TREBALLS D'ARQUEOLOGIA, 9

# Oldowan: Rather more than smashing stones

## First Hominid Technology Workshop

Bellaterra, December 2001

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Rafael Mora Torcal
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Editores

Universitat Autònoma de Barcelona

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# Contents

# Oldowan, rather more than smashing stones: An introduction to "The Technology of First Humans" workshop.

*Jorge Martínez-Moreno*
*Rafael Mora Torcal*
*Ignacio de la Torre*

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*"Even the simplest tool made out of a broken bough or a chipped stone is the fruit of long experience- of trials and errors, impressions noticed, remembered, and compared. The skill to make it has been acquired by observation, by recolection, and by experiment. It may seem an exaggeration, but it is yet true to say that any tool is an embodiment of science"*

Vere Gordon Childe

## New questions for old stones

The appearance of the earliest artefacts is a prominent area of study within the overall field of the exploration of Human Origins. For a variety of reasons, the systematic use of stone tools has been considered a key piece of evidence in understanding the evolutionary process of the human species.

In recent years this affirmation has undergone revision. The application of actualistic studies in the reconstruction of these scenarios has attempted to integrate the appearance of the earliest industries as one more element to be considered within this process of adaptation, yet with a less transcendental character than that traditionally conceded it (see for instance Oliver et al. (ed.) 1994). The lesson behind this proposal almost certainly rest with seeing a need for the appearance of the first stone tools to be embraced within a wider general context.

Yet in parallel with this, we believe that the analysis of these lithic assemblages is an analytical objective that is important in its own specific right. Perhaps this is the reason why we have selected this quotation from Vere Gordon Childe, taking as our own an observation made over half a century ago.

Artefacts have played a trascendental role in the human evolutionary process, not only due to the implications entailed in the study of mechanisms related to the making and managing of these stone tools. It is equally important to remember that in this activity we can recognise other associated questions such as the transmission of information, learning and others behaviours not directly observable in the fossil record, but which are strongly involved in the definition of "human nature".

This is why we believe that this quotation is still completely valid, since many current discussions are directly or indirectly related to the existence of these artefacts. Just by way of an example, the following considerations occur to us as giving cohesion to central questions in current research, such as:

a) to determine the possible causes associated with the appearance of the first artefacts: when and why these hominids began to "depend" on formatted artefacts to carry out their daily activities,

b) the variability and change in early lithic technology: whether they should be considered as being unique and unchanging entity, or whether to the contrary we should introduce various factors as ecological, cultural or temporal in order to explain their composition,

c) the notion of "stasis": which elements explain how these artefacts survive for periods of time measured in millions of years, and why they come to be replaced. In the same way, the causes that promote this substitution process do not appear to be well determined either.

These questions represent the "Oldowan" idea, a concept which in recent years has been the object of important contributions, as we shall outline in the following pages. Traditionally, and from an essentially taxonomic perspective, it has been considered that technocomplexes as a whole prior to the appearances of industries with bifacial tools (Acheulean) should be grouped together under the generic description of Oldowan, thus becoming a type of "hotchpotch".

We are currently seeing an important replacement of these designations by other, apparently looser concepts like Mode I and Mode II, ideas that owe their origins to the proposal made by G. Clark (1977), and updated by various authors (e.g. Foley and Lahr 1997). We believe that this nominative replacement fails to solve the problems of definition entailed both by the cultural nomenclature and the recent proposal.

The term Oldowan (or its synonym Mode I) unites those groups of stone tools appearing in a space-time context corresponding firstly to that which would be termed "African Oldowan", i.e. those technocomplexes described in the deposits inserted in the Rift Valley area (from Tanzania to Ethiopia) and the caves of South Africa, and with chronologies that can be assigned to the Late Pliocene - Early Lower Pleistocene.

At present it is assumed that their distribution includes those stone tools presumably sharing some techno-typological and morphological attributes with those observed in this classic area and which have been described in the North of Africa (Sahnouini 1988), the Middle East (Bar-Yosef and Goren Inbar 1993), the Caucasus (Gabunia et al. 2001) and the Iberian Peninsula (Bermudez de Castro et al 1995; Martinez-Navarro et al. 1997).

In fact, the presence of these technocomplexes outside of the African continent necessarily denotes the dispersion of these hominids over the Euro-Asian continent.

The causes related to the expansion of these hominids over a wide and diverse spectrum of ecological niches has only recently begun to be discussed thoroughly (Roebroeks 2001).

If the geographical dispersion of these assemblages is imprecise, the chronological framework it embraces seems just as confused. Recent discoveries suggest that the oldest known artefacts are to be found at Gona -Kada Gona and Ouna Gona- in Middle Awash (Ethiopia)-, having a chronology which is estimated to be not less than 2.6 million years (Semaw et al. 2003). In the same area, in Bouri, and with a similar chronology, cut-marks are mentioned which, according to the authors, were made by stone instruments, although no lithic tools are documented associated with human bone modified (Heizenlin et al. 1999).

In the not too distant future it is more than likely that artefacts with an earlier chronology will be discovered. Despite this predictable constant revision of the date of appearance of artefacts, what the causes are which brought about the need to obtain stones, knapp and use them in a systematic way, and how this need affected and altered the behaviour of these hominids, are questions whose answers remain elusive.

If the origins of this activity are unknown, its disappearance, substitution or possible affiliation with the Acheulean is equally obscure. Faced with an unilinear view linking the recent Oldowan and Acheulean assemblages, there are lines of argument suggesting that the appearance of what are termed the Mode II imply important transformations, possibly related to the appearance of a new species of hominid, with more complex cognitive capacities, and which could be more closely related to the idea traditionally used to define the genus Homo (Cachel and Harris 1998).

Between the beginning and the end of what we term Oldowan it can be affirmed that this technological tradition survived for almost two million years.

These arbitrary limits can be defined by adopting the chronologies proposed for the earliest dated tools in the east of Africa, or to cite an example from the Iberian Peninsula, the case of the artefacts from level Td-6 of the Gran Dolina at Atapuerca, also assigned to Mode I (Bermudez de Castro et al 1995; Carbonell et al. 1999).

The enduring over time of these technocomplexes is possibly associated with another of the challenges, classic in its interpretation and regularly conceptualised like "Oldowan stasis" (Semaw 2000).

A question which may explain this longevity or stasis rests on the fact that Oldowan is considered to be a static entity and with limited internal variability. In fact, the idea of "Oldowan" embraces those technocomplexes characterised essentially by the presence of pebble tools and flakes.

This classic diagnosis was formulated from assemblages recovered in Beds I and II at Olduvai, in which choppers and chopping tools are considered as “artefacts type” in its definition (Leakey 1971).

Any attempt at defining is always problematical since it tries to delimit entities that are heterogeneous or present a degree of variability. In the case of the Oldowan artefacts, they are considered as the result of a simple process; this notion of products created in an expeditive way, without fulfilling any organisational criteria, considering the knapping as the mere application of force on the cobbles or supports to obtain cutting edges.

This identification resting on the definition of these technocomplexes and the activities associated with these artefacts, usually implies an immediate nature and a low level of planning which would have as its correlate a behavioral development similar to that of modern chimpanzees (Wynn 1993).

Faced with this perspective, recent discoveries made at various sites in Eastern Africa question this view. The incipient descriptions from Lokalelei 2c (Roche et al. 1999) or in several findings at Gona (Semaw 2000; Semaw et al. 2003), make up a panorama which is at least critical of this interpretation.

At present only preliminary descriptions are available, but the insistence is that, in these assemblages, dated as more than 2.3 million years old, the artefacts are the result of knapping strategies which cannot be characterised as simple.

For these authors, these artefacts demonstrate that hominids had acquired a certain technical competence which implied a complete understanding of the physical principles associated with concoid fracture. This knowledge, combined with an effective neuromotor capacity, allowed them to have a precise control of the organisation of the knapping, managing volumes with the aim of obtaining supports in which an incipient morphometric standardisation can be detected.

