youngest

Acheulian found anywhere in the world (Haslam *et al*., 2011; Shipton *et al*., in press). The duration of the Acheulian in India is thus approximately 1.5 million years; 10,000 times longer than the eventful 150 years since Bruce Foote's first Acheulian discovery.

Given this vast timescale it is unsurprising that several researchers have suggested there may be temporal trends in the Indian Acheulian (Misra 1978; Gaillard *et al.* 1986; Mishra 2007; Paddayya 2007; Shipton *et al.* 2009a; Shipton 2013). The observed patterns usually relate to the diagnostic artefacts of the Acheulian, the shaped bifaces that we call handaxes and cleavers. The trends include a decrease in mean biface size but an increase in the relative thinness of bifaces; a decrease in the elongation of bifaces but an increase in biface flake scar density and a decrease in the shape variation of bifaces but an increase in the size variation of bifaces; and an increase in the use of flake blanks and cryptocrystalline materials. While these trends have been noted, there has been relatively little statistical testing; hence they remain somewhat tentative. The goal of this article is to quantitatively compare these variables across a sample of earlier and later Acheulian assemblages.

While the chronology of the Indian Acheulian is not yet refined enough to confidently assign ages to many individual sites, a few assemblages can at least be divided into earlier and later groups (Gaillard *et al.* 2010a). Palaeomagnetic chronologies have enabled assignation of some sites to one side or the other of the Matuyama-Brunhes polarity switch 0.78 Ma ago. In this study we use this convenient boundary, lying approximately halfway through the Indian Acheulian, to divide our assemblages into two groups.

The Key Sites (Fig. 1)

Isampur

Isampur is located in the Hunsgi Valley in Karnataka, on the eastern edge of the Deccan plateau, roughly in the centre of peninsula India (Paddayya and Petraglia 1997). The site occurs on a siliceous limestone pediment on the western edge of a 2-3 m deep palaeo-drainage channel that has silted up since the hominin occupation (Paddayya *et al.* 1999; Petraglia *et al.* 1999). Acheulian artefacts were discovered here by Paddayya in 1982-83 field season after much of the black and brown clayey silts overlying the limestone pediment were removed to serve as fill material for the embakment of an irrigation canal. The artefacts occur in a thin horizon (15 - 30 cm), set in a hard matrix of carbonate rich brown silt lying on the bedrock. Taphonomic study attests to the high integrity of the site, particularly Trench 1, as proved by the non-rounded condition of artefacts and natural clasts, presence of very small artefacts (< 1 cm^3) and horizontal orientation of the artefacts. ESR dating of two fossilized *Bos* teeth put the age of hominin occupation at Isampur at 1.2 ± 0.17 Ma, assuming a linear uptake model (Paddayya *et al.* 2002). The limestone bedrock weathers in a predictable way leaving joint-bounded slabs of thicknesses varying from 2 to 20 cm. The slab pieces from bedrock at Isampur were being pried out by hominins for lithic manufacture. The larger slabs were being used as giant cores for obtaining cleaver blanks, while the smaller slabs were being shaped into handaxes (Shipton *et al.* 2009b).

Teggihalli II

Teggihalli II is located in the Baichbal Valley, about 200 m from the Doddahalla stream. Here Acheulian artefacts, mostly of limestone, and a small amount of fossil fauna were found in a discrete patch, within a brown clayey silt matrix (Paddayya 2007). Farming activities and the resultant soil erosion resulted in the recent deflation of the overlying deposits, but the artefacts were still buried by a metre of sediment and appeared to be undisturbed. A Uranium-Thorium date on a fossilized tooth from the cultural layer produced an age of 287 Kyr (Szabo *et al.* 1990). Unlike Isampur and some other sites in the Hunsgi and Baichbal Valleys where artefacts lay directly on the bedrock or in the eroding gruss, at Teggihalli the artefact bearing horizon is separated from the bedrock by around 1m of culturally sterile silt (Paddayya 2007).

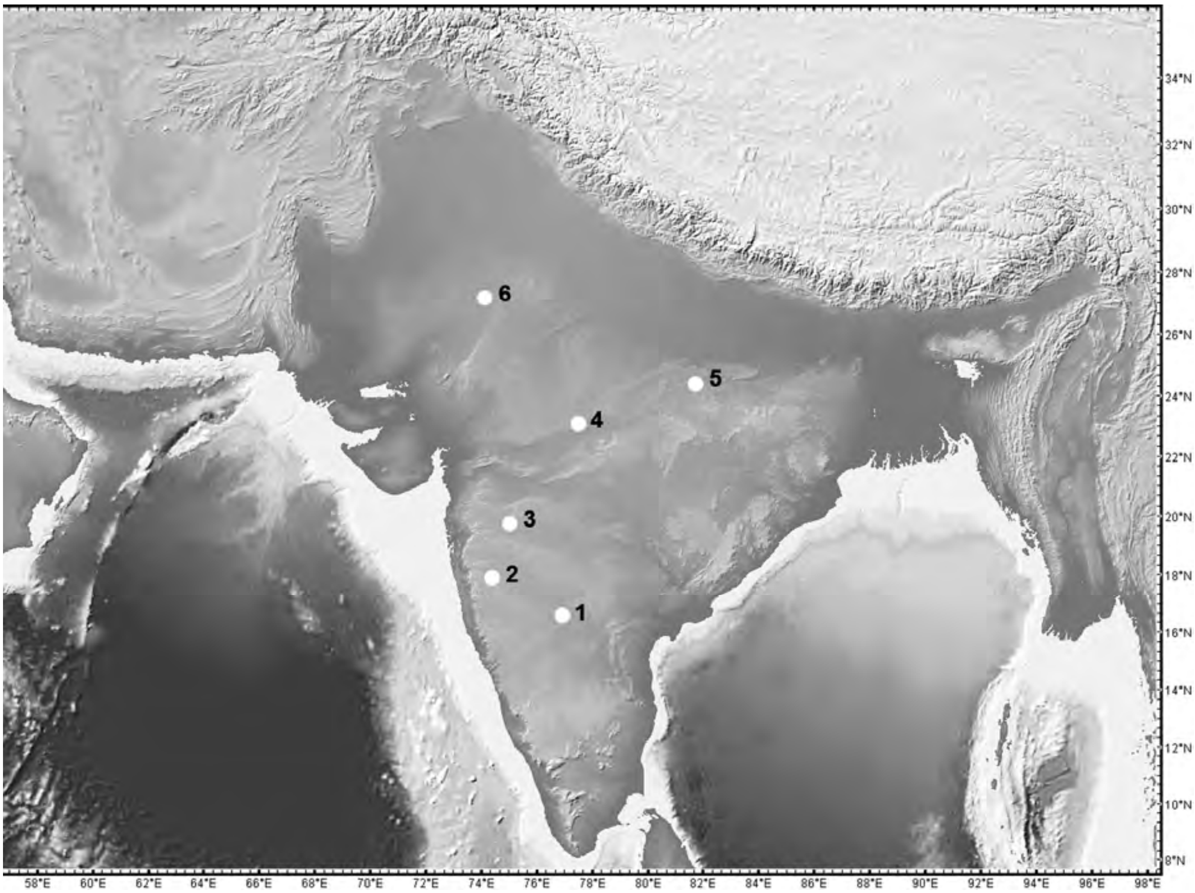


Fig. 1: The location of the study sites within the Indian Subcontinent. 1. The Hunsgi and Baichbal Valleys (including Isampur, Teggihalli II and Mudnur X); 2. Morgaon; 3. Chirki-on-Pravara; 4. Bhimbetka; 5. Patpara; 6. Singi Talav.

Mudnur X

Mudnur X is also located in the Baichbal Valley, about 2 km upstream from Teggihalli II where the Tallahalli stream meets the Doddahalla stream. Three discrete artefact clusters were found here in a distinct 10-15 cm thick horizon within the same brown clayey silt layer that occurs at Teggihalli II (Paddayya 2007). At Mudnur X the Acheulian horizon was some 4 m above the bedrock and 2 m below the present ground surface. As with the above mentioned sites from Hunsgi and Baichbal Valleys, the majority of the artefacts from Mudnur X were made on the siliceous limestone that can be found in the Valley.

Morgaon

Morgaon is located in Maharashtra on the western side of the Deccan plateau in a basaltic landscape. The site occurs near the bank of the seasonal Karha river, a tributary of the Bhima. Excavations at the site produced large basalt artefacts, derived from sandy basalt gravels laid down by flash floods in a braided stream (Deo *et al.* 2007; Mishra *et al.* 2009). The fresh condition of the excavated artefacts and the presence of relatively small pieces indicate the site has not undergone much post-depositional disturbance. A palaeomagnetic study of the Morgaon sequence indicates that the deposits fall within the Matuyama period (Sangode *et al.* 2007), while lenses of Toba Tephra occur stratigraphically above the Acheulian horizon (Gaillard *et al*. 2010a).

Chirki-on-Pravara

The site of Chirki is located on the Pravara river, near Nevasa town in Maharashtra, in the central part of Deccan plateau. Acheulian artefacts occur in a basal colluvial gravel on top of the basalt bedrock, sealed by a fluvial cross-bedded gravel, which is in turn capped by a black fissured clay (Corvinus 1983). While some of the smaller artefacts may have been winnowed from the site the bifaces are in fresh condition and have not undergone much post-depositional transport. Paleomagnetic study of the black fissured clay at the site of Laxmi Nala a few kilometres upstream showed that it belonged to the Matuyama period. Therefore the underlying gravels, which also occur in the Laxmi Nala, may be assigned to this period as well (Sangode *et al*. 2007). A Uranium-Thorium date on calcrete in the artefact-bearing layer at Laxmi Nala produced an age of at least 350 Kyr (Gaillard *et al.* 2010b). The artefacts from Chirki are made of basalt - an amygdaloidal basalt available at the site and a more compact basalt from a dyke several kilometres away (Corvinus 1983).

Bhimbetka IIIF-23

Bhimbetka is a complex of sandstone rockshelters on the northern edge of the Vindhayan hills in Madhya Pradesh. Rockshelter IIIF-23 is one of the largest in the complex and excavation here produced a continuous 3.5 m deep sequence spanning from the microlithic to the Acheulian period (Misra 1978). Three Acheulian-bearing layers (6, 7 and 8) were exposed and these measured around 2.4 m in total thickness. The presence of occasional handaxes and cleavers in the Middle Palaeolithic assemblage of layer 5, together with the presence of Levallois technology in Layer 6, indicates a gradual transition from the Acheulian to the Middle Palaeolithic at the site (Misra 1978). The Acheulian artefacts are similar in character throughout the sequence so the industry may be broadly assigned to the Late Acheulian. The artefacts are in very fresh condition and occur in horizontally bedded floors indicating they were deposited *in situ* by hominins occupying the shelter. Nearly all artefacts were made on orange quartzitic sandstone, with the bifaces made on a purplish iron rich variety that is particularly hard, while the smaller artefacts were made on a yellowish softer variety (Misra 1978). The yellowish quartzitic sandstone is available on and around the shelter while the purplish variety occurs as a discrete vein some distance away. The cortex on some of the cleavers is weathered, showing that the purplish quartzite was obtained from the regolith, similarly to the nearby site of Adamgarh (Joshi 1964).

Patpara

Patpara is another transitional Acheulian to Middle Palaeolithic assemblage from a site in the Son valley in Madhya Pradesh. The Son river flows northwards and eastwards from the Vindhyan and Maikal hills of central India, and is a major tributary of the Ganga. The site occurs on the northern side of an east-west trending quartzitic sandstone ridge in the middle part of the Son valley (Blumenschine *et al.* 1983). Associated Acheulian and Middle Palaeolithic artefacts were excavated from red-brown gravelly and sandy clays, at three different localities (Shipton *et al*., in press). The artefacts are very fresh and have undergone minimal post-depositional transport although they may have clustered in local topographic lows (Blumenschine *et al*. 1983). Statistically indistinguishable OSL ages of 137 and 140 Kyr were obtained from two Acheulian bearing horizons at Patpara locality III (Haslam *et al*. 2011). The artefacts are made both on the local quartzitic sandstone of the ridge and from chert probably obtained from the Kaimur Hills several kilometres away.

Singi Talav

On the edge of the Thar desert in western Rajasthan, hominin occupation has been observed around the Didwana palaeo-lake. In the Singi Talav depression, 2 km south of Didwana town, two levels of Acheulian occupation were exposed and these were interpreted as occurring on a lakeshore (Misra *et al.* 1982). The same lacustrine deposits occur at the site of Amarpura 3 km to the west of Didwana where they are particularly thick, with the Acheulian artefacts also occurring in the upper Amarpura section (Gaillard *et al.* 1986). The upper part of the Amarpura lacustrine sequence was dated by ESR to 797 Kyr (Kailath *et al.* 2000), and based on stratigraphic correlation (Gaillard 1985) this is regarded as a minimum date for the Acheulian layers at Singi Talav (Gaillard *et al*. 2010b). The Singi Talav artefacts are in fresh condition and there is little difference between the two occupation layers except in the proportions of artefact types (Gaillard *et al*. 2010b). Bifaces from Singi Talav were made on schistose quartzite slabs, small flake tools were struck from a different homogenous quartzite; and polyhedrons, spheroids and hammerstones were made on a coarse-grained quartzite.

Table 1: Comparison of mean values for length, refinement, elongation and flake scar density between earlier and later assemblages

	Age	N	Mean	SD	Significance
Volume	Earlier	178	284567	209066	
	Later	111	128721	76750	P<0.001
Refinement	Earlier	178	0.5657	0.12706	
	Later	111	0.4429	0.09841	P<0.001
Elongation	Earlier	178	1.5890	0.25574	
	Later	111	1.4848	0.20267	P<0.001
Flake scar density	Earlier	178	0.1028	0.05106	
	Later	110	0.2029	0.12792	P<0.001

Table 2. The relationship (r^2 linear) between biface dimensions for each assemblage

	Length-Width	Length-Thickness	Width-Thickness
Isampur	0.54	0.459	0.435
Morgaon	0.101	0.301	0.002
Chirki	0.544	0.422	0.297
SingiTalav	0.542	0.687	0.439
Teggihalli II	0.777	0.439	0.406
Mudnur X	0.577	0.34	0.283
Bhimbetka	0.351	0.003	0.01
Patpara	0.774	0.684	0.497

Analysis

The assemblages were divided into two groups for statistical analyses. The first group of assemblages older than 780 Kyr comprised Isampur, Morgaon, Chirki and Singi Talav; the second group of assemblages younger than 780 Kyr comprised Teggihalli II, Mudnur X, Bhimbetka IIIF-23 and Patpara. All bifaces were measured for Isampur, Singi Talav, Teggihalli II, Mudnur X and Patpara, while samples of over 30 bifaces were taken for Chirki, Morgaon and Bhimbetka IIIF-23.

For illustrating the variation in biface length, thickness to width ratio, length to width ratio, and flake scar density we created box plots of each variable by assemblage (Figs. 2-5). These figures show that bifaces from the younger assemblages tend to be smaller, relatively thinner, less elongate, and have higher flake scar densities. These are not hard and fast rules as there are exceptions with Mudnur X having thicker and more elongate bifaces than those of Morgaon, while the Bhimbetka bifaces have low flake scar densities. Despite these exceptions there are clearly discernible patterns in these variables, so we tested the significance of the difference in mean values for the early and late bifaces (Table 1). Unequal variances t-tests produced highly significant differences between earlier and later bifaces for each of the variables (Table 1).

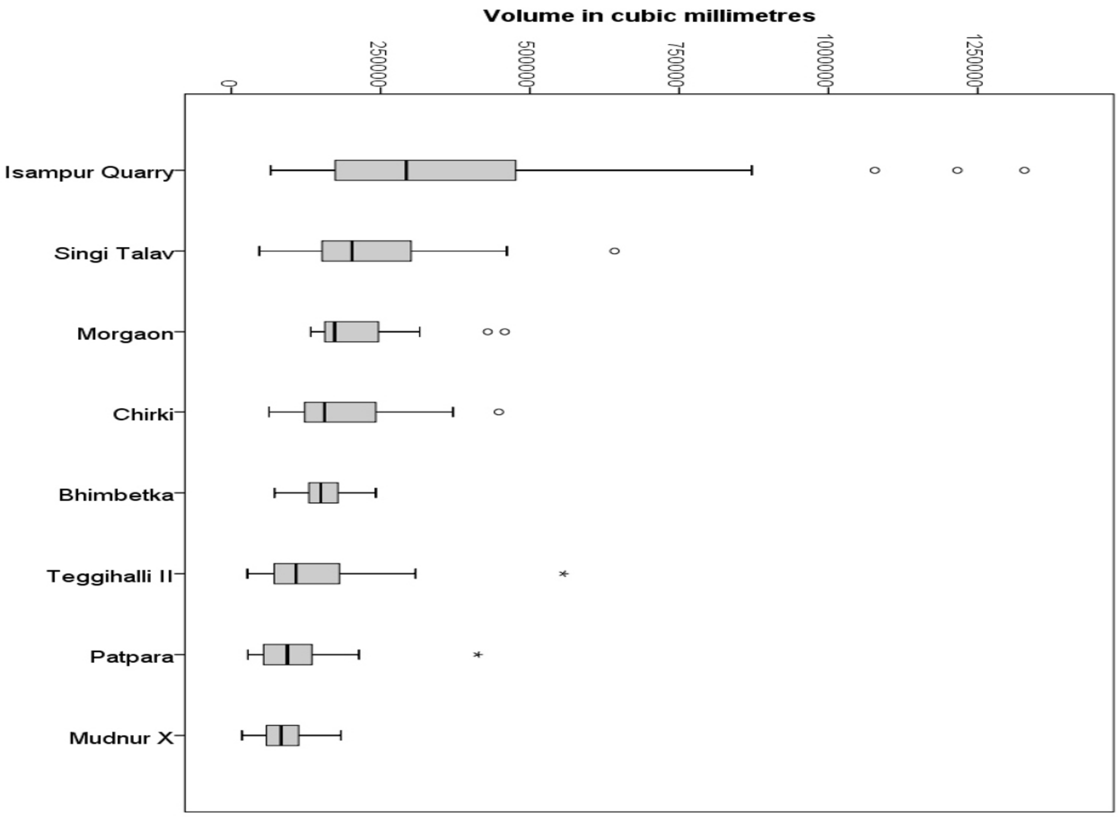


Fig. 2: Box plot of biface volume in cubic millimetres. Horizontal lines show the median value, boxes show interquartile range, bars show the 90th and 10th percentiles. Open circles denote outliers defined as 1.5 to 3 times the interquartile range beyond the interquartile range, while asterisks denote outliers greater than 3 times the interquartile range. Assemblages are ordered by mean value.

Fig. 2 shows the variation in biface volume for each of the assemblages with Isampur having the highest variation in volume. We used a D'AD test to test the difference in the coefficient of variation (standard deviation divided by the mean) between the early and late assemblages and found that the higher variation in the earlier Acheulian sample could be due to chance (p=0.1). In addition the sample could be biased by the fact that Isampur is a quarry and manufacturing locale and may contain both newly made and worn out bifaces.

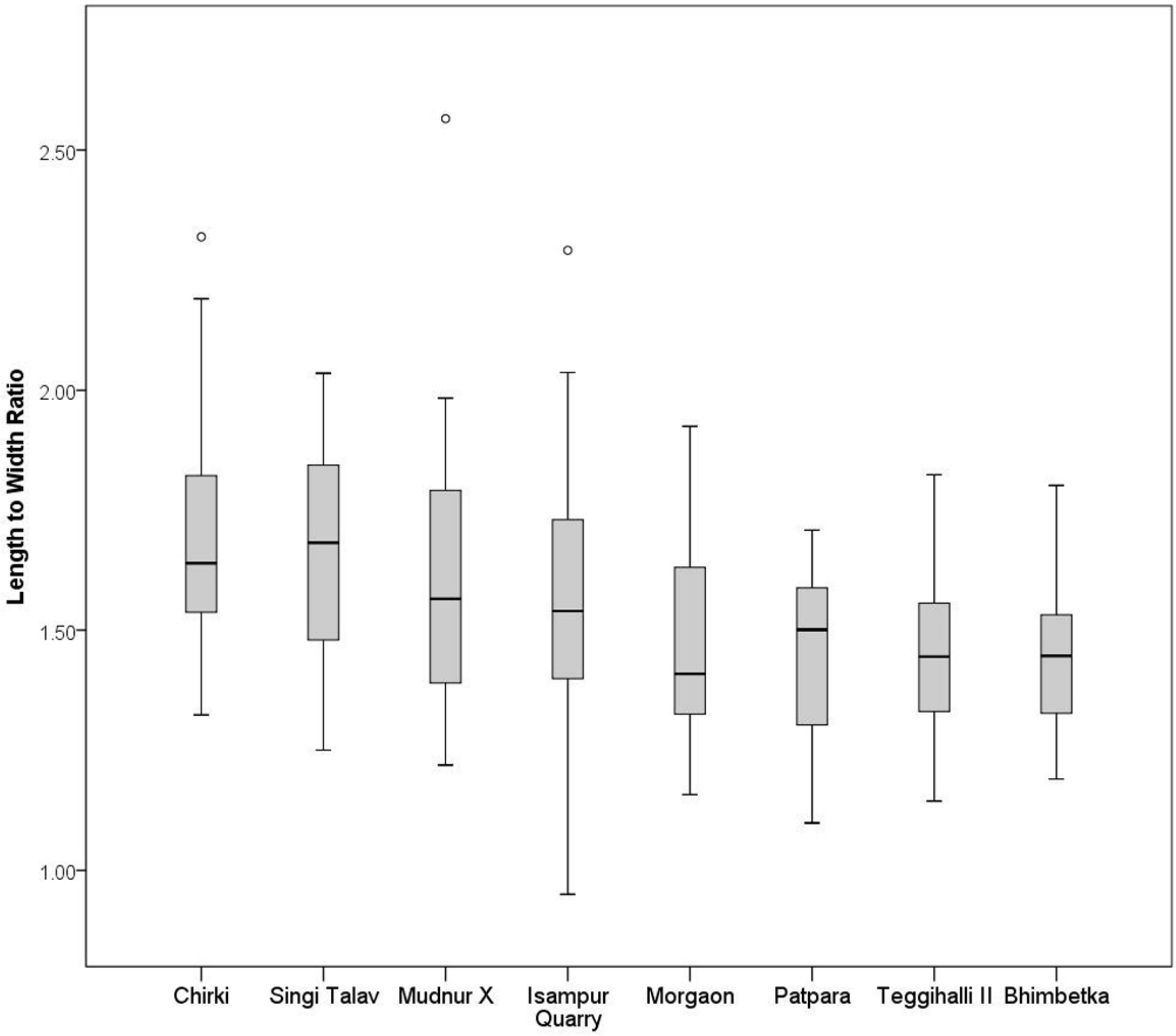


Fig. 3: Box plot of biface thickness to width ratio (refinement)

To explore changing patterns of blank preference we plotted blank type by site (Fig. 6). Fig. 6 shows that most of the later assemblages are dominated by flake blanks, while the earlier assemblages, with the exception of Morgaon, have more of a mixture of blanks. A chi-squared test comparing blank types between the earlier and later assemblages was significant at the $p<0.001$ level, suggesting that there is a strong preference for flake blanks over cobbles and slabs in the later Acheulian (cobbles and slabs were grouped together for this test).

To test the hypothesis that there was a preference for cryptocrystalline materials in the later Acheulian we conducted a Fisher's Exact test on the frequency of bifaces made on cryptocrystalline materials (such as chert and quartz) versus those made on microcrystalline materials (such as quartzite, limestone, basalt, dolerite and schist) (Table 3). The test showed that there is no significant difference ($p=0.4129$) in the selection of these materials for biface manufacture between the earlier and later traditions.

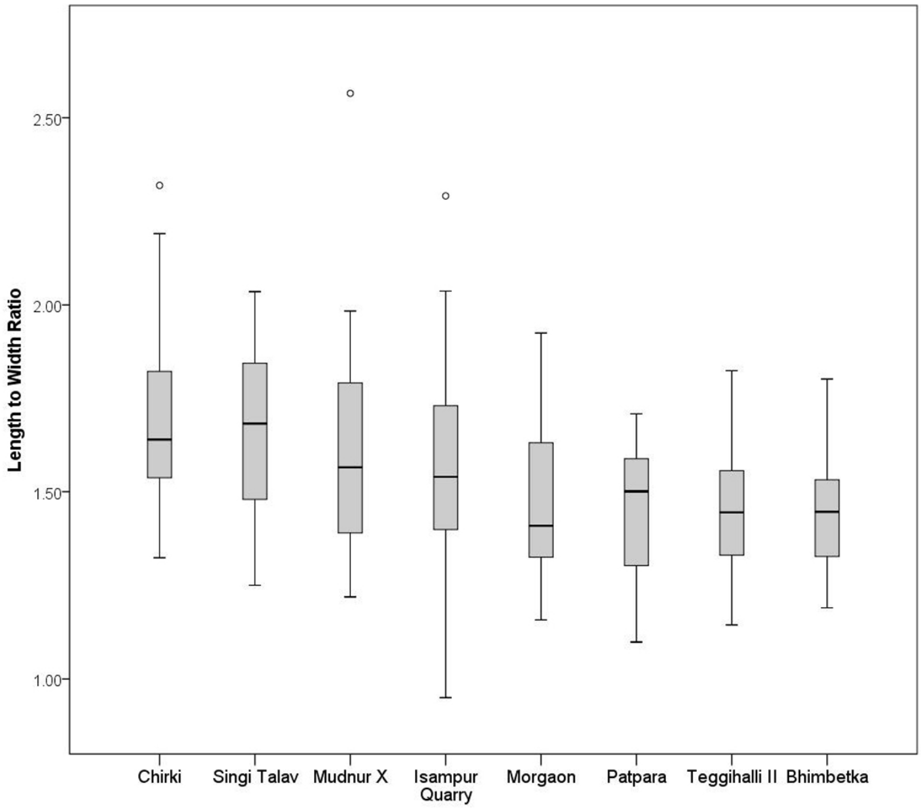


Fig. 4: Box plot of biface length to width ratio (elongation)

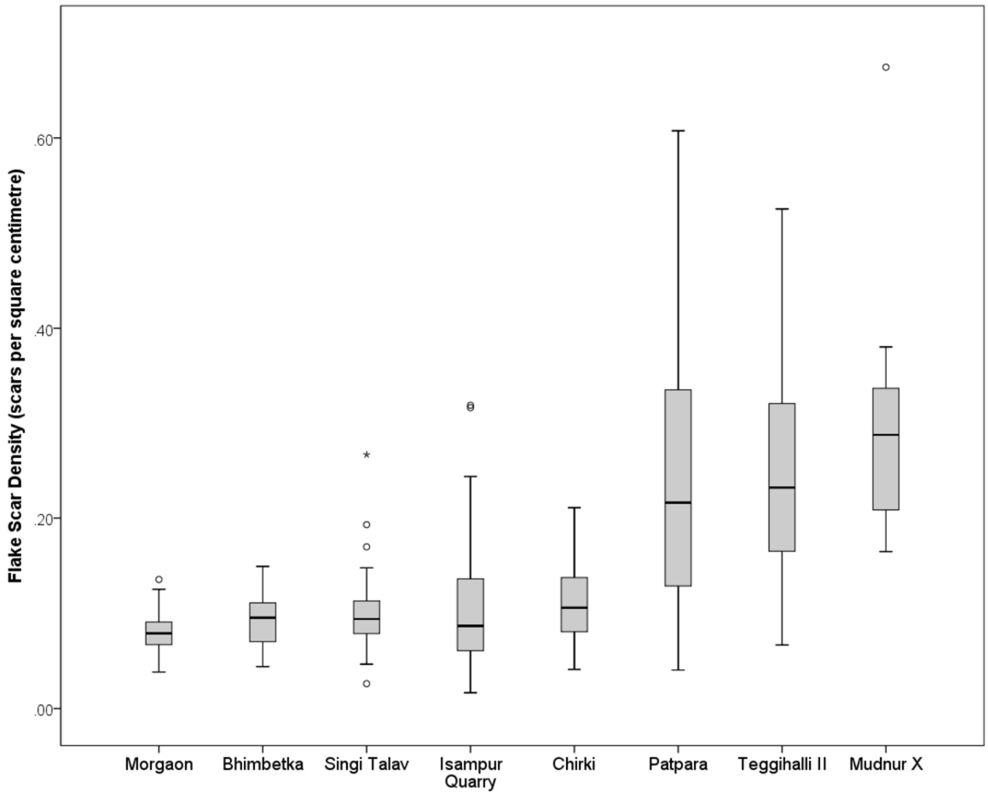


Fig. 5: Box plot of biface flake scar density in scars per square cm

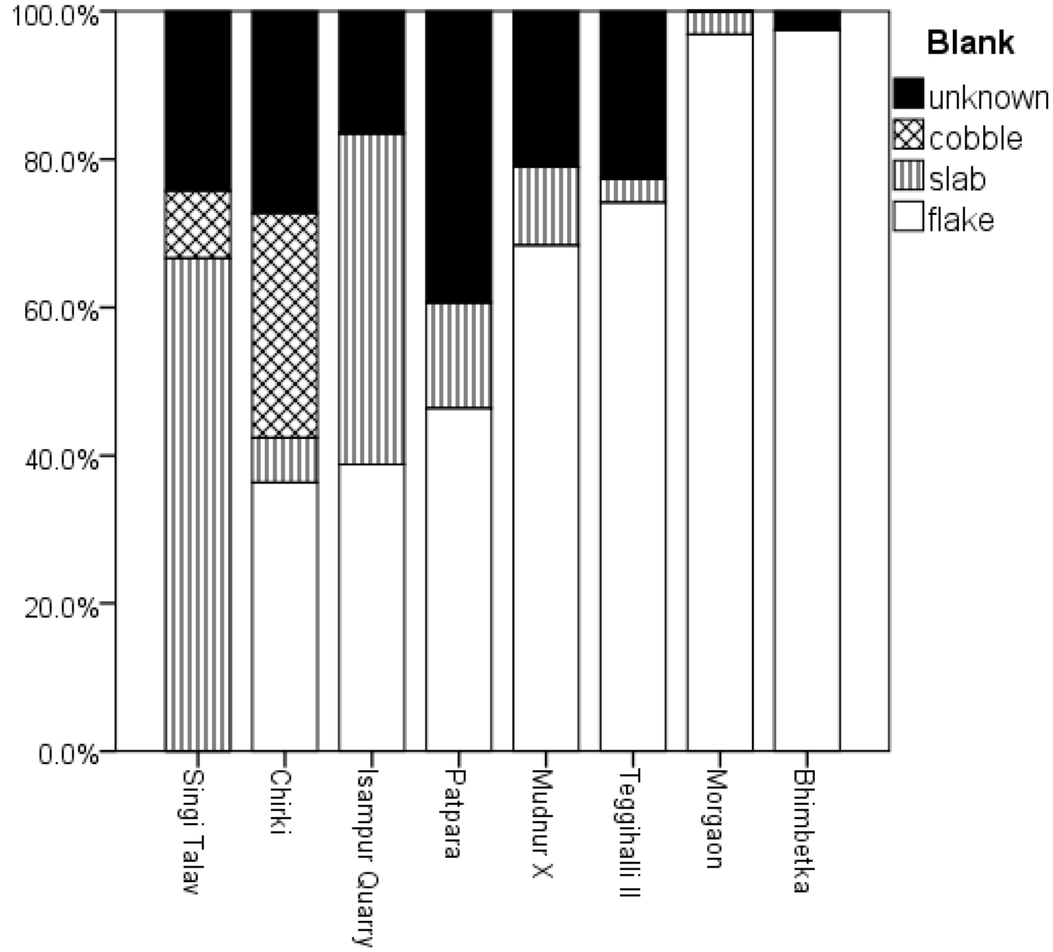


Fig. 6: Blank type by assemblage

Table 3: The frequency of bifaces made on microcrystalline and cryptocrystalline materials for the earlier and later Acheulian

	Earlier	Later
Microcrystalline	176	111
Cryptocrystalline	7	7

Discussion

In the forgoing pages we have assessed purported trends in the Indian Acheulian using quantitative analyses. Our results show that some of the trends, such as increasing biface shape standardization and an increasing preference for cryptocrystalline materials in biface manufacture, are illusory. It could be that cryptocrystalline materials were being favoured for tools other than bifaces, but that is beyond the scope of this article. Most of the previously identified trends in Acheulian bifaces are however supported by the above analyses. There are often exceptions within these trends which indicate that we are not dealing with absolute distinctions but only general trends that may be influenced by multiple aspects of behaviour.

The metric analyses revealed four important temporal distinctions in Acheulian bifaces: later bifaces tend to be smaller, relatively thinner and shorter, and have higher flake scar densities (Fig. 7). While there are exceptions to these trends, in combination they are reliable indicators of whether a biface assemblage belongs to the earlier or later Acheulian.

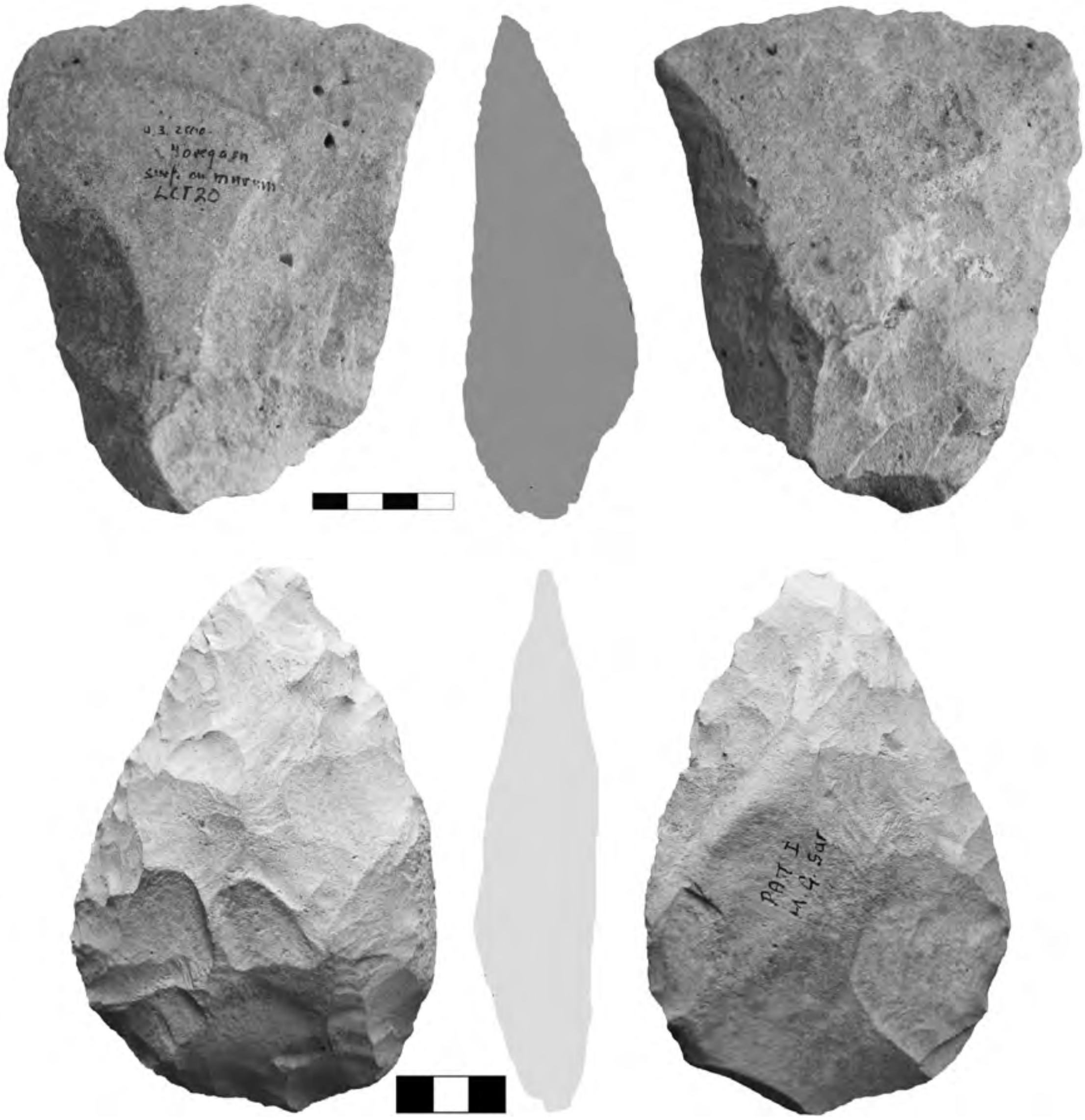


Fig. 7: A cleaver from Morgaon (above) and a handaxe from Patpara (below). Note the differences in flake scar density and thinness between the two.

The decrease in size and the increase in flake scar density may reflect greater reduction of bifaces in the later Acheulian. As bifaces are flaked they will accrue more flake scars whilst their volume is reduced. This is particularly true of bifaces made on flake blanks which start out with few flake scars. Bifaces which are small because they are heavily reduced will have high flake scar densities, but those that are small because they are made on small flakes or clasts will not (Shipton 2011). The later Acheulian bifaces with high scar densities from Teggihalli II, Mudnur X and Patpara are thus small because they are highly reduced. Increased reduction may have a number of non-mutually exclusive explanations.

Knapping actions are not rigid templates imposed on the stone, but rather represent dynamic outgrowths resulting from a practical understanding of the changing stone morphology and its potentials (Roux and Brill 2005). Flake scar density reflects the number of flaking decisions made while repeatedly re-evaluating the object in order to arrive at a target form. Greater flake scar densities on bifaces indicate greater employment of dynamic planning. Increased reduction may also reflect enhanced re-sharpening of bifaces as a result of greater curation. In the Hunsgi and Baichbal valleys the bifaces from Teggihalli II and Mudnur X occur further away from their raw material sources than those at Isampur and other sites with large, low scar density bifaces (Shipton 2013). It has been suggested that biface re-sharpening preferentially reduces the tip (McPherron 2006), which may be one explanation for why later bifaces are less elongate. Alternatively the shift away from elongate bifaces may reflect cultural divergence from the ancestral African Acheulian, which is characterized by more elongate bifaces. A pattern supported by this study is the increasing preference for flake blanks in the later Acheulian. This may reflect the increasing use of prepared core techniques for the production of standardized flakes. In India and elsewhere, the later Acheulian is often associated with prepared core techniques, foreshadowing the preference for small prepared cores in the succeeding Middle Palaeolithic period (DeBono and Goren-Inbar 2001; Petraglia *et al.* 2003; Sharon and Beaumont 2006). The use of core preparation again suggests greater planning in the later Acheulian.

Bifaces in the later Indian Acheulian are relatively thinner than those of the earlier Acheulian. This temporal pattern has been observed across assemblages throughout the Acheulian world (Shipton 2013). Producing a thin tool is perhaps the most challenging aspect of biface manufacture. A thin biface often requires the production of a large, thin flake blank. This involves careful preparation of a large core and striking a precise forceful blow at such an angle as to facilate the removal of a large flake, without either shattering the stone or striking ineffectually (Edwards 2001). Alternatively, producing a thin lenticular profile from an amorphous nodule or a rounded cobble is equally challenging, as the starting form is far removed from the end goal. Making a thin biface requires sufficiently invasive flakes to be struck to thin the piece whilst maintaining adequate width for an extensive cutting edge (Callahan 1990). This may involve using soft hammers at the later stages of reduction and careful platform preparation. Step fractures must also be avoided or removed to allow flakes to travel across the surface (Edwards 2001). The smaller and thinner a biface is, the more liable it is to break due to end-shock during manufacture. Avoiding end-shock requires delicate and precise flaking, as well as cushioning the blow by co-ordinating between the striking hand and the hand in which the biface is held. Producing a thin biface thus requires both planning and dexterity. Due to these difficulties the thin bifaces typical of the later Acheulian can only be replicated by modern knappers after lengthy periods of practice (Bradley and Sampson 1986; Edwards 2001). The pattern of thinner bifaces in the later Acheulian may be attributed to an evolutionary increase in hominin skill, with more skilled knappers being able to flake more delicately and precisely as well as anticipating and removing potential barriers to reduction.