These preliminary observations suggest that in very early chronological contexts (certainly far more than in contexts on which the classic Oldowan diagnosis is based) there exists a technical competence which is higher than is usually supposed.

This would indicate that these hominids possessed abilities which were far more developed than hitherto proposed. In other words, this diagnosis does not fit well with the notion of artefacts being made in an immediate and rudimentary manner, as has been defended traditionally.

In the same way, they prompt a new question: if in very early assemblages, such as those at Lokalelei or Gona, systematic knapping methods are defined which can be described as "complex", what were the preceding strategies like that encouraged the appearance of these sophisticated systems?

In other words, what are those primitive technological traces associated with the appearance of these knapping systems like? Or to the contrary, should it be assumed that the complexity of the knapping is knowledge that is quickly acquired and that does not suffer subsequent modifications.

There exists another important variable in this discussion which does not escape us: who is the agent that generates these artefacts? Are these assemblages produced solely by that which we have described as the genus Homo, or to the contrary, is it feasible to suppose that several species of hominid were creating artefacts simultaneously? This is another aspect of the debate which will sooner or later have to be dealt with, from the different perspectives involved in the study of Human Origins.

These questions suggest the need to establish comparative frameworks that allow possible changes inside this record commonly described as Oldowan to be detected. The possibility cannot be ruled out that these differences observed between the classic descriptions and recent ones obey questions referring to the archaeographic description of the artefacts.

The emphasis on the interpretation of the material from Lokalelei from a perspective related to the "chaîne operatoire" concept, and in which refitting is a basic analythic tool allows a more dynamic approach to be taken regarding technical behaviours and the difficulties involved in the knappi ng of stone instruments (Roche et al. 1999).

This focus, scarcely developed in the study of collections of a very early chronology, allows for a more integrative understanding than that derived from the comparison of the number of items or percentages of artefacts. These studies have often brought little of interest to the internal description of the variability which these artefacts present; and in the case we are examining, this question may not be a secondary one.

The study of the first technological manifestations is a subject which is attaining a certain degree of complexity and which has to face up to new challenges.

It is possible that these differences that are beginning to be commented on have the underlying implication that different technological traditions are being mixed under the Oldowan label which may correspond to profound and diverse forms in the conception of the making and using of these artefacts. Neither can it be discounted that these differences may be due to distinct species of hominids.

Or perhaps they only denote the deep methodological divergences with which the authors attempt to describe an archaeological entity. Whatever the case, we believe that the idea of "smashing stones" can not longer be sustained.

## Putting together some pieces of the puzzle

This diversity of question marks motivated us to hold a scientific meeting which focused on discussing aspects referring to the idea of Oldowan and restricted the scope of the discussion to the material recovered specifically in the African continent. The causes of this decision are various and are bound up with the genesis of this book.

The idea of this meeting was linked to the research project being carried out since the mid-nineties by Manuel Dominguez-Rodrigo in the Peninj-Lake Natron archaeological area (Tanzania). Following a series of surveys aimed at surveying the archaeo-paleontological potential of the area, systematic excavations were begun to verify the important archaeological potential detected in the area.

This project was carried out during 2000, 2001 and 2002, and the work was directed by Rafael Mora and financed by the Spanish Ministerio de Ciencia y Tecnologia and Ministerio de Asuntos Exteriores, and the Vice-Rectorat de Investigació at the Universitat Autònoma of Barcelona.

After studying the stone collections recovered during these seasons, the conclusion we came to did not correspond to the characterisation usually adhered to in the literature on describing Oldowan technocomplexes (e.g. Kimura 2002).

The impression given was that the apparent morphological simplicity of these artefacts might conceal a greater degree of complexity, just as other authors had previously proposed (Gowlett 1986; Texier 1995). Within these assemblages a significant internal variability was noted, i.e. distinct technical systems of artefact making were detected.

The example of Peninj allowed discussing the general characteristics implicit in the definition of the classic Oldowan, the interpretation of the technological variability within these collections; and at the same time to analyze the possible relationships between Oldowan and Acheulean artifacts.

In the same way, this meeting hoped to reduce a substantial deficiency in research in the Iberian Peninsula. The discussion of the significance of the first technologies documented in the African continent was, despite being a relevant subject at an international level, an aspect that had only been dealt with tangentially in the framework of isolated conferences.

Our idea however consisted of organising a scientific meeting in which people could participate and set out in detail the results obtained by various projects under way, focusing on the definition of the Oldowan concept.

This meeting was held over the 18th, 19th and 20th of December 2001 in the Universitat Autònoma of Barcelona (Bellaterra, Spain), within the framework of the 12th Seminar on Prehistoric Technology, and with the participation of Erella Hovers of the Hebrew University of Jerusalem (Israel), David Braun and Jack Harris of the Rutgers University of New Jersey (USA), Pierre-Jean Texier of the CNRS Sophia-Antipolis (France), Rosalia Gallotti, Marcello Piperno and Maria Grazia Bulgarelli of the University of Naples (Italy) and Manuel Domínguez-Rodrigo of the Universidad Complutense of Madrid (Spain). Ignacio de la Torre of the History Instituto de Historia of the CSIC, Jorge Martínez-Moreno and Rafael Mora of the CEPAP-UAB co-ordinated the meeting.

The central objective rested on discussing various questions mentioned throughout these pages, and which were in some way related to the question marks that had arisen as a consequence of the results obtained from the stone assemblages from Peninj.We were able to discuss whether the African Oldowan should be considered as a single entity in which no changes could be observed over more than a million years, or whether, to the contrary, phases of internal change could be established.

In accepting this second possibility, these technical and technological changes were associated with the appearance of some new species of hominid. This proposition was inter-related with another, equally important question: is this variability a consequence of a process of adaptation to the environment, or is it a response to "cultural traditions" differentiated in an analogous way to that recently described in the genus Pan? (Whiten et al. 1999).

In addition, the results obtained from these projects were set out in an attempt to contextualise these reflections and how they affect the research into the origins of human behaviour. It therefore struck us as interesting how the different researchers who had come up against materials that were allegedly similar attempted to define what it was that they understood by Oldowan.

In this attempt at definition elements were combined relating both to the recovery of these materials (sampling and excavation methods) and to the methods involved in the description and interpretation of these artefacts.

These contributions provided the opportunity to visit some of the research projects currently being developed in Eastern Africa. Below we would like to set out the basic points presented by the various participants. These notes can serve as general introductions to the contributions made by those authors in this book.

Marcello Pirpeno and Rosalia Galleoti present the results of the Italian Archaeological Mission in Melka Kunture (Ethiopia). In the Melka Kunture Formation the classic sites of Garba, Gombore or Balchit are documented. This important area has been excavated since the 60's and the results obtained by the team originally led by J. Chavaillon and currently by M. Piperno have been published in preliminary form (Chavaillon et al. 1979, and references therein).Just as they explained, following a long period of studying the materials, the authors are currently preparing to bring out a monographic publication of the results obtained in this archaeological area crucial for understanding the significance of the Oldowan and Acheulean assemblages.

Marcello Piperno and Rosalia Galloti's contribution focuses on two different though interconnected aspects. In the first part, they synthesise the general information available about these classic sites. This review serves as an introduction to a detailed examination of the fossil record recovered in Garba IV, stressing the spatial distribution patterns observed at this site.

The application of a GIS enables an analysis of the distribution of archaeological materials, discussing the impact of the site formation processes. The examination of these excavated surfaces allows general intra-site ideas to be dealt with, to which ussually it has attributed a secondary importance.

At the same time, they discuss the need to link inferences about the material distribution with a precise monitoring of the vertical dispersion of the materials. These reflections give us an accurate understanding of the significance of this site and are a good example of the archaeological potential to be found at Melka Kunture.

Since the middle of the 90's, Manuel Dominguez-Rodrigo has co-ordinated a research project in the Peninj area (Lake Natron, Tanzania). Interest was shown in this area in the sixties by Glynn Isaac (Isaac, 1965). At the beginning of the 80's, Glynn Isaac began a research project which was cut short by his sudden death. The work currently being carried out validates the notion that Peninj is an area with an immense archaeo-paleontological potential, just as Isaac had alerted.

This study stresses the general characteristics of that know as the Type Section, classifying it within the regional geological framework of the Lake Natron area, discussing its chronology and the sedimentary environments that favour the formation of these deposits. This presentation introduces us to the general characteristics of the archaeological assemblages recovered in the area, which come from the excavation of several sites, whose results were set out in other studies (Dominguez-Rodrigo et al. 2002).

This presentation stressed the need to carry out suitable reconstructions of the ecological contexts with the aim of evaluating the framework in which these early hominids interacted, in a line similar to that proposed by the Landscape Archaeology model developed by G. Isaac in Koobi Fora (Isaac 1984, Isaac (ed.) 1997), and which is being carried out at Olduvai Gorge (Blumenschine and Masao 1991; Blumenschine and Peters 1998).

Finally, it also deals with the question of the important variability documented in the technical systems of knapping detected in the stone artefacts coming from the Type Section at Peninj, a question which has been presented and discussed at length in another recently published article (de la Torre et al. 2003).

The Koobi Fora Archaeological Project, led by Jack Harris, continues to be one of the basic references for analysing the significance of the Oldowan assemblages. Since the end of the 60´s this has been a basic enclave within the studies referring to Human Origins, due to a great extent to the work carried out by G. Isaac, and whose culmination has been the publication of the monographic study on the achaeology of these sites (Isaac (ed.) 1997).

This study marks the end of the series represented by the research carried out during the 70´s. Jack Harris has continued working in this area and has co-ordinated a line of research centred on the important archaeological record preserved in this region.

The contribution set out in this book is a result of this project. The study carried out by David Braun and Jack Harris into the technology of the Koobi Fora Oldowan artefacts proposes the development of an instrumental methodology with which to quantify an essential parameter: the size of the cutting edge of the tools. Using an image treatment system and the application of statistic tests, the aim is to evaluate technological and behavioural aspects of the earliest hominids.

The determination of the origin of the raw materials allows analysis of the interactions between technology and raw material sources. Armed with these results, they discuss how the change in the provisioning of the source areas affects the composition of the stone collections from the KBS and Okote Formations.

Discussion of this and other factors allow us to visualise changes in the behaviour of the hominids, fundamental requirement for understanding both the organisation of internal technological guidelines and the transformations observed within those two chronological horizons contained between 1.8-1.6 million years.

The significance of the archaeological sites at Hadar (Ethiopia) was presented by Erella Hovers. The Hadar sites are of great importance in the field of Paleoanthropology due to the discovery in the nineteen seventies of Australopithecus afarensis. In recent years, work has begun in several Pliocene deposits in which lithic tools appear.

In this contribution she focuses her study on the stone collection recovered in site A. L. 894, since, with a chronology of over 2.3 million years, it can be considered as one of the oldest sites in which the presence of lithic artefacts has been detected. The emphasis placed in her study on linking stone analysis and formation processes induces us to think of the need to homogenise this type of observation when making comparisons between sites. As she argues, these processes may have profoundly affected the analysis of the asssemblages and in consequence may limit the validity of the intra-site comparisons as it is usually carried out.

Her analysis of the stone artefacts from this site leads her to consider that the knapping systems are a consequence of strategies aimed at obtaining flakes with cutting edges, with nuclear forms like choppers not being detected. Another element of discussion raised in this study is the need to integrate the site formation processes when analysing the significance of the pieces that have been retouched.

At least in the case that Hovers describes, the supposed retouch may be the consequence of natural processes, and not the result of an intentional activity directed to modify the edge of the pieces. This observation would make it necessary to review the archaeological contexts in which the presence of retouched pieces has been described.

The contributions presented in this colloquium focus on the four key archaeological areas within the studies into Human Origins: Melka Kunture and Hadar (Ethiopia), Koobi Fora (Kenya) and Peninj or Olduvai (Tanzania).

In parallel with these presentations, various presentations were given during the congress by P. J. Texier and J. Harris.

Pierre-Jean Texier gave two presentations that were of undeniable interest with regard to analysing different questions that arose during the seminar.

On the one hand, he set out his results regarding the NY 18 site at Nyabusosi (Uganda), a generally little-known but nevertheless very interesting site. The technological and conceptual implications highlighted about these Oldowan artefacts are important to bear in mind when it comes to evaluating the concept of technical complexity in the configuration of archaic artefacts (Texier 1995).

The second presentation dealt with research being carried out at the West Turkana French Archaeological Project co-ordinated by Hélène Roche of the CNRS. He presented the discoveries at sites which are set to become relevant for demonstrating the technical competence demonstrated by hominids in ancient contexts. On the one hand there was an account of the work at Lokalelei 2c, which has been published in preliminary form (Roche et al. 1999).

Also presented was Kokiselei 5, a site which will certainly need to be taken into account when analysing the origin of Acheulean industries as well as the relationships between the Oldowan and Acheulean technical systems.

Jack Harris carried out an important synthesis in which he reviewed his lengthy experience in studies into Human origins. Starting with the classic work on the Karari industries, he reviewed the significance of a number of classic sites, such as the Hippo Artefact Site, the Kay Behrensmeyer Site or FxJj 50, all of these in Koobi Fora.Especially revealing were his observations about the new taphonomic and zooarchaeological studies being carried out at these sites and about others that are currently being excavated.

These studies assume that some of the ideas defended in classic work should be reformulated in the light of aspects which were not taken into account in the classic studies (Isaac (ed.) 1997).

Although he focused on the results provided by Koobi Fora, his reflection incorporated results from other sites such as Fejej, Senga 5 and Gona, in which he has participated actively in a direct or indirect manner. He also defended the use of fire as a common element in the activities of the hominids 1.8 million years ago, described in FxJj 20 main. He argued that the discrepancies in the archaeological record in relation to the use of fire, which does not begin to become evident and indisputable until approximately 300,000 years ago, could be due to difficulties in the identification of this activity.

**Rather more than smashing stones...**

Despite the breadth of subjects dealt with during the presentations that made up this seminar, those attending were left with the feeling that the idea of "Oldowan" is far from being dealt with as a well defined entity and cannot be considered as a closed question. In addition, new discoveries like those made in recent years, such as Gona (Semaw et al. 2003), Kanjera (Plummer et al. 1999), or the aforementioned West Turkana, Koobi Fora or Peninj, provide new clues with which to re-evaluate this idea.

It has already been mentioned above that Oldowan has traditionally been understood as a uniform entity, with little internal variability in the composition of those stone collections both in terms of their temporal and their spatial distribution. This notion was discussed throughout this seminar, since, in contrast to this monolithic view anchored in the unilinear evolutionary paradigm, several contributions do not share this perspective.

We consider that these differences of interpretation are related to important methodological differences and that that they have a clear correspondence to equally different theoretical proposals. This diversity becomes patently clear when discussing ideas related to the technical capacities involved in the knapping of instruments and their possible implications with regard to the cognitive capacities of the hominids.

These important differences in the interpretation of this aspect are seen when comparing the proposals developed from the perspective advocated essentially by North American research groups influenced directly or indirectly by the proposals put forward by G. Isaac.

This perspective insists on the need to include paleoecological and paleoenvironmental aspects in order to study the complex interaction of the hominids within their natural environment. Using this perspective, the study of these industries is vital in order to draw conclusions about the behaviour of the hominids referred to in terms of activities and processes associated with the management and use of these instruments. From this perspective, the stone tools would be considered as an interface within that adaptative setting, which allows a series of behavioural inferences to be made which must be contrasted to those provided by other aspects of the fossil record.

In contrast to this position, the alternative line of research insists on the need to analyse the artefacts as a consequence of a process which is essentially aimed at identifying the motivations entailed in the knapping. This conception is linked to the notion of "chaîne operatoire" essentially developed by French authors, and stresses the importance of studying the elements involved in the making of artefacts, i.e. the "methods" and "techniques" involved in those "systems" (Inizan et al. 1995).

Reffiting is one of the possible reconstruction techniques with which to identify how the different technical gestures involved in the shaping of artefacts were formulated.