A quantitative approach allows perceived patterns in the archaeological record to be assessed objectively. In this article we have demonstrated the veracity of many proposed temporal trends in the Indian Acheulian. Our inferences about the causes of this variation suggest some trends may relate to evolving hominin cognition, in particular increases in planning and dexterity. In other words, the vast time span of the Indian Acheulian has the potential to reveal much about the evolution of the human mind.

Acknowledgements
We would like to thank M. Yogesh, Jose Raphael, Tosabanta Padhan and Burhan Ahmad for assistance during data collection. This research was funded by a University of Queensland Post-Doctoral Fellowship awarded to CS.

References

Blackwell, B., S. Fevrier, J. Blickstein, K. Paddayya, M. Petraglia, R. Jhaldiyal and A. Skinner 2001. Esr Dating of an Acheulian Quarry Site at Isampur, India. *Journal of Human Evolution* 40(3): A3.

Blumenschine, R., S. Brandt and J. Clark 1983. Excavations and Analysis of Middle Palaeolithic Artifacts from Patpara, Madhya Pradesh, in *Palaeoenvironments and Prehistory in* *the Middle Son Valley* (Sharma, G.R., Clark, J.D. Eds), pp. 39-114. Allahabad: Abinash Prakashan.

Bradley, B. and C.G. Sampson 1986. Analysis by Replication of Two Acheulian Artefact Assemblages, in *Stone Age Prehistory: Studies in Honour of Charles McBurney* (G. Bailey and P. Callow Eds*)*, pp. 29-45.

Callahan, E. 1990. *The Basics of Biface Knapping in the Eastern Fluted Point Tradition: A Manual for Flintknappers and Lithic Analysts*. Eastern States Archeological Federation.

Corvinus, G. 1983. *A Survey of the Pravara River System in Western Maharashtra, India: The Excavations of the Acheulian Site of Chirki-on-Pravara*. Tübingen: Tübinger Monographien zur Urgeschichte 7: 2.

Debono, H. and N. Goren-Inbar 2001. Note on a Link between Acheulian Handaxes and the Levallois Method. *Journal of the Israel Prehistoric Society* 31: 9-23.

Deo, Sushama, Sheila. Mishra, S. N. Rajaguru, and Savita Ghate. 2007a. Antiquity of Acheulian Culture in Upland Maharashtra: A Geoarchaeological Approach, in *Human Origin, Genome and People of India: Genome, Palaeontological and Archaeological Evidence* (A. R. Sankhayn and V. R. Rao Eds.), pp. 292-308. Kolkata: Anthropological Survey of India and Allied Publishers Pvt. Limited.

Edwards, S.W. 2001. A Modern Knapper's Assessment of the Technical Skills of the Late Acheulian Biface Workers at Kalambo Falls, in *Kalambo Falls Prehistoric Site* (Clark, J. D. Ed.), 3, pp. 605-611. London: Cambridge University Press.

Gaillard, C. 1985. Le Site Acheuléen De Singi-Talav À Didwana, Rajasthan, Inde in Séance Du 23-X-85: Archéologie Française à L'étranger, *Bulletin de la Société Préhistorique Française. Comptes Rendus des Séances Mensuelles Paris* 82(7): 196-197.

Gaillard, C., S. Mishra, M. Singh, S. Deo and R. Abbas 2010a. Lower and Early Middle Pleistocene Acheulian in the Indian Sub-Continent, *Quaternary International* 223: 234-241.

Gaillard, C., S. Mishra, M. Singh, S. Deo and R. Abbas 2010b. Reply To:'Comment On Lower and Early Middle Pleistocene Acheulian in the Indian Sub-Continent' by P. Chauhan, *Quaternary International* 223: 260-264.

Gaillard, C., D. Raju, V. Misra and S. Rajaguru 1986. Handaxe Assemblages from the Didwana Region, Thar Desert, India: A Metrical Analysis, *Proceedings of the Prehistoric Society* 52: 89-214.

Haslam, M., R.G. Roberts, C. Shipton, J. Pal, J.L. Fenwick, P. Ditchfield, N. Boivin, A. Dubey, M. Gupta and M. Petraglia 2011. Late Acheulian Hominins at the Marine Isotope Stage 6/5e Transition in North-Central India, *Quaternary Research* 75(3): 670-682.

Joshi, R. 1964. Acheulian Succession in Central India, *Asian Perspectives* 8 (1): 150-163.

Kailath, A., T. Rao, R. Dhir, K. Nambi, V. Gogte and A. Singhvi 2000. Electron Spin Resonance Characterization of Calcretes from Thar Desert for Dating Applications, *Radiation Measurements* 32(4): 371-383.

McPherron, S.P. 2006. What Typology Can Tell Us about Acheulian Handaxe Production, in *Axe Age: Acheulian Tool-Making from Quarry to Discard* (N. Goren Inbar and G. Sharon Eds.), pp. 267-285. London: Equinox.

Mishra, S. 1994. The South Asian Lower Palaeolithic, *Man and Environment* 19(1-2): 57-72.

Mishra, S. 1995. Chronology of the Indian Stone Age: The Impact of Recent Absolute and Relative Dating Attempts, *Man and Environment* 20 (2): 11-16.

Mishra, S. 2007. The Indian Lower Palaeolithic, *Bulletin of the Deccan College Postgraduate and Research Institute* 66: 47-94.

Mishra, S., S. Deo, R. Abbas, S. Naik, G. Shete, N. Agrawal and S. Rajaguru 2008. Excavations at the Early Acheulian Site of Morgaon, Maharashtra (2000–2007), in *Recent Research Trends in South Asian Archaeology* (Paddayya K., P. P. Joglekar, K. K. Basa and R. Sawant Eds.), pp. 121-137. Pune: Deccan College.

Mishra, S., T. Venkatesan, S. Rajaguru and B. Somayajulu 1995. Earliest Acheulian Industry from Peninsular India, *Current Anthropology* 36(5): 847-851.

Misra, V. N. 1978. The Acheulian Industry of Rock Shelter IIIF-23 at Bhimbetka, Central India: A Preliminary Study, *Australian Archaeology* (8): 63-106.

Misra, V.N., S.N. Rajaguru, R. Wasson, G. Singh and D. P. Agrawal 1982. Further Light on Lower Palaeolithic Occupation and Palaeoenvironment in Semi-Arid Zone of Rajasthan, *Purātattva* 11: 11.

Paddayya, K. 2007. Evolution within the Acheulian in India: A Case Study from the Hunsgi and Baichbal Valleys, Karnataka, *Bulletin of the Deccan College Research Institute* 66-67: 95-111.

Paddayya, K., B. Blackwell, R. Jhaldiyal, M. Petraglia, S. Fevrier, D.A. Chaderton II, I.I.B. Blickstein and A.R. Skinner 2002. Recent Findings on the Acheulian of the Hunsgi and Baichbal Valleys, Karnataka, with Special Reference to the Isampur Excavation and Its Dating, *Current Science* 83(5): 101-107.

Paddayya, K., R. Jhaldiyal and M.D. Petraglia 1999. Geoarchaeology of the Acheulian Workshop at Isampur, Hunsgi Valley, Karnataka, *Man and Environment* 24(1): 167-184.

Paddayya, K. and M.D. Petraglia 1997. Isampur: An Acheulian Workshop Site in the Hunsgi Valley, Gulbarga District, Karnataka, *Man and Environment* 22 (2): 95-110.

Pappu, S., Y. Gunnell, K. Akhilesh, R. Braucher, M. Taieb, F. Demory and N. Thouveny 2011. Early Pleistocene Presence of Acheulian Hominins in South India, *Science* 331(6024): 1596-1599.

Petraglia, M., P. Laporta and K. Paddayya 1999. The First Acheulian Quarry in India: Stone Tool Manufacture, Biface Morphology, and Behaviors, *Journal of Anthropological Research* (55): 41-70.

Petraglia, M.D., J. Schuldenrein and R. Korisettar 2003. Landscapes, Activity, and the Acheulian to Middle Paleolithic Transition in the Kaladgi Basin, India, *Eurasian Prehistory* 1(2): 3-24.

Roux, V. and B. Brill 2005. *Stone Knapping: The Necessary Conditions for a Uniquely Hominin Behaviour.* Cambridge: McDonald Institute for Archaeological Research.

Sangode, S., S. Mishra, S. Naik and S. Deo 2007. Magnetostratigraphy of the Quaternary Sediments Associated with Some Toba Tephra and Acheulian Artefact Bearing Localities in the Western and Central India, *Gondwana Magazine* 10: 111-121.

Sharon, G. and P. Beaumont 2006. Victoria West: A Highly Standardized Prepared Core Technology, in *Axe age: Acheulian toolmaking from Quarry to Discard* (N. Goren Inbar and G. Sharon Eds.), pp. 181-200. London: Equinox.

Shipton, C. 2011. Taphonomy and Behaviour at the Acheulian Site of Kariandusi, Kenya, *African Archaeological Review* 28(2): 141-155.

Shipton, C. 2013. *A Million Years of Hominin Sociality and Cognition: Acheulian Bifaces in the Hunsgi-Baichbal Valley, India*. Oxford: Archaeopress (British Archaeological Reports).

Shipton, C., C. Clarkson , J.N.Pal , S.C.Jones , R.G.Roberts, C. Harris , M.C.Gupta , Ditchfield, P.W. and M.D. Petraglia 2013. Generativity, Hierarchical Action and Recursion in the Acheulian to Middle Palaeolithic Transition: A Perspective from the Son Valley, India, *Journal of Human Evolution* http://dx.doi.org/10.1016/j.jhevol.2013.03.007

Shipton, C., M. Petraglia and K. Paddayya 2009a. Acheulian Biface Refinement in the Hunsgi-Baichbal Valley, Karnataka, India in *Theoretical and Methodological Issues in Evolutionary Archaeology: Toward a Unified Darwinian Paradigm*.(H. J. Muscio and G. E. J. Lopez Eds.) pp. 95-102. Oxford: Archaeopress.

Shipton, C., M. D. Petraglia and K. Paddayya 2009b. Stone Tool Experiments and Reduction Methods at the Acheulian Site of Isampur Quarry, India, *Antiquity* 83(321): 769-785.

Szabo, B., C. Mckinney, T.S. Dalbey and K. Paddayya 1990. On the Age of the Acheulian Culture of the Hunsgi-Baichbal Valleys, Peninsular India, *Bulletin of the Deccan College Postgraduate and Research Institute* 50: 317-321.

Claire Gaillard and Mukesh Singh, in *Recent Advances in Acheulian Culture Studies in India*
(K.Paddayya and S.G. Deo Eds.), pp. 37-46 [2014]

The Acheulian in the Siwaliks of Northwestern India

Claire Gaillard and Mukesh Singh[1]

Department of Prehistory, National Museum of Natural History, IPH, 1 rue René Panhard, 75013 Paris
E-mail: gaillacl@mnhn.fr

1 Society for Archaeological and Anthropological Research, H. n° 1447, 160022 Chandigarh
E-mail: muksingh21@yahoo.co.in

Abstract

The Siwalik Hills that fringe the Himalayan Range provide evidence of Acheulian occupation mainly in the western sector. Between the Beas and Ghaggar rivers, the Acheulian-yielding localities are located along the faults bordering the Siwalik Frontal Range on both sides. The recent reactivation of these faults exposes sediments of the Pinjor Formation and the Acheulian tools embedded in them; these date to between 1 Ma and 0.6 Ma. Nearly 20 localities have been recorded so far. The main Acheulian site is Atbarapur in Hoshiarpur district, where 15 handaxes and 37 cleavers have been found in association with choppers, cores and flakes. The Acheulian implements from the western Siwaliks are made on large flakes obtained through a simple core reduction method and with short sequences of production. They belong to the "Large Flake Based Acheulian" tradition identified in Africa, the Near East and South Asia.

Introduction

Acheulian occupation is attested by a few sites in the Siwalik Range bordering the Himalayas, especially in the western reaches. The Siwaliks are mostly known for the Soanian Palaeolithic tradition (Early and Late Soanian), represented by numerous sites yielding mostly cobble tools and being located on the river terraces as well as on the divides. Typical Acheulian tools (handaxes and cleavers) usually occur in small numbers at "find spots" rather than sites proper. They are mostly found on the Pinjor Formation or in the *choes* (seasonal streams) eroding it, and therefore they probably originate from this formation. They are often abraded and are never as well preserved as the Soanian artefacts occurring in the vicinity, as noticed by many field archaeologists (for instance, Allchin 1995; Teilhard de Chardin 1936). The difference between Acheulian and Soanian tool kits in the Siwaliks is therefore not a matter of different cultures, as stated by de Terra and Paterson (1939) and emphasized by Movius (1944), but a matter of chronology (Gaillard and Mishra 2001; Mishra 2008); the so-called Late Soanian belongs to the Middle Palaeolithic (Lycett 2007; Teilhard de Chardin 1936; de Terra and Paterson 1939) while the Early Soanian seems to be related to the Hoabinhian in South-east Asia (Gaillard *et al.* 2011, 2012) and therefore actually postdates the Late Soanian. In other words, it would belong to the late Pleistocene.

From the earliest surveys in the 1930s Acheulian artefacts have been reported especially from the Potwar plateau in the western Siwaliks (Teilhard de Chardin 1936; Teilhard de Chardin and de Terra 1936; de Terra and Paterson 1939). Further southeast, the first Acheulian tools were discovered in the 1970s in the Janauri anticline / Hoshiarpur Siwalik Frontal Range, between the Beas and the Sutlej (Mohapatra 1981, 1990; Mohapatra and Singh 1979). Later on, Acheulian was also evidenced in the Chandigarh Siwalik

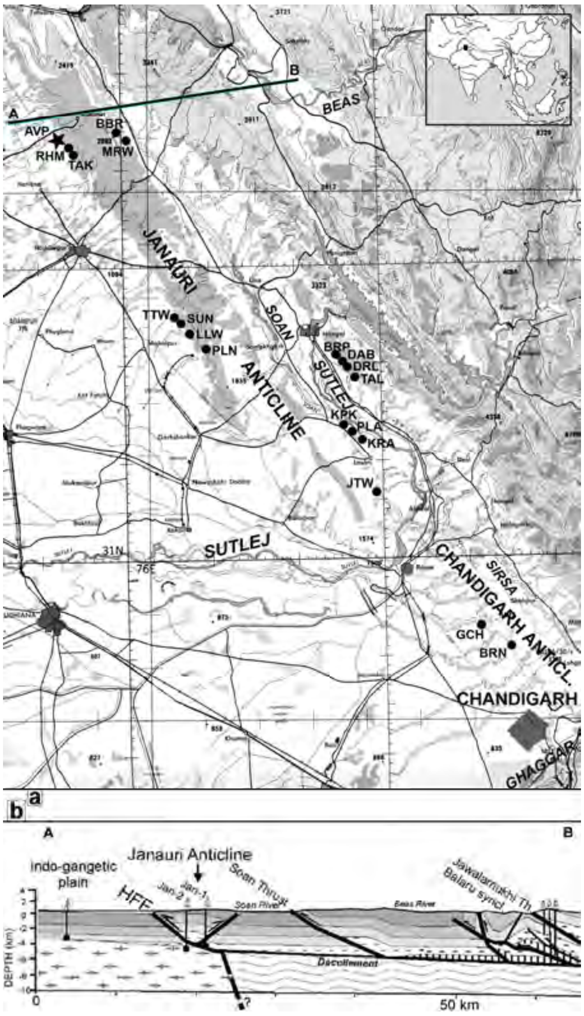


Fig. 1a: Map showing the Acheulian sites in the Siwaliks of north-western India; from North to South: Atbarapur (AVP), Rahmnapur (RHM), Takhni (TAK), Baber (BBR), Marwari (MRW), Tutewal (TTW), Suna (SUN), Lalwan (LLW), Polian (PLN), Brahmpur (BRP), Dabkera (DAB), Drauli (DRL), Taluh (TAL), Kahnpur Khui (KPK), Plata (PLA), Karura (KRA), Jatwar (JTW), Gochar (GCH), Bari Nagal (BRN).
b: Structural cross-section following line A-B of the map above (after Delcaillau *et al*. 2006; Powers *et al*. 1998).

Frontal Range, between the Sutlej and Ghaggar rivers and then on the Sutlej terrace T2 (Kumar and Rishi 1986; Singh *et al*. 1998). The artefacts usually occur either on the surface of the Pinjor Formation, spanning from 2.6 Ma to between 1 Ma and 0.6 Ma (Nanda 2002) or on the slopes of Sutlej terraces, except at Thalu in the Soan-Sirsa *dun* (tributaries of the Sutlej), where two cleavers have been found *in situ* in the section of the terrace T2 (Singh *et al.* 1998).

Atbarapur, located in Hoshiarpur district of Punjab (Fig. 1) is the only site so far known in the entire Siwaliks, where more than 50 typical Acheulian artefacts have been found, along with flakes, cobble tools and cores (Rishi 1989). This paper bears on the Acheulian tradition in northwestern India, mostly represented by the collection from Atbarapur but also from nearly 20 other localities.

Geographical and Geological Context

The majority of Acheulian sites are located on the slopes of the Siwalik Frontal Range. This hill range is mostly made up of Upper Siwalik Formations: Tatrot (late Pliocene), Pinjor (Lower Pleistocene and at places Middle Pleistocene) and Boulder Conglomerate (discontinuous and time-transgressive formation belonging to the Lower and/or Middle Pleistocene). During and after uplift, which started in the second half of the Middle Pleistocene and continued till the early Holocene (Delcaillau *et al.* 2006), the relief was reshaped by the rivers and *choes*, entrenching the sediments and forming terraces. Most of the Acheulian sites are in the context of *choes* and gullies facing the Punjab plains (Fig. 1a), especially the richest site of Atbarapur in Hoshiarpur district. The neighbouring localities of Rehmnapur and Takhni also yield Acheulian tools, as well as further south at the sites of Tutewal, Suna, Lalwan and, inside the hills, Polian. To the east of Atbarapur on the other slope of the range and facing the Soan-Sirsa *dun* (structural valley between Lesser Himalayas and Siwalik Frontal Range), are the sites of Baber and Marwari. Further south-east, Khanpur Khui, Plata, Karura, and Jatwar have provided a few typical tools. To the southeast of the Sutlej the Chandigarh Siwalik Frontal Range extends up to the Ghaggar River; near the villages of Bari Nagal and Gochar, a few handaxes and cleavers have also been found from the piedmont slopes towards the Punjab Plains, on deposits eroding from the Pinjor Formation.

In the alluvium of the terrace T2 of the Sutluj river, in the *dun* close to the confluence with the Soan, some Acheulian occurrences have been discovered at Brahmpur, Dabkera, Drauli and Taluh (Singh *et al.* 1998).

At Atbarapur the *choe* where artefacts occur starts in the Siwalik Hills and flows towards the Punjab plains; its course is *ca.* 1.6 km long. It is bordered by terraces on both sides near its outlet from the Siwalik Hills. Unfortunately (for archaeologists) the construction of a dam has now partly filled up this *choe* with silty deposits and considerably modified the local landscape. The Acheulian collection was mainly made in the years immediately following the discovery of the site in 1978; a few more tools were found upstream in 2003. Surrounding outcrops are comprised of sandstones with inter-bedding, loose conglomerates composed of quartzite pebbles, cobbles and boulders, belonging to the Pinjor Formation (Rishi 1989).

Chronology

Although radiometric dates are not available for the Acheulian occurrences from the Siwaliks, their consistent geological context provides some chronological indication. It is especially striking that most of the Acheulian localities in north-western India are aligned along the two faults which pinch the Siwalik Frontal Range upwards on both sides, south-western (Punjab Plains) and northeastern (Soan-Sirsa *dun)* (Fig. 1a and 1b). This particular position of the sites suggests that the reactivation of the faults, especially the Himalayan Frontal Thrust (Malik and Mohanty 2007), increased the rate of erosion and resulted in exposing the archaeological material buried in the Upper Siwalik formations, mainly in the Pinjor Formation, as the Boulder Conglomerates is almost absent in this sector and Tatrot Formation is too deep to be exposed (except in a few places). The Pinjor Formation begins at the Gauss / Matuyama boundary and ends at different times according to the locations. In the Chandigarh anticline, the palaeomagnetic analysis of the entire stratigraphic sequence along the Patiali Rao *choe*, demonstrated that the last deposits of Pinjor Formation occurred around 0.6 Ma (Ranga Rao 1993). The availability of cobbles and boulders for the Acheulian people to make their tools implies that they were occupying the region in the later stages of the Pinjor deposition, as conglomeratic layers were becoming more frequent, especially around 1 Ma, due to active uplift in the Himalayas (Nanda 2002). Therefore it is highly probable that the Acheulian occupation occurred in this region during the Lower Pleistocene or early Middle Pleistocene, between 1 Ma and 0.6 Ma. At that time the landscape was still the extension of the Indo-Gangetic Plains.

A similar time period was proposed for the Acheulian artefacts from Dina and Jalapur in the Jhelum basin (Siwaliks of Pakistan). These occurring in uplifted (at about 0.5 or 0.4 Ma) sediments belonging to the Brunhes chron, they were dated to between 0.7 and 0.4 Ma (Rendell and Dennell 1985; Rendell *et al*. 1989). At Satpati, in central Nepal, the Upper Siwalik formation equivalent to Pinjor and therefore dated to before 0.6 Ma, has yielded a few handaxes (Corvinus 1990, 1995a,b, 2007). In Peninsular India, the Acheulian is dated to 1.5 Ma at Attirampakkam in Tamil Nadu (Pappu *et al*. 2011) and to 1.2 Ma at Isampur in Karnataka (Paddayya *et al*. 2002). It belongs to the Lower Pleistocene in several sites (Gaillard *et al*. 2010a, b, Sangode *et al*. 2007) e.g. Morgaon in Maharashtra (Deo *et al.* 2007; Mishra *et al*. 2009) and Singi Talav near Didwana in Rajasthan (Kailath *et al.* 2000). It is dated to 0.67 Ma at Bori in Maharashtra (Mishra *et al*. 1995).

Composition of the Assemblages

From the different find spots, the assemblages are almost exclusively composed of cleavers and handaxes. Apart from Atbarapur, a total of 8 handaxes and 16 cleavers have been collected (at least analysed in the present study) during the last 30 years. The ratio of about 1/3 of handaxes and 2/3 of cleavers among the typical Acheulian artefacts is the same as in the Atbarapur series. From Atbarapur, the assemblage is more diverse but it is characterized by a majority of typical Acheulian tools, i. e. handaxes and cleavers (15 and 37, respectively). Although their relative numbers to the total collection may have little statistical significance as a sample from a reworked site, like Atbarpur their proportions relative to each other are relevant -it is in agreement with the overall collections from the Siwaliks of north-western India. Besides these Acheulian tools made on large flakes there are only a few other tools on flake: 2 knives (large backed scrapers), one scraper and one denticulate. Unretouched flakes represent a small group (10) and half of them are large flakes (> 10 cm). The choppers, made on both flakes and cobbles, are as equally represented as the cores, usually on cobbles (13 of each). The Atbarapur assemblage is quite homogenous as far as the size is concerned: large cores are missing as well as small flakes. It may be a result of taphonomic processes or it may relate to the management of lithic production by the Acheulian group.

As for the dimensions of the Acheulian tools from all other localities, they are quite homogenous as well. The graph representing the breadth *vs.* length (Fig. 2) is almost symmetrical, showing that the large flakes, either end-struck or side-struck, were selected (or produced) according to their dimensions. However side-struck flakes are more common than end-struck flakes.

Raw Materials

All of these artefacts are on medium to fine-grained quartzite, which is rather dark in colour (red, green, grey). In the Siwaliks, dark-coloured quartzites are more silicified and homogenous than the light-coloured ones and they were usually selected by prehistoric people for making tools. These rocks were collected in the form of cobbles and boulders, as can be assumed from the patches of cortex remaining on the artefacts. These cobbles and boulders are available in the riverbeds and in the Upper Siwalik formations where they were brought by rivers from the Himalayas. In the Pinjor formation they can be found in occasional conglomeratic beds, becoming more frequent in the upper part up to the Boulder Conglomerate.

Cleavers

The cleavers represent the most important component of the Acheulian collection from the Siwaliks (Figs. 3-5); they are twice the number of handaxes. Almost all of them are made on side-struck flakes, only a few being on end-struck flakes; one is on a split cobble. Striking platforms are as often cortical as plain non-cortical; among the latter, dihedral platforms are quite common. The others are not identifiable as they have been removed by shaping. The percussion point is often in the angle although not on the majority of the flake-blanks. Many dorsal faces are entirely cortical, but the majority are without cortex or with a small cortical patch, often as a back. Among the latter, the Kombewa flakes or flakes from split cobbles/boulders are the most common. Such flakes are absent in the handaxe group. The cleavers are usually shaped on the margins only; sometimes the scars extend to half of each face or even more, especially on the ventral face (this may be related to the thinning of the bulb). For half of the cleavers shaping consists of just one generation of scars without further regularization of the edges (which are not supposed to be working edges). The others show two generations and rarely more. Therefore, the original shape of the blank flakes is hardly modified. The outlines are mostly trapezoidal, rectangular or oval.

By definition, the cleavers have an unretouched transversal cutting edge. It is supposed to be the main functional part of the tool, but the other edges may have been utilised as well. Damage, possibly by utilisation, is attested by chipping on the edge, either on both faces or on one face only, and there are a few edges that appear intact. The butt opposite to the cutting edge is a bevel (edge angle > 50°) in most cases, otherwise it is a steep edge (or back) and rarely a cutting edge. Chipping and sometimes crushing (use marks or natural damage?) are observed on the cleavers' base whatever their form, if they are devoid of cortex. It seems there is no link between the damage/utilisation of the cleaver cutting edge and that of the butt. All the lateral edges of the cleavers are shaped, barring four exceptions. This shaping does not modify much of the original morphology of edges and it is bifaciallly executed in nearly half of the cleavers. Most of the edges are either steep, forming a back, or bevelled; they are rarely sharp. Damage or use marks are quite common on the lateral edges, especially chipping and more rarely crushing marks.

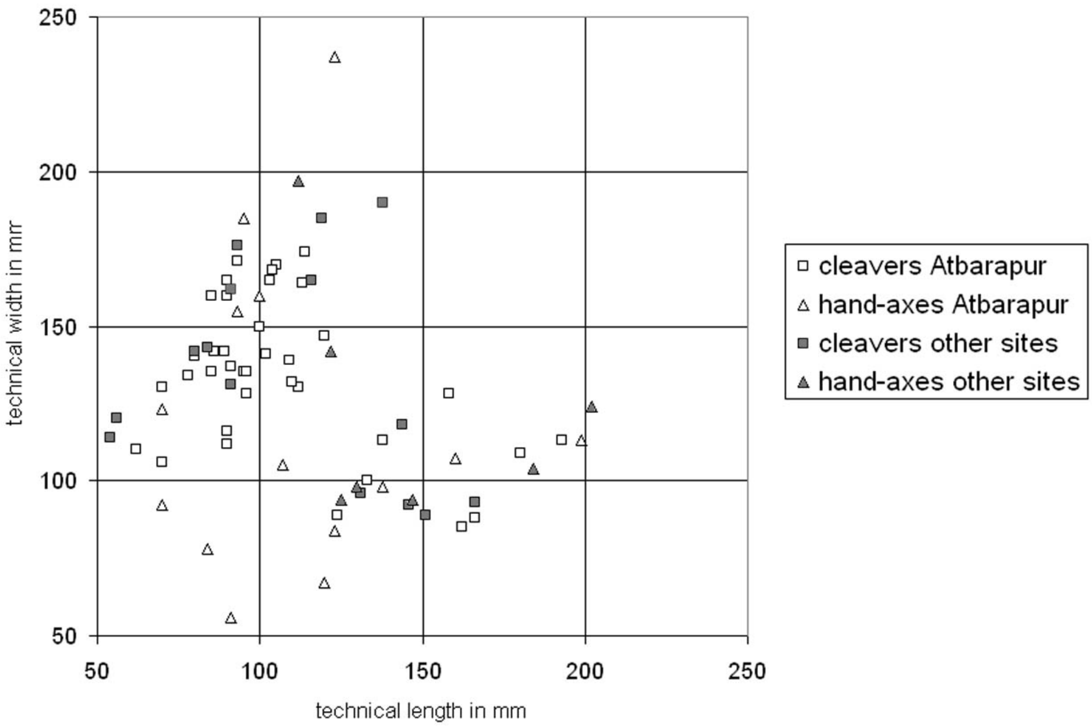


Fig. 2: Bi-dimensional diagram of length and width of Acheulian tools from the Siwaliks of north-western India measured according to their technological orientation (flake-blank orientation, except for the few undetermined blanks: morphological orientation)

Handaxes

All of the handaxes are made on flakes, except one that was possibly made on a small slab and a few undetermined blanks, all without any remaining cortex (Fig. 6). Therefore none of these tools are made directly from a cobble. When the flakes used as blanks still keep their striking platform or some technological orientation mark, they appear as side-struck flakes (technically short) more often than end-struck flakes (technically long). Only in a few cases striking platforms are preserved (others are removed by the shaping): they are more often cortical than without cortex. When visible, the point of percussion is usually at an angle rather than in the middle. The dorsal face is variable: it is often without cortex or with just some cortex on a lateral steep side (back), and in some cases it is entirely cortical or partly cortical. It is to be noted that no Kombewa flakes are identifiable among the handaxes, unlike in case of cleavers. Kombewa flakes, removed from the bulbar, ventral face of larger flakes usually offer a sharp cutting edge on the long side of their periphery. They are ideal for making cleavers, whereas they do not fit the pattern of handaxes.

Fig. 3: Cleavers from Atbarapur

Fig. 4: Cleaver from Karura

Fig. 5: Cleaver from Drauli

The flake scars resulting from shaping (and sharpening) the blanks into handaxes never cover the entire faces, except one example, which is typo-technologically between a hand-axe and a core. Apart from this one, trimming generally extends to about half of each face, slightly more on the ventral face than on the dorsal face. Usually two generations of scars can be observed, the second one regularizing the edge shaped by the first one. A few handaxes are trimmed by one generation of flaking only; some others are more carefully worked and show three generations.

Fig. 6: Handaxe from Bari Nagal

The overall shape of the handaxes is either triangular or oval, except one that has a trapezoidal shape and also excluding broken specimens. It is interesting to observe that none of them is properly pointed. Most of the tips are more or less rounded or they are cutting edges or short steep edges, others being broken. Some of these tips are not even trimmed; when trimmed, the retouch is unifacial rather than bifacial. Damage (use marks?) is very common in the form of chipping, either on both faces or on one face only. One of the tips also bears crush marks. The butt of the handaxes is unworked on a third of them and otherwise trimmed by unifacial inverse or bifacial retouch into a bevel or a sharp cutting edge or even a point. The butts seem to have been utilised too, as they show some chipping; crush marks occur on one of the cortical butts. Most of the lateral edges of the handaxes are more than 50° (bevel); only a few specimens have sharper edges. They are usually bifacially trimmed on both sides but three of them have only one bifacial edge, the opposite one being unifacially worked.

The handaxes from the Siwaliks are made on large flakes not much modified by flaking which barely covers more than half of each face. Therefore these tools result from limited work and the points are not especially shaped: they appear to be just the continuation and junction of the lateral edges. These tools were utilised in many ways as they show use marks in the form of chipping on different parts of their edges, preferentially on the cutting edges but also on the steep sides, whatever their location (the lateral sides, the tip or the butt).

Core Reduction Sequence

The assemblage recovered from Atbarapur (nearly 100 artefacts) allows a reconstruction of the core reduction process (Gaillard *et al.* 2008, 2010b). In this assemblage the flakes are on average bigger than the cores. Therefore the former did not result from the reduction of the latter, or they may represent the first stage only of their reduction sequence when the debitage products are at their largest size. However, the assemblage from Atbarapur, has neither any exhausted core nor any core showing intensive exploitation, possibly deriving from a big nodule having previously provided large flakes. Moreover, the study of the cores and their remaining cortex shows that they were all probably cobbles at the beginning of the reduction sequence and were already smaller than the large flakes. Therefore these large flakes cannot correspond to the first stage of exploitation of the cores from Atbarapur: they definitely derived from other larger cores, which are not found at the site.

Nonetheless, the method of flaking is quite similar for both types of production (large and small). The flakes from the assemblage suggest six or seven products from each cobble/boulder-core and the studied cores show a mean number of seven scars, involving an average production of seven to nine flakes. The flaking directions are, both on flakes and cores, mostly unidirectional, but these are sometimes perpendicular or crossed. There is no preparation of the striking platforms (usually plain) nor of the flaked surfaces and this is clearly visible on both the flakes and the cores. The Kombewa method or production from split cobbles or boulders is witnessed by several flakes and suggested by some of the cores.

A notable feature of this debitage is the high proportion of short flakes, which may indicate that no attention was paid to the longitudinal convexity of the cores. This is also a simple and convenient method for obtaining a wide cleaver cutting edge on the lateral side of the flake, formed by the previous removal from the same striking platform (unipolar exploitation of the core). The point of percussion at the angle of the flakes, for one quarter of them, remains to be understood through more detailed observation and experimentation. The Kombewa method, also used for a quarter of the production, may be advantageous for producing large cutting edges. Therefore, although simple, the core reduction sequence was oriented and adapted to the production of blanks for manufacturing cleavers.

It seems that the large and small flakes were produced in parallel sequences at one or at several locations. Right from the beginning the cores were selected according to the size of the flakes to be produced. Both groups were processed in the same way, following a short and simple sequence (mostly less than ten flakes per core).

Conclusion

The Acheulian in the Siwaliks of northwestern India is known from find spots yielding only a few tools, and also from the site of Atbarapur (Hoshiarpur district), the only one in the entire Siwalik Range having so far provided more than 50 handaxes and cleavers in association with other artefacts. Most of these occurrences are located between the Beas and Ghaggar rivers in the Siwalik Frontal Range along the faults linked to its uplift. This location implies an age between 1 and 0.6 Ma. A few sites are in the context of the Sutlej river terraces. This Acheulian technological tradition is characterized by predominance of cleavers over handaxes (2/3 and 1/3 respectively among the large cutting tools). Both tool types are made on large flakes obtained through simple core reduction methods and short sequences of production. These large flakes perfectly meet the needs for cleaver manufacture:

minimal shaping (confined to the edges) turns them into tools. For the handaxes the process of shaping is more developed (larger flake removals, sometimes stepped) but does not thoroughly modify the original blanks. Atbarapur assemblage is composed of large flakes (> 10 cm) on the one hand, and of cores, choppers and very few smaller flakes on the other. Both groups are almost equal in number. They correspond to two parallel reduction sequences following the same modalities, but one uses boulders as cores (absent at the site) and the other uses cobbles (from which the flake products are missing). Such a situation of incomplete sequence of production is common at the Acheulian sites. Apart from the formation processes, the splitting of the *chaîne opératoire* in several places and the time span implied in this process result in incomplete sets of products at each locality (Mishra 2008). Similar behaviour is observed in peninsular India and also in Africa (see for example Torre *et al*. 2008). The Acheulian industry from the Siwaliks of northwestern India displays techno-typological features that refer to the "Large Flake Based Acheulian" (Sharon 2007) well represented in Africa, Near East and South Asia (Mishra *et al*. 2010).

References

Allchin, B. 1995. Early Human Cultures and Environments in Pakistan, in *Quaternary Environment and Geoarchaeology of India* (S. Wadia, R. Korrisettar and V.S. Kale Eds), pp. 150-167. Bangalore: Geological Society of India Memoir 32.

Corvinus, G. 1990. A Note on the Discovery of Handaxes in Nepal. *Man and Environment* 15(2):9-11.

Corvinus, G. 1995a. Quaternary Stratigraphy of the Intermontane Dun Valleys of Dang-Deokhuri and Associated Prehistoric Settlements in Western Nepal, in *Quaternary Environment and Geoarchaeology of India* (S. Wadia, R. Korrisettar and V.S. Kale Eds), pp. 124-149. Bangalore: Geological Society of India Memoir 32.

Corvinus, G. 1995b. The Satpati Handaxe Site and the Chabeni Uniface Site in Southern Nepal, *Quartär* 45/46:15-36.

Corvinus, G. 2007. *Prehistoric Cultures in Nepal*, Volume 1 and 2. Wiesbaden: Harrassowitz Verlag,

Delcaillau, B., J.M. Carozza, E. Laville 2006. Recent Fold Growth and Drainage Development: The Janauri and Chandigarh anticlines in the Siwalik foothills, Northwest India, *Geomorphology* 76: 241–256.

Deo, S., S. Mishra, S.N. Rajaguru and S. Ghate 2007. Antiquity of Acheulian culture in upland Maharashtra. A geoarchaeological approach, in *Genome and People of India* (Sankhyan, A.R. Ed.), pp. 292–308. Calcutta: Concept Publishers.

Gaillard, C. and S. Mishra 2001. The Lower Palaeolithic in South Asia, in *Origin of Settlements and Chronology of the Paleolithic Cultures in Southeast Asia.* (Semah, F., Falgueres, C., Grimaund-Herve, D and Semah A-M. Semenanjuang Eds), pp.73-92. Paris.

Gaillard, C., S. Mishra, M. Singh, S. Deo and R. Abbas 2010a. Lower and early Middle Pleistocene Acheulian in the Indian sub-continent, *Quaternary International* 223-224: 234-241.

Gaillard, C., M. Singh, K.K. Rishi and V. Bhardwaj 2010b. Atbarapur (Hoshiarpur District, Punjab), the Acheulian of the Siwalik Range within the South Asian context, *Comptes Rendus Palevol* 9(5): 237-243.

Gaillard, C., M. Singh and A. Dambricourt Malassé 2011. Late Pleistocene to early Holocene lithic industries in the Southern Fringes of the Himalaya, *Quaternary International* 229: 112-122.

Gaillard, C., M. Singh and A. Dambricourt Malassé 2012. Hoabinhian in the Siwaliks of north-western India? in *Crossing Borders – Selected Papers from the 13th International Conference of the European Association of Southeast Asian Archaeologists* (Tjoa-Bonatz M.L., Reinecke A. & Bonatz D. Eds.), pp. 13-25. Singapore: NUS Press.

Gaillard, C., M. Singh and K.K. Rishi 2008. Technological Analysis of the Acheulian Assemblage from Atbarapur in the Siwalik Range (Hoshiarpur District, Punjab), *Man and Environment* 33 (2): 1-14.

Kailath, A.J., T.K.G. Rao, R.P.Dhir, K.S.V. Nambi, V.D. Gogte, A.K. Singhvi 2000. Electron Spin Resonance Characterization of Calcretes from Thar Desert for Dating Applications, *Radiation Measurements* 32: 371-383.

Kumar, M. and K.K. Rishi 1986. Acheulian Elements from Hoshiarpur Region (Punjab), *Man and Environment* 10: 141-142.

Lycett S.J. 2007. Is the Soanian Techno-Complex a Mode 1 or Mode 2 Phenomenon? A Morphometric Assessment, *Journal of Archaeological Science* 34: 1434-1440.

Malik, J.N. and C. Mohanty 2007. Active Tectonic Influence on the Evolution of Drainage and Landscape: Geomorphic Signatures from Frontal and Hinterland Areas along the Northwestern Himalaya, India, *Journal of Asian Earth Sciences* 29: 604-618.