Under this premise, the act of knapping is the starting point from which to analyse the strategies of reduction and the technical "know-how" involved. This implies that the cutting movement is made up of an overall conception of this process, and as a consequence allows us to ponder the idea of technical competence and analyse the cognitive capacities of these hominids.

We believe that these perspectives need not be conflicting. In fact it is perfectly acceptable to suppose that stone instruments are basic tools of subsistence, and that as a consequence they should be considered as describers of the behaviour of these hominids. In the same way, the study of the sequencing of the decisions made, and actions carried out during the knapping describes the competence that these hominids had in obtaining essential artefacts.

In these decisions a set of choices are manifested and passed on through the generations, which in the end constitutes an environment of learning and knowledge shared by these collectives. The study of this process could be a route enabling us to answer questions about the cognitive environment of these hominids.

We should repeat that these aims are not mutually exclusive. Nevertheless, in this seminar these two proposals emerged sharply defined, and appeared as discourses which, if not incompatible, were at least two theoretical-methodological proposals with suppositions and aims that were well differentiated. Our interest does not lie in indicating the advantages or drawbacks of either of them, but we do wish to insist that these important differences in orientation when it comes to analysing a process like the making of artefacts, may be the origin of the significant disagreement that exists when it comes to describing this process.

It was previously mentioned that at the moment the classic characterisation of what is considered as Oldowan is being questioned. The idea of simple technocomplexes, characterised by the presence of choppers and flakes obtained without a precise organisation, appears not to be very appropriate.

Thus, in other assemblages it is argued that there exists a certain complexity, referring to aspects such as the selection of supports which are reduced; following systems that allow products to be obtained that are morphometrically standardised. I.e. the idea of predetermination could be introduced.

Faced with this type of observation, a question that might seem obvious is that referring to the interest that this type of conclusion can awaken. If these reflections are considered in a de-contextualised way, there is indeed a risk of considering them as essays or interesting examples, yet with a limited interest, since they do not allow generalisations about the activities carried out by these hominids.

Contrary to this, we consider that this type of study allows us to revise the idea of variability in the knapping systems on comparing the strategies involved in the obtaining of artefacts. This possibility should be examined with the aim of determining whether different systems really favour the appearance of assemblages that are apparently similar and characterised as homogenous and unvarying.

The different contributions to this seminar appear to coincide in the opinion that there are important differences in the knapping systems, and that these differences are already documented in very ancient chronological contexts. Establishing this variability could prove to be a new line of research from which it could be possible in the first place to demonstrate whether Oldowan should really be characterised as a long-lasting entity, or to the contrary, if different internal stages or phases can be differentiated.

In the same way, it could be a way of allowing comparison of the spatial distribution and dispersion of these systems, enabling us to verify whether these stone collections discovered in Africa, Asia and Europe are really homonymous.

The apparent simplicity of these Oldowan collections may be concealing a much more complex panorama than that usually supposed. Documenting these differences could imply important changes with regard to analysing specific aspects such as: What is the scenario implied in the use of stone instruments? Do artefacts allow us to analyse the cognitive capacities of the beings that have created them? Or is the genus *Homo* alone in being the only agent capable of making lithic artefacts?

As can be seen, the study of early technology is not a closed field. Numerous questions persist, and almost certainly the introduction of new questions will allow us to unravel these matters. Possibly, one of the consequences of this discussion may be to consider that these technocomplexes are rather more than smashing stones, since in these simple actions we can rediscover something that unites us with our forebears and links us to them.

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# Recent activities of the Italian Archaeological Mission at Melka Kunture (Ethiopia): the Open Air Museum Project and the GIS application to the study of the Oldowan sites

*Rosalia Galloti*
*Marcello Piperno*

## PART I

### Introduction

The site of Melka Kunture was discovered in 1963 by G. Dekker. The same year a French archaeologist, G. Bailloud, carried out the first surface surveys and collected important lithic materials and faunal remains.

Since 1965, a French-Ethiopian mission directed by Jean Chavaillon faced to the systematic investigation of the Palaeolithic site through intensive excavations in some of the archaeological levels and surveys of the large area occupied by prehistoric finds, the definition of the chronostratigraphy of the Lower and Middle Pleistocene sediments (Chavaillon, Taieb 1968; Schmitt et al. 1977; Cressier 1980; Wesphal et al. 1979) and the study of the lithic and faunal occurrences insofar put to light (Chavaillon 1968, 1973; Chavaillon et al. 1979). An interruption of field activities took place after the 1982 excavation campaign; in the following years, the study of a great part of archaeological materials discovered during extensive excavations and stored in the Melka Kunture Laboratory in Addis Ababa was nearly accomplished. Excavations in some Middle Pleistocene Acheulian sites of Melka Kunture started again in May 1993, under the direction of Jean Chavaillon.

Since January 1999 an Italian Archaeological Mission funded by the Italian Ministry of Foreign Affairs, the University of Naples "Federico II" and the IsIAO started a new project with the aim to publish previous works carried out at the site and to promote and organize the construction of an Open Air Museum (Piperno 1999).

The Italian Archaeological Mission at Melka Kunture has been organized in collaboration with Jean Chavaillon. Beside the Open Air Museum project, the main scientific purpose of this intervention concerns the reexamination of the archaeological, paleoanthropological and archaeozoological aspects of Melka Kunture, as well as the paleoenvironmental problems related to the geology, chronostratigraphy, volcanology, paleontology and palinology of the site (Bulgarelli & Piperno 2000; Berthelet, Bulgarelli, Chavaillon & Piperno 2001; Chavaillon & Piperno 2002).

The project will be realized in collaboration with specialists from the University of Naples "Federico II" and of Rome "La Sapienza", the French Universities of Bordeaux 1, Montpellier II, Clermont and P. et M. Curie, the Collège de France, the CNRS, the University of London and the University of Addis Ababa.

## Melka Kunture

The prehistoric site of Melka Kunture extends for several Km along both banks of the high Awash Valley, 50 Km to the south of Addis Ababa. Its geological nature consists in a series of superimposed fluvial terraces with Pleistocene and Holocene sediments altogether reaching a thickness of about 100 m. A series of more than seventy prehistoric levels is preserved in these sedimentary and volcanic formations, dated from the Oldowan until the Late Stone Age (Fig. 1).

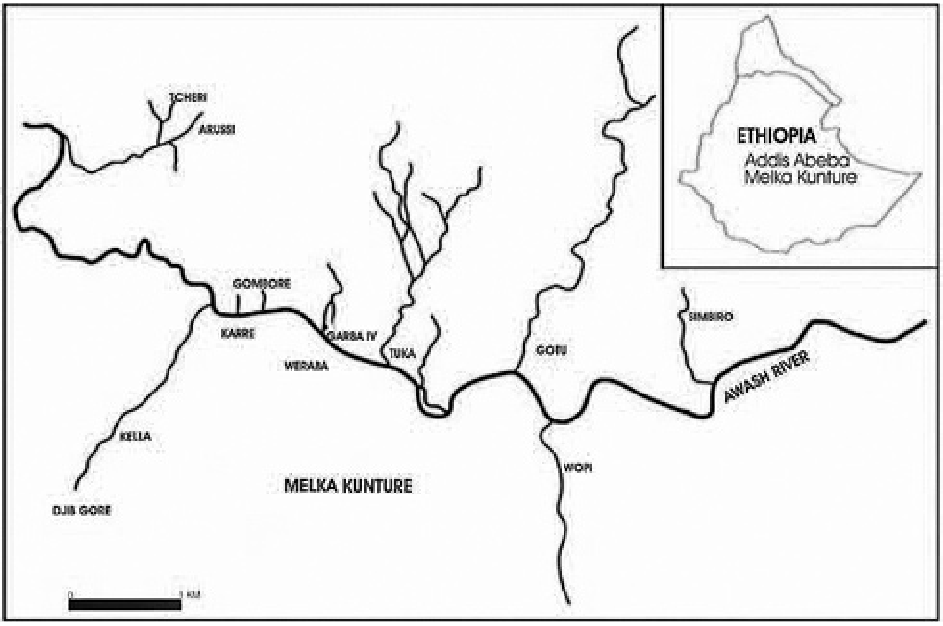



*Fig. 1. Map of the main prehistoric localities of Melka Kunture.*

Archaeological works carried out by Jean Chavaillon at Melka Kunture were focused to the exploration of some of the richest Oldowan and Acheulian levels. Excavations of large surfaces allowed to bring to light from 50 to 250 square meters for each site and to collect from 2,000 to 12,000 artifacts and faunal remains. The most important sites explored until now at Melka Kunture are the following:

Gombore I: An Oldowan site dated between 1.7 and 1.6 my (Fig. 2), very rich in lithic industry on pebbles (choppers, polyhedrons, rabots, etc.) and in faunal remains. A fragment of humerus belonging to Homo erectus (Chavaillon J. & N. 1969, 1976; Chavaillon et al. 1977) was found in this site (Fig. 3,1).

Garba IV: A Developed Oldowan site, comprised between 1.5 and 1.4 my (Fig. 4), where a large paleosurface (Level D) was extensively excavated since 1972 until 1982 (Chavaillon, Piperno 1975; Piperno, Bulgarelli 1975; Piperno 1977, 1986).

It yielded a very dense concentration of nearly 10,000 artifacts on obsidian and other volcanic rocks (Fig. 5) and over 2,700 faunal remains mostly of Bovids (Pelorovis oldowayensis, Connochaetes taurinus, Damaliscus cfr agelaius), Antelopes (Gazella sp.), Equids (including Stilohipparion), Suids (Kolpochoerus limnetes, Metridiochoerus andrewsi, Phacochoerus modestuy), Hippopotami (Hippopotamus amphibius), Elephants, Giraffes, and a Primate resembling the present-day gelada [Theropithecus (Simopithecus)] (Geraads 1979).

Lithic material comprises very few roughly shaped handaxes mostly on flakes (Fig. 6), two cleavers (Fig. 7), several hundred of pebble-tools and a large amount of flakes and retouched flakes (Fig. 8). A child mandible related to Homo erectus was also discovered in the lowest level of the site (Fig 3,2).

*Fig. 2. Melka Kunture. The Oldowan site of Gombore I before excavations.*


*Fig. 3. The hominid remains from Melka Kunture: 1) fragment of humerus of Homo erectus from Gombore I (Oldowan); 2) mandible of a 3/5 years old Homo erectus child from Garba IVE (Developed Oldowan); 3,4) parietal and frontal bones of Homo erectus from Gombore II (Middle Acheulian); 5): fragments of parietal and frontal scale of archaic Homo sapiens from Garba III (Final Acheulian-Middle Stone Age).*

Garba XII: An Acheulian site dated to around 900,000 years, where a transitional Oldowan/Acheulian phase has been observed.

Gombore II: A Middle Acheulian site dated to around 700,000 years with several levels (Brahimi 1976). Two fragments of human skull related to Homo erectus (Chavaillon et al. 1974, Chavaillon, Coppens 1986) were discovered in one of these levels (Fig 3,3-4).

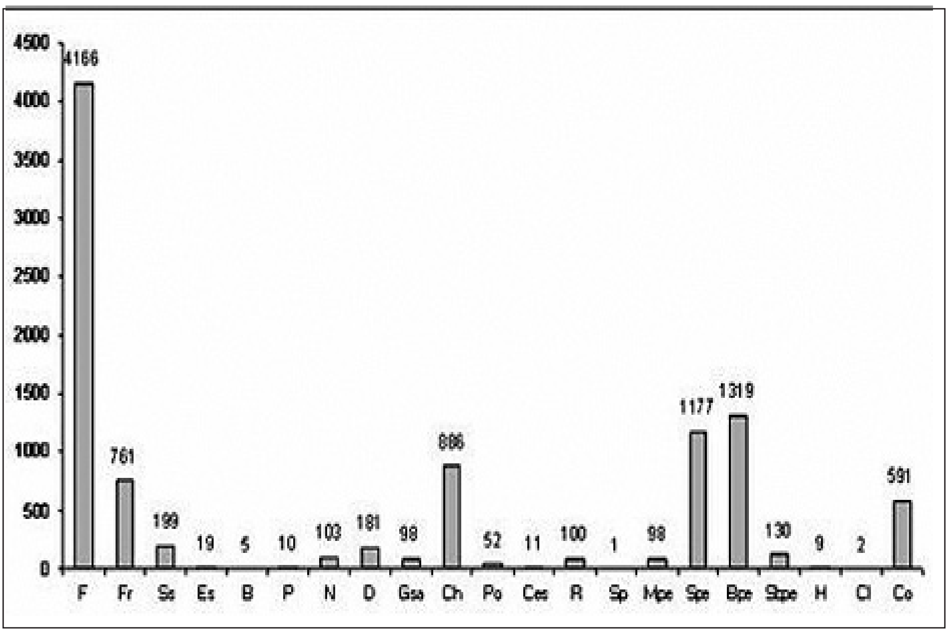
*Fig. 4. The western Sector of the extensive excavation of the Developed Oldowan site of Garba IV D (Melka Kunture).*

Garba I: An Upper Acheulian site dated to around 500,000 years, particularly interesting for the presence of hundred of handaxes associated to small sized flakes tools.

Garba III: A Final Acheulian site dated to around 250,000 years, which documents the transition towards Middle Stone Age, with the first presence of fossil human remains (Hours 1979; Chavaillon *et al*. 1987) attributed to archaic Homo sapiens (Fig. 3,5).

Kella: The site of Kella I is made up of volcanic-sedimentary formations with archaeological and faunal remains related to four main archaeological phases. Some artefacts referable to the Developed Oldowan were recovered at the base of the sequence; a Middle Acheulian complex was identified in an upper level. The Middle Stone Age is not well represented.

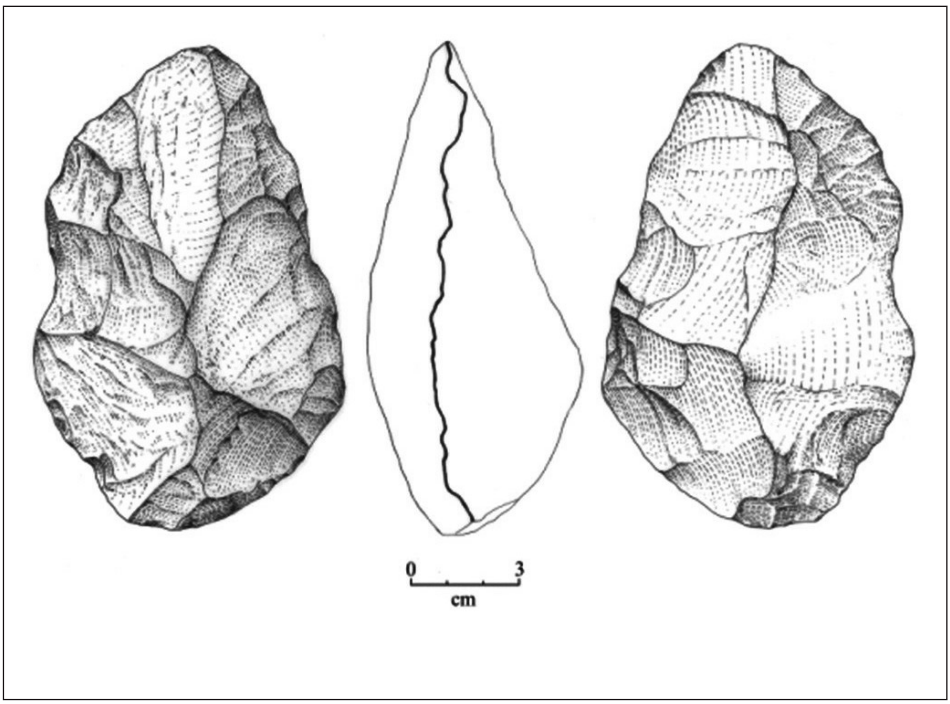
*Fig. 5. Garba IV D: typological structure of the lithic industry. F/f: Flakes and fragments; Ss: Side scrapers; Es: End scrapers; B: Burins; P: Perforators; N: Notches; D: Denticulates; Ch: Choppers; P: Polyhedrons; Ces: Carinated end scrapers; R: Rabots; Sp: Spheroids; Mp: Modified pebbles; Sp: Splitted pebbles; Bp: Battered pebbles; SBp: Splitted and battered pebbles; H/Ph: Handaxes and protohandaxes; Cl: Cleavers; C: Cores.*



Finally, at the top of the small hill of Kella, two partially eroded levels, where limited excavations were carried out in 1965 and 1970, contain in situ Late Stone Age materials. Lithic industry is characterized by numerous blades and bladelets, different kinds of burins and backed knives of Upper Palaeolithic type, notched and denticulates, borers, side-scrapers and small choppers (Makonnen Abye 1984; Hivernel Guerre 1976).