Mishra, S. 2008. The Indian Lower Palaeolithic, *Bulletin of the Deccan College Research Institute*, 66–67: 47–94.

Mishra, S., S. G. Deo, R. Abbas, S. Naik, G. Shete, N. Agrawal and S. N. Rajaguru 2009. Excavations at the Early Acheulian site of Morgaon, Maharashtra (2000-2007), in *Recent Research Trends in South Asian Archaeology*(Paddayya, K., P. P., Joglekar, K. K. Basa, and R. Sawant Eds.), pp. 121-137. Pune: Deccan College.

Mishra, S., C. Gaillard, S. Deo, M. Singh, R. Abbas and N. Agrawal 2010. Large Flake Acheulian in India: Implications for understanding Lower Pleistocene Human Dispersals, *Quaternary International* 223-224: 271-272.

Mishra, S., T.R. Venkatesan, S.N. Rajaguru and B.L.K. Somayajulu 1995. Earliest Acheulian Industry from Peninsular India, *Current Anthropology* 36: 847-851.

Mohapatra, G.C. 1981. Acheulian Discoveries in the Siwalik Frontal Range, *Current Anthropology* 22(4):433-435.

Mohapatra, G.C. 1990. On the Track of Early Man in Western Sub-Himalayas, *Presidential Address, 77th Indian Science Congress*, Indian Science Congress Association, Calcutta.

Mohapatra, G.C. and M. Singh 1979. Acheulian Discoveries in the Siwalik Frontal Range of Western Sub-Himalayas, *Punjab University Research Bulletin* 10(1-2): 65-77.

Movius, H.L. Jr., 1944. *Early Man and Pleistocene Stratigraphy in Southern and Eastern Asia.* Peabody Museum Paper 19.

Nanda, A. C. 2002. Upper Siwalik Mammalian Faunas of India and Associated Events, *Journal of Asian Earth Sciences* 21: 47-58.

Paddayya, K., B.A.B. Blackwell, R. Jhaldiyal, M.D. Petraglia, S. Fevrier, D.A. Chaderton II, J.I.B. Blickstein and A.R. Skinner 2002. Recent findings on the Acheulian of the Hunsgi and Baichabl valleys, Karnataka, with special reference to the Isampur excavation and its dating, *Current Science* 83(5): 641-647.

Pappu, S., Y. Gunnell, K. Akhilesh, R. Braucher, M. Taieb, F. Demory, N. Thouveny 2011. Early Pleistocene Presence of Acheulian Hominins in South India, *Science* 331: 1596-1599.

Powers, P.M., R.J. Lillie and R.S. Yeats 1998. Structure and Shortening of the Kangra and Dehra Dun Reentrants, Sub-Himalaya, India, *GSA Bulletin* 110 (8): 1010– 1027.

Ranga Rao, A., 1993. Magnetic Polarity Stratigraphy of Upper Siwalik of North-western Himalayan Foothills, *Current Science* 64 (11–12): 863–873.

Rendell, H. and R.W. Dennell 1985. Dated Lower Palaeolithic Artefacts from Northern Paksitan, *Current Anthropology* 26 (5): 393-395.

Rendell, H., R.W. Dennell and M.A. Halim 1989. *Pleistocene and Palaeolithic Investigations in the Soan*

Valley, Northern Pakistan., Oxford: B.A.R. International Series 544.

Rishi, K.K. 1989. *Palaeoliths from Atbarapur, Punjab*, Department of Cultural Affairs, Archaeology and Museums, Punjab.

Sangode, S., S. Mishra, S. Naik, S. Deo 2007. Magnetostratigraphy of the Quaternary Sediments Associated with Some Toba Tephra and Acheulian Artefact-bearing Localities in the Western and Central India, *Gondwana Magazine* Special Volume 10: 111–121.

Sharon, G. 2007. *Acheulian Large Flake Industries: Technology, Chronology and Significance*. Oxford: BAR International Series, 1701. Archaeopress.

Singh, M., B.S. Karir and S.N. Chopra 1998. *Prehistoric and Quaternary Studies of the Roop Nagar District of Punjab,* Research project sponsored by the Government of Punjab, Department of Cultural Affairs, Archaeology & Museums, Chandigarh, 265 pp. (unpublished manuscript).

Teilhard de Chardin, P. and H. de Terra 1936. Observations on the Upper Siwalik Formation and Later Pleistocene Deposits in India, *Proceeding of the American Philosophical Society* 76 (6): 791-822.

Teilhard de Chardin, P. 1936. Joint Geological and Prehistoric Studies in the Late Cenozoic in India, *Science*, 83, 2149: 233-236.

Terra, H. de and T.T. Paterson 1939. *Studies on the Ice Age in India and Associated Human Cultures.* Washington,D.C.: Carnegic Institution.

Torre, I.de la, R. Mora, J. Martınez-Moreno 2008. The early Acheulean in Peninj (Lake Natron, Tanzania). *Journal of Anthropological Archaeology* 27: 244–264.

V.N. Misra, in *Recent Advances in Acheulian Culture Studies in India*
(K.Paddayya and S.G. Deo Eds.), pp. 47-56 [2014]

An Overview of Acheulian Culture in the Thar Desert and at Bhimbetka, Central India

V.N. Misra
G-2, B Wing, Ganga Park
Mundhawa Road
Pune 411 036
E-mail: vnmisra1935@gmail.com

Abstract

Based on the research of my prolonged field studies including detailed excavations of Stone Age sites (Palaeolithic to Mesolithic) in the western and central parts of the country, this paper presents a résumé of the palaeoenvironmental and cultural aspects of the Acheulian assemblages from Singi Talav in Rajasthan and rockshelter III-F-23 at Bhimbetka in Madhya Pradesh.

Introduction

The discovery of a palaeolith by Robert Bruce Foote at Pallavaram, near Chennai, on the 30th May 1863 was an event of unprecedented importance. It laid the foundation of Indian prehistory. Much of the later work was inspired by Foote's pioneering discovery and it continues to do so to this day. For his monumental contribution Foote is rightly regarded as father of Indian prehistory. Here I present an overview of my prolonged studies on the Acheulian culture of the Thar Desert and of the Bhimbetka complex of rockshelters in Central India.

Acheulian Culture in the Thar Desert

The Thar Desert, which lies west of the Aravalli Hills in Rajasthan and extends beyond the Indus river into Pakistan, covers an area of about 300,000 km^2. The region receives an annual rainfall of between 500 mm on the east near Jaipur and less than 100 mm beyond Jaisalmer on the west. There are no perennial rivers in the region. The only river of any consequence is the Luni, the *Lavanvari* or brackish river of Sanskrit literature. It has many tributaries but all these including the parent river have flowing water only during the rainy season. Most of the land is covered by sand sheets and dunes, some of which have a length of over 50 km and a height of more than 40 m.

During my exploration of the desert from 1959 to 1967, I discovered the remains of a Late Acheulian culture in the Luni and its tributaries, besides several microilthic sites. The artefacts were found in cemented gravels along the banks of the rivers, sometimes found in eroded condition in the beds of the streams, and on chert outcrops near Sojat in Pali district. They were made of chert and rhyolite and feldspar porphyry, the latter two being volcanic rocks which occur in the hills of the Malani group near Siwana on the Luni river. They comprised small, symmetrical handaxes made by cylinder hammer technique with small, shallow scars, even surfaces and lenticular and biconvex cross-sections. The cleavers were also small and had a sharp straight or oblique cutting edge. Other artefacts comprised various types of scrapers, knives and points, Levallois flakes and blades. While the bifaces were made of volcanic rocks, the flake tools were made of fine quality chert found in veins extending from Bilara in the north to Sojat in the south.

The flake tools belonged to the Middle Palaeolithic tradition and the whole assemblage represented Late Acheulian features. This work was done as a part of my Ph.D. project. Subsequently, my geologist colleague, S.N. Rajaguru, joined me in undertaking an ambitious project on the prehistory and palaeoenvironment of the Thar Desert. Later we were joined in this Project by D.P. Agrawal of the Physical Research Laboratory (PRL), Ahmedabad, R.P. Dhir of the Central Arid Zone Research Institute (CAZRI), Jodhpur, Gurdip Singh and R.J. Wasson of the Australian National University, Canberra, M.A.J. Williams of the University of Adelaide, South Australia and Claire Gaillard of the Institut de Paleontologie Humaine, Paris. D.P. Agrawal dated two pedogenic carbonate samples, one from 16R, a site on the Bangur Canal, which we excavated afterwards. His colleague, A.K. Singhvi, dated sand and calcrete samples from Amarpura and 16R sites. Hema Achyuthan (née Raghavan) dated sand and calcrete samples from the lower levels of 16R by ^{234}U/34/^{230}Th methods.

While inspecting the deposits of the Didwana salt lake, pollen samples from which had been studied by Gurdip Singh, Rajaguru and I noticed a large and deep quarry of calcareous loam on the eastern edge of the Singi Talav depression. The surface of the quarry was littered with fresh Acheulian tools. Later we dug several trenches, measuring 4 x 4 m, adjacent to the quarry and recovered more Acheulian tools. We also dug a trench at Indola-ki-Dhani from which we recovered Middle Palaeolithic tools. We excavated several trenches at the Acheulian localities of Singi Talav, and the Middle Palaeolithic locality of Indola ki Dhani.

Later we found Acheulian tools in several abandoned quarries and excavated tanks for storing rainwater as also a colluvial gravel deposited at the base of Kolia Hill east of Didwana. The material from Singi Talav and Kolia Hill comprised crude handaxes and cleavers, polyhedrons, spheroids, scrapers, cores and flakes. In contrast, the material from Jankipura Talav comprised very finely made handaxes with shallow flake scars, symmetrical shapes and lenticular or biconvex cross-section.

While inspecting the banks of the abandoned Bangur canal, which had been dug during the famine of 1941-42 to bring water to Didwana ponds from the hills to the west of Balia village, we were unclear whether the canal banks were of alluvial or aeolian material. To resolve our doubt we dug a 18.40 m deep trench along the right bank of the canal west of Didwana town. The stratigrahy of the trench was divisible into three lithological units (Figs. 1 and 2).

Unit I consisted of pale brown weathered sand but produced no artefacts. Microliths were found on the surface of this Unit. At the junction of Units I and II, 2 m below the surface, an Upper Palaeolithic assemblage comprising blades and blade tools and three handaxes, one of them a miniature cordiform piece with shallow scars, symmetrical shape and lenticular cross-section, was found.

Fig. 1: Excavation at 16 R, Didwana

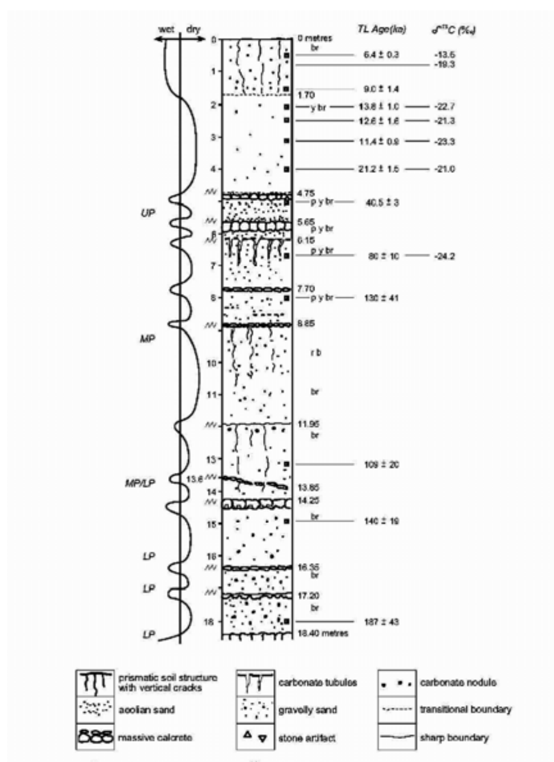


Fig. 2: Stratigraphy with chronology at 16 R (After Singhvi *et al*. 2010)

Unit III with a thickness of nearly 10 m was formed of deeply weathered, red-coloured highly compact sand. It produced a sizeable and representative Middle Palaeolithic assemblage from the deposit between 9 and 13 m. The two assemblages recovered from 17.20 and 18.40 m depths were too small for precise cultural identification but stratigraphically they must belong to the Acheulian stage. This horizon has been dated by one TL date of 163,000 ± 21,000 years and four ^{234}U/34/^{230}Th dates--: 144, 000 ± 12,000, 150,000 ± 10,000 years, 131,000 ± 12,000 and 390,000 ± 10,000 years B.P. Later the profile was dated by TL method by A.K. Singhvi and his colleagues. These scholars developed a chronology based on 12 TL ages and a basal age of ~ 190,000 Kyr.

The site has preserved 12 cycles of dune accretion, soil formation, calcrete development and subsequent erosion. It has also preserved stone artefacts ranging in age from Mesolithic to Lower Palaeolithic. These phases are coeval with more humid climatic interludes. Phases of soil development and calcrete formation were relatively wet so that there were 12 significant moist intervals, separated by 11 drier intervals during the past ~190 Kyr. The calculated time interval between successive phases of dune sand accumulation ranged from 22.5 Kyr to 15.8 Kyr with a mean of 19.0 Kyr. These values are consistent with a monsoonal influence on dune activity and on the associated onset of early monsoonal activity in this region. Carbon isotopes measured on organic matter within the sand profiles show consistent values close to -216 ± 1% pointing to deposition during a transitional climatic regime characterized by a change from open C3 grassland to C4 woodland or forest.

Central India

Central India mainly comprises the states of Madhya Pradesh, Chhattisgarh and Jharkhand, and parts of Rajasthan and U.P. It is largely hilly and forested. Two hill ranges – the Vindhyas and the Satpuras – straddle through it in a northeast–southwest direction and roughly parallel to each other. In the northeast, the Vindhyas are composed of sandstones and quartzites, the latter representing a metamorphosed version of the former. In the southwest the Vindhyas as well as the Satpuras are almost entirely formed of basaltic lavas. The Vindhyan rocks, mostly formed of sandstone, are ideally suited for the formation of rock shelters and occasionally caves. Several thousand of these are known from different parts of the region. Most of them contain microlith-bearing deposits on their floors, and paintings on their walls, ceilings and hollows in the walls. A small number of the shelters also contain Palaeolithic deposits.

Central India is blessed with fairly high rainfall and a large number of rivers, many of them flowing perennially. The major rivers are the Chambal on the west, the Mahanadi and the Son on the east, the Betwa, the Belan and the Tons in the centre, and the Narmada and the Tapti in the south. Most of the rivers of Central India flow through deep valleys cut through a rocky terrain. Thus there are only a few large alluvial plains like those of the Mahanadi, the Son, the Narmada and the Tapti. Rainfall, which is around 80 cm per annum, steadily increases towards the east to reach a maximum of 140 cm. Because of ample rainfall and fertile soils, the vegetation cover, wherever it has not been excessively tampered with for timber and firewood, is fairly dense, and consists of a woodland dominated by Sagon/Sagwan, i.e. (*Tectona grandis*) in the centre and west, and *sal* (*Shorea robusta*) in the east.

The Malwa plain in the west is drained by the Chambal and its tributaries and is extremely fertile because of its thick black soil. It produces rich crops of wheat, sugarcane and cotton. Agriculture appeared in Central India about five thousand years ago, and in areas to its east and south it appeared much later.

Because of its hilly, rocky and forested terrain, Central India is also the largest refuge zone in the country, inhabited by many tribal communities, speaking Dravidian, Austro-Asiatic, and Indo-Aryan languages. In the western part of the region consisting of Malwa or western Madhya Pradesh, and the adjoining parts of Rajasthan, Gujarat and Maharashtra, the Bhils constitute the principal tribal community. In the eastern part, the largest tribe consists of the Gonds, with their two main subdivisions, namely the Muria and Maria, and Baiga, Kamar and Korwa, the last speaking an Austro-Asiatic tongue. Nahali is spoken on the borders of Madhya Pradesh and Maharashtra;

its linguistic affiliations securely have yet to be resolved. Most of these communities still use a simple technology and practise an economy based on hunting-gathering, fishing, and shifting cultivation.

Being rich in primary resources like rocks suitable for the formation of caves and rock shelters, ample availability of water from its many perennial rivers and lakes, prehistoric hunting-gathering communities lived in this region since at least half-a-million years. There are a large number of Stone Age sites in the region, and they have been discovered since the later part of the nineteenth century. Bhimbetka, with a long sequence of Stone Age cultures and an exceptional wealth of prehistoric paintings, has been recognized by UNESCO as a World Heritage site.

Bhimbetka

Bhimbetka (22° 50' N; 77° 37' E) is the most important stratified Acheulian site in Central India. It is located on the northern margin of the Vindhya Hills in Sehore District of Madhya Padesh, 30 km. north of the Narmada. The Vindhya Hills form a great scarp overlooking the Narmada valley. Near Bhimbetka the hills recede to the sides to form a broad valley though which runs the Mumbai-Delhi line of the Central Railway. The hills at this point form a watershed. The drainage to the north flows into the Betwa and ultimately goes into the Ganga while the drainage to the south goes into the Narmada river. There is no perennial stream near Bhimbetka but a nala flows at the southern edge of the hill. It is a source of water even during the summer and was in fact the main source of water to our field camp located by its side.

The Bhimetka Hills runs N-S for about a kilometre and E-W for half a kilometre and rise to about 100 m high from the plain. A prominent feature of the hill is the presence in the upper part of a chain of discontinuous rocks which are a conspicuous feature of the local topography. Many of these rocks have been weathered to form caves and shelters of various sizes. Some of these caves, like IIIF-24 (Auditorium cave) are up to 40 m long, 4 to 12 m broad and 6 to 15 m high.

The northern and western slopes of the Bhimbetka Hill contain over 200 caves and shelters. A second hill to the west of Bhimbetka known as Lakha Juar and a third to the east known as Bhaurenwali, are almost equally rich in caves and shelters. Altogether in a stretch of 10 km. the hills contain over 1000 caves and shelters. Over 700 of them contain paintings on their walls and ceilings, the number of paintings in a single shelter ranging from one to over a hundred. On the basis of superimposition, subject matter, style and correlation with finds from excavations the paintings seem to range from the Mesolithic to Medieval times. Bhimbetka and its neighbouring hills have the largest known concentration of prehistoric paintings in India and perhaps in the world. A smaller though indeterminate number of shelters also contain on their floors occupation deposits of variable thickness covering the period from Late Acheulian to Late Mesolithic times.

Bhimbetka region receives an annual rainfall of over 120 cm, largely concentrated in the three months of July-September. The hills are thickly covered with deciduous forest vegetation. Though increasing population and consequent rising demand for timber and fuel are taking heavy toll of vegetation, the forest cover on hills away from human settlements is still fairly well preserved. At least thirty species of trees and plants in the forest have edible flowers, fruits and seeds, and several plants have edible roots and tubers. Among the former the more important are mahua (*Bassia latifolia*), *Buchnania latifolia,* Tendu (*Diosphyros tomentosa*), Bel (*Aegle marmelos*)*,* bhandara (*Erytherina indica*)*,* Am (*Mangifera indica),* Jamun (*Eugenia jambolana,* Gular (*Ficus glomerata*)*,* Amnla (*Phylanthus emblica*), Ber (*Zizyphus jujube*), papda (*Gardenia latifolia),*Imli (*Tamarindus indica*)*, gathor (Zizyphus xylopera), khajur (Phoenix sylvestris*), Sitaphal (*Anona squamosa),Kakhera¸ Kankher* and *Menar.* There is a variety of tubers and roots. Even today the local population for many kilometres around Bhimbetka extensively exploits the forest foods, especially Mahua and Achar.

Wildlife during living memory used to be plentiful but clearing of forests and indiscriminate hunting have largely exterminated it. However, several species still exist, including Sambar (*Cervus unicolor*), chital (*Axis axis*), blackbuck (*Antilope Cervicapra*), Nilgai (*Boselaphus* *tragocamelus*), wild boar (*Sus scrofa cristatus*), Hyena (*Hyaena hyaena*), Leopard (*Panthera pardus*), wolf (*Canis lupus*), sloth bear (*Melursus ursinus*), porcupine (*Hystrix indica*), hare (*Lupus nigricolis*), fox (*Vulpes bengalensis*), jackal (*Canis aureus*), and common langur (*Presbytis entellus*). However, hunting as a source of food is now practically non-existent. Fish are caught in the streams and ponds by professional castes and sold to other communities. There are several natural perennial springs close to Bhimbetka and these constitute the only source of water for the local human and animal populations. The Bhimbetka region is ideally suited ecologically for occupation by hunting-gathering populations. Judging from the thick occupation deposits in numerous caves and shelters spanning the period from Lower Palaeolithic to Late Mesolithic, it is clear that favourable ecological conditions have existed all through prehistoric times.

Table 1: Physical and cultural characteristics of layers in rock-shelter III F-23 at Bhimbetka

Layer	Thickness (cm)	Features
1	5-10	Geometric microlithic industry made on chalcedonic silica and a quantity of quartzite flakes, blades and microblades associated with hammers, grinders and querns of basalt, occasional stone beads, small quantities of highly fragmented sherds of plain red and grey ceramics and a few bone pieces.
2	20-25	Cultural material as in layer 1 but without pottery and beads; stone industry richer than in layer 1.
3	10-20	Quantity of stone chips declines as does the microlithic industry.
4	15-20	Silty clay, more rock fragments than in upper layers; no microliths, quartzite flakes, blades, side scrapers, end scrapers; Late Middle Palaeolithic or Upper Palaeolithic Industry.
5	40-50	Moist and sticky when freshly dug clay; a wide variety of side scrapers; less common but typical end scrapers; Levallois fakes and blades; a few handaxes and cleavers in lower l0-15 cm. many tools made on thin, flat natural slabs; artefacts have red staining; typical Middle Palaeolithic industry.
6	80-90	Siltier and more compact than layer 5; moist and sticky when freshly dug clay; a wide variety of side scrapers; size of stone blocks larger; artefacts red stained; late Acheuian industry.
7	90-100	Bright reddish brown; very moist and sticky when freshly dug; the junction between this layer and layer 6 is sharply marked; Late Acheulian industry.
8	80-90	An orange coloured deposit; heavily weathered chips and blocks of argillaceous sandstone; Late Acheulian industry; last 30 cm is sterile

Excavation and Stratigraphy

Excavation at Bhimbetka were conducted between 1973 and 1976 by V.S. Wakankar, who had discovered the excavated site in shelter III-24 or Auditorium cave. He found Mesolithtic material at the top and Acheulian material below. In the following years he found Acheulian material in shelters IIIA-29 and IIIA-30.

I excavated the shelter IIIF-23 (Fig. 3), one of the largest caves and having the thickest deposit. In this shelter an area of about 32 m^2 is enclosed by side walls and can be called cave proper while the massive rocky overhang extends forward and to the left over a further area of nearly 80 square metres. Its surface is even and has a gentle slope towards the outside. The shelter was put under a grid of 1 m^2, and one square metre was excavated at a time. Every piece that showed human workmanship, irrespective of its size, was carefully sorted and recorded immediately on the spot. The maximum deposit encountered in the excavation was 3.90 m. in thickness and was less in other squares. In all, eight layers were recognized in the deposit (Table 1). The Acheulian deposit is 2.40 m thick, covering layers 6, 7 and 8. Acheulian levels were reached only in the inner part of the shelter in an area of 26 square metres. However, only the material from an area of 18 m^2 was analyzed.

There was no evidence for the use of fire and no organic material has survived, probably because of the acidic nature of the deposit. However, there are other indications that the shelter was used not only for making tools but also for habitation. In trenches E and F, covering an area of 8 m^2, five stone-paved floors showing intentional structural activity were encountered at different depths. A number of handaxes and cleavers show clear signs of use in the form of edge damage, and many others survive only as fragments. These must have been used in and near the shelter and broken fragments seem to have been discarded within the shelter.

The artefact assemblage all through the deposit consists of shaped tools as well as cores, flakes and chips, showing that the tools were manufactured within the shelter. The raw material used throughout was, with one exception, orthoquartzite (partially metamorphosed sandstone). However, a very clear choice was made in the type of quartzite used for handaxes and cleavers on the one hand and for the rest of the artefacts on the other. The former with a few exceptions, are all made of a purple and grey quartzite which is rich in iron content, is more intensely metamorphosed; consequently it is tougher and more resistant to weathering than the light coloured quartzite. These tools have suffered little weathering even in the levels where other tools have been heavily weathered. The rest of the tools are made of a yellowish quartzite which has undergone only moderate metamorphism. These tools have suffered heavy weathering in the lowermost levels and tend to crumble into powder. Except in layer 8, all tools have a shining mint fresh look irrespective of the type of quartzite used.

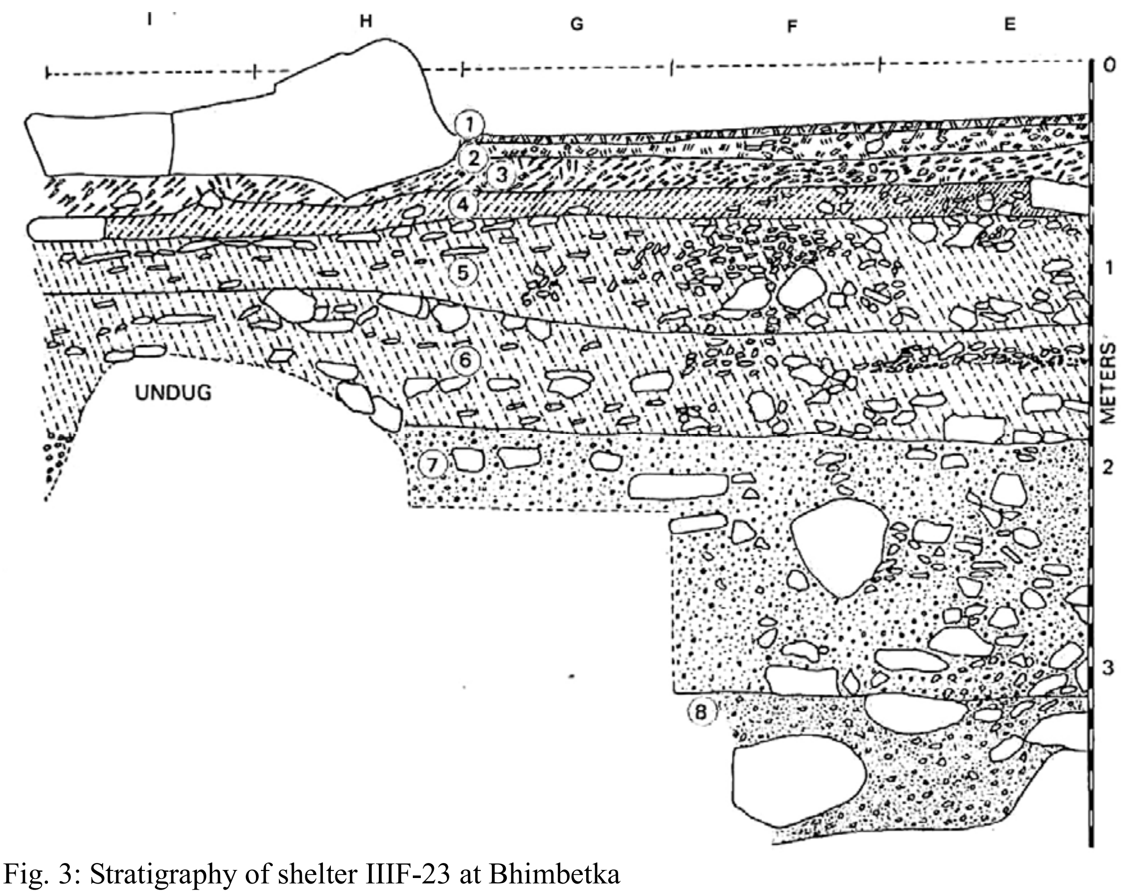


Fig. 3: Stratigraphy of shelter IIIF-23 at Bhimbetka

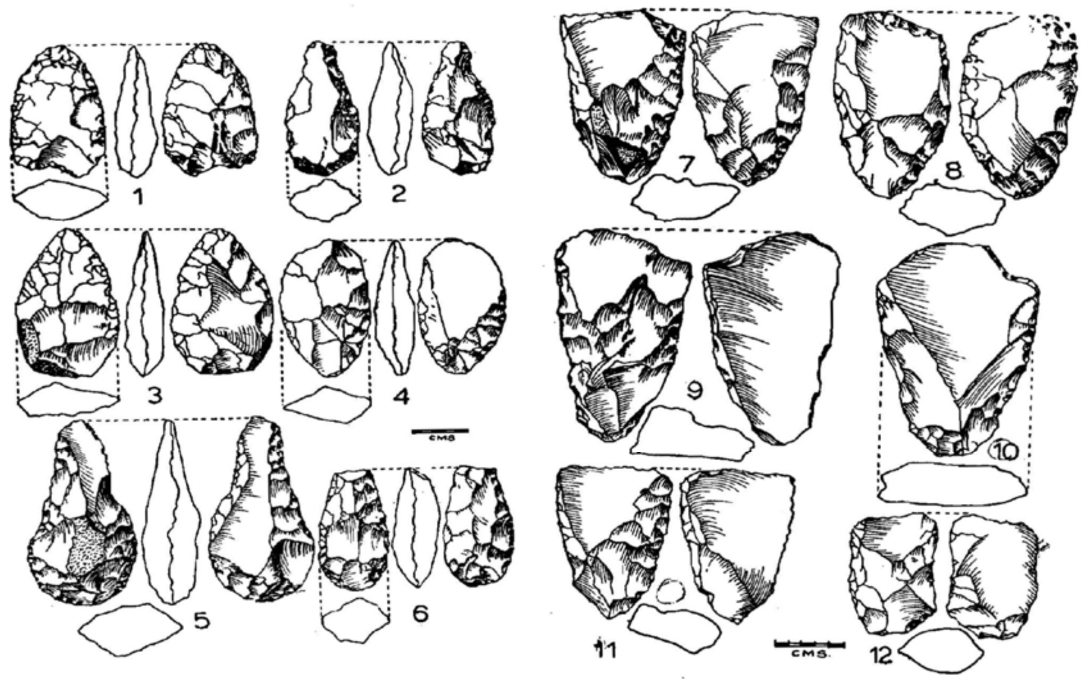


Fig. 4: Acheulian artefacts from Bhimbetka

Typo-technological Features (Fig. 4)

The main typological and technological features of the industry are as follows:

1. The industry consists of 4737 artefacts. Of these 32.32% are tools and 67.68 % are waste flakes. The horizontal and vertical distribution of tools in relation to waste materials is fairly uniform, and no area appears to be specifically marked off for tool manufacture. 2. The very high proportion of flakes (33.88%), chips (26. 8%), cores (3.36%) and debris (3.86%) shows clearly that most of the tool making activity took place inside the shelter.
3. Among flakes and blades, 14.26% are blades, 22.49% are side struck flakes and 19.63 % indeterminate flakes.
4. Among cores the majority (41.51%) are amorphous. The next most common types are bifacial (28.96 %) and discoidal forms. Levallois cores account for only 6.92 % of the collection. The remaining 6 (29%) are of diverse types.
5. Side scrapers and other non-bifacial tools account for 27.99 % of shaped artefacts and bifaces (handaxes and cleavers, including their fragments) form the remaining 4.33%. The biface element therefore plays a minor role in the Bhimbetka Acheulian industry.
6. Unretouched Levallois fkakes (including blades and points) constitute 12.37%
7. Side scrapers constitute the biggest class of tools (27.75%) and display the total range of types recognized by Bordes in the Lower and Middle Palaeolithic assemblages. In this class the most common types are the simple convex (7.47%), ventrally retouched simple straight (1.73%), convex 1.58 %) and dejete (offset) (1.21%).
8. End scrapers constitute 8.14%% of artefacts of the tool assemblage. The high percentage of end scrapers, a type characteristic of Upper Palaeolithic, is indicative of an evolutionary late stage of the industry.
9. Prepared back and naturally backed knives account for 12.29% of the assemblage.
10. Other common tool type are truncated flakes and blades (6.56 %), notches (8.37 %), and denticulate (5.88%). The presence of these tool types has rarely

been noticed in Indian Acheulian industries.

11. Intact handaxes constitute only 2.61% and intact cleavers 6.34 %, together constituting 8.95 of the finished tool group. Taken together with their fragments they constitute 3.59% and 9.80% of the industry, respectively, amounting to a total percentage of 13.39%. The large proportion of broken bifaces, particularly cleavers, shows that these types were used inside and in the close vicinity of the shelter.
12. The proportion of cleavers to handaxes is 3:1. Thus the biface element is clearly characterized by the predominance of cleavers.
13. Being small the handaxe sample does not lend itself to the perception of any clear typological preference. Nearly half of the intact specimens belong to cordiform and oval shapes. The rest are of elongated and other shapes. Most of the handaxes are made on flakes and have a symmetrical outline and thin section, and are characterized by shallow, even flake scars.
14. The cleavers are all made on flakes. While the upper surface is extensively worked, on the ventral face secondary work is confined to bulbar end and the sides. The most common lateral cross section is a parallelogram which lends itself ideally to hafting. The cleavers are regularly characterized by a symmetrical form and even surfaces. The most preferred shape has a rounded butt and transverse edge. The other preferred forms in order of quantity, are (2) pointed butt and transverse edge, (3) rounded butt and convex edge, (4) rounded butt and oblique edge, (5) pointed butt with convex edge and (6) pointed butt with oblique edge.

To summarize, the Bhimbetka Acheulian industry is characterized by a very low proportion of bifaces, high proportion of cleavers to handaxes, a remarkably high standard of workmanship in bifaces, specially cleavers, predominance and great diversity of non-biface tools, high percentage of end scrapers and Levallois flakes and complete absence of chopper-chopping tools. All these features show unequivocally the closeness of the industry to the Mousterian of Acheulian tradition. It is to be noted that the layer which overlies the Acheulian deposit is stratigraphically and culturally is a continuation of the Acheulian culture except for the disappearance of the biface element and a certain decline in the standard of workmanship. Thus there can be no doubt that the Bhimbetka industry represents the terminal phase of the Acheulian tradition.

In the absence of radiometric dates the Bhimbetka Acheulian industry cannot be dated in actual years. However, a relative chronology can be prepared by comparing the Acheulian industry of Shelter IIIF-23 of Bhimbetka with other Acheulian industries known from stratified contexts.

On the basis of stratigraphy, typology and technology two developmental stages can be recognized in the Indian Acheulian industries. The first, more primitive and probably chronologically earlier, is characterized by core tools like handaxes, choppers, polyhedrons and spheroids, a low proportion of crudely made cleavers and handaxes, choppers, polyhedrons and spheroids, a low proportion of crudely made flake tools, predominant use of stone hammer technique and the absence of Levallois technique. It is represented at sites like Singi Talav in Rajasthan, Chriki and Morgaon in Maharashtra, and Hunsgi and Anagwadi in Karnataka. The second and probably the younger one is marked by low proportion of bifaces, high ratio of cleavers to handaxes, the very high proportion of flake tools like scrapers, the extensive use of soft hammer techniques and the knowledge of the Levallois and discoid core techniques. This stage is represented in the rock shelters of Bhimbetka and the open-air sites like Purli Karar, Barkhera and Tikoda in Madhya Pradesh.

Acheulian in the Thar Desert: Select Publications

Achyuthan, H., J. Quade, L. Roe, and C. Placzek. 2007. Stable Isotopic Composition of Pedogenic Carbonates from the Eastern Margin of the Thar Desert, Rajasthan, India, *Quaternary International* 162-163:50-60.

Dhir, R.P., S.K. Tandon, B.K. Sareen, R. Ramesh, T.G. Rao, A.J. Kailath and N. Sharma. 2004. Calcretes in the Thar Desert: Genesis, Chronology and Palaeoenvironment, *Earth and Planetary Sciences* 113: 473-514.

Dhir, R. P. and A. K. Singhvi 2012. The Thar Desert and its Antiquity, *Current Science* 7: 1001-1008.

Gaillard, C., V.N. Misra, S.N. Rajaguru, D.R. Raju and H. Raghavan 1985. Acheulian Occupation in the Singi Talav, Thar Desert: A Preliminary Report on 1981 Excavation, *Bulletin of the Deccan College Postgraduate and Research Institute* 44: 141- 152.

Gaillard, C., D.R. Raju, V.N. Misra and S.N. Rajaguru 1983. Acheulian Occupation at Singi Talav in the Thar Desert: A Preliminary Report on 1982 Excavation, *Man and Environment* VII: 112-130.

Kailath A.J., Rao T.G., Dhir R.P., Nambi K.S.N., Gogate, V.D. and Singhvi A. 2000. Electron Spin Resonance of Calcrtes from Thar Desert for Dating Applications,*Radiation Measurements* 32:371-383.

Misra, V.N. 1995. Geoarchaeology of the Thar Desert, Northwest India, in *Memoir of Geological Society of India* 32 (Wadia, S., R. Korisettar and V.S. Kale Eds.), pp.210-230. Bangalore: Geological Society of India.

Misra, V. N. and S.N. Rajaguru 1987. History of Environment and Man in the Thar desert, *Indologica-Jaipurensia* I: 17-31.

Misra, V.N. and S.N. Rajaguru 1989. Palaeoenvironments and Prehistory of the Thar Desert, Rajasthan, India, in *South Asian Archeaology - 1985* (K.Frifelt and R.Sorensen Eds.), pp. 296-320. Copenhagen: Scandinavian Institute of Asian Studies Occasional Paper No.4. London: Curzon Press.

Misra, V.N., S.N. Rajaguru and H. Raghavan 1988a. Late Middle Pleistocene Environment of Acheulian Culture Around Didwana, Rajasthan, in *Palaeoclimatic and Palaeoenvironmental Changes in Asia (During the last 4 million years)*, pp. 93-106. New Delhi: Indian National Science Academy.

Misra, V.N., S.N. Rajaguru and H. Raghavan 1988b. Late Pleistocene Environment and Acheulian Culture around Didwana, Rajasthan, *Proceedings of the Indian National Science Academy* 54, A (3): 425-438.

Misra, V.N., S.N. Rajaguru, D.R. Raju, H. Raghavan and C. Gaillard 1982. Acheulian Occupation and Evolving Landscape around Didwana in the Thar Desert, India, *Man and Environment* 6: 72-86.

Misra, V.N., S.N.Rajaguru, D.P.Agarwal, P.K.Thomas, Zahid Hussain and P.S.Dutta 1980. Prehistory and Palaeoenvironments of Jayal, Western Rajasthan, *Man and Environment* IV : 9-31.

Raghavan H. 1987. *Quaternary Geology of Naguar District, Rajasthan*. Ph.D. Dissertation, University of Poona.

Raghavan, H., S.N. Rajaguru and V.N. Misra (1989). Radiometric Dating of a Quaternary Dune Section, Didwana, Rajasthan, *Man and Environment* 13: 19–22.

Rajaguru, S.N., Hemangi Deodhar and Savita Ghate 1992. Changes in Physical Environment of Western India During the Last 200 Ka: A Geomorphological Approach, in *Proceedings of International Symposium on Global Change (IGBP)* 27-29 March 1992, Waseda Unviersity, Tokyo. pp. 599-613. Japan: Secretariat of International Symposium on Global Change.

Singhvi A.K. and Amal Kar. 2004. The Aeolian Sedimentation Record of the

Thar Desert, *Earth and Planetary Sciences* 113: 371-401.

Singhvi, A. K., M. A. J. Williams, S. N.Rajaguru, V. N. Misra, S. Chawla, S. Stokes, N. Chauhan, T. Francis, R. K.Ganjoo, and G. S. Humphreys 2010. A ~200 Ka Record of Climatic Change and Dune Activity in the Thar Desert, India, *Quaternary Science Reviews* 29(2324): 3095-3105.