Balchit: During 2001 field season an important survey was conducted at Balchit, 6 km to the north of Melka Kunture (Berthelet *et al.* 2001). The site extends over several km( where large concentrations of obsidian flakes, blades, wastes and cores can be observed in different areas, some of them reaching an extension of more than 60 m with a thickness of more than 100 cm (Fig. 9).

*Fig. 6. Garba IV D. Handaxe on a basalt flake.*



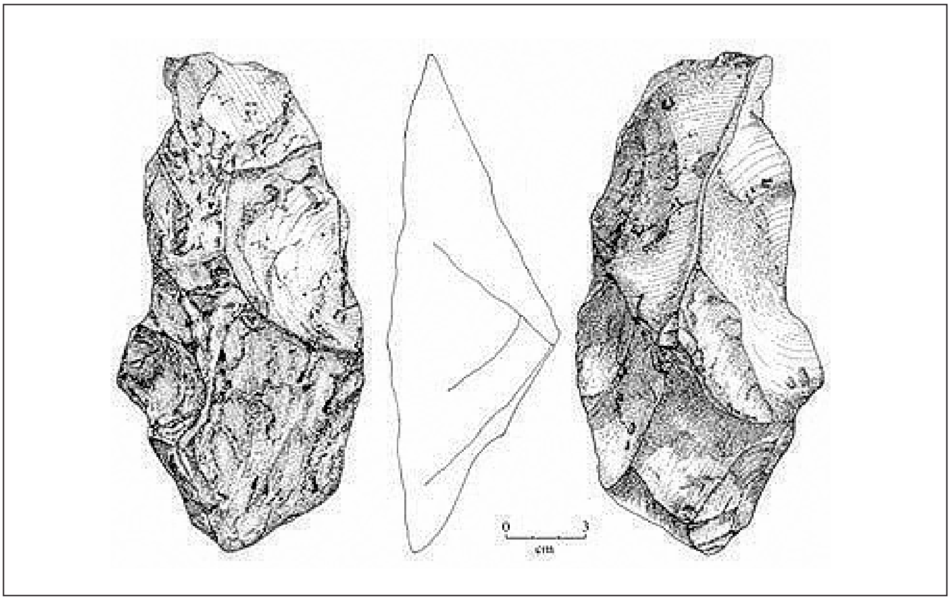



*Fig 7. Garba IV D. Cleaver on a large flake (MK 7216). Basalt. 1:1.*

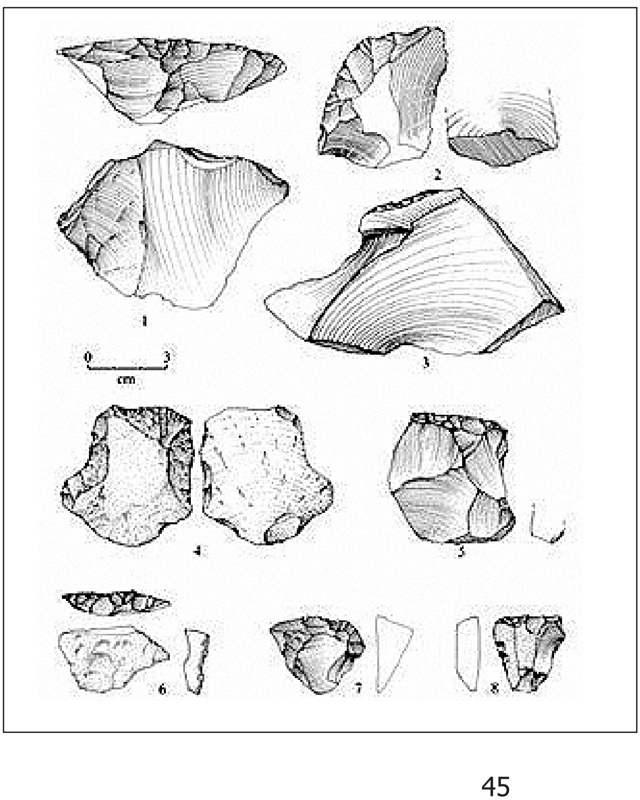



*Fig. 8. Garba IV D. 1-8: transversal side scrapers (MK 6684, 6630, 4428, 8482, 3573, 6583, 7087, 9195). 1-3,5-8: obsidian; 4: basalt. 1:1.*

Besides these accumulations there are more limited pit-like depressions, excavated by people trying to reach the veins in search of this raw material.

The site of Balchit has been repeatedly occupied during pre-historic times. The exploitation of obsidian occurred probably since the Late Stone Age until modern times. Analysis will show if the same sources were also utilized during Early and Middle Pleistocene at Melka Kunture.

## The Italian Archaeological Mission at Melka Kunture

At the very beginning of the Italian project in this site, two main objectives have been especially followed: the publication of the huge amount of data collected during more than 30 years of activity of the French Archaeological Mission and the realization of an Open Air Museum at Melka Kunture.

*Fig. 9. Balchit. Particular of a huge accumulation of obsidian blades, flakes and cores.*

*The publication*

The publication of Melka Kunture has been organized at three different levels:

-A small book of "Images", which has been published just one year ago as the result of a detailed photographic survey realized during the second Italian archaeological mission and concerning both the archaeological material stored in Addis Ababa and in Melka, and the natural environment inside the actual protected area of Melka Kunture. The book is also part of the project of the Open Air Museum and it will provide an easy and quick information on Melka Kunture (Bulgarelli & Piperno 2000).

-A "Guide" on the ancient Prehistory of Ethiopia and Melka Kunture has been conceived in order to give deeper and more detailed information of the different sites of Melka Kunture and to explain their cultural meaning in relation with the other most important prehistoric Ethiopian sites. The book was published in Italian, French, English and Ahmaric, and is illustrated with more than two hundred color photographs and drawings (Berthelet *et al.* 2001).

-Finally, the publication of the first monograph on Melka Kunture will be achieved within the half of 2002. It will present contributions on geology, paleontology, paleoanthropology, chronology and archaeology of the Melka Kunture Oldowan sites of Gombore I, Karre, Garba IV and Gombore I (Chavaillon & Piperno 2002).

Part of the book will be devoted to the taphonomic interpretation of the most important sites of Melka Kunture, through the analysis of detailed plans of the paleosurfaces, obtained using a sophisticated computerized GIS approach (see Part II).

*The Open Air Museum*

The road from Addis Ababa to Butajira in the Shoa Region could be rightly considered a very interesting and unique cultural itinerary.

Worldwide known prehistoric sites such as Melka Kunture as well as evidences such as the megalithic complex of the Tiya stele dating from the 12th to 15th centuries and the recently restored rock-hewn church of Adadi Mariam represent a unique cultural complex not too far from Addis Ababa.

It must be remembered that both Tiya and Adadi Mariam have been considered by the UNESCO as belonging to the common cultural heritage of all mankind and included in the UNESCO's world heritage list. Both the Tiya stelae and the rock church of Adadi Mariam have been recently restored and open to visitors.

The area of Melka Kunture included in the Open Air Museum Project will be transformed into a natural-archaeological Park (the first in Ethiopia) where both the archaeological and environmental features of the site could be exhibited.