Wasson, R.J., S.N. Rajaguru, V.N. Misra, D.P. Agarwal, R.P. Dhir, A. K. Singhvi and K. Kameswara Rao. 1983. Geomorphology, Late Quaternary Stratigraphy and Palaeoclimatology of the Thar Dunefield, *Zeitshrift fur Geomorphologie (N.F.)* 45: 117-151.

Acheulian at Bhimbetka: Select Publications

Alam, M. S. 1990 . *Morphometric Study of Palaeolithic Industries of Bhimbetka, Central India*. Ph.D. Dissertation. University of Pune.

Alam, M. S. 2001 . *Palaeolithic Industries of Bhimbetka, Central India: A Morphometric Study*. Dhaka, Bangla Academy.

Mathpal, Y. 1975 . Prehistoric Art of Bhimbetka, Central India: A Preliminary Study, *Journal of the University of Poona* 41: 95-108.

Mathpal, Y. 1984 . *Prehistoric Rock Paintings of Bhimbetka, Central India*. New Delhi, Abhinav Prakashan.

Misra, V. N. 1975-76 . The Acheulian Industry of Rock Shelter IIIF-23 at Bhimbetka, Central India – A Preliminary Study, *Puratattva* 8: 13-36.

Misra, V. N., Y. Matpal, Malti Nagar 1977. *Bhimbetka:Prehistoric Man and his Art in Central India*. Pune: Deccan College.

Misra, V. N. 1978. The Acheulian Industry of Rock Shelter III F- 23 at Bhimbetka, Central India, *Australian Archaeology* 8: 63-106.

Misra, V. N. 1978. The Acheulian Industry of Rock Shelter III F- 23 at Bhimbetka, Central India - A Preliminary Study, *Bulletin of the Indo-Pacific Prehistory Association* 1: 130- 171.

Misra, V. N. and Y. Mathpal 1979. Rock Art of Bhimbetka Region, Central India, *Man and Environment* 3: 27-33.

Misra, V. N. 1982. Evolution of the Blade Element in the Stone Industries of the Rock Shelter III F-23, Bhimbetka, in *Indian Archeaology: NewPerspectives* (R. K. Sharma Ed.), pp. 7-13. Delhi: Agam Kala Prakashan.

Misra, V. N. 1985. The Acheulian Succession at Bhimbetka, Central India, in *Recent Advances in Indo-Pacific Prehistory* (V. N. Misra and P. Bellwood Eds.), pp. 35-48. New Delhi: Oxford - IBH:

Nagar, M. 1983. Ethnoarchaeology of the Bhimbetka region, *Man and Environment* 7: 61-689.

UNESCO 2002. Bhimbetka Report. ICOMOS, March 2003

Wakankar, V. S. 1973. Bhimbetka Excavations, *Journal of the Indian History* 51 (1): 23-32.

Wakankar, V. S. 1975. Bhimbetka -- the Prehistoric Paradise, *Prachya Pratibha* 3 (2): 7-29.

Wakankar, V. S. 1985. Bhimbetka: The Stone Tool Industries and the Rock Paintings, in *Recent Advances in Indo-Pacific Prehistory* (V. N. Misra and P. Bellwood Eds.), pp. 175-176. New Delhi: Oxford - IBH:

Wakankar, V. S. 2005. *Painted Rock Shelters of Bhimbetka*. Bhopal.

S.B. Ota and S.G. Deo, in *Recent Advances in Acheulian Culture Studies in India*
(K.Paddayya and S.G. Deo Eds.), pp. 57-66 [2014]

Investigation of Acheulian Localities TKD-I and TKD-II at Tikoda, District Raisen, Madhya Pradesh (2010-12)

S.B. Ota and Sushama G. Deo[1]
Regional Director
Archaeological Survey of India, Bhopal
E-mail: simadriota@gmail.com

1. Department of Archaeology, Deccan College, Pune 411 006
E-mail: sushamadeo@yahoo.co.in

Abstract

Several clusters of open air Acheulian sites were reported as surface occurrences in Raisen district of Madhya Pradesh by Jerome Jacobson four decades ago. In 1982-83 the area was surveyed by Prehistory Branch of the Archaeological Survey of India and surface occurrence of large number of bifaces was recorded. Our reinvestigations since 2010 of this rich Stone Age record revealed that the Acheulian artefacts are not mere surface finds but are actually eroding out of more than eight metre thick sedimentary deposit. Acheulian artefacts are found in varied sedimentary contexts such as yellowish sediment, dark brown clay, and ferruginous gravel. This paper reports results of filed investigations at Localities I and II at Tikoda.

Introduction

Considerable progress has been made in understanding various aspects of Stone Age India since R. B. Foote's pioneering discoveries near Chennai in 1863. Since then abundant evidence for hominin presence in the form of stone tools has been found from almost every part of the Indian subcontinent. The Lower Palaeolithic in India is represented exclusively by the Acheulian stone technology. These lithic assemblages are found in abundance throughout the region in varying geomorphic contexts comprising fluvial, aeolian, coastal, regolith, pediment, and colluvial situations. In the present paper we report about the results of our on-going investigations at Tikoda in Raisen district of Madhya Pradesh.

In the 1970s Jacobson (1970, 1974, 1975, 1976a & b, 1985) discovered a large number of surface sites belonging to the Acheulian tradition and considered these to be of a relatively late age. He reported more than 90 sites in a small area of 175 km^2 and stated that this was one of the Heaviest concentrations of Lower Palaeolithic sites ever found anywhere in the Old World (Jacobson 1985:49).

Jacobson made a systematic sample collection of over 11600 artefacts from nine localities in the years 1965 and 1973-74 for studying intra- and inter-site variability. He recognized that these surface sites presented unusual challenges and opportunities in archaeological method and interpretations. Subsequently the Prehistory Branch of the Archaeological Survey of India (IAR 1982-83:38-39) also collected a large number of cleavers around Tikoda village, close to the area explored by Jacobson.

In 2009, we began reinvestigation of the sites around Narwar Hill and Tikoda village reported by Jacobson and the Prehistory Branch respectively (IAR 1982:38-39) with a view to understanding the geomorphic context of the artefacts. Our reconnaissance survey yielded encouraging results and prompted further detailed filed studies (Ota *et al*. 2013; Deo *et al.* 2013).

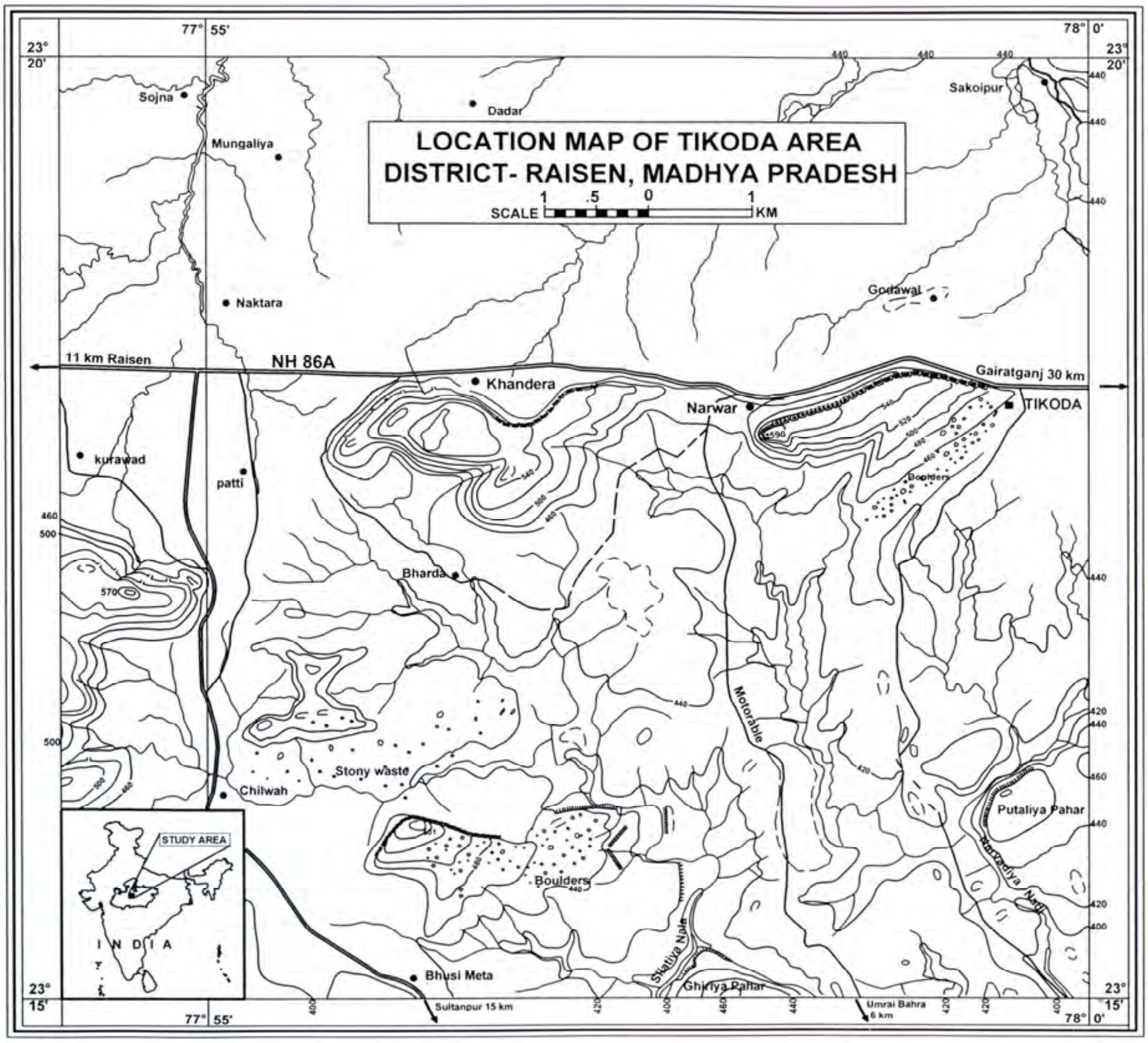


Fig. 1: Location of the study area

The Study Area (Fig. 1)
Tikoda village is located 22 km from Raisen district headquarter on the National Highway 86A heading to Sagar. The present study area is located between Narwar-Tikoda hill range to the north and Putliya Pahar range and Ghiriya Pahar to the south. Thereby the area forms a close 'V' shaped valley and can be considered as a micro-geographical unit. The Khandera-Narwar-Tikoda Hill range that borders the northern side of the study area is a waterdivide between the Betwa river (a major tributary of the river Yamuna) to the north and the Narmada to the south.

National Highway 86 A borders this hill range to the north and the southern part is mostly covered by the reserved forest of Tikoda village range. However, a major part of this reserved forest is now under cultivation. The rich Acheulian localities are situated in this forest zone; therefore, the present study area has been named after Tikoda village. The Narwar-Tikoda hill is oriented east-west with a stretch of 2.5 km with Tikoda on the east (23° 18' N; 77° 59' E) and Narwar (23° 18' N; 77° 58' E) on the west. The northern side of this hill has a steep slope, whereas the southern side has gentle slope and finally it merges with the undulating cultivated lands. The highest altitude is 590 m ASL from the Narwar hill where a temple is located that forms a distinct landmark in the area. On the other hand the Tikoda hill slope is oriented NE-SW and shows mainly the sandstone bedrock comprising boulders. This slope has a thin cover of yellowish sediment, mostly between elevations 438 m and 435 m ASL. Only during the monsoon season, a number of water pools and springs get activated and rest of the year this slope remains dry. As a result of large-scale wood cutting activity, there are no trees left on this slope.

The 'V' shaped valley is a distinctive feature of the study area. It is enclosed by low-lying Narwar-Tikoda ridge on one side; the other side opens into a broad river valley. The 'V' shaped valley floor has preserved a thick sedimentary deposit and gives appearance of badland topography. The average elevation of this valley floor ranges from 465 to 440 m ASL. Seasonal streamlets drain the valley and erode the thick sediments. Geologically, the area is dominated by the pre-Cambrian Vindhyan series of sandstones and quartzite of different shades, capped by an eroding deposit of the Cretaceous volcanic basalt rock. The area thus forms a transitional landscape between the Malwa plateau and the low outlying hills of the Central Vindhya Range. Climatically, the study area can be classified as the sub-humid zone with average annual rainfall of 1245 mm. It is covered with Southern Tropical Dry Deciduous with minor extent of Dry Deciduous Scrub forest type.

Objectives of the Project

As mentioned earlier, the study area has high potential for prehistoric research pertaining mainly to the Acheulian culture. Therefore, the present project is focused mainly on detailed studies of the Acheulian culture. This research project is divided into two phases: the first phase includes extensive field investigations and the second phase contains post-excavation analyses and report writing.

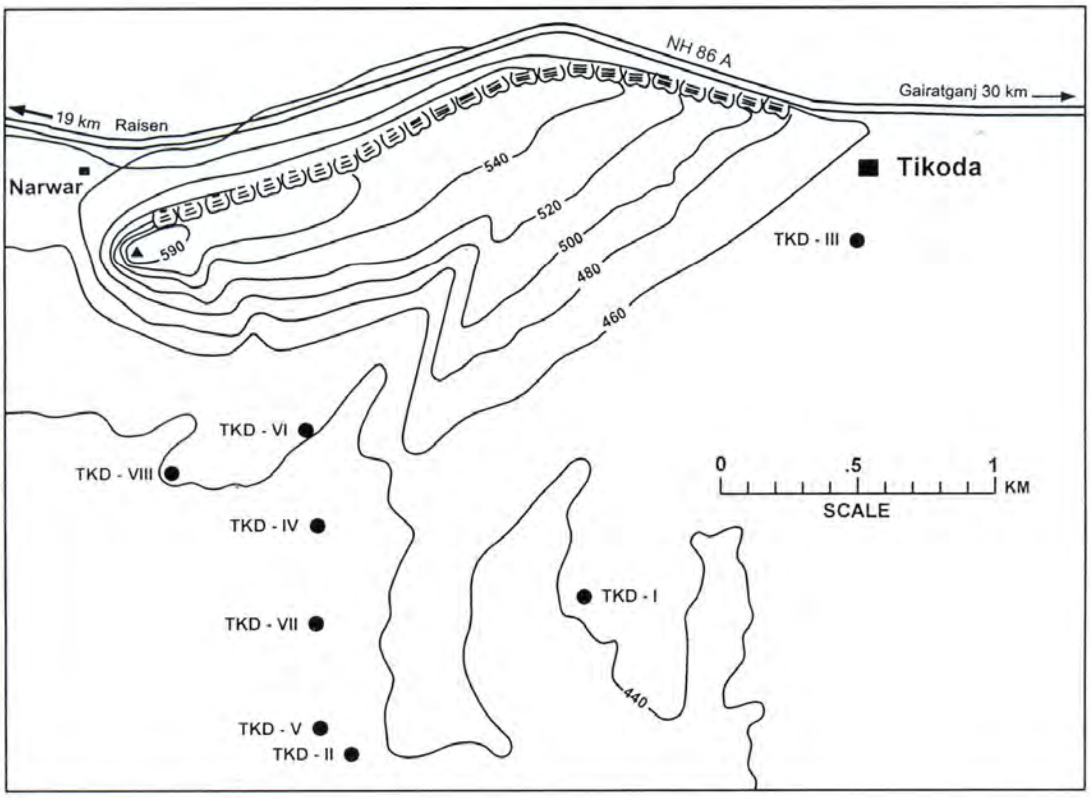


Fig. 2: Acheulian localities TKD-I to TKD-VIII

The main objectives of first phase of the project are: 1) to develop a methodology for the study the surface scatters of artefacts that are exposed due to recent surface erosion; 2) to study the formation processes of both the buried localities and localities with exposed artefacts; 3) to study the assemblage variability for understanding Acheulian hominin behaviour; and 4) to understand the palaeo-landscape during the Acheulian occupation.

To fulfill the above objectives we adopted the following methodology: systematic collection of artefacts eroded from sedimentary context in order to understand distribution pattern of artefacts and their contextual occurrence and formation processes operating on them, excavation at select localities in varied geological contexts, and systematic collection of soil samples for multidisciplinary studies and dating. In other words our ongoing work (since 2010) aims at establishing the nature of hominin activities at the site, environmental contexts of the site, and the age of the assemblages.

Table 2: Artefacts collected from Trench TKD-I

	Quartzite	Sandstone	Chert	Chalcedony
Flakes	15	10	17	3
Core	1	0	0	0
Cleaver	1	0	0	0
Flake Cores	2	0	0	0
Non-artefact	2	16	0	0

Acheulian Localities

Distinct concentrations of lithic scatter within the area are designated as localities. So far eight localities have been marked inthe area confined to the southern slope and 'V' shaped valley of Tikoda Hill. These localities have been named as Locality TKD-I to TKD-VIII (Fig. 2). Out of these, systematic surface collection and excavation were carried out at four localities during 2010-11 and 2011-12.

Fig. 3: Cluster of cleavers at Locality TKD-I

Locality TKD-I

During our initial exploration, several artefacts were found lying on the surface of the eastern hill slope. These artefacts were embedded in a matrix of the colluvial deposit that comprised slabs of sandstone and boulders of quartzite. The foothill is covered with a thin layer of dark yellow sandy silt with ferruginous pellets. At this locality we systematically collected the artefacts from the surface (Table 1). The majority of these artefacts are fresh and some are abraded. Out of 220 artefacts, 94% are made on quartzite and the rest on either chert or chalcedony. Typologically, the collection is dominated by flakes and cleavers with a few handaxes (Table 1). On the slope of the Tikoda Hill, clusters of artefacts were noticed during our exploration in 2009 (Fig.3); therefore, we decided to dig a trench near this cluster to find out from which sedimentary context these artefacts are coming out (23° 17’ 38.0” N; 77° 59’ 57.5” E). A 5x5 m trench (TKD-I) was laid down (Fig. 4) and out of which eight squares were taken up for excavation (Fig. 5 a). The total thickness of sandy-silt deposit with ferruginous pellets is 40 cm which is resting on the bedrock (Fig. 5 b and c). The artefacts collected from excavation mainly comprised flakes and one core and one cleaver (Table 2).

Fig. 4**: Trench 1 Locality TKD-I**

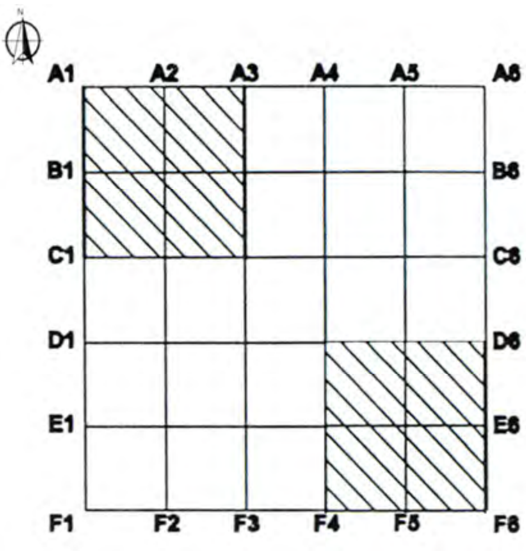


Fig. 5a: Key plan of excavated trench at Locality TKD-I

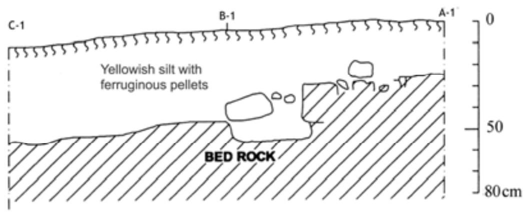


Fig. 5b: Section facing east, Trench 1, Locality TKD-I

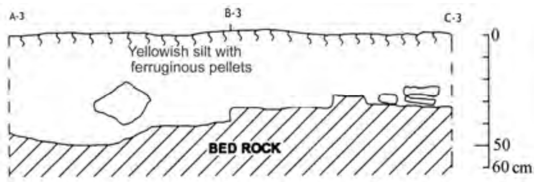


Fig. 5c: Section facing west, Trench 1, Locality TKD-I

Fig. 6: Density of artefacts exposed at Locality TKD-II

Locality TKD-II

Systematic surface collection

Locality TKD-II (23° 17' 24.6" N; 77° 58' 36.8" E) has preserved more than 8 m of alluvial deposit. The surface of this deposit is strewn with artefacts. Rain gullies are eroding this deposit severely and exposing many artefacts (Fig. 6). Since the artefacts occur at different elevations in the erosion gullies and also there was a differential density in the spatial occurrence of artefacts, a 'grid method' has been applied for systematic surface collection. An area of 679 m^2 was divided into 1 m^2 grids. Three clusters (Clusters I, II and III) of artefacts with high density were identified and used for systematic surface collection (Fig. 7).

Before picking up the artefacts, the area was surveyed for generating a contour map (Fig. 8) with a 0.5 m contour interval to understand the topography of this deposit. It showed that highest elevation at Locality TKD-II is 440 m ASL in the southeastern part. This locality can be divided into two geomorphic units, viz. the thick alluvial deposit forming the southern part and gently sloping quartzite hill to the northeastern part, strewn with boulders of quartzite. These boulders are embedded in a ferricrete gravel matrix. Large number of Acheulian artefacts including cleavers, large flakes and giant cores are part of this boulder bed. A first order stream separates these two geomorphic units.

All artefacts measuring 5 cm and above in length were collected after plotting, photographing and measuring dimensions. A total of 1545 artefacts were plotted cluster-wise onto the grid map of Locality TKD-II. Other attributes such as raw material, orientation, inclination and context were also recorded for each artefact. This exercise was applied in all three clusters at this locality, viz. clusters I, II, and III (Fig. 9).

Distribution of artefacts and non-artefacts from each of these clusters show that Cluster I has the maximum number of artefacts (Fig. 10).

Grid-wise distribution of finished tools (Fig. 11) shows variation in the three clusters. Cleavers and handaxes are present in all three clusters, but their number is more in Cluster I. Hammerstones are absent in Cluster III. Knives and choppers are present only in Cluster II.

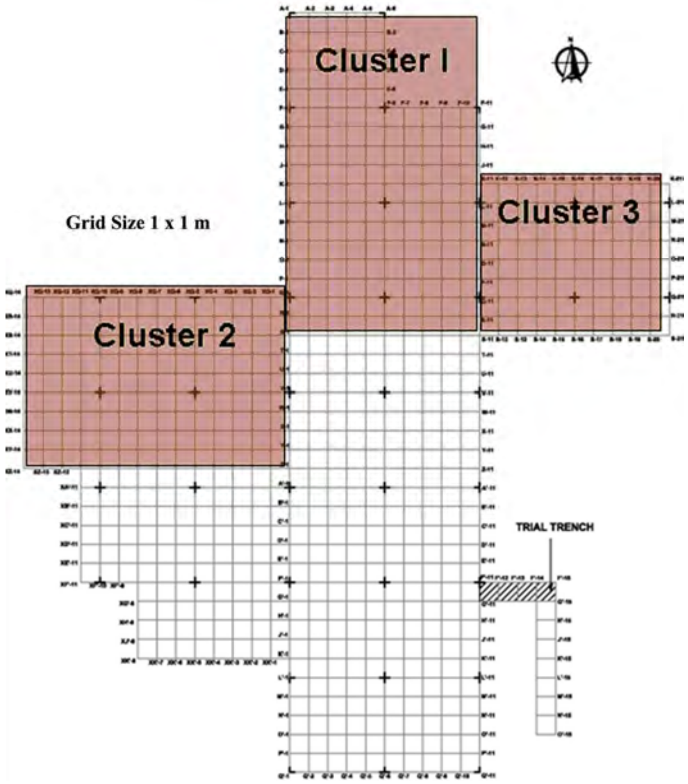


Fig. 7: Grid layout for surface collection, Locality TKD-II

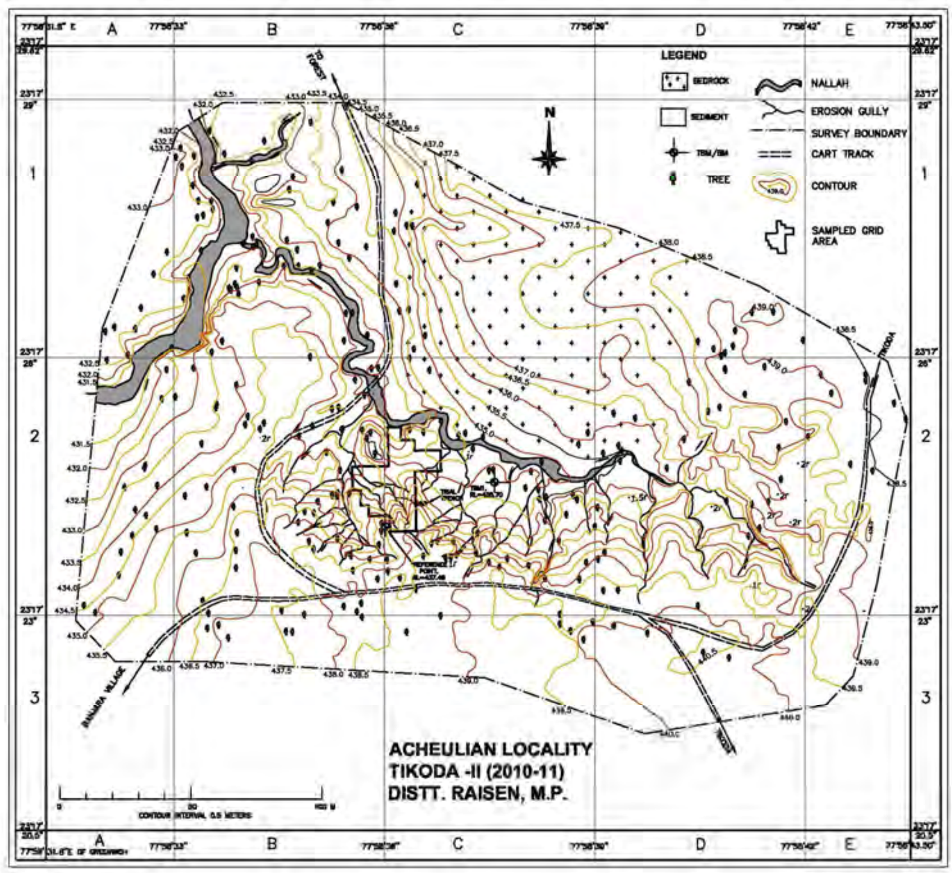


Fig. 8. Countour map for Loacality TDK-II

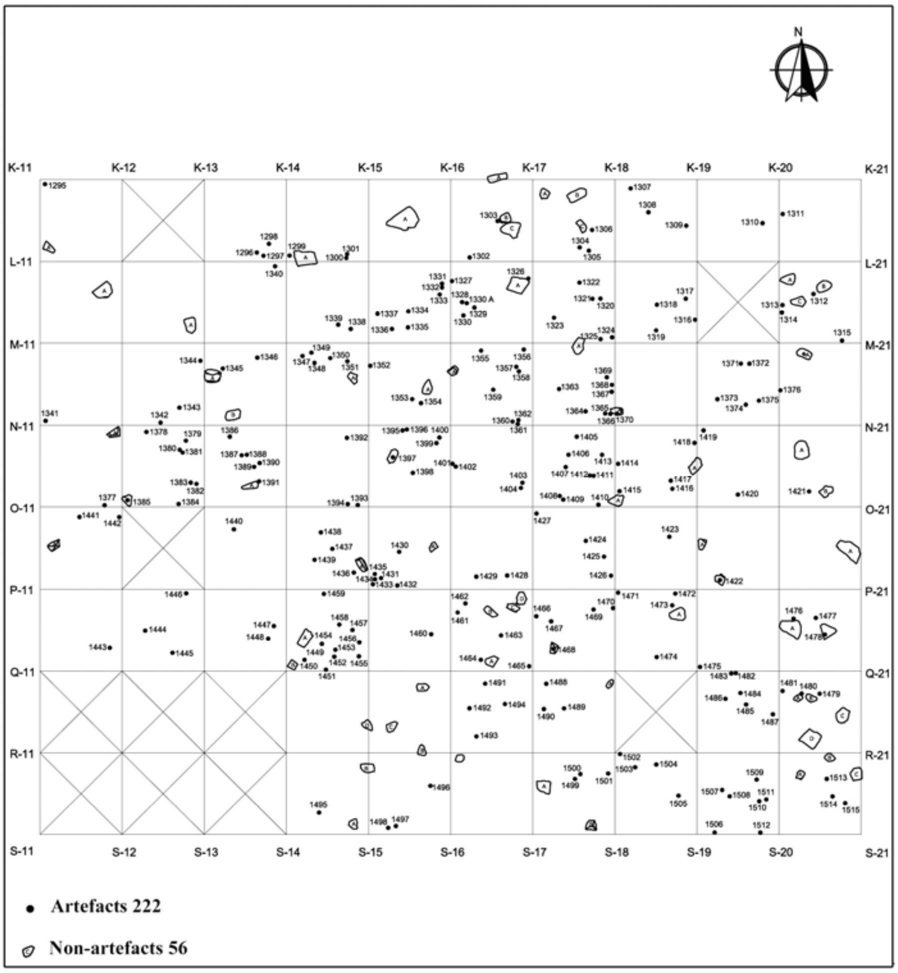


Fig. 9: Distribution of artefacts, Cluster III, Locality TKD-II

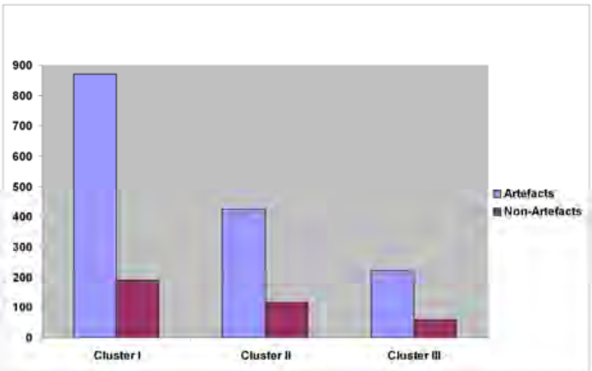


Fig.10: Cluster-wise distribution of artefacts and non-artefacts from Locality TKD-II

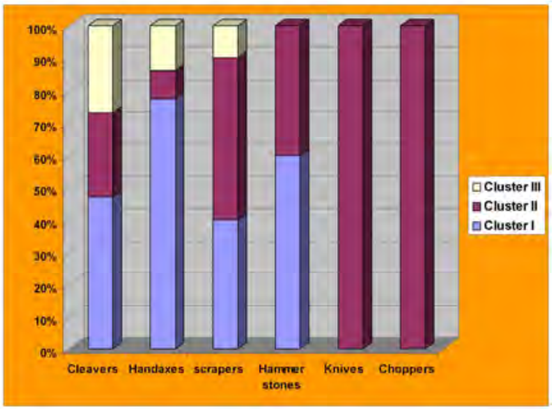


Fig.11: Cluster-wise distribution of finished tools from Locality TKD-II

Cluster-wise distribution of bifaces (Fig. 12) shows that cleavers are present in all three clusters outnumbering handaxes. Cluster I has the maximum number of handaxes. Like-wise side-flakes dominate over end-flakes in all three clusters (Fig. 13). Analysis of raw material used for making artefacts demonstrates that quartzite is the most preferred raw material (Fig. 14). A few artefacts are made using sandstone, chalcedony and chert. Quartzite is available in the form of core-stones on the low-lying hills.

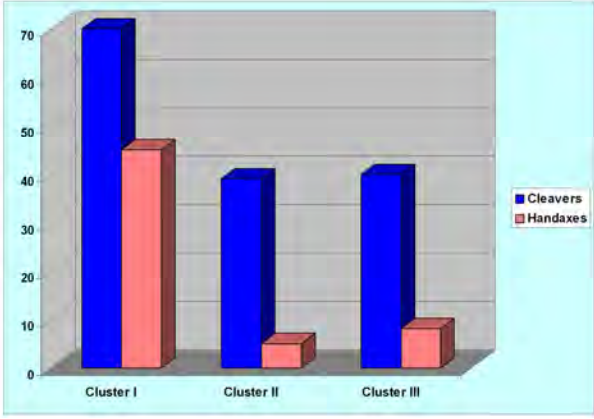


Fig.12: Cluster-wise frequency of bifaces from Locality TKD-II

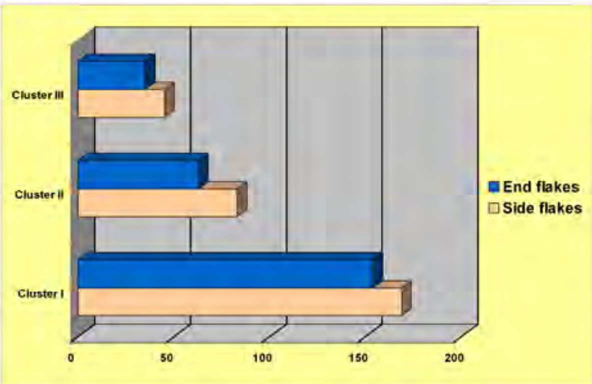


Fig.13. Cluster-wise frequency of flake types from Locality TKD-II

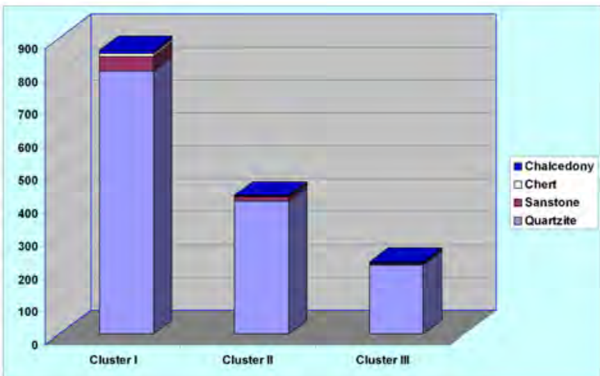


Fig.14: Cluster-wise raw material use from Locality TKD-II

Analysis of raw material used for making artefacts demonstrates that quartzite is the most preferred raw material (Fig. 14). A few artefacts are made using sandstone, chalcedony and chert. Quartzite is available in the form of core-stones on the low-lying hills.

Trial Trench I (Fig. 15)
Since at Locality TKD-II, a large number of artefacts are exposed due to recent erosional activities, we decided to excavate a small trench (1.5 x 1.0 m) to ascertain the sedimentary context of the Acheulian occupation. It was dug up to 4.40 m below the surface. The stratigraphic sequence is as follows. The top layer of brown silty clay with occasional calcrete nodules caps compact yellow brown silty sand (10 YR 5/4) and olive yellow brown clay (10 YR 5/4). This layer continues up to 2.19 m below surface. The fissured clay with light grey mottles on a brownish yellow (10 YR 6/8) background continues up to the base of the profile (4.10 m from surface), interrupted by a ferruginous sandy gravel at a depth of 2.84 m from surface. This gravel is capping a thin layer of soft haematite pellets. It has yielded a number of artefacts along with broken slabs of quartzite and is marked as Acheulian level 1. The artefact-bearing level is capping a sterile brown-yellow clay deposit (1.04 m thick) with light grey mottles and overlying second artefact-bearing gravel at a depth of 3.88 m from surface. The Acheulian level is comprised of few slabs and more artefacts.

Summary

The previous investigations carried out by Jacobson (1970a, 1974, 1975, 1985) and the Prehistory Branch of the ASI (IAR 1982:38-39) in Raisen district, Madhya Pradesh led to the following observations:

i. The area has clusters of Acheulian localities
ii. Occurrence of microlithic sites
iii. Painted rock-shelters at Putulikarar
iv. Acheulian assemblage is cleaver dominated
v. Acheulian occurrence is confined to laterite surface
vi. Acheulian occurrences are in a surface context and relatively late in age (Jacobson 1975).

Our detailed field investigations of the local geomorphological contexts revealed that Acheulian artefacts are found in varied contexts. At Localities TKD-I and TKD-III they occur on the sandstone bedrock covered by a thin cover of yellowish sediment. Locality TKD II is situated on thick alluvial clay sediment. Localities TKD-IV, V, VI, VII and VIII are associated with ferricretised gravel with yellow clayey silt. It is clear from the trial trench that Acheulian artefacts occur in a buried context. There are two different artefact horizons separated by a sterile deposit. Both the horizons yielded quartzite slabs, finished tools, large flakes as well as smaller fragments of quartzite. Acheulian artefacts are found in the context of 8-10 m thick Quaternary deposit. It has preserved one of the richest concentrations of Acheulian artefacts within a definite geographical unit. Therefore this area offers tremendous potentialities for a comprehensive understanding of the Acheulian phase in India.

Fig.15: Trial Trench 1, Locality TKD-II shows Acheulian levels 1 and 2 in the section

Acknowledgments

We are grateful to the Archaeological Survey of India and Deccan College, Pune for permitting us to initiate a collaborative project and for taking keen interest in reviving prehistoric investigations in the Survey. Thanks are due to R.K. Dwivedi, N.K.Nimje and P.L. Janbandhu B (All from Prehistory Branch, ASI, Nagpur) and C.K.Bhanarkar, S.S. Bisht and A.K.Sinha (Bhopal Circle, ASI) for their active participation in the field work. We are grateful to the villagers of Tikoda for their co-operation and help given during our investigations.

References

IAR: *Indian Archaeology 1982-83 – A Review* 1985. pp. 38-39. New Delhi: Archaeological Survey of India.

Deo, Sushama, S.B. Ota and Sheila Mishra 2013. (in press). Recent Investigations (2010-2011) of Acheulian Occurrences around Tikoda, District Raisen, Madhya Pradesh, *Bulletin of the Deccan College Research Institute* 72.

Jacobson, Jerome 1970(a). *Microlithic Contexts in the Vindhyan Hills of Central India.* Unpublished Ph.D. Thesis, New York: Columbia University.

Jacobson, Jerome 1970(b). On Palaeolithic Occupation Floors in India, *Current Anthropology* 11: 483.

Jacobson, Jerome 1974. Early Stone Age Habitation Patterns in Raisen District, Madhya Pradesh. Paper presented at *Seminar on Indian prehistory and Protohistory*, Deccan College, Poona, June 25-29.

Jacobson, Jerome 1975. Early Stone Age Habitation Sites in Eastern Malwa, *Proceedings of the American Philosophical Society* 119: 280-97.

Jacobson, Jerome 1985. Acheulian Surface Sites in Central India, in *Recent Advances in Indo-Pacific Prehistory*, (V.N. Misra and Peter Bellwood Eds.), pp. 49-57. New Delhi: Oxford & IBH Publishing Co.

Ota, S.B., Sushama G. Deo and Sheila Mishra 2013. *in press*. Geoarchaeological Investigations of Acheulian Localities in Tikoda Area, District Raisen: A Preliminary Report, *Ancient India* 2.

T. Padhan, in *Recent Advances in Acheulian Culture Studies in India*
(K.Paddayya and S.G. Deo Eds.), pp. 67-84 [2014]

The Acheulian Phase in Odisha with Special Reference to Recent Research in the Jonk Basin

Tosabanta Padhan
Deccan College (Deemed University)
Pune 411006
E-mail: tpadhan@gmail.com

Abstract

Acheulian sites have been known in Odisha since 1876 when Valentine Ball reported some artefacts from central and western Odisha. Since then more than 150 Acheulian sites have been found from Odisha, which are widely distributed all across the state except in the coastal zone. Acheulian sites occur in a variety of geological contexts such as hillslopes, foothills, river gravels, and erosional surfaces. The present paper reviews earlier work on the Acheulian of Odisha, summarizing the available information about site details, distribution, context, and lithic assemblages. The paper also includes results of recent field investigations in the Jonk river basin undertaken by the author as part of his doctoral research.

Introduction

The state of Odisha, located in the south-eastern part of India, holds an important position in the story of early hominin behaviour and dispersals. A large number of sites have been discovered in different parts of the state with the highest concentrations in the western highlands and Mayurbhanj plateau. However, central Odisha has also yielded a large number of Acheulian sites, particularly in the Brahmani river valley. In total the state has recorded 153 Acheulian sites (Table 3). The assemblages consist of variable numbers of handaxes, cleavers, flakes, retouched flakes, cores, choppers, hammerstones and modified cobble pieces. The typological composition of the assemblages varies in different areas of Odisha as does the raw material used to manufacture the tools. Local raw material sources dominate in all the assemblages.

The data for the present paper has been acquired both from published as well as unpublished sources, in the form of books, research articles, theses or reports, fieldwork and from personal communication from other scholars. It discusses the character of lithic assemblages and the general sedimentary contexts, and seeks to bring out the importance of these features from a broader perspective. It also incorporates the results of recent field investigations in the Jonk river basin. No Acheulian site in Odisha has been dated so far in absolute terms; only relative dating on the basis of stratigraphy and regional geology has been attempted.

The Region and Geological Background

The state covers an area of 155,707 km^2 between 17°49' and 22°34'N latitude and between 81°29' and 87° E longitude. A long coastline running to 482 km forms the eastern boundary of the state along the Bay of Bengal, while the high hills and mountains of Eastern Ghats constitute the western border. The geography of the state consists of five zones - coastal plains, central mountainous country, rolling uplands, river valleys and subdued plateau (Sinha 1971). The major portion of Odisha is covered by meta-sediments and granites of the Archaean age followed by the Cuddaphs and then Gondwanas. A major part of north Odisha is covered with Proterozoic metasediments. Coal-bearing Gondwana formations are found in central Odisha. High grade granulites, migmatites and gneiss occur in south Odisha and extensive granites and Vindhyan sedimentary rocks are distributed in western Odisha. The coastal region is covered with younger laterites and Quaternary sediments forming peneplains and plains in coastal Odisha (Mahalik 2000:2).

The rivers of Odisha originate from three divides. These are formed by the Chota Nagpur plateau in Jharkhand, the Amarkantak plateau in Chhattisgarh and the Eastern Ghats within Odisha. The Brahmani, the Mahanadi and the Vamsadhara are major rivers. The coastal plains of Odisha stretch along the eastern coast of India from the Subarnarekha in the north to the Rushikulya in the south and are regarded as a land of six deltas - the Subarnarekha, the Budhabalanga, the Baitarani, the Brahmani, the Mahanadi and the Rushikulya. The rolling mountains, which vary in altitude from 153m to 305 m ASL, are higher than the plateaus. The subdued plateaus (305-610 m ASL) have the peculiarities of peninsular tablelands. The vegetation in Odisha primarily belongs to the tropical-deciduous type. Hot summers with heavy monsoon downpours and cool and pleasant winters generally mark Odisha climate. Rainfall is the main source of water in Odisha and it ranges from 1200 to 1700 millimetres across the state.

Brief Review of Acheulian Phase in Odisha

Some reviews on the prehistoric archaeology of Odisha are available (e.g. Mohanty1992; Mohanty and Tripathy 1998; Basa1994, 2000, 2005 and Padhan 2006, 2013) but no exhaustive review of the Acheulian phase has been made so far. In the present review, an attempt has been made to incorporate the new discoveries.

Palaeolithic sites have been recorded in Odisha since the 19th century. In the late 19th century, Valentine Ball was the first to initiate prehistoric research in Odisha in a systematic manner and is credited with being the first discoverer of handaxes in the region (Mohapatra 1962: 26). He collected a few artefacts from Bhursapali in the Kuchinda subdivision of Sambalpur district, Kaliakata and Harichandanpur near Talcher in Angul district of Odisha in 1875 and published a small description of the same in *Proceedings of the Asiatic Society of Bengal* (Ball 1876:120-121).

Although the number of tools found was only four and description of the tools and the sites was sketchy, this work was of great significance as it brought the Acheulian sites of Odisha on the country's scene for the first time. Since then numerous field investigations have been carried out by prehistorians and amateur archaeologists from different parts of the state. Acharya and Worman discovered the site of Kuliana in Mayurbhanj district in 1939 and subsequently Bose and Sen of Calcutta University started investigations there. This work included excavations at some selected localities of the site, which were published in a monograph entitled, *Excavations in Mayurbhanj* (Bose and Sen 1948). The lithic assemblages from the site included choppers, handaxes and cleavers. Kuliana was in fact the first excavated Palaeolithic in the whole of India. Despite this early beginning, prehistoric research in Odisha is still in its infancy as no detailed work on any prehistoric site was conducted after Kuliana.

The excavation at Kuliana was followed by a number of explorations by Calcutta University in the 1950s. These surveys brought to light a number of Acheulian sites in Mayurbhanj district and the surrounding areas; these include Amisikara, Baripada, Brahmagaon, Bhuasuni, Buramara, Kalaberia, Kamta, Kendudiha, Koilisutra, Kuliana, Mundaboni, Nuaberi, Pariakoli, Patinja, Pratappur and Sandim. These sites are situated within a radius of around 30 km from Kuliana and are spread along the banks of the Burahabalang river (Ghosh and Basu 1969: 234). These are found in a similar geological context as at Kuliana. Ghosh and Basu (1969) observed five layers in the sections. The top layer comprised yellowish sediment mixed with fragments of laterite and the proportion of the later sediment increases along with the depth. Successively hard and compact layers in its lower level appeared with very few quartz fragments, devoid of any artefacts. In the exposed sections the lowest bed was of yellowish/greyish white clay, sticky in nature (Ghosh and Basu 1969).

Mohapatra (1962) made systematic surveys in the districts of Mayurbhanj, Keonjhar, Sundergarh, Sambalpur and Dhenkanal and brought to light 22 Palaeolithic sites from the Budhabalanga, Baitarani, Brahmani and Mahanadi valleys. He also made a distinction between the Lower and Middle Palaeolithic assemblages on the basis of stratigraphical and typo-technological grounds.

Early Stone Age (Lower Palaeolithic) assmeblages of Mohapatra comprised handaxes, cleavers, scrapers, cores, points, flakes and irregularly flaked pebbles. Handaxes predominate in his collection and cleavers were strikingly few and scrapers were mainly found in miniature varieties. He suggested that this culture might have belonged to the tradition of bifacial tools in which flakes and pebbles form an integral part of the assemblages. Stratigraphically, these occurred in the coarse gravel at the bottom of river sections, secondary laterites, in the loose gravel beds of the rivers, on the surfaces of river banks, slopes of the hills or in various secondary deposits.

Tripathi (1980) carried out intensive explorations in the Tel basin forming part of southwestern Odisha and reported the occurrence of three sites belonging to the pebble-tool industry and flake industry. Thus, the result of his study showed correlations with the research carried out by Mohapatra (1962).

Investigations by Ota (IAR 1981-82) in the Bagh and Khadag valleys (tributaries of the Mahanadi and Tel respectively) in the Phulbani district resulted in the discovery of a few Acheulian sites at Gurvelipadar, Kankolidungri, Rengali Hill, Kantamal, Sunadei Hill, and Barpadar. Most of the tools are made on quartzite pebbles and cobbles and are found in open-air contexts. The artefacts were collected from the surface of the red soil found in patches in the foothill zones as well as along river banks. Cores, flakes, hammerstones, and unifacial and bifacial choppers constitute the major tool types in Bagh and Khadag river basins.

Singh (1982, 1988, and 2000) carried out intensive field surveys in Dhenkanal district and found 53 Lower Palaeolithic sites. His collection comprised 1599 artefacts and are characterized by handaxes (n = 1302), cleavers (n = 128), discs (n = 25), choppers (n = 88), scrapers (n = 33), flakes (n = 14), and points (n = 9). Typologically, his collections were dominated by handaxes and cleavers and the majority of handaxes were made on cores and 75% of cleavers were made on flake blanks (Singh 2000:106-108).

Ratha and Bhattacharya (1988) discovered a Lower Palaeolithic site along the river Kharala near Kuchinda in Sambalpur district. The artefacts were found within secondary alluvial deposits spread over an area of 4 km^2 along the river Kharala, a tributary of the river Mahanadi. The lithic assemblage includes handaxes, cleavers, chopper-chopping tools, classic backed knives and side-scrapers. Most of the artefacts were made from dimensionally suitable river pebbles and cobbles. According to the nature of the lithic assemblage, Ratha and Bhattacharya (1988) assigned the Kuchinda assemblage to the middle phase of Acheulian culture.

Chakarabarti (1990) discovered four Lower Palaeolithic sites in channel bed and cliff section of the Bhandan and Khairi rivers around Khiching village in Mayurbhanj district. Choppers and handaxes form the major Lower Palaeolithic types; and scrapers, borers, and points constitute the Middle Palaeolithic types (Chakrabarti 1992; 2000). Sharma (1994) reported Palaeolithic finds in and around Burla and attempted to study the area's Palaeolithic assemblages which are located on the Sambalpur University campus and its adjoining areas. Sharma's explorations in the Burla area were carried forward by Behera *et al.* (1996) in and around the Mahanadi, Burla and Dari- dungri regions of Sambalpur; this work led to the discovery of 684 finished Palaeolithic tools. They studied the Acheulian artefacts in detail and provided the typo-technological analysis of the various lithic assemblages. Their collection included a total of 141 handaxes and 44 cleavers, which constituted the dominant tool types in the assemblages. The Daridungri hills located near Mahanadi river yielded 94 handaxes and 21 cleavers. Handaxe forms from these sites included cordiform, limande, ovate, sub-triangular, discoidal, atypical Micoquian, and irregular and or partial handaxes. The cleavers from these sites have large cutting edges with their butts being 'U' and 'V' shaped.

Ray *et al.* (1997) carried out systematic explorations in and around Malayagiri Hills in Dhenkanal district and took a trial trench at Jamsara, reaching up to 160 cm in depth. They collected 434 tools from both the surface and trial trench. The main lithic types were choppers, handaxes, cleavers, knives, point, cores, un-retouched flakes and a variety of scrapers. While this surface collection was dominated by scrapers, the excavated material was found to be dominated by handaxes. The tools found in the lower gravels were generally less refined in technology than those in the upper gravels. The work of Mohanty *et el.* (1997) in the Kharua river valley in Mayurbhanj district also brought to light four Lower Palaeolithic sites. Most of the reported Acheulian sites in the area occurred on lateritic terrain whereas the Mesolithic sites occurred on the compact red soil, in the foothill regions and on granitic outcrop. Field investigations under the direction of L.S. Rao of the Archaeological Survey of India, Bhubaneswar Circle, resulted in the discovery of 22 Acheulian sites in secondary context from the Bramhani river basin (IAR 1999-2000).

Kar (2008) carried out investigations for his doctoral research in the Singida valley (tributary of Brahmani in Talcher area of central Odisha). He has reported 25 sites and collected 155 Acheulian artefacts from the foothills and river cliff gravels including 6 choppers, 126 handaxes, 10 cleavers, and 13 scrapers.

Recent field investigations in the Bargarh upland by P.K. Behera and his students have resulted in the discovery of a large number of sites and collection of several thousand artefacts from the Bargarh uplands in western Odisha. As a result, several Acheulian sites have been discovered, e.g. Barpadar, Sarsara, Rohania, Dhanger, Khuntapali, Jamkitikra, Launsara, Baramkela, Deogaon, Beherapali, Urduna, Urduna (B), Rasali, Duanpali, Kharmunda, Jamchhapar, and Gopalpur (Pers. comm.: P. K. Behera). The hillslopes and foothills of the Barapahar represent a pedimented slope surface which has been undergoing large-scale erosion of surface soils, leading to the exposure of gravels that yield Acheulian artefacts. These artefacts belong to the 'Large Flake Acheulian' tradition (Sharon 2007) having a large number of handaxes, cleavers, polyhedrons, variety of scrapers, Kombewa flakes, variety of cores and some manufacturing debris. The assemblage contains very few choppers and Levallois flake tools and most of the artefacts from the Bargarh upland are made of quartzite.

General Observations

From the foregoing review it is clear that Stone Age studies concentrated in the western highland, Mayurbhanj plateau and central Orissa. Nothing is known from the eastern and southern districts of Koraput, Kalahandi, Gajapati, Raigada and Nawarangpur, Puri, Ganjam, Khurda, Jajpur, Khurdha, Cuttack, Kendrapada and Baleswar districts because there has been very little exploration. Barring a few coastal districts, these areas have suitable Quaternary geological exposures and hence the occurrence of Acheulian sites cannot be denied.

The existing studies of the region's Acheulian techno-chronological phase are based on the surface assemblages and available in the form of small research articles, unpublished dissertations, and so forth. These are again limited to basic reporting of sites and are devoid of any systematic sampling and detailed studies of the collected artefacts. Very few of these publications contain site distribution maps and provide adequate information about metrical details of stone tools, associated technological processes, sedimentary context of the lithic assemblages, raw material used and such other aspects that could be used for reconstructing human behaviour.

Acheulian sites in Odisha are mostly found in three contexts: hillslope, slope-pedimented erosional surface and river section deposits. The stratigraphic context of this tradition is ubiquitously observed within the fluvial river section; sandy-cobbly, sandy-pebbly, and pebbly-cobbly gravels, or cemented gravel layer overlies the weathered Achaean bedrock and occasionally on mottled clay. However, Acheulian sites have also been reported from forests and slopes of the hills and in secondary laterite gravel quarries.

The majority of Acheulian sites in western Odisha have been reported from foothills, older surfaces, river bank sections and hill slopes, all actively undergoing erosion. The contexts for sedimentary burial are the river alluvium or locally transported regolith. In the hill slope contexts, artefacts are found overlying untransported weathered bedrock and form part of an erosional lag deposit. This was covered by transported weathered material, which is currently being stripped off through natural processes. Most of the artefacts have been exposed to weathering over a long time and are poorly preserved although they may be lying close to the original locations used by the early hominins. The artefacts from the alluvial context on the other hand appear to have been rapidly buried after discard and are generally in a better condition than the ones in regolith context.

Recent Field Investigation in Jonk Basin

The present author's doctoral research was aimed to interpret the Stone Age archaeological record of the Jonk valley and its sedimentary contexts for reconstructing prehistoric adaptations to the local Quaternary landscapes. The Jonk is a tributary of the Mahanadi river. It originates in the north Sunabera plateau (20° 29' 59.66" N; 82° 26' 35.08" E) in Nuwapada district of Odisha at an altitude of 660 ASL. Then it passes through several small and big mountain ranges. After flowing through a narrow rocky channel of Nawapara Hill range it turns into the Mahanadi near Seorinarayan (21° 42' 43.42"N; 82° 34' 34.03" E) at an elevation of about 234 ASL.

Recent field investigations spanning four seasons (2008 to 2012) and covering more than 250 km^2 area of the river basin has brought to light 15 new Acheulian sites in western Odisha and eastern Chhattisgarh (Fig. 1). The vegetation cover in this region belongs to the of tropical deciduous type and chiefly consists of Mahua trees on flat land near the river banks and savanna woodland in the highland and valleys. The area receives 1300-1600 mm rainfall per year.

The Jonk river and its catchment zone are occupied by Precambrian granites, gneisses of the Eastern Ghat Supergroup, Bengpal Group and Sonakhan Group with local basic intrusive and volcanic lithologies; limestones, sandstones, and occasional occurrences of quartzite. The upper Jonk is dominated by the upper level structural plateau of Proterozoic rocks and part of it is the lower level structural plateau of the Proterozoic rocks. In the foothill area pediment surface dominates the landscape. In the middle part of the river course some structural hills create a water divide between the river Jonk and its parallel river Ong. In the lower part the river cuts across several structural hills and valleys of the Nuwapada hill range. The banks of the Jonk river and its tributaries are covered with flood plain deposits and at some places these are filled with older river channel deposit.

The study area was intensively surveyed on motor cycle for four field seasons. The potential cliff sections along the banks of the Jonk and its tributaries, pedimented erosional surfaces, rocky areas, waste land, badland, hill slopes and small hill tops were scanned for Palaeolithic sites and for understanding the pre-Quaternary geology and provenance of raw materials for making tools. The majority of prehistoric sites in this area were found in the foothills (Figs. 2-4). A limited number of artefacts were also found in the river gravels and on the surface of cliff sections (see Fig. 5).

A total of 306 artefacts were collected from the 15 Acheulian sites and metrical analysis was done on all artefacts. Prime importance was given to the reconstruction of *chaîne opératoire.* Various technological aspects and other information such as tool types, technology and their function, role of raw materials, and morphological variability within the assemblage in general were studied. Detailed typological analysis shows that flakes constitute the largest type (39.54%), followed by cores (15.36%) and core fragments (4.90%). Handaxes are 57 (18.63%), cleavers are 15 in number and constitute 4.90% of the assemblages. In addition, 13 choppers are found and these make 4.25% of the collection. The other types include four cleaver flakes, four handaxes/cleavers (1.31%), two denticulates, one pick, and six utilised cobbles.

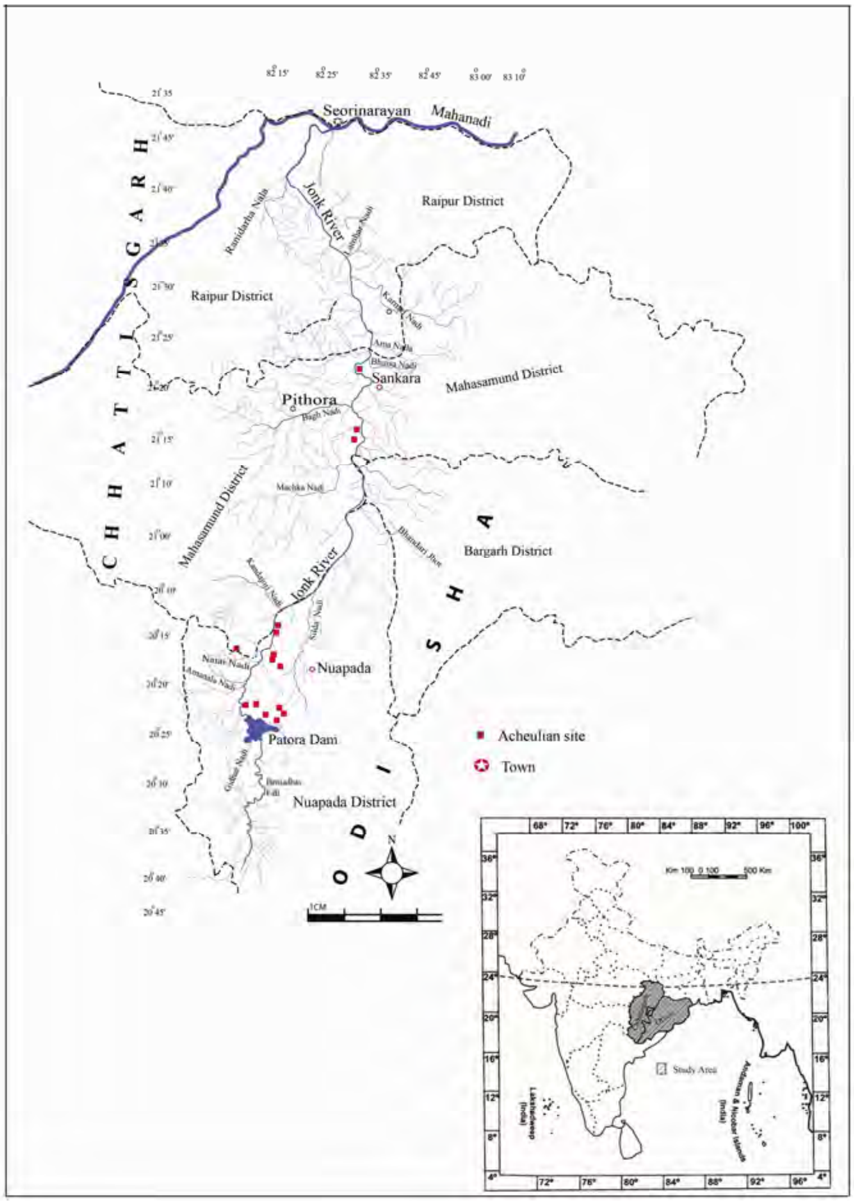


Fig.1: Distribution of Acheulian sites in the Jonk river basin

Fig. 2: Panoramic view of the Acheulian site at Chipajhar-1

Fig. 2: Artefact clusters at the hill slope Acheulian site of Chipajhar-2

Fig. 3: Close-up of two handaxes at Chipajhar-1

Fig. 5: Artefacts within gravel in the river section

Approximately 64% of the artefacts are made from flakes and the rest from cores. Debitage is not very common and only a few core fragments are noted. Even evidence of bifacial-thinning flakes is absent at the sites. Bifacial elements are smaller than 8 cm are absent in the lithic assemblages. Most of the Acheulian artefacts in the assemblage represent finished tools such as well-shaped handaxes, cleavers and flake tools.

Handaxes

A large amount of shaping is observed on handaxes and these are more heavily retouched than cleavers (Fig. 6). These fall within the 8.5 to 18.8 cm size range. The average length, breadth and thickness measured 12.2 cm, 7.9 cm and 4.3 cm, respectively. A number of bifacial artefacts (1.31%) were probably used as both handaxes and cleavers. The handaxes are made both on nodules and flakes. Ovate (32%) and almond (39%) shapes occur at all sites. The weight range varies significantly (79-1144 gm) depending on the use of nodules or flakes for their manufacture. These are heavier and thicker than those made on flakes. Most of the ovate handaxes are made on flakes and there is absence of cortex on them. Striking platforms of bifacial artefacts are modified, but in some cases not much importance has been given to removing the butt and bulbar parts. Even in the case of bifacial artefacts, thinning was not extensively done as observed at Bhimbetka in Central India (Misra 1978).

Cleavers (Fig. 7)

Cleavers show less variability than the handaxes. Cleaver lengths ranged between 8.9 -16.2 cm with an average length of 12.9 cm, an average breadth of 9.1 cm and an average thickness of 4.3 cm. The cutting-edges of 56% of the cleavers were broken possibly due to intensive use. Straight and oblique cutting edges are common. Cleavers are primarily made on large flakes involving heavy retouch on lateral sides with minimal retouch on ventral sides: 38% cleavers were made on end-flakes while 41% were made on possible Kombewa flakes and 20% were made on side-flakes. In several cases secondary working was in unifacial direction (from ventral to dorsal side). In some cleavers, some flakes were removed to make the cutting edge thinner and sharper. Most of the cleavers are rectangular in shape; a few specimens have a high backed shape. All cleaver butts are generally 'U'-shaped, square or round in shape, and there is a complete absence of the 'V'-shaped butts commonly found at other sites in India including Odisha.

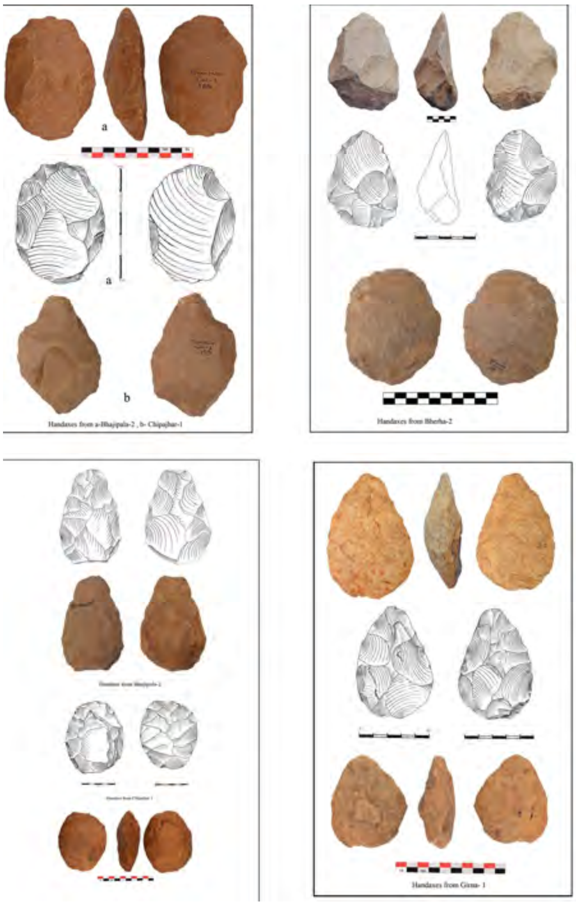


Fig. 6: Handaxes from the Jonk basin

Other Technological Features

Most of the flakes which were converted into tools do not have any uniformity in size and working and retouching is also varied. Large flakes were removed from giant cores by heavy hard hammer or anvil or 'Clactonian' techniques. For the production of cleavers and handaxes, large end-stuck or side-struck flakes were preferred. Desired shaped tools were obtained by using medium to small sized hammerstones. The Levallois or prepared core technique is rare, but the Kombewa technique is more common. The weight of cores ranges between 105.60 and 3921.45 gm, with an average weight of 958 gm. The cores are mostly of cobble size.

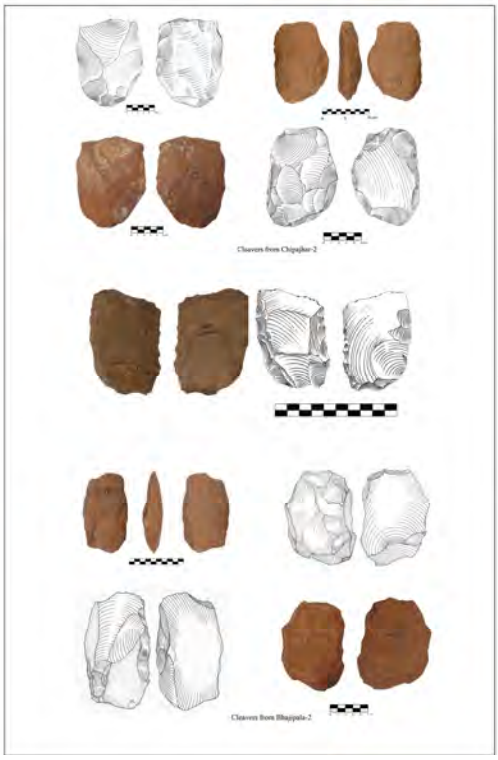


Fig. 7: Cleavers from the Jonk basin

Our analysis shows that 3.87% of the artefacts are found in fresh condition. The rest show various degrees of weathering. 15.14% are slightly weathered, 56.69% moderately weathered and 24.30% of the artefacts are in a heavily weathered condition.

Five different rocks have been used for manufacturing of Acheulian tools in the study area: quartzite (90.91%), pegmatite (2.80%), sandstone (3.85%), banded chert (1.4%) and quartz (1.05%). Most of the Acheulian sites show a preference for locally available materials.

It appears that most of the bifacial tools or flakes were transported to the localities from elsewhere because of the lack evidence for production activities (e.g. debitage). Some utilised cobbles were noticed at most of the sites and these appeared to have been brought into the sites for breaking hard substances such as bone, hard-shelled fruits, and nuts, etc.

In the absence of absolute dates at this stage of the work, it is difficult to assign any exact date to the Acheulian assemblages of the Jonk basin. However, on typo-technological grounds, it can be suggested that the assemblages belong to the large flake Acheulian (LFA) tradition as they are mostly larger than 10 cm. The assemblages do not appear to be Early Acheulian but are closer to the Late Acheulian phase, as supported by general size and refinement attributes. In terms of Quaternary chronology of the Jonk basin, Acheulian assemblages may date to the closing part of Middle Pleistocene or Late Pleistocene.

Table 1: Cleavers (in mm) from Orissa in comparison to the major Indian sites

Site	**Variables**	**Length**	**Breadth**	**Thickness**	**Reference**
Jonk	Range	83-163	60-110	28-89	Padhan 2013
	Average	129.27	91.26	43.58	
	SD	22.98	14.46	13.02	
Dari-Dungri	Range	79-179	60-139	26-61	Behera*et.al* 1996
	Average	124.5	90.43	41.05	
	SD	16.96	18.22	9.33	
Mayurbhanj	Range	96-132	40-85	Not Available	Ghosh and Roy 1964
	Average	118	71	Not Available	
	SD	9.86	12.2	Not Available	
Hunsgi	Average	140	90	46	Sharon 2007
Yediyapur VI	Average	137	84	38	Sharon 2007
Chirki	Average	137	82	44	Sharon 2007
Bhimbetka	Average	124	73	37	Sharon 2007
Lalitpur	Average	130.19	90.03	40.46	Agrawal 2012

Table 2: Handaxe measurements (in cm) from major sites of Odisha (after Chauhan 2010)

Sites	Length	Length SD	width	Breadth SD	Thickness	Thickness SD
Dari-dungri	12.22	2.70	7.65	1.35	4.01	0.85
Mayurbhanj	14.53	2.48	9.07	1.80	4.83	1.68
Keonjhar Group-1	15.20	5.86	10.07	3.00	5.33	2.30
Keonjhar Group-2	12.97	2.62	8.43	1.33	4.41	0.98
Jonk	12.26	2.29	8.02	1.27	4.28	1.04

General Observations on the Technology of Acheulian in Odisha

The Acheulian tool inventory in Odisha comprises handaxes, cleavers, scrapers, cores, giant cores, polyhedrons, pointed flakes, irregularly flaked pebbles, and a variety of hammerstones. Handaxes repeatedly outnumbered the types in the collections made by previous investigators. Cleavers are strikingly few and scrapers are mainly found in miniature varieties. The assemblages from sites found near major and minor rivers are characterized by the use of pebbles and cobbles for the production of Acheulian artefacts,.while the sites away from rivers show dominance of tools based on the use of large flakes .Hard-hammer technique is the most commonly used method for flaking, as shown by the occurrence of a variety of quartzite hammerstones amd the presence of deep flake scars on the artefacts. Soft hammer technique is observed on a limited number of bifacial artefacts. River pebbles were initially used as hammerstones, but later on some of these pebbles served as cores for flake removal.

In length Jonk valley cleavers range from 8.3 to 16.3 cm (with an average of 12.9 cm); breadth ranges from 6 to 11 cm (with an average breadth of 9.1cm); and thickness ranges from 2.8 to 8.9 cm (with an average of 4.3 cm). The cleavers from Dari-Dungri range in length from 7.9 to 17.9 cm (with an average length of 12.4 cm). The Mayurbhanj specimens, as reported by Ghosh and Ray (1964), range from 9.6 to 13.2 cm in length (with an average length of 11.8 cm). Cutting edge of cleavers from Mayurbhanj ranges in length between 7 and 11 cm. Cleavers from Hunsgi, Chirki, Yediapur and Lalitpur are larger than those from Odisha (Table 1).

According to Singh (2000:107), handaxes from Panchmahala and Remuna in Dhenkanal are very weathered. Most of the spcimens (32%) found by him are in the length range of 10.1 to 12.0 cm. Among these 37% are made on cores and 41.1% are made on flakes. Handaxes from Keonjhar Group-1 have an average length of 15.2 cm, followed by Mayurbhanj handaxes with an average length of 14.53 cm. Handaxes from Dari-Dungri, Jonk and Keonjhar Group-2 compare well in length (Table 2).

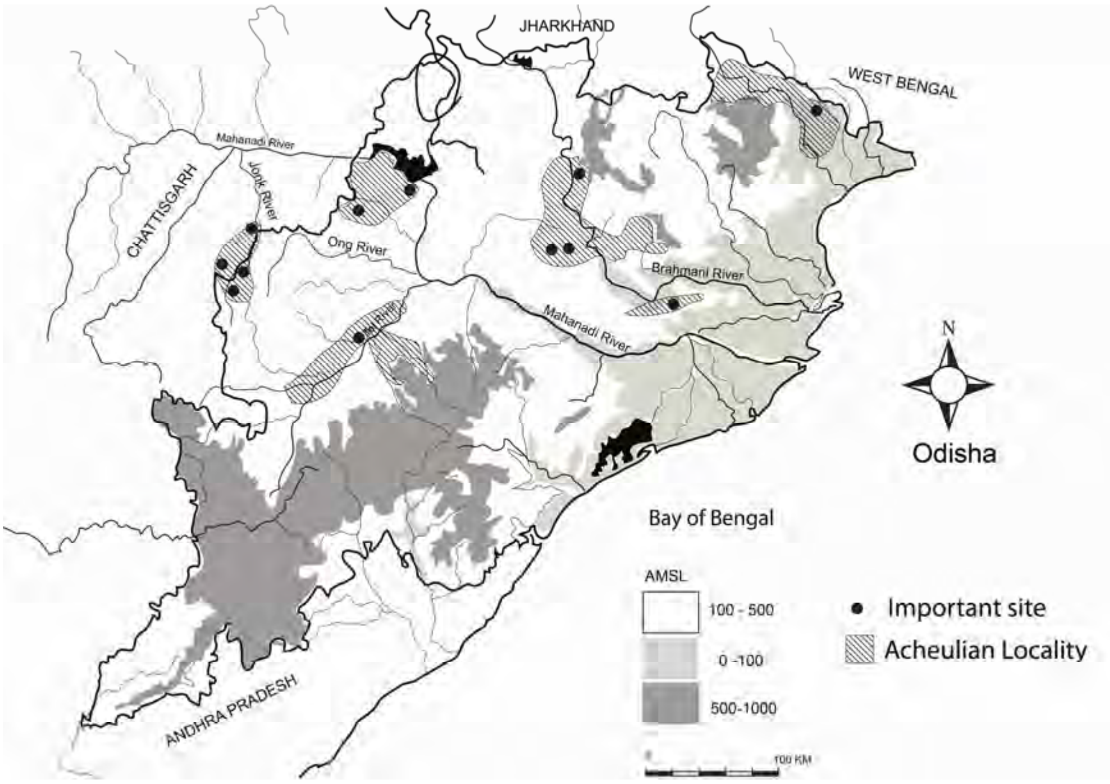


Fig. 8. Distribution of Acheulian zones in Odisha

Conclusion

Investigations into the Acheulian of Odisha are still in the beginning stage. Initial work was done from the 1940s to 1960s and then only sporadic reporting of sites has taken place. So far no pre-Acheulian sites have been discovered in the region. However, choppers are very often found associated with bifacial tools. No primary occurrence and factory sites are known; and most of the reported sites have yielded finished tools. Typo-technologically, both Early and Late Acheulian bifacial elements occur together as mixed assemblages and no developmental phases can be distinguished at any of the reported sites. However in some of the of the Jonk and Jira river basins, Early and Late Acheulian types can be identified on the basis of size, shape and morphology of artefacts, as well as on the basis of technological variability and amount of secondary working and retouching found on the bifaces.

The distribution of Acheulian sites illustrates successful occupation of a wide range of ecological zones across the state except the coastal regions, where the absence of site may be due to deposition of recent alluvium or else due to lack of planned and comprehensive field investigations (Fig. 8). The dominance of handaxes over cleavers is a noteworthy feature of the bifacial assemblage of eastern India. In spite of the historical significance of discovery of the site of Kuliana and its excavation no large scale excavation of a Stone Age sites has been carried out in any part of the state since then. Identification and excavation of the primary and *in situ* Stone Age sites, represented by multidisciplinary investigations and absolute dating, are clearly needed.

Acknowledgements

The paper would not have been completed without the constant support and encouragement of Profs. Sheila Mishra, R.K. Mohanty, P.K. Behera and K.K. Basa. Shantanu Vaidya, Parth R. Chauhan, Pankaj Goyal, Burhan Ahmed and Garima Khansili are gratefully acknowledged for going through the manuscript and suggesting some corrections.

References

Ball, V.1876. On Stone Implements Found in the Tributary States of Orissa, *Proceedings of Asiatic Society of Bengal* 12:120-123.

Basa. K. K. 1994. Problems and Prospects in Archaeology of Orissa, India. *Occasional Paper in Anthropology*, Utkal University. Bhubaneswar.

Basa K.K. 2000. History of Archaeology in Orissa, in *Archaeology of Orissa*, (K. K. Basa and P. Mohanty Eds.), pp. 16-61. New Delhi: Pratibha Prakashan.

Basa, K. K. 2005. River Systems and the Emergence of Complex Society in Orissa: An Archaeological Perspective, in *River Valley Cultures of India* (K. K. Chakravarty and G. L. Badam Eds.), pp. 69-83. New Delhi: Aryan books International.

Behera .P.K., P. Panda and N. Thakur 1996. Techno-typological Analysis of Lithic Artefacts from Dari-Dunguri Achulian Site, Sambalpur District Orissa, *Man and Environment,* XXI (2):15-26.

Bose, N. K., and D. Sen 1948. *Excavations in Mayurbhanj*. Calcutta: University of Calcutta.

Chakrabarti, S. 1990. The Stone Age Prehistory of Kiching, Orissa, *Man and Environment* XV(2): 13-21.

Chakrabarti, S. 1992. New Perspective on Palaeolithic Archaeology of Kuliana, Northern Orissa. Eastern India, in *Proceedings of the XX Conference of Indian Society for Prehistoric and Quaternary Studies*, pp 1-3. Dharwad: Karnataka University.

Chakrabarti, S. 2000. Recent Advances in Prehistory of Mayurbhanj, in *Archaeology of Orissa* (K. K. Basa and P. Mohanty Eds.), pp. 16-61. New Delhi: Pratibha Prakashan.

Chakrabarti, D. K. and R. K. Chattopadhyay 1988. A Note on the Lithic Industries of Mayurbhanj and Keonjhar, Orissa, *Man and Environment* XII: 203-208.

Chakrabarti, D.K. 1993. *Archaeology of Eastern India.* New Delhi: Munshiram Manoharlal Publishers Pvt. Ltd

Ghosh, A. K. and A. N. Basu 1969a. An Appraisal of Palaeolithic Industries in Mayurbhanj in the Light of Recent Discoveries, *Science and Culture* 35 (9): 476-479.

Ghosh, A.K. and A.N Basu 1969b. An Analysis of Mayurbhanj Palaeolithic Industry, *Journal of Indian Anthropological Society* 5:233-248.

Ghosh, R. and G. A. Ray 1964, Technological Study of the Cleavers of Mayurbhanj, *Man in India*, 44(1): 50-74.

IAR: Indian Archaeology- A Review. New Delhi: Archaeological Survey of India.

Kar, S. K. 2008. *Archaeology of the Singida Valley, Central Orissa, India*.

Unpublished Ph. D. Dissertation. Bhubaneswar: Utkal University..

Mahalik, N.K.2000. Geomorphology of Orissa in Stone Age Culture of Central Orissa, in *Archaeology of Orissa* (K. K. Basa and P. Mohanty Eds.), pp. 1-15. New Delhi: Pratibha Prakashan.

Misra,V.N. 1978. The Acheulian Industry of Rock shelter IIIF-23 at Bhimbetka, Central India - a Preliminary Study, *Bulletin of the Indo-Pacific Prehistory Association* 1:130-171.

Mohapatra, G.C. 1990. Acheulian Terrain in Orissa: Nature and Connections. Paper presented at the *International Seminar on Rising Trends in Palaeoanthropology, Environmental Change and Human Response*. Pune: Deccan College.

Mohapatra, G.C. 1962. *The Stone Age Culture of Orissa*. Pune: Deccan College.

Mohanty, P.K 1992. Stone Age Research in Orissa: An Overview, *Man in India* 72: 207- 232.

Mohanty, P.K and B. Tripathy 1997-98. The Prehistoric, Proto-historic and the Early Historic Cultures of Orissa, *Pragdhara.*8: 69-99.

Padhan, T. 2006. *Mesolithic Culture of Orissa*, P.G. Diploma Dissertation, Pune: Deccan College.

Padhan, T. 2013. *Prehistoric Archaeology of the Jonk River in Odisha and Chhattisgarh*, Ph.D. Dissertation. Pune: Deccan College.

Ratha, S.N and D.K. Bhattacharya 1988. Lower Palaeolithic from Kuchinda (Orissa), *Man and Environment* 12:13-27.