The Open Air Museum at Melka Kunture will therefore provide a great opportunity to transform the road to Butajira into a highly interesting and unique cultural itinerary.

The peculiar preservation of the Melka Kunture area is due to the fact that the site has been protected since many years by the Ethiopian Authorities with fences and guardians, providing the preservation of both archaeological sites and natural environment.

Moreover, its proximity to the Awash river has favored the restoration of a unique natural environment along the river itself, which is actually inhabited by several species of birds and small mammals. The original vegetation has been well preserved and contributes to the peculiar beauty of the site along both river sides.

The Open Air Museum Project was officially presented to the Italian and Ethiopian Authorities two years ago. Thanks to economic support of the Italian Ministry of Foreign Affairs, the University of Naples "Federico II" and the ISIAO, it has been possible until now to realize the important restoration of the camp and of the existing small Museum within the protected area of the site.

The project foresees the construction of four buildings in local style in order to present the archaeological, paleontological and paleoanthropological evidences of this site (Fig. 10); the restoration of the road from the Awash village to the camp; the organization of itineraries and picnic areas along the Awash River in order to enjoy not only the archaeological evidences of Melka but also its very important natural environment.

The location of the area for the Open Air Museum have been chosen due to its closeness to the Melka Kunture camp and to the Awash River and considering the archaeological and paleontological interest of the area itself.

The interventions during the 2001 field activity in order to protect the area consisted in the construction of a metal fence surrounding and protecting a roughly pentagonal area of about 10.000 square meters, connected to the Melka Kunture camp with a large path also practicable by cars.

The fenced area comprises a great part of the Gombore locality, where several prehistoric sites, dating from the Oldowan (1.7 my) to the Middle Acheulian (0.7 my), have been identified and some of them also extensively excavated.The sites which will be presented in the Open Air Museum (Gombore II and Gombore II Butchering Site) are related to the Acheulian period:

<u>Gombore II</u>

The Middle Acheulian site of Gombore II, discovered in 1965, extends over more than 1000 $m^2$.

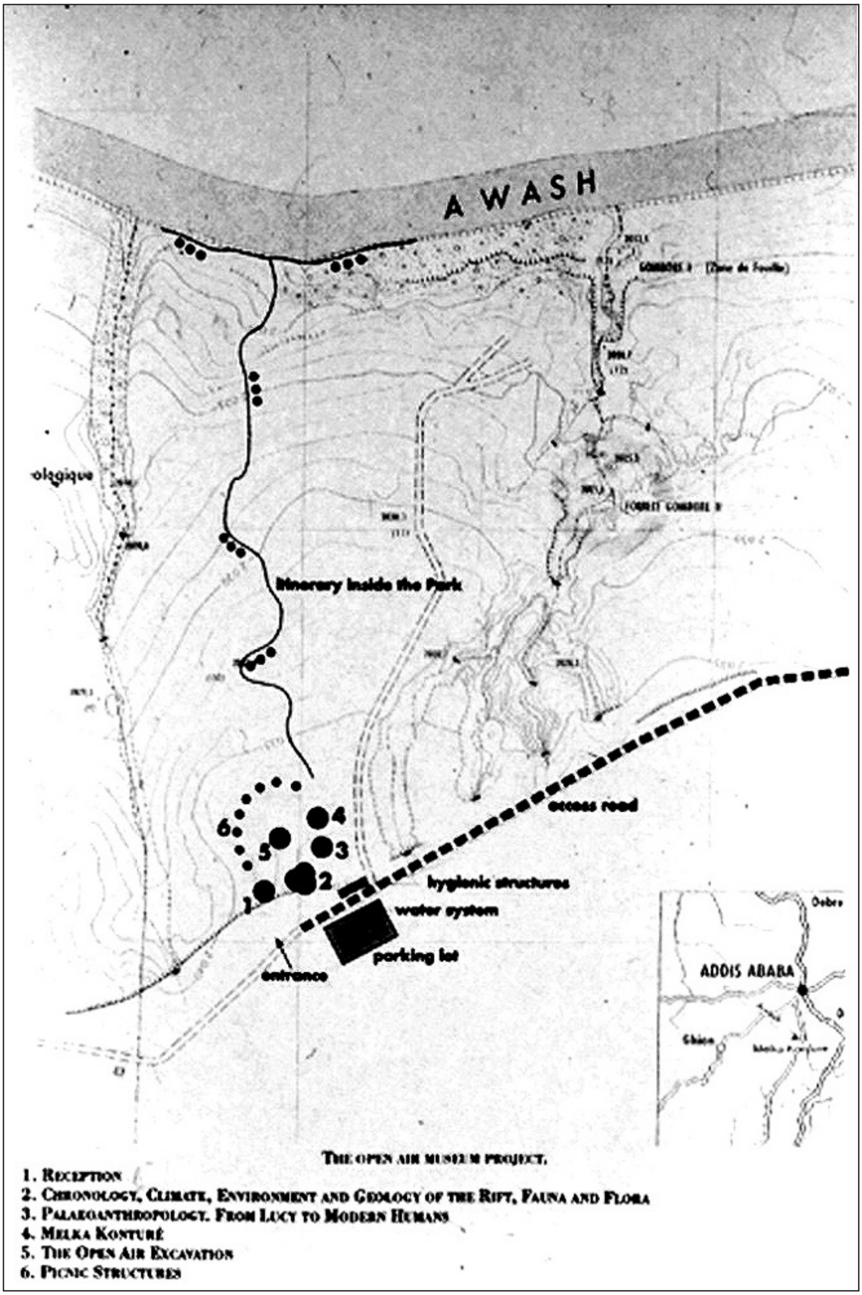



*Fig. 10. Melka Kunture. The Project of the Open Air Museum.*

The main excavation was carried out at Locality 1, corresponding to a beach of consolidated pebbles lying above a volcanic level (Tuff B), which is dated by Paleomagnetism to around 840,000 years.

A diversified fauna, characterized by frequent remains of Bovids, Giraffes, Hippopotami, Suids, and Equids, including Stylohipparion sp. was recovered at this site

The lithic tool kit is made of basalt and obsidian. Handaxes, mainly of obsidian, are carefully manufactured. Their main characteristic, independently from dimensions, is that they often present edges with a twist profile. Cleavers from trachybasalt are rare. Flakes showing a well developed technological level are frequent while tools on flake (side scrapers, end scrapers, borers) are less numerous.

A left parietal of Homo erectus was discovered in 1973, while a frontal bone possibly belonging to the same individual was recovered in 1975.

The area definitely prepared for visitors during the 2001 Mission is the  Gombore II Butchering Site. More than 250 paleontological remains found during previous excavations have been cast, colored and positioned on the paleosurface (Fig. 11).

In the same area didactic panels with photos and texts both in Amharic and English have been positioned, while some others, with general information on stratigraphy, paleontology and palaeoanthropology of Melka Kunture, were placed near the Museum.

Finally a metal panel, indicating in Amharic, English and Oromo the presence of the prehistoric site of Melka Kunture, was also placed immediately after the bridge crossing the Awash River.

Within the fenced area of Gombore II, the Project foresees the presentation of two excavated areas, after their restoration and consolidation.