Ray R., S. Prasad and U. Basu 1997. Stone tools from the Jamara Site, Malaygiri Foothills, Orissa, *Bulletin of the Indo-Pacific Prehistory Association*, 16: 33-34.

Sharma, H.C.1994. Palaeolithic Finds around Burla, District Sambalpur, Orissa, *Man and Environment* 19(1): 285-290.

Singh, P.K. 2000. Stone Age Culture of Central Orissa, in *Archaeology of Orissa.* (K. K. Basa and P. Mohanty Eds.), pp. 102-113. New Delhi: Pratibha Prakashan.

Singh, P.K.1988. Cultural Succession of Prehistoric Culture in Central Orissa, in *Culture of Past* (K. L. Bhowmick Ed.), pp.87-99, New Delhi: Inter India Publication.

Singh, P.K.1982. Palaeoanthropology of Central Orissa, *Manav* 1.

Sinha, B.N. 1971. *Geography of Orissa,* New Delhi: National Book Trust.

Tripathi, K. C. 1980. *Lithic industries in India: A Study of South –Western Orissa.* New Delhi: Inter India Publication.

Tripathi, K. C. 1977. Prehistoric Studies in Orissa, in *Sidelights on History and Culture of Orissa* (M.N. Das Ed.), Cuttack : Vidyapuri.

Tripathi, K. C. 1973. South Orissa Prehistory-the First Record of Stone Age Tools, *Asian Perspectives* 4:47-59.

Tripathi, K. C. 1972. *Lithic Industries of South-Western Orissa.* Ph.D. Dissertation, Bhubaneswar: Utkal University.

Tripathi, K.C. and U.C. Mohanty 1972. Lithic Industries of South-Western Orissa, *Prakruti* (Utkal University Journal of Science) 9:1-2.

Table 3: List of Acheulian sites in Odisha

No	Site Name	River/Hills name	District	Latitude/ Longitude	Reference
1.	Kaliakata	-	Angul	Not Available	Ball 1876
2.	Harichandnpur	-	Angul	Not Available	Ball 1876
3.	Dhenkanal sadar	-	Dhenkanal	Not Available	Ball 1876
4.	Bhursapali	-	Sambalpur	Not Available	Ball 1876
5.	Brahmangaon	Budhabalanga	Baripada	22° 5' 26" N, 86° 38' 30" E	Bose and Sen 1948

6.	Buramara	Budhabalanga	Baripada	22° 6' 3l" N, 86° 39' 10" E	Bose and Sen 1948
7.	Patinja	Budhabalanga	Baripada	22° 3' 45" N, 86° 37' 41 "E	Bose and Sen 1948
8.	Mundaboni	Budhabalanga	Baripada	22° 2' 50" N, 86° 35' 48" E	Bose and Sen 1948
9.	Bhuasuni	Budhabalanga	Baripada	22° 2' 50" N, 86° 32' 30"E	Bose and Sen 1948
10.	Pariakoli	Budhabalanga	Baripada	Not Available	Bose and Sen 1948
11.	Nuaberi	Budhabalanga	Kendujhar	Not Available	Bose and Sen, 1948
12.	Bhuasuni	Budhabalanga	Kendujhar	Not Available	Bose and Sen, 1948
13.	Harichandanpur	Small stream	Dhenkanal	Not Available	Mohapatra, 1962
14.	Pallahara	Stream Mankara	Dhenkanal	Not Available	Mohapatra, 1962
15.	Pallahara Loc I	Left bank of Mankara	Dhenkanal	Not Available	Mohapatra 1960
16.	Pallahara Loc II	Left bank of Mankara	Dhenkanal	Not Available	Mohapatra 1960
17.	Pallahara Loc III	Junction of Mankara & Kukhra	Dhenkanal	Not Available	Mohapatra 1960
18.	Pallahara Loc IV	Stream Mankara	Dhenkanal	Not Available	Mohapatra 1960
19.	Pallahara Loc V	Right bank of Neta	Dhenkanal	Not Available	Mohapatra 1960
20.	Pallahara Loc VI	stream Neta	Dhenkanal	Not Available	Mohapatra 1960
21.	Pallahara Loc VII	Nudei stream	Dhenkanal	Not Available	Mohapatra 1960
22.	Kaliakata	Singhadajor tributary of the Brahmani	Dhenkanal	Not Available	Mohapatra, 1962
23.	Parang	Nandira stream	Dhenkanal	Not Available	Mohapatra, 1962
24.	Barasol	Khairi and Bhandan stream	Mayurbhanj	Not Available	Mohapatra, 1962
25.	Bhaliatundi	Cliff section left bank of the Brahmani river	Dhenkanal	Not Available	Mohapatra, 1962
26.	Bijatala	Right bank of the stream Bankbal	Mayurbhanj	Not Available	Mohapatra, 1962
27.	Bisai	Bankbal	Mayurbhanj	Not Available	Mohapatra, 1962
28.	Champua	River gravel of Baitharani	Keonjhar	Not Available	Mohapatra, 1962
29.	Ghantasila	River Gangahar	Mayurbhanj	Not Available	Mohapatra, 1962
30.	Jangra	River Brahmani	Sundergarh	Not Available	Mohapatra, 1962
31.	Kankili	Hill slopes	Dhenkanal	Not Available	Mohapatra, 1962
32.	Kharagprasad	Right bank of the river Brahmani	Angul	Not Available	Mohapatra, 1962
33.	Kulei	Right bank of the river Brahmani	Dhenkanal	Not Available	Mohapatra, 1962
34.	Mahulia	River Burhabalang	Mayurbhanj	Not Available	Mohapatra, 1962
35.	Pratappur	Burhabalang	Sundergarh	Not Available	Mohapatra, 1962
36.	Satkuta	Stream of Luijor	Sundergarh	Not Available	Mohapatra, 1962
37.	Talcher	Right bank of river Brahmani	Angul	Not Available	Mohapatra, 1962
38.	Bhimkand	River gravels Brahmani	Dhenkanal	Not Available	Mohapatra 1960
39.	Chakrasil	Hill slopes	Dhenkanal	Not Available	Mohapatra 1960
40.	Hindol road	Small stream	Dhenkanal	Not Available	Mohapatra 1960
41.	Samal	Brahmani	Dhenkanal	Not Available	Mohapatra 1960
42.	Bonaigarh	River Brahmani	Sundergarh	Not Available	Mohapatra 1960
43.	Domuhani	Gravel bed Burhabalang	Mayurbhanj	Not Available	Mohapatra 1960

44.	Banspal	River Son	Mayurbhanj	Not Available	Mohapatra 1960
45.	Mendhakhai	Laterite gravel of a tank	Mayurbhanj	Not Available	Mohapatra 1960
46.	Ramala	River Baitharani	Kendujhar	Not Available	Mohapatra 1960
47.	Tikarapara	Gravel bed of the river Mahanadi	Angul	Not Available	Mohapatra 1960
48.	Bishalbury	Bank of Saphei stream	-	Not Available	Mohapatra 1960
49.	Brahmagaon	Burahabalang river	Mayurbhanj	Not Available	Ghosh and Basu 1969
50.	Bhuasuni	Burahabalang river	Mayurbhanj	Not Available	Ghosh and Basu 1969
51.	Buramara	Burahabalang river	Mayurbhanj	Not Available	Ghosh and Basu 1969
52.	Buramara	Burahabalang river	Mayurbhanj	Not Available	Ghosh and Basu 1969
53.	Kalaberia	Burahabalang river	Mayurbhanj	Not Available	Ghosh and Basu 1969
54.	Kamta	Burahabalang river	Mayurbhanj	Not Available	Ghosh and Basu 1969
55.	Baripada	Burahabalang river	Mayurbhanj	Not Available	Ghosh and Basu 1969
56.	Sandim	Burahabalang river	Mayurbhanj	Not Available	Ghosh and Basu 1969
57.	Pratappur	Burahabalang river	Mayurbhanj	Not Available	Ghosh and Basu 1969
58.	Patinja,	Burahabalang river	Mayurbhanj	Not Available	Ghosh and Basu 1969
59.	Pariakoli,	Burahabalang river	Mayurbhanj	Not Available	Ghosh and Basu 1969:
60.	Nuaberi,	Burahabalang river	Mayurbhanj	Not Available	Ghosh and Basu 1969
61.	Mundaboni	Burahabalang river	Mayurbhanj	Not Available	Ghosh and Basu 1969
62.	Amisikara	Burahabalang river	Mayurbhanj	Not Available	Ghosh and Basu 1969
63.	Koilisutra	Burahabalang river	Mayurbhanj	Not Available	Ghosh and Basu 1969
64.	Kendudiha	Burahabalang river	Mayurbhanj	Not Available	Ghosh and Basu 1969
65.	Dhenkanal	Laterite conglomerate	Dhenkanal	Not Available	Sahu 1979
66.	Angul	Bed of stream	Angul	Not Available	Sahu 1979
67.	Talcher	Surface	Angul	Not Available	Sahu 1979
68.	Kuliana (Quarry‘C’)	Bed of boulder conglomerate	Mayurbhanj	Not Available	Sahu 1979
69.	Kuliana tank ‘A’	Budhabalang	Mayurbhanj	Not Available	Sahu 1979
70.	Kuliana tank ‘B’	Budhabalang	Mayurbhanj	Not Available	Sahu 1979
71.	Kamata Quarry ‘C’	Bed of boulder Conglomerate	Mayurbhanj	Not Available	Sahu 1979
72.	Kharala	Kharala-tributary of Mahanadi	Sambalpur	21° 45° N; 84° 35' E	Ratha and Bhattacharya 1988
73.	Jamara	Chhonuri hill extension of the Malayagiri hill	Mayurbhanj	21° 25 N ; 85° 16° E	Ray *et al.* 1997
74.	Barkalpal		Dhenkanal	Not Available	Roy 1995
75.	Burla	Dari-Dungri-hill-Mahanadi	Sambalpur	Not Available	Sharma 1994, Behera *et al.* 1996
76.	Gengaraj,	Kharua River	Mayurbhanj	Not Available	Mohanty *et al.* 1997
77.	Joshipur,	Kharua River	Mayurbhanj	Not Available	Mohanty *et al.*

					1997
78.	Kalabadia	Kharua River	Mayurbhanj	Not Available	Mohanty *et al.* 1997
79.	Kalabaria	-	Mayurbhanj	22° 5' 20" N, 86° 38' 57"E	Bose and Sen 1948
80.	Bankathi	Boulder conglomerate small stream	Mayurbhanj	Not Available	Chakrabarti and Chattopadhyay, 1988b
81.	Banskathia	Laterite conglomerate	Mayurbhanj	Not Available	Chakrabarti and Chattopadhyay, 1988
82.	Damodarpur	Laterite conglomerate	Mayurbhanj	Not Available	Chakrabarti and Chattopadhyay, 1988
83.	Kuliana	Budhabalanga	Mayurbhanj	22° 04 N; 86° 39' E	Bose and Sen, 1948
84.	Kolmunda	-	Kendujhar	Not Available	Chakrabarti and Chattopadhyay, 1988
85.	Khiching-I	Bhandan	Mayurbhanj	Not Available	Chakrabarti 1990
86.	Khiching-II	Bhandan -Khairi river junction	Mayurbhanj	Not Available	Chakrabarti 1990
87.	Khiching-III	Right bank Bhandan river	Mayurbhanj	Not Available	Chakrabarti 1990
88.	Khiching-IV	Left Bank Khairi river	Mayurbhanj	Not Available	Chakrabarti 1990
89.	Andherikhola	Left bank Brahmani river	Dhenkanal	21° 04' N; 85° 13 'E	IAR 1999-2000
90.	Ankila	Left bank Brhamani river	Dhenkanal	21° 12' N; 85° 08' E	IAR 1999-2000
91.	Bhaliabcrha	Left bank of River Brahmani	Dhenkanal	21° 14' N; 85° 04'E	IAR 1999-2000
92.	Bilinda	Right bank of River Brahmani,	Dhenkanal	21° 04' N; 85° 09' E	IAR 1999-2000
93.	Dangarabera	Lft bank of River Brahmani	Dhenkanal	21° 05 'N; 85° 09' E	IAR 1999-2000
94.	Dhiramunda	Right bank of River Brahmani	Dhenkanal	Not Available	IAR 1999-2000
95.	Dwarabandha	Right bank of River Brahmani	Dhenkanal	21° 14' N; 85° 06' E	IAR 1999-2000
96.	Dwarabandha	On the right bank of River Brahmani	Dhenkanal	21° 13' N; 85° 06' E	IAR 1999-2000
97.	Ekagharia	Right bank of River Brahmani,	Dhenkanal	21° 03' N; 85° 09' E	IAR 1999-2000
98.	Gengutia-1	Left bank of River Brahmani at a	Dhenkanal	21° 15'N; 85° 04'E	IAR 1999-2000
99.	Hanumanapur	Right bank of Brahmani at a distance	Dhenkanal	21° 08' N; 85°04'E	IAR 1999-2000
100.	Jadunathapur	Right bank of Brahmani	Dhenkanal	21° 02' N; 85° 07' E	IAR 1999-2000
101.	Jambua	Left bank of Brahmani	Dhenkanal	21° 14' N; 85° 08' E	IAR 1999-2000
102.	Kantola	Left bank of River Brahmani	Dhenkanal	21° 13' N; 85° 03' E	IAR 1999-2000
103.	Karadakhamana	Left bank of River Brahmani	Dhenkanal	21° 13' N; 85° 07' E	IAR 1999-2000
104.	Karnapala	Left bank of Brahmani	Dhenkanal	21° 7' N; 85° 09' E	IAR 1999-2000
105.	Patakhamana	Left bank of River Tikara, tributary of Brahmani,	Dhenkanal	21° 06' N; 85° 03' E	IAR 1999-2000

106.	Patuapali	Left bank- River Brahmani	Dhenkanal	21° 04' N; 85° 12' E	IAR 1999-2000
107.	Poragarh	Left bank of River Brahmani	Dhenkanal	21° 09' N; 85° 03' E	IAR 1999-2000
108.	Purunapani	Left bank of River Brahmani	Dhenkanal	21° 13'N; 85° 09'E	IAR 1999-2000
109.	Radharamanapur	Right bank of Brahmani,	Dhenkanal	Not Available	IAR 1999-2000
110.	Shriramapur	Right bank of River Brahmani	Dhenkanal	Not Available	IAR 1999-2000
111.	Jharbandh		Kalahandi	19° 55' 08" N; 82° 58' 32" E	
112.	Gurvelipadar,	Bagh-Khadak tributary of Mahanadi	Phulbani	Not Available	IAR 1981-82
113.	Kankolidungri	Bagh-Khadak tributary of Mahanadi	Phulbani	Not Available	IAR 1981-82
114.	Rengali hill,	Bagh-Khadak tributary of Mahanadi	Phulbani	Not Available	IAR 1981-82
115.	Kantamal,	Tel river	Phulbani	Not Available	IAR 1981-82
116.	Sunadei hill	Bagh-Khadak tributary of Mahanadi	Phulbani	Not Available	IAR 1981-82
117.	Barpadar	Bagh-Khadak tributary of Mahanadi	Phulbani	Not Available	IAR 1981-82
118.	Asrubahal	Singida river	Angul	20° 58' N; 84° 49' E	Kara 2008
119.	Badamul	Singida river	Angul	20° 57' N; 84° 49' E	Kara 2008
120.	Balangi	Singida river	Angul	21° 06' N ; 85° 04' E	Kara 2008
121.	Balangi	Singida river	Angul	21°03' N; 85°05'E	Kara 2008
122.	Belparha	Singida river	Angul	21° 02' N; 85° 11' E	Kara 2008
123.	Bilinda	Singida river	Angul	21° 04' N; 85° 09 'E	Kara 2008
124.	Brahmanibila	Singida river	Angul	21° 03' N; 84° 56' E	Kara 2008
125.	Chakundapal	Singida river	Angul	21° 00' N; 84° 54' E	Kara 2008
126.	Dubamalia	Singida river	Angul	20° 57' N; 84° 57' E	Kara 2008
127.	Durgapur Kandha sahi	Singida river	Angul	20° 55' N; 84° 52' E	Kara 2008
128.	Durgapur -Tangirisahi	Singida river	Angul	20° 55' N; 84° 56' E	Kara 2008
129.	Ekagharia	Singida river	Angul	21° 02' 30'N; 85° 10' E	Kara 2008
130.	Gopiballabhapur	Singida river	Angul	20° 58' N; 84° 56' E	Kara 2008
131.	Gopinathpur	Singida river	Angul	20° 58' N;20' 84° 56' E	Kara 2008
132.	Guha Sahi	Singida river	Angul	21° 02' N; 85° 02' E	Kara 2008
133.	Jadunanthpur	Singida river	Angul	21° 02' N; 85° 07' E	Kara 2008
134.	Jamunali	Singida river	Angul	20° 03' N; 84° 03' E	Kara 2008
135.	Kisinda	Singida river	Angul	20° 57' N; 20'	Kara 2008

				84° 54' E	
136.	Korara	Singida river	Angul	20° 57' N; 84° 49' E	Kara 2008
137.	Kukurpetha	Singida river	Angul	20° 02' N; 84° 53' E	Kara 2008
138.	Nakanaka	Singida river	Angul	20°58' N;85°52'E	Kara 2008
139.	Pitachari	Singida river	Angul	21° 02' N; 84° 50' E	Kara 2008
140.	Sanagunduri	Singida river	Angul	21° 04' N; 85° 02' E	Kara 2008
141.	Srirampur	Singida river	Angul	21° 02' N; 85° 08' E	Kara 2008
142.	Sunakhani	Singida river	Angul	21°02' N;85°10'E	Kara 2008
143.	Banka	Junction of Banka nala and Jonk river	Nuapada	20° 49' 41.36" N; 82° 29' 21.29" E	Padhan 2013
144.	Bherha Loc-1	Jonk River section	Nuapada	20°46'54.61"N; 82°26'16.51"E	Padhan 2013
145.	Bherha Loc-2	Foot Hills near by Jonk	Nuapada	20° 46' 25.72" N; 82° 27' 58.57" E	Padhan 2013
146.	Bherha Loc-3	Foot Hills near by Jonk	Nuapada	20° 45' 52.24" N; 82° 26' 50.33" E	Padhan 2013
147.	Bhajipala Loc-1	Foot Hills near by Jonk	Nuapada	20° 49' 52.57" N; 82° 29' 1.86" E	Padhan 2013
148.	Bhajipala Loc-2	Foot Hills near by Jonk	Nuapada	20° 49' 52.57" N; 82° 29' 1.86" E	Padhan 2013
149.	Bhaisimundi	Foot Hills near by Jonk	Nuapada	20° 49' 9.36" N; 82° 29' 25.85" E	Padhan 2013
150.	Muragaon	Jonk River Section	Nuapada	20° 53' 15.27" N; 82° 29' 30.49" E	Padhan 2013
151.	Patharpunji	Foot Hills near by Jonk	Nuapada	20° 46' 8.99" N; 82° 26' 1.03" E	Padhan 2013
152.	Chipajhar Loc-1	Hill Slope near by Jonk	Nuapada	20° 46' 51.92" N; 82° 28' 11.87" E	Padhan 2013
153.	Chipajhar Loc-2-	Foot Hills near by Jonk	Nuapada	20° 46' 57.76" N; 82° 28' 39.92" E	Padhan 2013

K. Paddayya, in *Recent Advances in Acheulian Culture Studies in India*
(K.Paddayya and S.G. Deo Eds.), pp. 85-112 [2014]

The Acheulian Culture Studies in India: A Long Story but Many Unfinished Tasks

K. Paddayya
Department of Archaeology
Deccan College (Deemed University)
Pune 411 006
E-mail: k.paddayya@gmail.com

Abstract

This paper first of all places Robert Bruce Foote's work in the context of scientific ferment that came up in Western Europe in the nineteenth century. It then highlights his efforts to initiate Palaeolithic research in India. This is followed by a brief review of the results of the author's prolonged research on the Acheulian sites of the Hunsgi and Baichbal valleys in North Karnataka. Finally, attention is drawn to some of the major issues concerning the Acheulian culture which still need to be addressed.

Nineteenth-Century Scientific Ferment in Western Europe

One thing that is unmistakable about Robert Bruce Foote's prehistoric discoveries in India is that his recovery of a spearhead-shaped Palaeolithic implement from a ballistic pit at Pallavaram near Madras (now Chennai) on 30 May 1863 (Figs. 1- 2) was not a one-time happening nor was it a chance finding that just came up as part of 'Sunday afternoon outings' with family and friends. On the contrary, it was part of well-intended and three-decade-long efforts that had clearly been influenced by the epoch-making scientific developments taking place in Europe. Foote himself clarified the matter in these words: "In the early sixties of last century one interested in the origin of mankind had been greatly stirred by the thorough confirmation by the great English geologists, Joseph Prestwich, John Evans and Hugh Falconer, of Boucher de Perthes' discovery in the drift beds of the Somme river valley of chipped flint implements, the earliest human artefacts then known. The news of this remarkable revelation had turned my thoughts to the necessity of looking for possible similar traces of early human art in South India where my work then lay" (Foote 1916: v).[1]

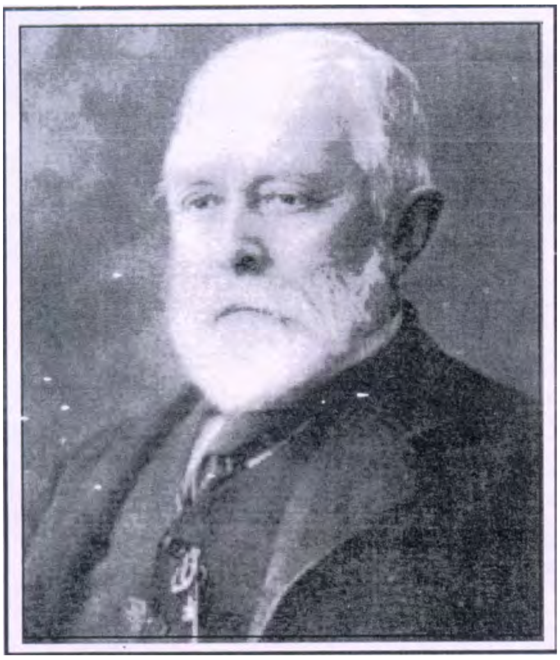


Fig. 1: Robert Bruce Foote (1834-1912)

One must also recall here that much before the Somme valley discoveries – in 1797, to be precise – John Frere found similar flint implements in association with fossil fauna in a gravelly soil at a depth of about 12 feet (3.65 m) below surface at Hoxne in England. In his two-page but cogently drafted note on these finds, Frere significantly concluded that these implements were "evidently weapons of war, fabricated and used by a people who had not the use of metals… The situation in which they were found may tempt us to refer them to a very remote period indeed, even beyond that of the present world… The manner in which they lie would lead to the persuasion that it was a place of their manufacture and not of their accidental deposit…" (Frere 1800: 204-5) (Figs. 3-4). Although the recognition of their importance had to wait for six decades, these findings from Hoxne mark the true beginnings of Palaeolithic prehistory (for references about the excavations undertaken at this site in the last century, see Roe 1981: 200-2; McNabb 2007:151-4). While Frere's use of stratigraphy to ascribe the stone implements to a pre-metal age is amazing, no less remarkable is the fact that his comments on their context of occurrence already presage present-day debates about formation processes.

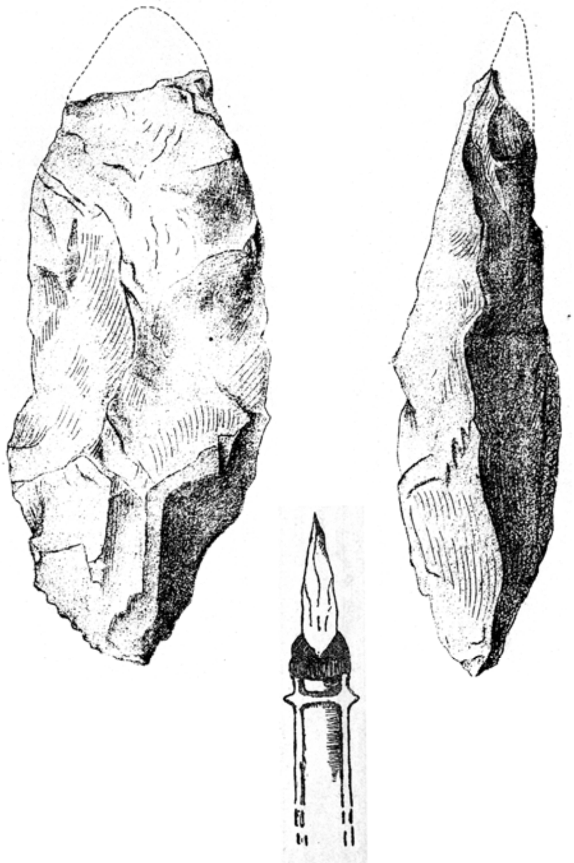


Fig. 2: Palaeolithic quartzite implement (13.5 x 3.4 cm) found by Robert Bruce Foote at Pallavaram on 30 May 1863.Foote called it a spearhead because the lower end has a tang-like projection. Drawn by Foote's wife Elizabeth Ann Percival. After Foote 1866, 1916

Fig. 3: John Frere (1740-1807) who discovered the Palaeolithic site at Hoxne in England in 1797

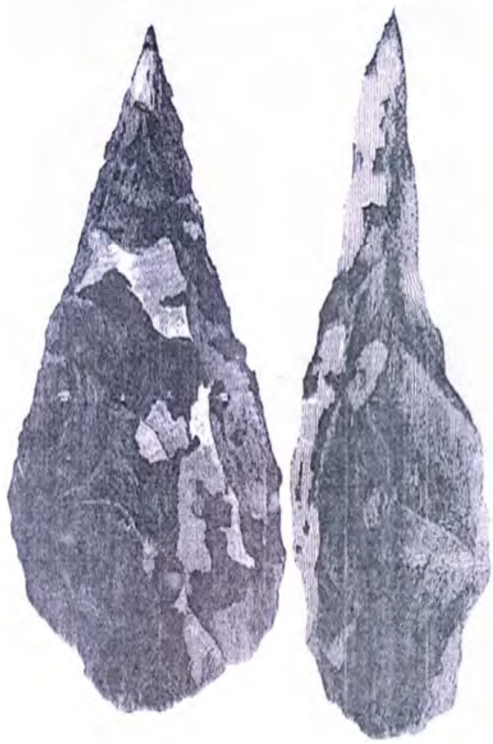


Fig. 4: Flint handaxe found by John Frere at Hoxne

Fig. 5: British scientists examining the flint implements from drift gravels of Somme valley. Left to right: Joseph Prestwich, John Morris, F.E. Edwards and Searles V. Wood

Fig. 6: Jacques Boucher de Crevecoeur de Perthes (1788-1868), the customs director of Abbeville, France

Fig. 7: Hugh Falconer (1808-1865), the Scottish palaeontologist who studied the Siwalik fauna for many years

Fig. 8: Sir John Evans (1823-1908), the British archaeologist and author of *The Ancient Stone Implements, Weapons, and Ornaments of Great Britain* (1872)

In celebration of the completion of 150 years of the Royal Society's ratification of the Somme valley findings referred to by Foote in the above-cited passage, the journal *Antiquity* (Volume 83, 2009, pp. 458-501) published five special research articles (Figs. 5-8). At some other places too in his publications Foote alludes to the intellectual developments taking place on the European soil. While he found no occasion to go beyond these brief references, it seems reasonable to assume that Foote kept himself regularly posted about the multi-sided ferment that took a firm shape in the European scientific circles in the third quarter of the nineteenth century, which Wallace (1901: v) designated as the Wonderful Century. This ferment comprised four different strands of thought, all contributing to the broadening of the temporal purview of natural and human history much beyond the confines of Biblical chronology and all also viewing causality in terms of natural processes in replacement of God-willed events. I have elsewhere drawn attention to this wider context of Foote's discoveries and it would not be out of place to briefly repeat these observations here (Paddayya 2013: 5-8).

The writings of James Hutton and later, more comprehensively, those of Charles Lyell heralded radical changes in man's long-standing conceptions and beliefs about earth's history in two ways. First, these writings questioned Christian theology's proposition that the earth was created in 4004 B.C. Secondly, these also raised questions about the role of any divine agency in its creation. The work of Charles Lyell, the barrister-turned-geologist of Scottish origin, played a key role in this transformation (Fig. 9). His three-volume book *Principles of Geology* (published between 1830 and 1833) is a long argument in favour of the new thought. In short, Lyell dismissed both these popular conceptions about earth and its history. As indicated by the sub-title of his book, he sought to explain the formation of earth's surface features with the help of natural forces or processes still in operation in different parts of the world. This notion of the present offering clues for reconstructing the past emerged as the principle of uniformitarianism, which in turn influenced many earth, biological and human sciences.

Fig. 9: Sir Charles Lyell (1797-1875), author of *Principles of Geology* (1830-1833)

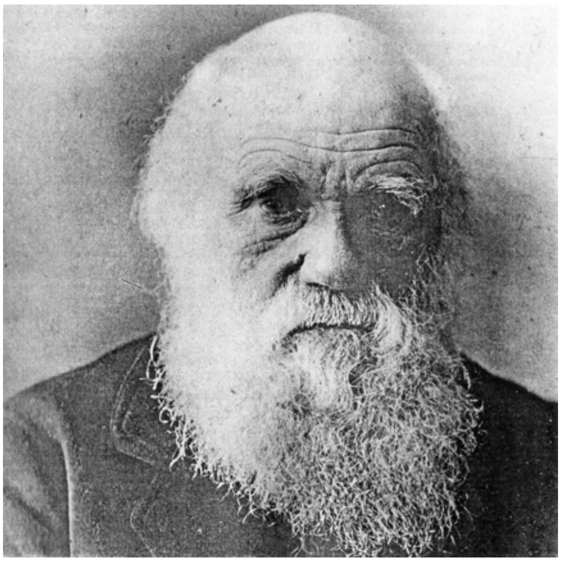


Fig. 10: Charles Darwin (1809-1882), author of *The Origin of Species* (1859).

In the very opening chapter of the first volume Lyell cited analogies between geology and history in respect of both the aims of study and methods to be adopted. In the second chapter he even drew attention to the fact that, as against 6000 and odd years of earth's history provided by Christian theology, ancient Oriental thought made provision for an immense duration of time. He cited Sir William Jones' work *Edicts of Manu*, which refers to an unending cycle of creation, destruction and recreation (Lyell 1830: 5-6). Lyell's three volumes are an admirable exemplification of the historical method. He cited copious historical instances from different parts of the world to illustrate the effects which natural processes such as volcanic activity, tectonic moments, and river/sea erosion and deposition produce on earth's surface. These views exercised a profound effect on earth sciences in the subsequent decades.

Fig. 11: Thomas Henry Huxley (1825-1895), the famous British scientist who stoutly defended the theory of evolution and antiquity of mankind

In the studies relating to the biological world too serious doubts began to crop up about the Biblical conceptions right from the end of the eighteenth century. These were further spurred by the publication of Lyell's three volumes. Happily, the first volume fell into the hands of the young naturalist Charles Darwin when he commenced his five-year-long voyage on the *Beagle* to the southern hemisphere.

Fig. 12: Sir John Lubbock, first Baron Avebury (1834-1913), British banker, parliamentarian and author of *Prehistoric Times* (1865)

We are familiar with the views of Darwin and his compatriot Alfred Russel Wallace who independently arrived at similar observations about the origin of living species involving the principle of natural selection (Wallace 1901: 138-9). Finally, it was Darwin who formally announced to the world the theory of evolution through the publication of his book *On the Origin of Species* in November 1859 (Fig. 10). Like Lyell's book, this work too used, in addition to the ideas from other sources, the present for explaining the past, i.e. the changes or modifications induced by modern breeders in plants and animals serving as clues for understanding transformation of species in the past. This work added a second influential facet to the emerging scientific conception of the natural world.

Darwin's book, not unexpectedly, provoked considerable reaction from the religious circles. There is the well-known instance of the oral encounter between Thomas Henry Huxley and Bishop Wilberforce at the annual meeting of the British Association for Advancement of Science held at Oxford in 1860. Huxley (Fig. 11) played a pivotal role in defending Darwin's views and had in fact written to him shortly before the publication of *On the Origin of Species* that he "was sharpening his claws and beak" in anticipation of intense opposition.[2] In his book Darwin was silent about man's ancestry and was content with the statement that "Light will be thrown on the origin of man and his history." It was only in 1873 that he published his other famous book *The Descent of Man.* But meanwhile, in 1863, the topic was well attended to by two of the staunch supporters of his general theory of evolution. Charles Lyell and Thomas Huxley published their books, respectively, entitled *Geological Evidences of the Antiquity of Man* and *Evidence as to Man's Place in Nature.*

These developments in biological thought raised the crescendo of scientific ferment to a higher level. And, quite aside from its far-reaching implications for studies in the history of biological world, Darwin's (1968: 460) concluding statement in *On the Origin of Species* that "… whilst this planet has gone cycling on according to the fixed law of gravity, from so simple a beginning endless forms most beautiful and wonderful have been, and are being, evolved", was pregnant with meaning for studies in human cultural history too (see Stocking, Jr. 1987: 144-85). Also Darwin's work on the formation of vegetable moulds around buried objects like coins due to earthworm activity already anticipated the now popular topic dealing with the study of formation processes (see Evans 2009).

Thanks to the bulwark of support raised by Huxley and others, these developments in man's understanding of natural history found a firm foothold in the 1860s and 1870s. Complementary to these new conceptions, social thought too witnessed radical changes. The schemes of developmental stages in human history such as hunting and foraging, pastoralism, agriculture and civilization, as postulated by Turgot and other Enlightenment thinkers, gained support from the nineteenth-century ethnographic accounts being sent by European workers from various parts of the world. These workers reported the existence of simple communities based on diverse modes of existence such as hunting, fishing, pastoralism, and plant husbandry and living alongside civilized ways of life. These accounts, forming what has been called Victorian anthropology (Stocking, Jr. 1987), inevitably led to the postulation of evolutionary stages in human cultural history. These ideas constitute classical evolutionism and are best expressed in the writings of workers such as E.B. Tylor, John Lubbock and John McLennan. The main propositions of evolutionism included stage-wise arrangement of societies based on different modes of existence; law-like regularities governing socio-cultural phenomena both in the past and present; and cumulative effects of man-nature interaction resulting in differential cultural forms in space and time (Stocking, Jr. 1987: 169-72).

C.J. Thomsen's Three Age System and its elaboration at the hands of later workers added antiquarian support to these ideas of cultural evolution. This is one contribution which does not find mention in Grayson's otherwise well-documented book *The Establishment of Human Antiquity* (1983) and O'Connor's recent book *Finding Time for the Old Stone Age* (2007), and merited only a brief paragraph in Bowdoin van Riper's book *Men Among the Mammoths* (1993: 41). We must note here that Boucher de Perthes visited the National Museum in Copenhagen in July 1854 as part of his tour of the North European territories. He met there C.J. Thomsen and studied the stone tools in his collection (Street-Jensen 1985: 4). The provision for Stone Age made by C.J. Thomsen as the beginning phase of his Three Age System must have served to strengthen Boucher de Perthes' ideas about the antiquity of his Somme valley findings.

It is remarkable that already by 1865 Lubbock, in his book *Prehistoric Times* (1913), felt emboldened enough to divide the Stone Age into Palaeolithic and Neolithic stages (Fig. 12). Incidentally this is the first book in which the principles and methods of prehistory (a New Science, as Lubbock called it) were expounded (see van Riper 1993: 199-201). The seventh edition of this book not only referred to Foote's discoveries in South India but reproduced figures of two bifaces from his collection (Lubbock 1913: 343, 347). Lubbock was familiar with the Oriental literature and included the *Mahabharata* and the *Ramayana* among the 100 best works read by him (Hutchinson 1914: 93). Five years later appeared his ethnographic work *The Origins of Civilization,* postulating various stages of cultural evolution. The work in the French caves and rock shelters led to the identification of stages within the Palaeolithic, just as the findings of North European workers led to the division of Bronze and Iron Ages into sub-stages. Also standard works in typology began to appear. Worsaee's book *The Primeval Antiquities of Denmark* appeared in 1849. In 1872 John Evans published his famous book *Ancient Stone Implements, Weapons and Ornaments of Great Britain.* All these rapid developments made it possible for persons like de Mortillet to put forward an elaborate culture-sequence comprising both prehistory and protohistory (de Mortillet 1882). Soon a series of excellent book-length syntheses of prehistory started appearing (Clodd 1895; Sollas 1911; Quinnel and Quinnel 1921; de Morgan 1924; MacCurdy 1924; Renard 1929). And prehistory found a secure place in the academic world.

These four strands of thought were interpenetrating and complemented one another. Through letter-writing and face-to-face contact much exchange of ideas took place among the protagonists of these new streams of thought. For example, Darwin himself kept in touch with antiquarian workers including John Lubbock and John Evans. He made a reference to the findings of Boucher de Perthes and other developments in the later editions of *On the Origin of Species* and *The Descent of Man* (Evans 2009: 76-8). John Evans and Lane Fox (later known as Pitt-Rivers) used the ideas of evolution in their studies of the development of British coins, and stone and metal tools, respectively (Evans 1875; Lane Fox 1875). After listening to James Fergusson's lectures on the development of architectural styles of ancient Indian temples, Huxley recognized traces of the impact of 'Darwinismus' (Allchin 1961: 242). We may also recall here that Huxley published articles on topics like Indian geography and ethnology and called India "the greatest of the possessions of the Empire (1869: 90). He also wrote to Sir M.E. Grant Duff, the Governor of Madras Presidency, to make arrangements for fresh field investigations into the fossil-bearing Billasurgam caves in the Kurnool limestone formations reported by Captain Newbold in 1844. It was against this background that Bruce Foote and his son Henry Foote carried out their excavations between 1883 and 1885. This wide-ranging and cross-disciplinary ferment displaced notions of God and Creation and called for the adoption of a scientific bent of mind while dealing with both human and natural history. At the end of a short autobiographical note published in 1893, Huxley (1968: 17) called this set of radical ideas the New Reformation, of which he himself was an outstanding spokesman.

Robert Bruce Foote and Indian Prehistory

I have made above a rather lengthy reference to this new wave of thought that got crystallized in Europe in the third quarter of the nineteenth-century because I strongly believe that Bruce Foote was inspired by these developments not only in initiating and continuing his remarkable field discoveries on the Indian soil for well over three decades but also in the study and interpretation of various findings made by him. It is important to realize that Foote's notion of prehistoric past was a comprehensive one and synonymous with the whole range of unwritten past. Foote grouped his findings under four successive "stages of man's progress in civilization", viz. Palaeolithic period, Neolithic period, Early Iron Age and Later Iron Age. He put forward the core idea of this division of the past in 1895 (1895: 206-7) and developed it fully in 1916. Of the 459 sites found by him, he assigned 42 to the Palaeolithic, 252 to the Neolithic and 17 to the Early Iron Age.[3]

Foote inferred that the Palaeolithic groups were "an uncultured people but not gross savages, their artefacts in stone being in kind more numerous than, and in shape and make far superior to those of the Tasmanians and Australians…" (Foote 1916: 8). The Neolithic people used the techniques of grinding and polishing for making stone tools, built houses, raised crops and kept domestic animals, and developed crafts like pottery-making. In Later Iron Age, gold, copper and tin also made their appearance.

This inclusive notion of the prehistoric past that prevailed in the mind of Foote notwithstanding, it is clear from his publications that he focused attention on the Palaeolithic and Neolithic phases at the levels of both field discoveries and their study and interpretation. This is particularly evident in his review easy entitled 'Notes on Some Recent Neolithic and Palaeolithic Finds in Southern India' published in *Journal of the Asiatic Society of Bengal* (Foote 1887) and the 46-page-long introduction to his main catalogue (1916: 1-46). Narrowing the focus further, there are strong reasons for saying that Palaeolithic discoveries occupied a special place in his work. First, these represent the positive outcome of the inspiration he derived from the French and British Paleolithic findings that had been duly certified by the Royal Society. Secondly, the discovery of megalithic monuments and polished stone tools had already begun in India in the early part of the nineteenth century, whereas Foote's Palaeolithic findings alone added a completely new chapter to the country's preliterate past. Thirdly, these findings from India provided an extra dimension to the growing scientific ferment in Europe. The workers there quickly realized that primitive human groups making simple stone tools similar to those found in Western Europe existed in the southern hemisphere too in the distant past. In tune with the fact that this special issue of *Man and Environment* is devoted to Acheulian culture studies, I would now like to make some observations about Foote's Palaeolithic discoveries.

Antiquity of Sites

Lacking as he did modern-day radiometric methods for dating sites, Foote made use of the geological principle of stratigraphy for ascertaining the antiquity of Palaeolithic sites. For this purpose he made a close study of the landscape and sedimentary contexts of lithic assemblages (for a review of his prolonged geological surveys in South India, see Srikantia 2013). Following closely upon the Pallavaram finding, Foote and his colleague William King discovered a series of regular sites in the Kortallayar valley. In the course of their survey work in the Attirampakkam area they identified at several spots sedimentary sections exposed by the rain gullies draining into the Attirampakkam nullah, which itself is a feeder stream of the Kortallayar river. Resting on shales, these sections measured 10 to 15 feet (3.05 to 4.57m) in thickness and consisted of three or four layers of gravels, sands and clays. Foote gave details, along with section-drawings, of two of these profiles showing two layers each of lateritic conglomerate and sandy clay (Foote 1873: 43-58; Figs. 1 and 2). The occurrence of quartzite implements in the gravel conglomerate at some depth below surface was a clear proof of their antiquity (Fig. 13).

Foote employed this principle of sedimentary stratigraphy at a number of sites in other areas too.[4] In 1930 Cammiade and Burkitt used it for subdividing the Stone Age into four stages (Series I to IV). Subsequently it became a major methodological strategy in Stone Age research in the country.

Primary Sites

The majority of Palaeolithic sites found by Foote are associated with fluviatile gravels. But in three cases he did suspect the existence of primary sites in the immediate vicinity. Kaira on the river Malaprabha is one such site. Based upon the negligible traces of smoothening noticed on the surfaces of artefacts, Foote inferred that these tools were washed down from the nearby original spots located on the higher slopes of river banks (Foote 1916: 131). He refers to the existence of similar localities in the Attirampakkam area (Foote 1873: 46).

More illustrative is the case of Halakundi site located in the foot-hill zone of the Copper Mountain (Suggammadevi Betta) near Bellary town in Karnataka. Here he found a large number of haematite quartzite implements in a fan-shaped gravel spread laid down by rills draining the hills. Judging once again from the negligible traces of abrasion found on the tools, Foote drew the decisive conclusion: "From this fact the inference may be drawn that the people to whom they had belonged and who were probably their makers resided nearby and very likely on the spurs of the Copper Mountain from which the implements were washed down by local rains and buried in the shingle fans formed by the local torrents" (Foote 1916: 78; see also 1885: 208). Foote thus deserves a place in the present-day debates about primary versus secondary sites and their formation processes. But this is not to say that he was always error-free. For example, his views about the contemporary nature of Palaeolithic sites of the east coast with laterite formation, the marine origin of this sediment, and post-Stone Age elevation of the east coast by 500 to 600 feet (152 to 183 m) were already being held as untenable by his colleague William King (see also S. Pappu 2001).

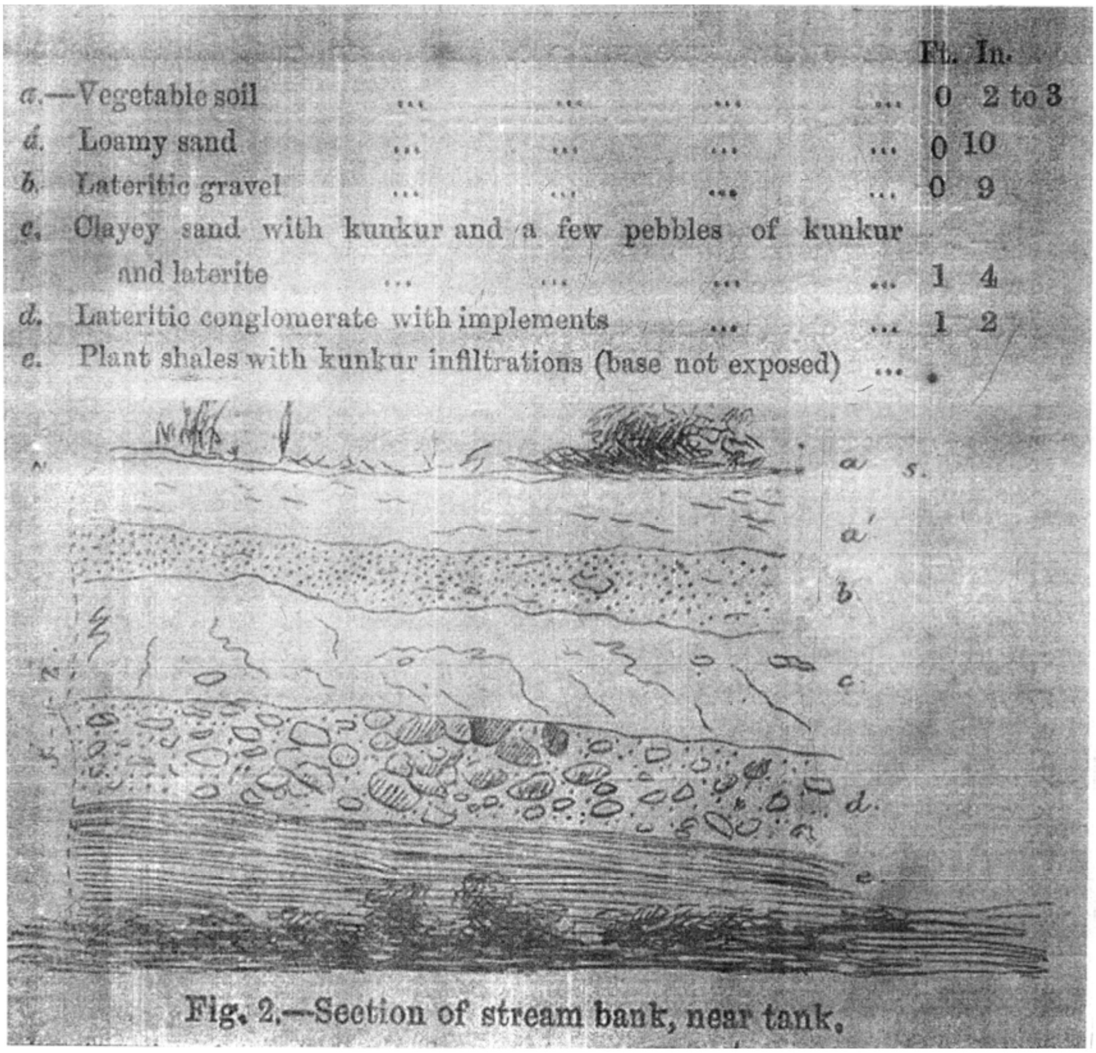


Fig. 13: A nullah-bank section recorded by Foote (1873) at Attirampakkam showing the stratigraphical position of tool-bearing laterite conglomerate

Cultural Status of the Palaeolithic

Foote (1916: 14) flatly denied the existence of eoliths in India. What is the specific cultural status which he assigned to the Palaeolithic sites found by him in South India and Gujarat? While these have been commonly grouped by later workers under the label Acheulian, Foote himself was content with the designation Chelleo-Moustérien, implying a large degree of continuity in the early stage of the Palaeolithic comprising what are now called the Lower (Acheulian) and Middle Palaeolithic phases. In his own words: "The palaeoliths found in Southern and Western India, if judged from their general shape, agree best with the *Chelleo-Moustérien* type belonging to the lowest division of the palaeolithic age which lies above the deposits of the preglacial period in the Europe" (Foote 1916: 42). Foote's use of the suffix Moustérien was probably influenced by the occurrence of what he calls knives (longish flakes) and scrapers in some of his site assemblages. These are listed as two specific classes in his classification of Palaeolithic tools (Foote 1916: 9). Foote probably found it difficult to give a separate cultural status to these flake-tools (we now designate these as the Middle Palaeolithic) because the "Palaeolith-bearing lateritic deposits of the East Coast and of the Deccan, which, as far I have been able to interpret them, do not allow of any sub-divisions of importance being recognized" (1916: 38).

But he did make a provision for the recognition of a later and much advanced stage within the Palaeolithic. This arose from the findings of his excavations in the Billasurgam caves. As mentioned earlier, he and his son Henry Foote undertook excavations in these caves for three seasons between 1883 and 1885 (Foote 1884a, b; 1885). Diggings in the inner chambers of these caves exposed 30 to 40 feet (9.15 to 12.2 m) thick deposit, which they divided into eight or nine layers. These layers yielded rich assemblages of bones of both living and extinct animals representing birds, lizards, amphibians and mammals. Among these bones Foote found a number of cut or worked specimens and classified them into various types such as awls, spear- and harpoon-heads, knives, scrapers and chisels. He also found a cylindrical bone bead and pendants of teeth. These cultural remains reminded Foote (1916: 191) of the Magdalenian culture of France. Later excavations in these caves confirmed the existence of Upper Palaeolithic phase (Murty 1974). More recent excavations in rock shelter locality 9 at Jwalapuram stretched the antiquity of blade-based microlithic tradition to 34,000 B.P.; this is associated with beads of bone and stone (Clarkson *et al.* 2009).

Typology and Functional Interpretations

Foote surely deserves the credit for making the first ever classification of both Palaeolithic and Neolithic stone implements in the context of Indian prehistory. He has devoted as many as 20 pages to this topic in his main catalogue (1916: 7-27). For this purpose he used as his guide John Evans' 640-page-long volume entitled *Ancient Stone Implements, Weapons and Ornaments of Britain*, published in 1872. Foote maintained personal contact with Evans and more than once refers to his book in the main catalogue (e.g. Foote 1916: 86). Evans' volume, "still regarded as cornerstone of Palaeolithic research" (Roberts and Brooks 2008: 95), is a book-length elaboration of the typology put forward in the papers which he had read before the Society of Antiquaries in 1859 and 1861. Its scope is basically confined to the British collections but Evans does make references to stone tools found in other parts of the world. He actually handled some of the Indian Palaeolithic implements which Foote brought to England as part of his visits. It is therefore little surprise that he included a reference to these in his book (Evans 1872: 570). Of the 25 chapters, the first two deal with the three-age division of the past and various techniques of stone tool manufacture and the last four with Palaeolithic implements and their contexts of occurrence. The remaining nineteen chapters are devoted to the Neolithic implements.

Foote obviously benefited from Evans' detailed descriptions and illustration of various types of implements. He identified as many as 11 types among the shaped Palaeolithic implements he had found in India (1916: 7-11). These include axes (with four sub-types), spears (with two sub-types), digging tools, circular implements, choppers, knives and scrapers. What is important to note is that he went beyond formal classification of shapes of implements and attempted interpretations of their functions. He inferred that the oval-shaped axes were not used in hand but hafted to split-ended wooden handles. The bifacially worked and point-ended specimens like the first artefact he had recovered from Pallavaram were used as spearheads (1916: 173). He interpreted that cleavers were meant for trimming and paring surfaces of wood; and the thick-butted axes were digging tools for obtaining roots and bulbs from the ground. Relying upon some historical references and living analogies, he inferred that the Palaeolithic groups would also have widely used hard woods like *Hardwickia binata* and *Xylia dolabriformis* for making spear shafts and would also have employed thorn-tipped arrows for hunting purposes (Foote 1916: 12).

General Cultural Patterns

Foote did not rest content with individual site discoveries and analysis of their cultural contents but used all this information to arrive at some general observations about the life and times of these distant Stone Age groups. This overall anthropological orientation to the mute antiquarian remains from the remote past is all the more amazing when we recall that he was as of profession a hard rock geologist of outstanding calibre.

I tend to think that Foote would have assigned a maximum age of about 0.22 million years for the Palaeolithic phase in India. My presumption arises from two considerations. First, he was struck by the fact the implements were found in the basal gravels, which in the Sabarmati valley were overlain by thick layers of silts and gravels (measuring 100 to 200 feet or 30.5 to 61 m in thickness). Their deposition impliedly involved long periods of time. Secondly, he refers to, with implicit approval, de Mortillet's scheme allocating durations of 33,000 years, 11,000 years, 1,00,000 years and 78,000 years, respectively, for the French Magdalenian, Solutrean, Mousterian and Chellean cultural phases (Foote 1916: 44). This would mean that the Chelleo-Mousterian phase in India flourished from about 0.22 million years to about 45,000 years B.P.

Foote's observations about the distribution of Palaeolithic sites foreshadowed modern-day ecological approaches (Foote 1916: Introduction). He inferred that corresponding to the glacial periods of northern latitudes, tropical regions witnessed wet climatic periods. He further pointed out that the Palaeolithic groups lived in an environment rich in wild animals of various kinds. Thanks to their abilities to make tools to serve as extensions to their hands, they were able to overcome all dangers and continue their way of life.

In order to be able to recognize possible patterns in the spatial spread of sites, Foote plotted all of them on a large map (69 x 49 cm) appended to his catalogue of 1916 **(**Fig. 14) and considered their distribution in relation to differences in terrain features, rainfall, vegetation, and nature and availability of rocks suitable for tool-making (1916: 36-46). His observations in this regard still retain much force. For example, he stated that the Palaeolithic groups avoided mountainous tracts receiving high rainfall and covered with thick forests. He made a specific reference to Western Ghats and the Konkan. Till today no true Palaeolithic sites are known from these tracts.

Secondly, without being overdeterministic in his view, Foote also thought of a direct relationship between the availability of a good raw material for tool making and concentration of sites. He was struck by the rich concentration of sites in quartzite-bearing areas such as the Kaladgi basin, Kurnool and Cuddapah formations, and the Upper Gondwana rocks of Tamil Nadu. This is fully borne out by the rich clusters of sites revealed by later investigations in these areas. However, Foote did recognize that, in the absence of quartzites, other rocks like haematite quartzite and limestone could have been employed by the Stone Age groups. He also observed that it remained to be ascertained whether basaltic rocks would have been employed by the Stone Age groups in the Trap country of Upper Deccan. Surely, we now have a large number of Acheulian sites based on the working of a variety of rocks such as limestone, dolerites, granite/pegmatite and fossil wood.

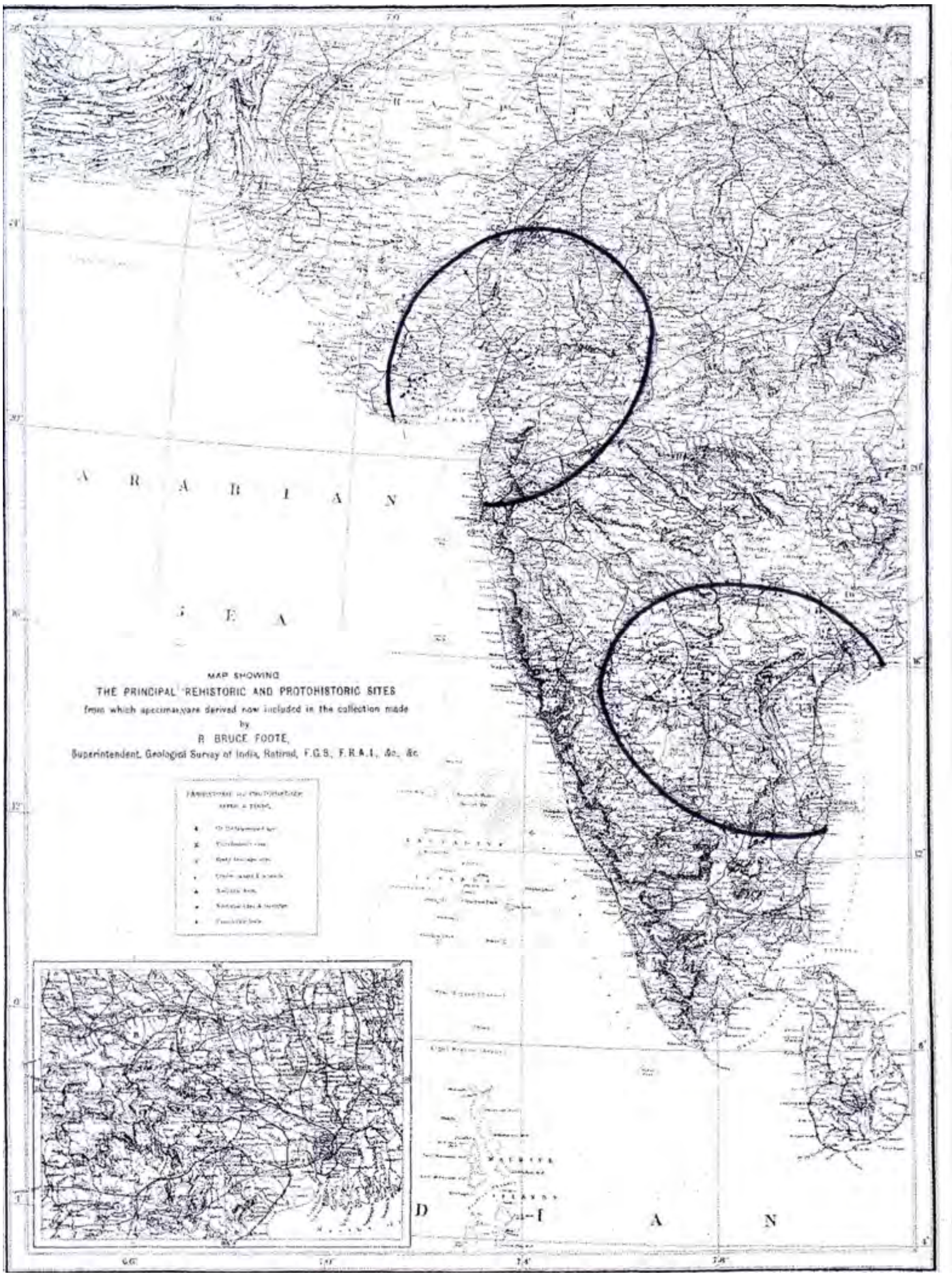


Fig. 14: Robert Bruce Foote's (1916) map showing pre- and protohistoric sites found by him in peninsular India. These occur in two clusters – one covering North Karnataka, Rayalaseema of Andhra Pradesh and North Tamil Nadu, and the other covering Central and North Gujarat and Saurashtra

Finally, a word about the impact of Foote's discoveries. Through his visits to Europe, personal contacts with several workers there and publication of his early findings as papers in England (Foote 1868, 1869), Foote was able to create much interest and enthusiasm about the Indian findings in the scientific circles in Europe. One should note that this was at a time when East Africa and the Levant were yet to make their mark in world prehistory. Palaeolithic sites began to be found in these regions only in the last quarter of the nineteenth century (Gowlett 1990; Bar-Yosef, in press).

In India Foote's pioneering work exercised a profound effect on subsequent developments in both Palaeolithic and Neolithic studies. Based upon the details of sedimentary stratigraphy observed in the river sections of the Kurnool region and the careful collection of stone implements from the various layers by the district collector L.A. Cammiade, a four-series Stone Age sequence was put forward by him in 1930 jointly with the Cambridge prehistorian Miles Burkitt (Cammiade and Burkitt 1930). It provided for a three-phase division within the Palaeolithic (Lower, Middle and Upper) and also a secure place for the Mesolithic. Cammiade and Burkitt also interpreted the deposition of river gravels and silts in terms of wet and dry climatic episodes, respectively. It is this stratigraphical-cum-cultural-cum-climatic sequence which served as a model and was replicated in different parts of India after Independence. In the post-Independence period Foote's work inspired a large number of field projects concerning both Palaeolithic and Neolithic cultures in different parts of South India and Gujarat. Even till today it is the three catalogues (1901, 1914, 1916) and various papers published by Foote with which one starts while initiating fresh work in different regions of peninsular India. Furthermore, Foote's tenacity of purpose, his love and fascination for the Indian landscape, his skills in locating antiquarian remains in the field, and his astuteness in arriving at final inferences are an unending source of inspiration to workers.

Viewed in a larger context, Foote's work added yet another facet to the contributions made by the Madras School of Orientalism. In the early decades of the nineteenth century this School had already made several major discoveries of far-reaching importance, e.g. Colonel Mackenzie's investigations into South Indian history and culture; recognition of Jainism as an independent religion; and characterization of South Indian languages as constituting a distinct group called the Dravidian family by Francis Whyte Ellis and his colleagues (Trautmann 2009; Venkateswarlu 2012). Foote prefixed a prehistoric prelude to the whole story.

Acheulian Culture Studies in Hunsgi and Baichbal Valleys

Coming now to the work undertaken on the Acheulian sites in India subsequent to the discoveries of Foote, R.S. Pappu (2001) has published a masterly and book-length account on this topic. It deals with the various regional surveys carried out in different parts of the country, leading to the discovery of numerous open air and cave sites; nature of lithic assemblages and fossil fauna recovered from these sites; excavations carried out at several primary or near primary sites and the findings from these sites bearing upon hominin behavioural patterns; and chronology as facilitated by dates obtained by means of radiometric methods. Pappu's book, read together with the review articles that have appeared since then (Misra 1987; 1989; Misra 1994, 1995, 2008; Petraglia and Korisettar 1998; Paddayya 2008; Dennell 2009; Pappu 2013), gives an up-to-date and comprehensive picture of the formative phase of the country's prehistoric past. So it is unnecessary to attempt another review here. Instead, I would like to make some observations about my own quarter-century-long project concerning the Acheulian sites of the Hunsgi and Baichbal valleys. Elsewhere I published a detailed paper about the various stages through which this project passed (Paddayya 2001), so my comments here will be brief.

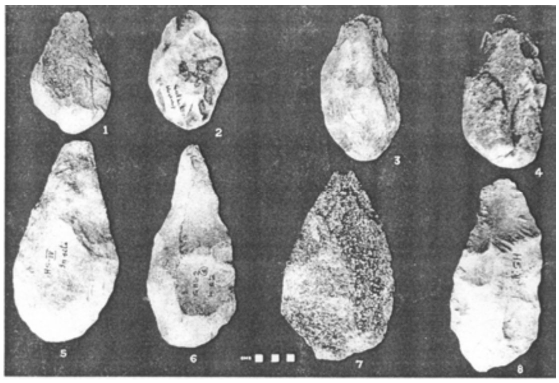


Fig. 15: Acheulian handaxes from Gulbal and Hunsgi in Hunsgi valley. The specimen in No. 6 was found at Gulbal in February 1969

The Hunsgi and Baichbal valleys, separated from each other by a narrow strip of shale-limestone tableland, constitute an erosional basin of Tertiary age and are enclosed by Archaean formations on the eastern side and by shale-limestone tablelands on the other sides. The two valleys together measure about 500 km^2 in extent and are located in the southwestern corner of the Shorapur Doab formed at the confluence of the Bhima with the Krishna river. As part of my doctoral research I discovered from 1965 onwards many Middle and Upper Palaeolithic sites in the context of high level gravels and other laterally formed sedimentary deposits lying away from the Krishna. Although as far back as 15 April 1870 Foote found a few limestone bifacial implements at Yedihalli in the Baichbal valley (Foote 1876: 247; 1916: 122, Plate 2), I did not expect to find any Lower Palaeolithic sites in the area because quartzite which was widely used as the raw material for tool-making in other areas of the country, is practically absent here. However, to my pleasant surprise, in February 1969 a well-shaped handaxe and few other bifacial implements of limestone were found in a fluviatile gravel deposit at Gulbal in the Hunsgi valley (Paddayya 1971). From the nearly fresh condition of the specimens and location of the deposit itself close to the foothill zone of limestone uplands, it was clear that not only Lower Palaeolithic sites of the Acheulian character exist in the area but one could in fact also expect to find them in a primary context (Fig. 15). Special significance was attached to the latter aspect, since a vast majority of Stone Age sites reported earlier from various parts of the country were of a secondary context associated with long-transported alluvial sediments and therefore not helpful for behavioural interpretations.

These assumptions proved to be correct when a regular site in a near primary context was exposed in 1974 at the nearby Hunsgi village in the course of soil quarrying work forming part of the construction of an anicut or low dam across the Hunsgi stream. Several dozen fresh implements of limestone were found at the Hunsgi site (Paddayya 1975). This was the beginning of a regular research project which I continued for the next eight years. Intensive foot-surveys were undertaken in the Hunsgi valley, leading to the discovery of 45 primary and 13 secondary localities. Two of the localities at Hunsgi were excavated to expose primary occupation levels. The results of these field studies were so encouraging that I felt bold enough to argue for a redefinition of the aims and methods of Palaeolithic research in the country in order to elevate it to a level over and above what Wheeler (1960) aptly called preoccupations with "Stones" and "More Stones" (Paddayya 1978). Ethnographic data was also gathered from the valley about seasonal variability in the availability of surface water sources (as formed by seep-springs) as well as wild plant and animal foods.

Pooling together all these data, a settlement system model was put forward to reconstruct the functioning of the Acheulian culture of the valley on an annual basis with reference to the seasonality of monsoonal climate. The major finding was that the Acheulian groups adopted two principal seasonal resource management strategies: a) wet season dispersal of the groups across the valley floor, as facilitated by the availability of valley floor water pools and a variety of wild plant foods and small fauna; and b) dry season aggregation of the groups at the two-kilometre stretch of the Hunsgi stream between Hunsgi and Devapur (as facilitated by a perennial water flow resulting from seep-springs) and reliance on large game hunting (Paddayya 1982).

Far from concluding the research project, this work spurred further and more intensive field studies in the area which continued till 2001. There are four or five aspects of this later work which deserve attention. First, encouraged by the results of intensive foot-surveys in the Hunsgi valley, annual surveys were conducted both in the unexplored stretches of the Hunsgi valley itself and in the adjacent Baichbal valley. The survey team usually consisted of four or five persons, walking at distances of 15 to 20 m from one another. These surveys took place in February-March and coincided with the harvesting of *jowar* and cotton crops, thereby affording greater visibility of archaeological remains. The efficacy of these surveys could be judged from the fact that over 150 additional Acheulian localities were identified in the two valleys. This was in addition to scores of sites belonging to later cultures. These two valleys may well constitute the most intensively surveyed area in the country from the point of view of archaeological sites.

Fig. 16: Oval-shaped crushers of pegmatite from Acheulian level at Yediyapur VI, showing marks of scarring on the periphery

Secondly, the freshly developed perspective of formation processes (Schiffer 1987) was used for understanding the landscape and sedimentary contexts of localities. The use of this perspective proved to be very helpful for purposes of behavioural interpretations. The sites were first grouped into two classes: secondary and primary (Paddayya and Petraglia 1995). Based upon their locational and sedimentary contexts, three types were noted among secondary sites: a) fluviatile conglomerates; b) colluvial gravels; and c) sites which were affected by surface runoff and rill erosion. Primary sites comprise original spots (this feature was called spot provenience) which actually witnessed occupation or other kinds of hominin activity. Among these again three or four functional classes could be identified, viz. regular occupation sites with possible examples of point provenience, i.e. individual artefacts still lying in the original positions; b) food-processing localities with remains of fossil fauna; c) off-sites or non-sites representing single-episode events; and d) caches of stone implements meant for future use.

Another important outcome of these intensive surveys relates to the recovery of small quantities of fossil fauna from many localities in the Hunsgi and Baichbal valleys (Paddayya 1985). The assemblage comprises dental and post-cranial bone pieces of wild cattle and deer, dental remains of wild horse, and tusk pieces of wild elephant. This was a most welcome category of evidence as it gave clues both about the savanna woodland type of ecology that prevailed in the area at the time of hominin occupation and about the dietary base of the hominin groups. In addition to its usefulness for reconstructing Stone Age food economy, the fossil fauna has proved to be a useful medium for dating purposes by means of radiometric techniques. These dates, together with stratigraphical data and typological and technological features of lithic assemblages, have been helpful in discerning an evolutionary sequence within the Acheulian culture of the two valleys (Paddayya 2008). As against a broad two-stage division of the Acheulian assemblages of the country suggested by earlier workers, it is for the first time that a three-phase sequence has been put forward within the Acheulian culture of one specific region.

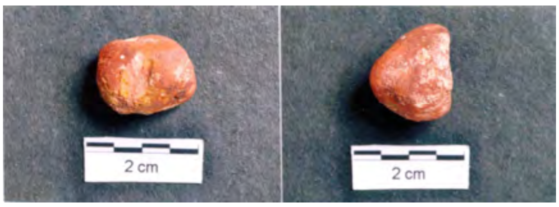


Fig. 17: Haematite nodule from Yediyapur VI excavation producing streaks of red colour and showing possible striation marks

As part of this second phase of work excavations were conducted at the occupation sites of Yediyapur (1986) in the Baichbal valley and Isampur (1997-2001) in the

Hunsgi valley. At both these sites the Stone Age occupation levels were exposed to surface due to removal of overlying silt cover (50 cm to 2 m in thickness) in the course of modern land-development activities to facilitate introduction of river irrigation into the valleys. The Yediyapur lithic assemblage, belonging to the mid-Acheulian phase, is based on the working of coarse-grained but locally available rock called pegmatite. Interestingly, this assemblage includes a dozen specimens of a class of artefacts designated as crushers (Fig. 16). These are oval or discoidal artefacts of non-edge category made from flat pegmatite slab pieces and bear on their blunt periphery patches showing marks of scarring or pitting, probably resulting from pounding and crushing of plant foods such as seeds, leafy greens, nuts, etc. (Paddayya 2010). Another interesting finding from this site concerns the occurrence of a few haematite nodules producing streaks of red colour (Fig. 17). Dr. J. Bednarik of Australia recognized striation marks on one of the pieces during his visit to the Deccan College, Pune in March 1990. It is probable that these pieces were used by the site occupants for colouring purposes.

At Isampur the Acheulian level is associated with a weathered bed of silicified limestone and covers an area of three-quarters of a hectare. Five trenches were dug covering a total area of 159 m^2. In the main trench (70 m^2) seven chipping clusters (Fig. 18) were identified, yielding a total of 13,043 limestone artefacts comprising both finished tools and waste products. The Isampur excavation occupies a special place in the Indian Palaeolithic studies inasmuch as it has given us excellent evidence of the whole chain of steps involved in tool-making – identifying a patch of weathered bed of limestone as a source of raw material; selecting (sometimes prizing out) limestone slab pieces of suitable shapes and sizes to serve as cores for flaking; collecting hammerstones of harder rocks like chert and basalt from site vicinity for flaking; fashioning flakes so detached into bifaces and other artefacts; and preparation of specialized types such as knives and perforators by blunting edges (Paddayya, Jhaldiyal and Petraglia 2006). From the relative positions of limestone blocks, cores and hammer stones found in some of the chipping clusters, it was inferred that flaking was not a one-man task but involved two or more persons. This evidence, together with data pertaining to flaking methods and symmetry of tool shapes, gives us clues about sociality and cognitive dimensions of the hominin groups (Shipton 2013). The Isampur site also yielded a small amount of fossil fauna including dental and bone remains of deer and wild cattle, and tortoise shell pieces indicating that it was not merely a tool-making spot but served as a home base. It is also important to note that enamel from bovid teeth from this excavation has been dated by the ESR method to 1.2 million years (Paddayya *et al.* 2002).

Finally, this fresh research also made it possible to go beyond the coarse-grained wet season dispersal and dry season aggregation model of settlement system that had been put forward by me earlier on the basis of recognition of two major clusters of sites in the area – one each in the Hunsgi and Baichbal valleys (Fig. 19). It is now possible to make inferences about the day-to-day or short-term versions of spatial behaviour of the Acheulian groups that occupied the two valleys. For this purpose, analogies drawn from studies of habitat use by non-human primate groups such as the chimpanzee, the gorilla and the baboon have proved to be helpful. Group living (ranging up to 30 individuals) and home range or occupation of a restricted territory (25 to 40 km^2) with a core spot or patch of land within it used intensively for group activities are common features of land use among these primate groups (e.g. Washburn and Hamburg 1965; for more recent studies on this topic, see essays in Harcourt and Sherwood 2002).

Using these analogies in the context of available data about the Acheulian sites of Hunsgi and Baichbal valleys (their spatial distribution, availability of water bodies resulting from seep-springs, sources of raw material for tool-making, and availability of plant and animal foods), it is possible to recognize the existence of five home ranges (each probably occupied by a group of 15 or 20 individuals) in the Husngi valley and another four in the Baichbal valley (Fig. 20). Each one of these home ranges had one or two principal sites serving as hubs, from where members of the hominin group mapped on to the surrounding landscape as part of daily foraging activities. Hunsgi, Isampur and Yediyapur were some of these hubs or core spots of activity.

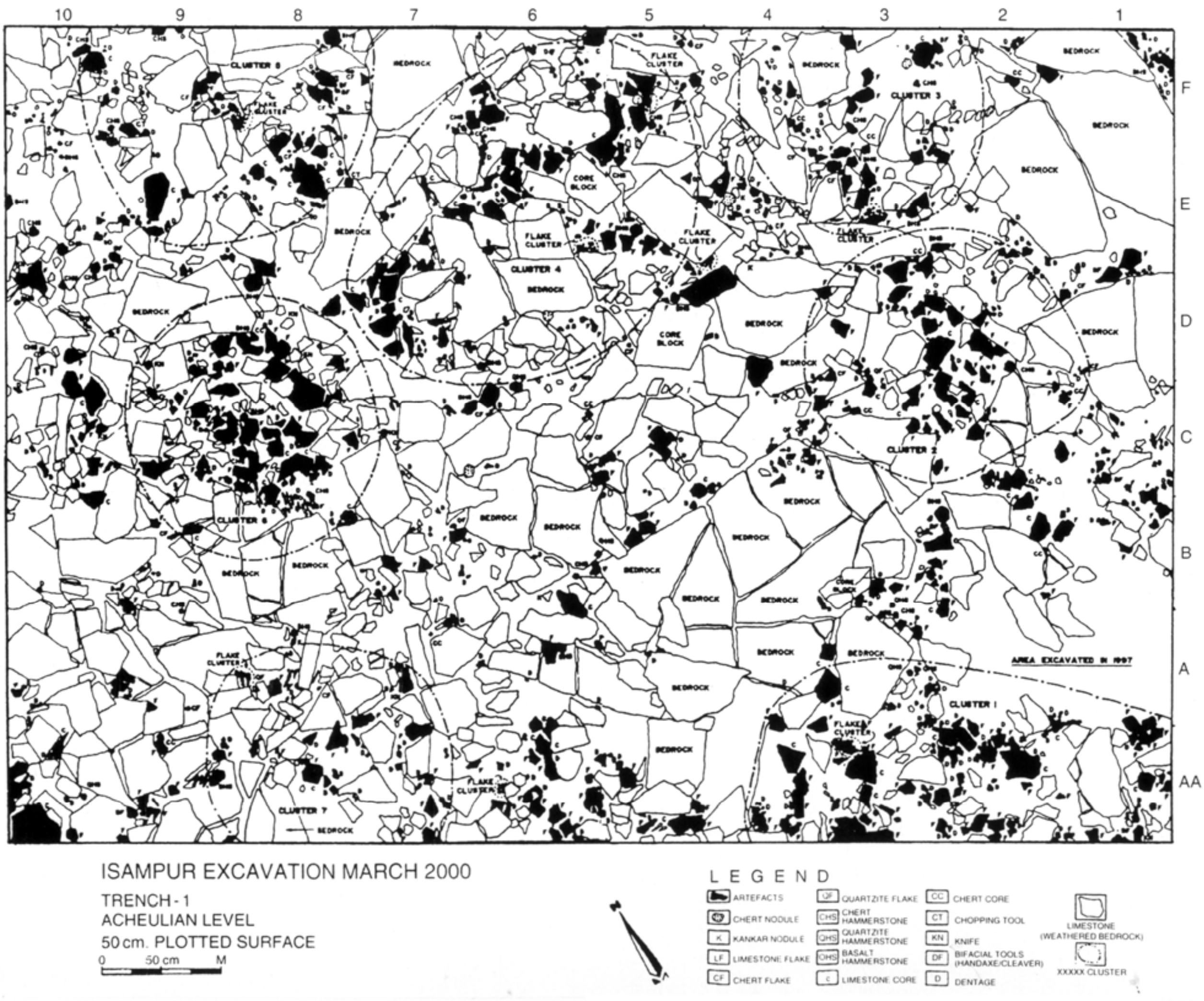


Fig. 18: Acheulian level exposed in Trench 1 at Isampur, Hunsgi valley, showing various chipping clusters. The artefacts are shown in black

Larger Issues Ahead

Notwithstanding the advances described at length in Pappu'sbook and other writings in our understanding of the Acheulian culture of the country as a whole and the encouraging results of my own prolonged field investigations in the Hunsgi and Baichbal valleys, there still exist several gaps that need immediate attention. As concerns my own work, there is the issue of the formation of Hunsgi and Baichbal valleys themselves. While their erosional origin is beyond doubt, we still need to ascertain their age and formation processes on a sounder footing. The clues for this are provided by three kinds of sedimentary deposit, viz. a) kankar conglomerates or angular to sub-angular colluvial spreads of limestone found extensively in the foothill zone of shale-limestone uplands; b) high-level gravels consisting of sub-angular to rounded pieces of chert derived from Inter-trappean beds; and c) travertine deposits resulting from seep-spring activity, as found at Devapur and Kaldevanhalli in Hunsgi valley and at Mudnur in Baichbal valley. Detailed contour mapping of the valley floors and surrounding uplands as well as field and laboratory studies of these sedimentary deposits will be required for a better understanding of the age and phases in the formation of the two erosional basins. Simultaneously we will also be able to explain why the valleys were preferred for hominin occupation.

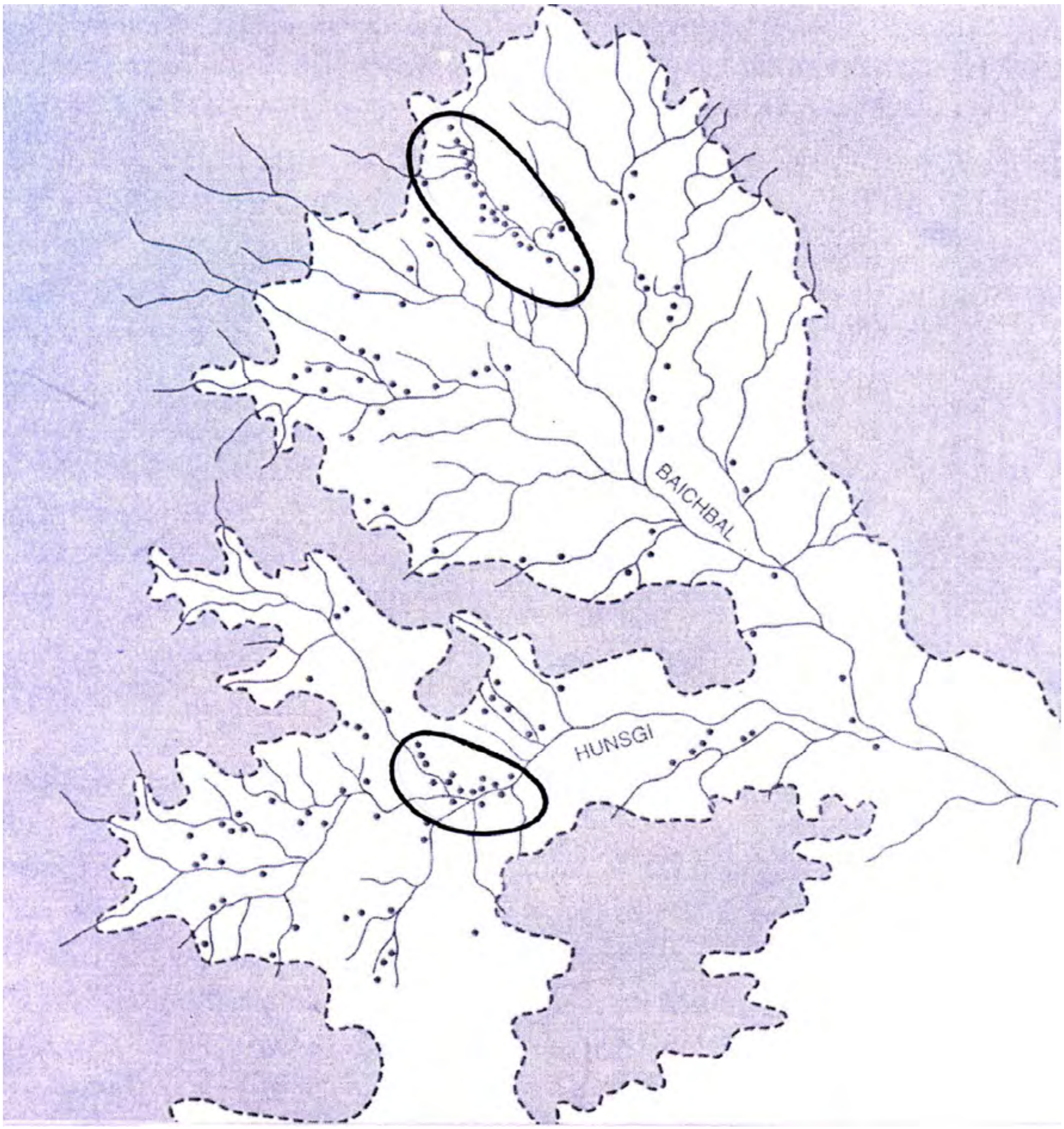


Fig. 19: Map showing two major clusters of Acheulian sites – one each in the Hunsgi and Baichbal valleys

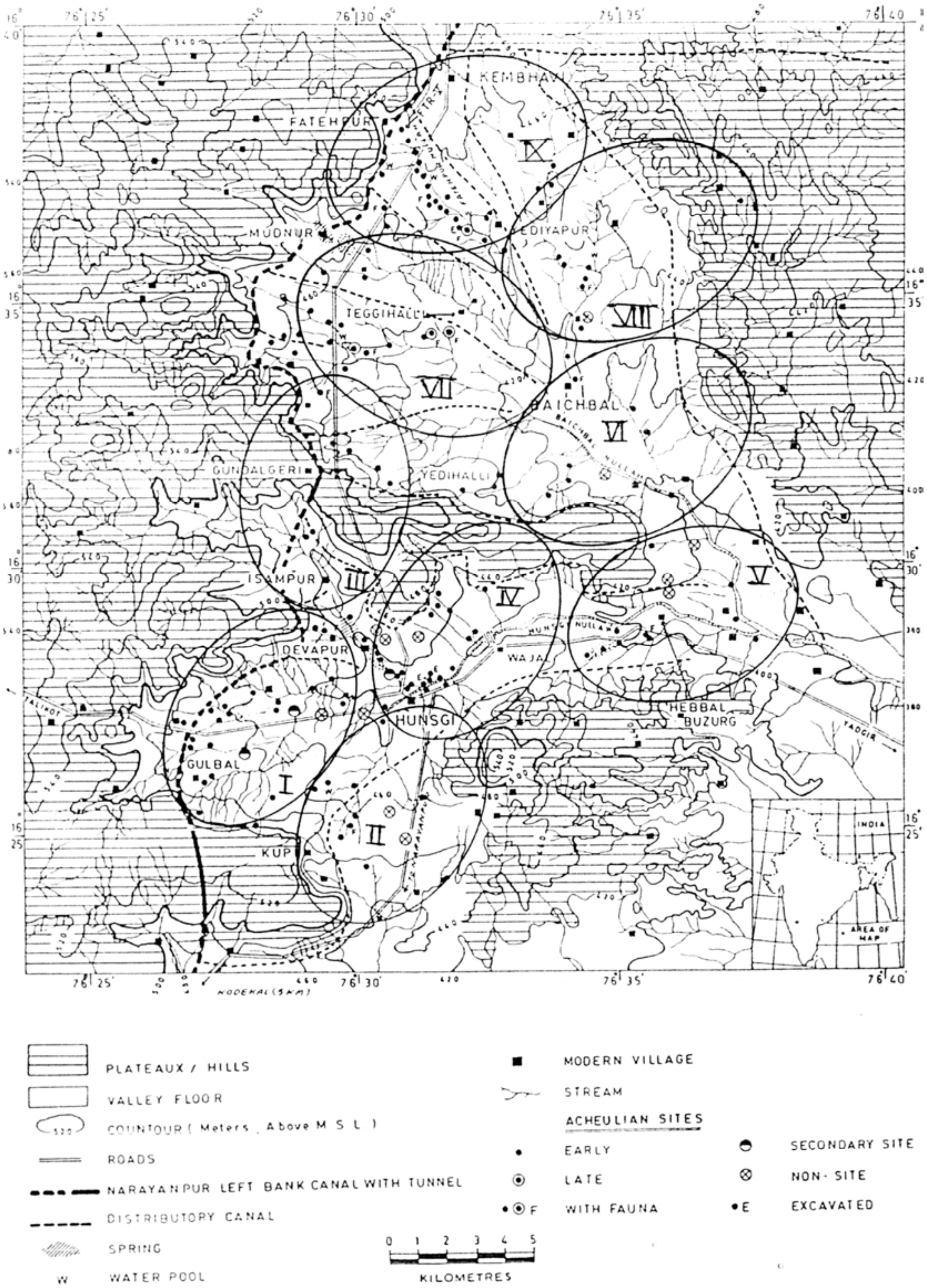


Fig. 20: Map of the Hunsgi and Baichbal valleys showing the spatial extent of various Acheulian home ranges

Another aspect concerns the reconstruction of biophysical environments of the valleys during Stone Age occupation. The occurrence of fossil fauna representing wild cattle, horse, elephant, and deer indicates that the valleys were clothed in savannah woodland type of vegetation and supported rich wild life of various forms. A closer understanding of these environmental aspects can be expected from detailed stratigraphical and sedimentological studies of brown and black silt deposits overlying the Acheulian and later cultural horizons. A detailed study of the depositional processes of these sediments could give clues for understanding the minor topographical changes taking place in the basins at the time of hominin occupation and also enable us to relate the preservation of Stone Age sites to the slow and episodic nature of sediment derivation and deposition. Studies of these deposits from the point of view of micro-fauna may give clues about the biological environments.

Thirdly, the inference about the three-phase internal evolution within the Acheulian culture of the two valleys also needs to be ascertained by additional stratigraphical evidence and radiometric dates. Further we need to know whether this notion of continuity also holds good from the Acheulian to the Middle Palaeolithic and later cultural phases. This may necessitate excavation of primary sites of the Middle Palaeolithic and later sites.

The functional aspect of stone tools is another topic that deserves immediate attention. The examples of crushers identified at Yediyapur suggest exploitation of plant foods on a large scale. In this connection we may recall that on a purely intuitive basis D.D. Kosambi(1965: Chapter 2; see also Paterson and Drummond 1962: Last Chapter) emphasized, half a century ago, the importance of plant foods in Early Man's subsistence in tropical regions like India. These inferences now need to be verified in the light of recently developed residues analysis. Plant residues (of grass seeds, roots, etc.) have been identified on stone tools belonging to the Middle Stone Age in Mozambique and the Upper Palaeolithic culture in Russia, Czechoslovakia and Italy (e.g. Piperno *et al.* 2004).

Considering the matter at the national level, we note that Acheulian sites are now known from most parts of the country, covering coastal, desertic, plateau and basin tracts and spread over equally varied ecological zones ranging from semi-desertic areas with scant rainfall to moist deciduous tracts with annual rainfall ranging up to 120 cm. We are now also familiar with the fact that the hominins were not governed by raw material determinism but actually exploited a variety of igneous, sedimentary and metamorphic rocks. Also we have fairly good knowledge of the typo-technological features of the various assemblages. Fresh field studies including excavations are currently under way in the Raisen region of Madhya Pradesh where Jerome Jacobson found a large number of open air sites in the 1970s (see the paper by Ota and Deo in this volume), Attirampakkam area of Tamil Nadu (Pappu*et al.* 2011a), Bundelkhand region containing the Lalitpur group of sites (Agarwal 2014), and at Kondapeta in coastal Andhra Pradesh (Singh *et al.* 2013).

Another major advance concerns chronology. Radiometric methods have given us a series of absolute dates for the cultural phase. Unsurprisingly, the dates of 1.2 and 1.5 million years obtained, respectively, for Isampur (Paddayya *et al.* 2002) and Attirampakkam (Pappu *et al.* 2011b) have created much euphoria and excitement among the workers. Provocative views are being put forward about the old topic of cultural origins and dispersals. Alongside the existing views deriving the Lower Palaeolithic of India from East Africa via coastal or inland routes, the new dates for the Acheulian have given rise to views that this phase originated in peninsular India itself and spread both westwards and eastwards (e.g. Mishra *et al.* 2010). Such possibilities cannot be ruled out. I only tend to think that it is more logical that these views follow upon and not precede resolution of certain more fundamental issues, lest we should be accused of promoting radiometric antiquarianism.

First, there are indications that Acheulian sites occur in many hitherto unrecognized areas. In recent years some sites have been reported in the Aravalli ridges close to Delhi (Trivedi 2009), the terai zone of Nepal (Corvinus 2007) and the Siwalik hills of northwestern India (see the paper in this volume by Gaillard and Singh). Some sites have been found in the upper Mahanadi basinof Orissa (Behera *et al.* 1996; see also the paper by Padhan in this volume). In the early decades of the last century the Hyderabad State geologist Leonard Munn (1928) reported some artefacts from the middle reaches of the Godavari in the Telangana area.

As I have mentioned earlier, Foote (1895: 208, 1916: 78) himself found an assemblage of haematite quartzite in a colluvial gravel spread in the foothill area of the Copper Mountain near Bellary in the Archaean zone. Thus there are clear indications that there are many unexplored areas in the country which contain Acheulian and other Stone Age sites. It is impossible to exaggerate the importance of even a preliminary account of the nature of archaeological record of these areas for reconstructing the country's Stone Age settlement history. Systematic and urgent explorations are called for in the interior areas away from major rivers for an additional reason too. That is, the Stone Age sites of these areas are being lost rapidly due to various land development activities.

Secondly, we also need to give up the notion of the Acheulian culture having been a homogeneous, pan-Indian entity. This also applies to other phases of the Stone Age. Apart from the existence of temporal variability, there is scope for identifying different regional variants within the cultural phases. Over and above typo-technological peculiarities, the identity of these regional variants needs to be established at the level of organizational strategies that were employed for resource procurement and use. These resources and their availability are themselves linked to habitat peculiarities and environmental diversity. Settlement system perspective is the only appropriate research strategy for realizing this goal. The adoption of this strategy entails the use of an ecosystem-based regional approach to sites and functional interpretations of technological components (Binford and Binford 1979; Binford 1980). Ethnographic analogies have an important role to play in this respect. Particularly helpful from this point of view is Binford's massive volume *Constructing Frames of Reference* (2001), which is based on a comparative study of 340 hunter-gatherer societies and environmental data obtained from over a thousand weather stations and wildlife sanctuaries spread all across the world. The book has many low- and high-level generalizations which can guide the workers in anticipating patterns in the archaeological record.

Another serious gap concerns the woefully inadequate nature of hominin fossil record from South Asia. The skeletal material from the microlith-bearing levels in the caves of Sri Lanka, and the skull cap and two clavicles from Hathnora on the Narmada, ascribed to an archaic form of *Homo sapiens,* are the only remains that can be dated to the Pleistocene (Kennedy 2000). We truly need to enlarge this paltry record by taking up planned field studies. For this purpose intensive combing of the environs of major primary sites is called for. Relying upon luck and chance is not really an attribute of scientific approach to natural and human history. It is good to recall Wheeler's comments in this regard. While emphasizing the need for planned research, he remarked that "A well thought-out plan is generally exempt from the disadvantages, but not the advantages, of chance. It wins both ways" (Wheeler 1949: 11).

Acknowledgements
I am grateful to the staff of Hatcher, Buhr and Natural History libraries of University of Michigan at Ann Arbor and Deccan College library in Pune for their support and cooperation in the preparation of this paper. The library work at Ann Arbor was undertaken between March and May 2013 during a private visit to my daughter Vijayalakshmi, her husband Sreechand and their infant son Vivek.

Notes

1. Foote is obviously referring here to the epoch-making paper entitled 'On the Occurrence of Flint Implements, associated with Remains of Animals of Extinct Mammalia in Undisturbed Beds of a late Geological Period' which the British geologist Joseph Prestwich read before the Royal Society in London on 26 May 1859. The audience included Sir Charles Lyell, Thomas Huxley and many other leading scientists of the day. After briefly referring to the previous discoveries of primitive stone tools in association with fossil fauna from caves and other sites in Germany, Belgium, France and other countries, Prestwich reported about his recent visits to the Somme valley localities in France as well as Hoxne and Brixham cave in England. He certified the findings of stone tools

and fossil fauna from these sites as authentic. He made the following corroborative statements (Prestwich 1860: 58):

“That the flint-implements are the work of man.
“That they were found in undisturbed ground.
“That they are associated with the remains of extinct Mammalia.
“That the period was a late geological one and anterior to the surface assuming its present outline, so far as some of its minor features are concerned.”

Prestwich’s paper concluded with a brief note by the archaeologist John Evans about the typology of implements.

Workers in India will be glad to note that Prestwich was motivated to visit the Somme valley sites by a letter written to him by the famous paleontologist Hugh Falconer (his niece was married to Prestwich). Falconer had worked in India from 1830 in the East India Company’s medical and garden departments and returned to Britain in 1856. During his stay in India he studied the Siwalik fossil fauna and also found animal fossils of Pleiocene age in the kankar beds of the Yamuna between Agra and Allahabad. He further expressed the hope that in future both animal fossils and stone artefacts would be found in the alluvial deposits of the Ganga valley (Falconer 1868: 647). The Indian experiences obviously helped Falconer in recognizing the significance of Somme valley discoveries of Boucher de Perthes which he had personally seen on his way to Italy in November 1858. It was against this background that he sent a letter to Prestwich requesting him to visit the French sites (Prestwich 1899: 119).

Just a week after Prestwich’s presentation before the Royal Society, on 2 June, Evans read a detailed paper on this topic entitled ‘On the Occurrence of Flint Implements in Undisturbed Beds of Gravel, Silt, Sand and Clay’ before the Society of Antqiuaries in London (Evans 1860). In this paper Evans took a review of the stratigraphy of the drift gravels and associated fossil fauna found at various localities near Abbeville and Amiens on the Somme and at Hoxne in England. He then took up the study of stone implements and classified these into three groups: a) flint flakes (arrowheads or knives); b) pointed weapons (lance- or spearheads); and c) oval or almond-shaped implements with a cutting edge all round. He further asserted that “a uniformity of shape, a correctness of outline and a sharpness about the cutting edges and points” clearly distinguished these specimens from naturally fractured rock pieces (1860: 288). Evans concluded his paper with a firm statement about the remoteness of man’s antiquity: “Thus much appears to be established beyond a doubt; that in a period of antiquity, remote beyond any of which we have hitherto found traces, this portion of the globe was peopled by man; and that mankind has here witnessed some of these geological changes by which these so-called diluvial beds were deposited” (1860: 306). Two years later, on 16 May 1861, he read before the Society a more comprehensive paper on the topic and gave an elaborate classification of stone implements (Evans1863; for an estimate of Evans’ multi-sided contributions, see the essays in MacGregor 2008).

To continue the story a little further, a few months later, in September 1859, Sir Charles Lyell presented his three-page presidential address entitled ‘On the Occurrence of Works of Human Art in Post-Pleiocene Deposits’ to the Geology Section at the Twenty-Ninth Meeting of the British Association for the Advancement of Science held at Aberdeen. In this paper he lent his full support to the antiquity of findings made in France and England, as presented by Prestwich before the Royal Society. Equally interesting, Lyell also mentioned that Charles Darwin would shortly publish his work on the origin of species and further stated that “He (Darwin) appears to me to have succeeded, by his investigations and reasonings, in throwing a flood of light on many classes of phenomena connected with the affinities, geographical distribution, and geological succession of organic beings, for which no other hypothesis has been able, or has even attempted, to account” (Lyell 1860: 95).

Finally, a year after Prestwich’s paper before the Royal Soceity, on 7 June 1860, Boucher de Perthes himself made a comprehensive presentation entitled ‘De l'Homme Antediluvien et de ses Oeuvres' before the Société d' Emulation in Paris (Boucher de Perthes 1864). In this paper Boucher de Perthes thanked Prestwich and other British workers for their support. He took a review of his findings in the Somme valley since the 1830s and gave further details about the stratigraphy exposed at some of the localities in the Somme valley and about flint implement types and the probable ways in which they were hafted.

2. To be sure, far from being dead, the opposition to the theory of evolution continues well into the twenty-first century. Surprisingly, it is particularly strong in the United States where it has also entered the political, legal and pedagogical spheres of the society. A large volume of literature is available about the evolution versus creationism controversy (e.g. Scott 2004; Young and Largent 2007).

3. This tripartite division was in refutation of an entirely different point of view about the country's prehistoric past that had been advocated by Valentine Ball, one of Foote's own colleagues in the Geological Survey. Based upon his collections of stone tools from Bihar, Bengal and other parts of eastern India, Ball read in 1878 a paper before the Royal Irish Academy (Ball 1879). He put forward the view that the polished stone tools of Northeast India, cores and flake tools of Northwest India, and chipped tools of South India belonged to the same period but were prepared by different races of people.

4. In the Orsang, Mahi and Sabarmati valleys of central and northern Gujarat Foote recorded thick sedimentary record measuring between 100 and 200 feet (30.5 m to 61 m). He found Palaeolithic implements in the basal gravels, while the loessic (sand dune) deposits capping the sections yielded flakes and cores of chert and chalcedony which he assigned to the Neolithic period. Since the thick intervening gravel and silt layers were culturally sterile, Foote was led to postulate a Mesolithic hiatus between the Palaeolithic and Neolithic periods (Foote 1895: 207-8; 1916: 15-17). But we now know that Foote erred in this interpretation. Carllyle, one of Alexander Cunningham's assistants, found a series of microlithic sites in the Mirzapur hills of Central India between 1867-68 and 1880-81. V.A. Smith published a detailed paper on these findings in 1906, which unfortunately went unnoticed by Foote while preparing his catalogue of 1916. As part of his first Gujarat Prehistoric Expedition in 1941-42, Sankalia (1946) carried out fresh fieldwork in Gujarat. He showed that the siliceous artefacts occurring in the top levels of river sections were part of a microlithic tradition. Sankalia's studies heralded Mesolithic research in the country.

References

Agarwal, Neetu 2014. *The Technology of Large Flake Acheulian at Lalitpur, Cenral India.* Unpublished Ph.D. thesis, Universitat Rovira i Virgili, Tarragona, Spain.

Allchin, F.R. 1961. Ideas of History in Indian Archaeological Writing: A Preliminary Study, in *Historians of India, Pakistan and Ceylon* (C.H. Philips Ed.), pp. 241-59. London: Oxford University Press.

Bar-Yosef, O. (in press).*Prehistory of the Holy Land.*

Behera, P.K., P. Panda and N. Thakur 1996. Techno-Typological Analysis of Lithic Artefacts from Dari-DunguriAcheulian Site, Sambalpur District, Orissa, *Man and Environment* 21: 15-26.

Binford, Lewis R. 1980. Willow Smoke and Dogs' Tails: Hunter-Gatherer Settlement Systems and Archaeological Site Formation, *American Antiquity* 45: 4-20.

Binford, Lewis R. 2001. *Constructing Frames of Reference: An Analytical Method for Archaeological Theory Building – Using Ethnographic and Environmental Data Sets.* Berkeley: University of California Press.

Binford, Lewis R. and Sally R. Binford 1979. Stone Tools and Human Behaviour, in *Human Ancestors* (G. Isaac and R.E.F. Leakey Eds.), pp. 92-101. San Francisco: W.H. Freeman.

Boucher de Perthes, Jacques 1864. De L'Homme Antediluvien et de ses Oeuvres (Address delivered before Société d' Emulation in Paris on 7 June 1860), in *Antiquités Celtiques et Antediluviennes,* Volume III, pp. 1-103. Paris: Jung-Treuttel.

Cammiade, L.A. and M.C. Burkitt 1930. Fresh Light on the Stone Age of Southeast India, *Antiquity* 4: 327-339.

Clarkson, C., M.D. Petraglia, R.Korisettar, M. Haslam, N. Boivin, A. Crowther, P. Ditchfield,

D. Fuller, P. Miracle, C. Harris, K. Cornell and J. Koshy 2009. The Oldest and Longest Enduring Microlithic Sequence in India: 35,000 Years of Modern Human Occupation and Change at the Jwalapuram Locality 9 Rock Shelter, *Antiquity* 83: 326-348.

Clodd, E. 1895. *The Story of "Primitive"Man.* London: George Newnes.

Cook, J. and H.D. Martingell 1994. *The Carllyle Collection of Stone Age Artefacts from Central India.* London: British Museum.

Corvinus, Gudrun 2007.*Prehistoric Cultures in Nepal: From the Early Palaeolithic to the Neolithic and the Quaternary Geology of the Dang-Deokhuri Valleys.* Wiesbaden: Otto Harrosowitz.

Darwin, Charles 1968. *The Origin of Species by Means of Natural Selection, or Preservation of Favoured Races in the Struggle for Life.* Harmondsworth: Penguin Books. Originally published in 1859 by John Murray, London.

Darwin, Charles 1871. *The Descent of Man, and Selection in Relation to Sex.* London: John Murray.

de Morgan, Jacques 1924. *Prehistoric Man: A General Outline of Prehistory.* London: Kegan Paul, Trench, Trubner& Co. Translated from French by J.H. Paxton and U.C.C. Collum.

De Mortillet, Gabriel 1883. *Le Prehistorique:Antiquités de l'Homme.* Paris: Reinwald.

Dennell, R.W. 2009. *The Palaeolithic Settlement of Asia*. Cambridge: Cambridge University Press.

Evans, Christopher 2009a. Marking Time, *Antiquity* 83(320): 458-461.

Evans, Christopher 2009b. Small Agencies and Great Consequences: Darwin's Archaeology, *Antiquity* 83: 475-88.

Evans, John 1860. On the Occurrence of Flint Implements in Undisturbed Beds of Gravel, Silt, Sand and Clay, *Archaeologia* 38: 280-307.

Evans, John 1863. Account of Some Further Discoveries of Flint Implements in the Drift on the Continent and in England, *Archaeologia* 39: 57-84.

Evans, John 1872. *The Ancient Stone Implements, Weapons, and Ornaments of Great Britain.* London: Longmans, Green,

Evans, John 1872. On the Coinage of Ancient Britons, and Natural Selection, *Notices of the Proceedings at the Meetings of the Members of the Royal Institution of Great Britain* VII: 476-87.

Falconer, Hugh 1868. On the Asserted Occurrence of Human Bones in Ancient Fluviatile Deposits of the Nile and Ganges with Comparative Remarks on the Alluvial Formations of the two Valleys, in *Palaeontological Memories and Notes on the Late Hugh Falconer,* Volume II (C. Murchison Ed.), pp. 632-647. London: Robert Hardwicke.

Foote, Robert Bruce 1866. On the Occurrence of Stone Implements in Lateritic Formations in Various Parts of Madras and North Arcot Districts, *The Madras Journal of Literature and Science, Third Series – Part 2*: 1-41. With an Appendix by William King on 'Notes on the Occurrence of Stone Implements in North Arcot District.'

Foote, Robert Bruce 1868. On the Distribution of Stone Implements in Southern India. *Quarterly Journal of the Geological Society of London*: 24: 484-495.

Foote, Robert Bruce 1869. On Quartzite Implements of Palaeolithic Types from the Laterite Formation of the East Coast of India, in *International Congress of Prehistoric Archaeology: Transactions of the Third Session held at Norwich and London in August 1868,* pp. 224-239. London: Longman, Green and Co.

Foote, Robert Bruce 1873. On the Geology of Parts of the Madras and North Arcot Districts lying north of the Palar River, and included in Sheet 78 of the Indian Atlas, *Memoirs of the Geological Survey of India* 10: 1-32.

Foote, Robert Bruce 1876. The Geological Features of the South Mahratta Country and Adjacent Districts, *Memoirs of the Geological Survey of India* 12: 1-268.

Foote, Robert Bruce 1884a. Rough Notes on Billa Surgam and Other Caves in the Kurnool District, *Records of the Geological Survey of India* 17, Part 1: 34-37.
Foote, Robert Bruce 1884b. Mr. H.B. Foote's Work at the Billa Surgam Caves, *Records of the Geological Survey of India* 17, Part 4: 200-208.
Foote, Robert Bruce 1885. Notes on the Results of Mr. H.B. Foote's Further Excavations in the Bill Surgam Caves, *Records of the Geological Survey of India* 18, Part 4: 227-235.
Foote, Robert Bruce 1887. Notes on Some Recent Neolithic and Palaeolithic Finds in Southern India, *Journal of the Asiatic Society of Bengal* 56, Part 2, No. 3: 259-282.
Foote, Robert Bruce 1895. Geology of Bellary District, Madras Presidency, *Memoirs of the Geological Survey of India* 25.
Foote, Robert Bruce 1901. *Catalogue of the Prehistoric Antiquities.* Madras: Government Museum.
Foote, Robert Bruce 1914. *The Foote Collection of Indian Prehistoric and Protohistoric Antiquities: Catalogue Raisonne.* Madras: Government Museum.
Foote, Robert Bruce 1916. *The Foote Collection of Indian Prehistoric and Protohistoric Antiquities: Notes on their Ages and Distribution.* Madras: Government Museum.
Frere, John 1800. Account of Flint Weapons discovered at Hoxne in Suffolk. *Archaeologia*13: 202-205.
Gamble, Clive and Robert Kruszynski 2009. John Evans, Joseph Prestwich and the Stone that Shattered the Time Barrier, *Antiquity* 83 (320): 461-475.
Gowlett, J.A.J. 1990. Archaeological Studies of Human Origins and Early Prehistory in Africa, in *A History of African Archaeology* (P. Robertshaw Ed.), pp. 13-38. London: James Currey.
Grayson, Donald K. 1983. *The Establishment of Human Antiquity.* New York: Academic Press.
Harcourt, Caroline S. and Bryan R. Sherwood (Eds.) 2002.*New Perspectives in Primate Evolution and Behaviour.* Otley (U.K.): Westburg.
Hutchinson, Horace G. 1914. *Life of Sir John Lubbock (Lord Avebury),* Volume II. London: Macmillan and Co.
Huxley, Thomas Henry 1869. On the Ethnology and Archaeology of India, *The Journal of the Ethnological Society of London* (New Series), Volume 1: 89-93.
Huxley, Thomas Henry 1968. Autobiography, in *Method and Results: Essays,* pp. 1-17. New York: Greenwood Press. Originally published in 1916 by D. Appleton and Co, New York.
Kennedy, K.A.R. 2000.*God-Apes and Fossil Men: Paleoanthropology of South Asia.* Ann Arbor: University of Michigan Press.
Kosambi, D.D. 1965. *Culture and Civilisation of Ancient India in Historical Outline.* London: Routledge and Kegan Paul.
Lane Fox, A. (later Pitt-Rivers) 1875. On the Evolution of Culture, *Notices of the Proceedings at the Meetings of the Members of the Royal Institution of Great Britain* VII: 496-520.
Lubbock, John (Lord Avebury) 1913. *Prehistoric Time, as Illustrated by Ancient Remains, and Manners and Customs of Modern Savages.* Seventh Edition. London: Williams and Norgate. Originally published in 1865.
Lubbock, John 1870. *The Origin of Civilization and the Primitive Conditions of Man.* London: Longman.
Lyell, Charles 1830. *Principles of Geology, being an Attempt to explain the former Changes of the Earth's Surface by Reference to Causes now in Action,* Volume I. London: John Murray.
Lyell, Charles 1860. On the Occurrence of Works of Human Art in post-Pleiocene Deposits (Presidential Address to Geology Section), in *Report of 29th Meeting of the British Association for the Advancement of Science* held at Aberdeen in September 1859, pp. 93-95.
Lyell, Charles 1863. *The Geological Evidences of the Antiquity of Man with Remarks on Theories of the Origin of Species by Variation.* London: John Murray.

MacCurdy, George Grant 1924. *Human Origins: A Manual of Prehistory,* Volumes I and II. New York: D. Appleton and Company.

MacGregor, Arthur (Ed.) 2008. *Sir John Evans 1823-1908: Antiquity, Commerce and Natural Science in the Age of Darwin.* Oxford: Ashmolean Museum.

McNabb, John 2007. *The British Lower Paleolithic - Stones in Contention*. Abingdon (U.K.): Routledge.

Mishra, Sheila 1994. The South Asian Lower Palaeolithic, *Man and Environment* 19: 57-92.

Mishra, Sheila 1995. Chronology of the Indian Stone Age: The Imapct of Recent Absolute and Relative Dating Attempts, *Man and Environment* 20: 11-16.

Mishra, Sheila 2008. The Indian Lower Palaeolithic, *Bulletin of the Deccan College Research Institute* 66-67 (2006-2007): 47-94.

Mishra, Sheila, Claire Gaillard, Sushma Deo, Mukesh Singh, Riza Abbas and Neetu Agarwal 2010. Large Flake Acheulian in India: Implications for Understanding Lower Pleistocene Human Dispersals, *Quaternary International* 223-224: 271-272.

Misra, V.N. 1987. Middle Pleistocene Adaptations in India, in *Pleistocene Old World: Regional Perspectives* (Olga Soffer Ed.), pp. 99-114. New York: Plenum Press.

Misra, V.N. 1989. Stone Age India: An Ecological Perspective, *Man and Environment* 14: 17-64.

Munn, Leonard 1928. Notes on Human Artefacts and Fossilized Bones found in Godavari Valley, Hyderabad State, *Annual Report of Archaeology Department of Hyderabad State for 1925-26:* 19-20.

Murray, Tim 2009. Illustrating 'Savagery': Sir John Lubbock and Ernet Griset, *Antiquity* 83(320): 488-499.

Murty, M.L.K. 1974. A Late Pleistocene Cave Site in Southern India, *Proceedings of the American Philosophical Society* 118: 196-230.

O'Connor, Anne 2007. *Finding Time for the Old Stone Age: A History of Palaeolithic Archaeology and Quaternary Geology in Britain, 1860 – 1960*. New York: Oxford University Press.

Paddayya, K. 1971. High Level Gravels and Related Palaeolithic Sites of the Shorapur Doab, Peninsular India, *Quartär*22: 95-110.

Paddayya, K. 1975. Investigations into the Acheulian Phase in the Shorapur Doab, Peninsular India, *Quartär* 26: 5-11.

Paddayya, K. 1978. New Research Designs and Field Techniques in the Palaeolithic Archaeology of India, *World Archaeology* 10: 94-110.

Paddayya, K. 1982. *The Acheulian Culture of the Hunsgi Valley (Peninsular India): A Settlement System Perspective.* Pune: Deccan College.

Paddayya, K. 1985. Acheulian Occupation Sites and Associated Fossil Fauna from the Hunsgi and Baichbal Valleys, Peninsular India, *Anthropos* 80: 653-8.

Paddayya, K. 2001. The Acheulian Culture Project of the Hunsgi and Baichbal Valleys, Peninsular India, in *Human Roots: Africa and Asia in the Middle Pleistocene* (L. Barham and K. Robson-Brown Eds.), pp. 235-58. Bristol: Western Academic Press.

Paddayya, K. 2008. Evolution within the Acheulian in India: A Case Study from the Hunsgi and Baichbal Valleys, Karnataka, *Bulletin of the Deccan College Research Institute* 66-67 (2006-2007): 95-111.

Paddayya, K. 2010. Excavation at Acheulian Locality VI near Yediyapur in Baichbal Valley, Gulbarga District, Karnataka, *Bulletin of the Deccan College Research Institute* 68-69 (2008-2009): 31-69.

Paddayya, K. 2013. Robert Bruce Foote and Indian Prehistory: Then and Now. Keynote Address at the National Seminar on the Acheulian Culture in India: Issues, Trends and Challenges, held at Utkal University, Bhubaneswar.

Paddayya, K., R. Jhaldiyal and M.D. Petraglia 2006. The Acheulian Quarry at Isampur, Lower Deccan, India, in *Axe Age: Acheulian Tool Making from Quarry to Discard* (N. Goren-Inbar and G. Sharon Eds.), pp. 45-73. London: Equinox Publishing.

Paddayya, K. and M.D. Petraglia 1995. Natural and Cultural Formation Processes of the Acheulian Sites of the Hunsgi and Baichbal Valleys, Karanataka, in *Quaternary*

Environments and Geoarchaeology of India (S. Wadia, R. Korisettar and V.S. Kale Eds.) pp. 333-51. Bangalore: Geological Society of India.

Paddayya, K., B.A.B. Blackwell, R. Jhaldiyal, M.D. Petraglia, S. Fevrier, D.A. Chanderton II, I.I.B. Blickstein and A.R. Skinner 2002. Recent Findings on the Acheulian of the Hunsgi and Baichbal Valleys, Karnataka, with Special Reference to the Isampur Excavation and its Dating, *Current Science* 83(5): 641-57.

Pappu, R.S. 2001. *Acheulian Culture in Peninsular India: An Ecological Perspective.* New Delhi: D.K. Printworld.

Pappu, R.S. 2013. Early Hunter-Gatherers: The Lower Palaeolithic, in *Prehistory of India* (M.K. Dhavalikar Ed.), pp. 29-75. New Delhi: Manohar Publishers.

Pappu, Shanti 2001.*A Re-Examination of the Palaeolithic Archaeological Record of Northern Tamil Nadu, South India.* Oxford: BAR International Reports.

Pappu, Shanti, Kumar Akhilesh, Sudha Ravindranath and Uday Raj 2011a. From Stone Tools to Satellites: Recent Research into the Prehistory of Tamil Nadu, *Ancient India* (New Series) 1: 87-100.

Pappu, Shanti, Y. Gunnell, Kumar Akhilesh, Regis Braucher, Maurice Taieb, Francois Demory and Nicolas Thouveny 2011b. Early Pleistocene of Presence of Hominins in South India, *Science* 331 (25 March): 1596-1599.

Paterson, T.T. and H.J.H. Drummond 1962. *Soan: The Palaeolithic of Pakistan*. Karachi: Department of Archaeology.

Petraglia, M.D. and R. Korisettar (Eds.) 1998. *Early Human Behaviour in the Global Context: The Rise and Diversity of the Lower Palaeolithic Record.* London: Routledge.

Piperno, D.R., E. Weiss, I. Hoist and D. Nadel 2004. Processing of Wild Cereal Grains in the Upper Palaeolithic Revealed by Starch Grain Analysis, *Nature* 430 (5 August 2004): 670-673.

Prestwich, Grace Anne 1899. *Life and Letters of Sir Joseph Prestwich.* Edinburgh: William Blackwood and Sons.

Prestwich, Joseph 1860. On the Occurrence of Flint Implements, associated with the Remains of Animals of Extinct Species in Beds of a late Geological Period, in France at Amiens and Abbeville, and in England at Hoxne, *Proceedings of the Royal Society of London* 10: 50-59.

Quinnel, Marjorie and C.H.B. Quinnel 1921.*Everyday Life in Prehistoric Times.* London: B.T. Batsford. Revised in 1951.

Renfrew, Colin 2009. 1859 + 150: Time Depth and Process, *Antiquity* 83(320): 499-501.

Roberts, Alison and Nick Barton 2008. Reading the Unwritten History: Evans and *Ancient Stone Implements,* in *Sir John Evans 1823-1908: Antiquity, Commerce and Natural Science in the Age of Darwin* (A. MacGregor Ed.), pp. 95-115. Oxford: Ashmolean Museum.

Roe, Derek A. 1981. *The Lower and Middle Palaeolithic Periods in Britain*. London: Routledge and Kegan Paul Ltd.

Schiffer, Michael B. 1987. *Formation Processes of the Archaeological Record.*Albuquerque: University of New Mexico Press.

Scott, Eugenie C. 2004. *Evolution Vs Creationism: An Introduction.* Westport (CT): Greenwood Press.

Shipton, Ceri B.K. 2013. *A Million Years of Hominin Sociality and Cognition: Acheulian Bifaces in the Hunsgi-Baichbal Valley, India.* Oxford: BAR International Series.

Singh, Manoj Kumar, Tiasunep, D.K. Bhattacharya, K. Thimma Reddy and Pankaj Srivastava 2013. Excavation of Kondapeta I, Prakasam District, Andhra Pradesh: A Preliminary Report, *Puratattva* 43: 100-116.

Smith, V.A. 1906. Pygmy Flints, *The Indian Antiquary* 35: 185-195.

Srikantia, S.V. 2013. Robert Bruce Foote: His Contribution to the Geology of Karnataka, the Southern Peninsular India and Indian Prehistory, *Journal of the Geological Society of India* 81 (January 2013): 17-26.

Stocking, Jr., G.W. 1987.*Victorian Anthropology.* London: Collier Macmillan.

Street-Jensen, J. 1985.*Christian Jurgensen Thomsen und Ludwig Lindenschmidt: Eine Gelehrten Korrespondenz aus der Frühzeit der Altertumskunde (1853-1864).* Mainz: Romisch Germanisches Zentral Museum.

Trautmann, Thomas R. (Ed.) 2009. *The Madras School of Orientalism: Producing Knowledge in Colonial South India.* New Delhi: Oxford University Press.

Trivedi, Mudit 2009. On the Surface Things appear to be … Perspectives on the Archaeology of the Delhi Ridge, in *Ancient India: New Research* (Upinder Singh and Nayanjot Lahiri Eds.), pp. 39-70. New Delhi: Oxford University Press.

Van Riper, Bowdoin A. 1993.*Men Among the Mammoths: Victorian Science and the Discoveries of Human Prehistory.* Chicago: University of Chicago Press.

Venkateswarlu, K. 2012. *Colonialism, Orientalism and the Dravidian Languages*. New Delhi: Routledge.

Wallace, Alfred Russel 1901. *The Wonderful Century: Its Successes and Failures.* London: Swan Sconnenschein & Co.

Washburn, S.L. and D.A. Hamburg 1965. The Implications of Primate Research, in *Primate Behavior: Field Studies of Monkeys and Apes* (I. De Vore Ed.), pp. 607-622. New York: Holt, Reinehart and Winson.

Wheeler, R.E.M. 1949. Archaeological Fieldwork in India: Planning Ahead. *Ancient India* 5: 4-11.

Wheeler, R.E.M. 1960. *Early India and Pakistan.* London: Thames and Hudson.

Worsaee, J.J.A. 1849. *Primeval Antiquities of Denmark* (translated from Danish by William J. Thomas). London: John Henry Parker.

ISBN 978-81-938330-5-9

Publisher
Indian Socety for Prehistoric and Quaternary Studies
Pune

Year of Publication: 2014

Not for sale

Available in e-format: www.manandenvironment.org