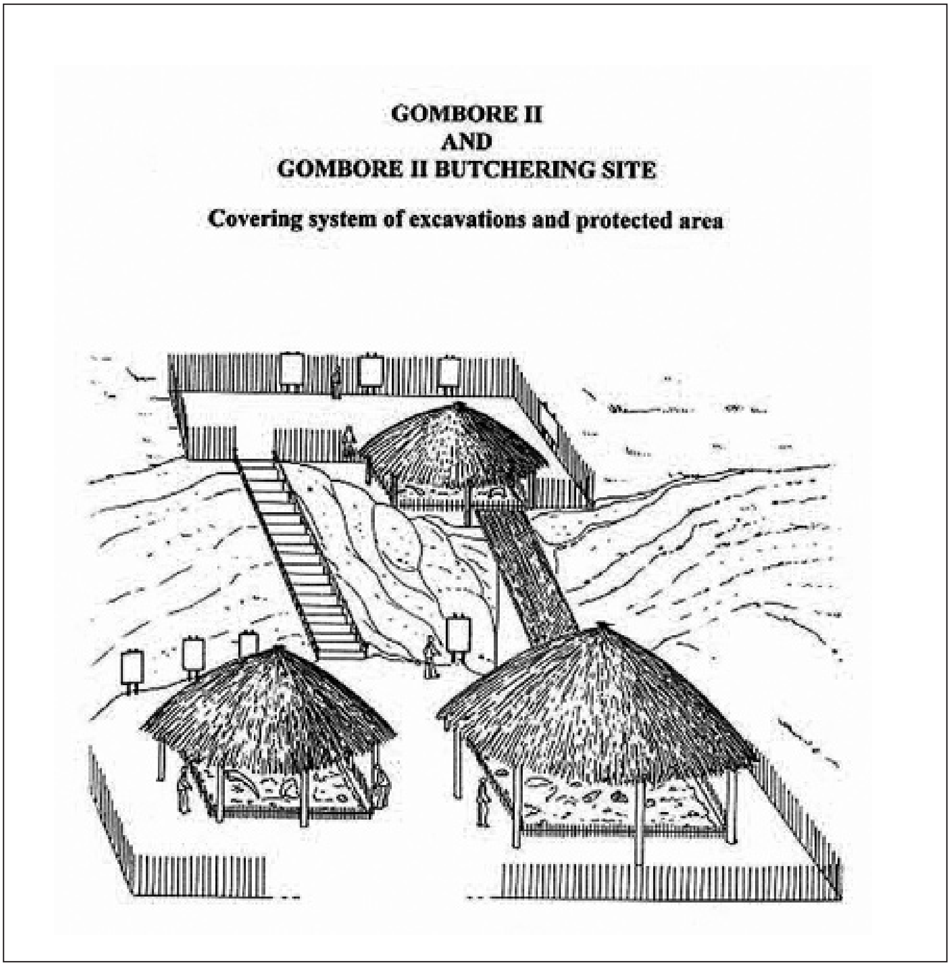



*Fig. 11. Melka Kunture. The Gombore II and Gombore II Butchering sites within the area of the Open Air Museum.*

Limited excavations carried out during 2001 field research suggested the choose of two areas related to a Middle Acheulian occupation dated to around 800.000 years ago, very rich in archaeological and paleontological remains. Roofs built in local style will protect the excavated areas against animals, rain and wind.

Gombore II Butchering Site

The limited excavation of this site, discovered in 1974, allowed the identification of a possible butchery area of two hippopotami dating to about 700,000 years. This interpretation was confirmed by the 1992 excavation when fragmentary remains of two hippopotami were recovered in association with some lithic artifacts.

The faunal remains, including some vertebrae and ribs, can be attributed to Hippopotamus amphibius.The lithic industry is rare: both basalt and obsidian have been used (choppers, polyhedrons, flakes); a basalt handaxe has also been recovered.

Balchit

The extension of this site, the quantity of obsidian accumulations and outcrops, the abundance of flakes, blades and cores make Balchit an extremely interesting site. The locality was included in the Open Air Museum Project and will be presented with casts and original lithic tools in the Open Air Museum at Melka Kunture.

*Local development possibilities*

The Melka Open Air Museum will provide for the first time the possibility to visit the archaeological site along the year. Its presence could also contribute to the development of the local economy of the Awash village, both ensuring employment to many people during the realization of the Museum and giving the possibility to show and sell local items or gadgets (such as post cards and casts) related to the Prehistory of Ethiopia and Melka Kunture in the village itself and in the Welcome Building.

Local people could also be employed to warrant the efficiency of the buildings, to keep clean the roads and the other structures in the Park itself and to facilitate the visit within the Park.

As well documented in other Open Air Museums built elsewhere in the World, the presence of a Melka Open Air Museum will enlarge the possibility for students and other cultural operators in Addis Ababa to work during the realization of the project as well as for its running.

Masters at the University of Addis Ababa could be organized in order to give the necessary cultural background to students willing to cooperate during the realization and the running of the Melka Open Air Museum.

Training at the National Museum could also be developed in order to guarantee the realization of casts of archaeological and paleoanthropological specimens to be sell at the Melka Open Air Museum.

This long term project could be realized within three years since its starting. The worldwide importance of the prehistoric site of Melka Kunture justifies its realization.

## PART II

### The intra-site GIS application to the Oldowan sites of Melka Kunture

An important aspect of the research work of the Italian Archaeological Mission over the last few years has been specifically aimed to the study and the taphonomic interpretation of the Oldowan levels of the different sites of Melka Kunture. This involved the use of modern spatial technology (as for example a GIS intra-site) applied to the archaeological excavation (Hodder & Orton 1976; Haining 1994; Djindjian 2001).

Our choice of using a GIS application was determined by the difficulty of organizing thousands of information related to the finds excavated on the different paleosurfaces.

The need to correlate the spatial distribution of evidence with the analytic study of each find makes spatial technology, and especially GIS, very useful in the study of possibly significant associations of artefacts.

A three dimensional GIS application has been also recently proposed for the site of Swartkrans, in order to archive and visualize fossil, artefacts and geological data in their spatial context and to begin to distinguish taphonomic factors responsible for such accumulation (Nigro *et al.* 2001).

Our application of this kind of system was firstly focused on the Developed Oldowan level D of Garba IV, dating to about 1.5 my (D'Andrea *et al*. 2000), and recently also applied to the 1.7 my old Oldowan sites of Gombore I and Karre.

Two main reasons suggested that the site of Garba IV D could adapt itself particularly well to an experiment in the techniques of spatial statistic: the extension of the investigated area (about 100 square meters) and the high number of lithic and faunal remains (over 12,000).

The initial step was to find an application which could perform the following operations:

a) visualization of all the remains as spatial variables;

b) realization of thematic maps (faunal remains, basalt and obsidian lithic tools, manuports, etc.),

c) bidimensional and tridimensional spatial queries (topographical selections, removal of post-depositional noise) in order to reconstruct the post-depositional processes, due to both anthropic and natural events, which led to the formation of the deposit, and the modalities of the different phases of the site occupation;

d) statistic inference of spatial data (spatial correlation and autocorrelation; trend surface analysis) to highlight concentrations and eventually significant associations or relationships between different finds.

To make up for the limitations imposed by "electronic translation", the logical and physical structure of the application must be accurately planned. Special care has been devoted to plan and create the alphanumeric archives of the application, and to program its vectorial graphics.

The description and organization of informative levels includes no explicit interpretation or explanation of the nature of associations between investigated objects. The most important initial point for the deduction, reconstruction and explanation of the spatial phenomena consists therefore in the structuring of spatial entities and in the description of the associated variables.

The first step in our research was to convert all the data into a digital format, in order to give a structure to the information and to make it compatible with a digital processing.

The existing documentation consisted on the catalogue of the finds written after each year of the excavation, on the plans of the excavated area and on a series of catalogues, in which the typological and technological data of the lithic industry and the paleontological determinations were reported.

These archives were converted into a database allowing a wide range of single or multiple queries capable to group and to count the entire set of data, a fundamental function for statistic analyses.

The next step consisted on the computerisation into a vector format of the original cartography of the plans of the excavated sites. All the remains have been drawn on different plans and represented with different line styles to document overlaying objects on site.

Each object was assigned an exclusive value (or primary key) consisting of its inventory number and the same key provided the link for importing the database.

It is hence possible to interrogate simultaneously both the graphic plans of the finds and the information connected with them in the database. The information of an alphanumeric archive can be visualized in a new data table or in a thematic map. Different types of maps can be produced by visualizing finds on the paleosurface either individually or in association with any other type of information.

## Preliminary results and interpretations

The use of a GIS application has proved especially useful in the taphonomic interpretation of specific classes of materials showing significant distributions, allowing us to reach some interesting conclusions on the evidence of Garba IV D.

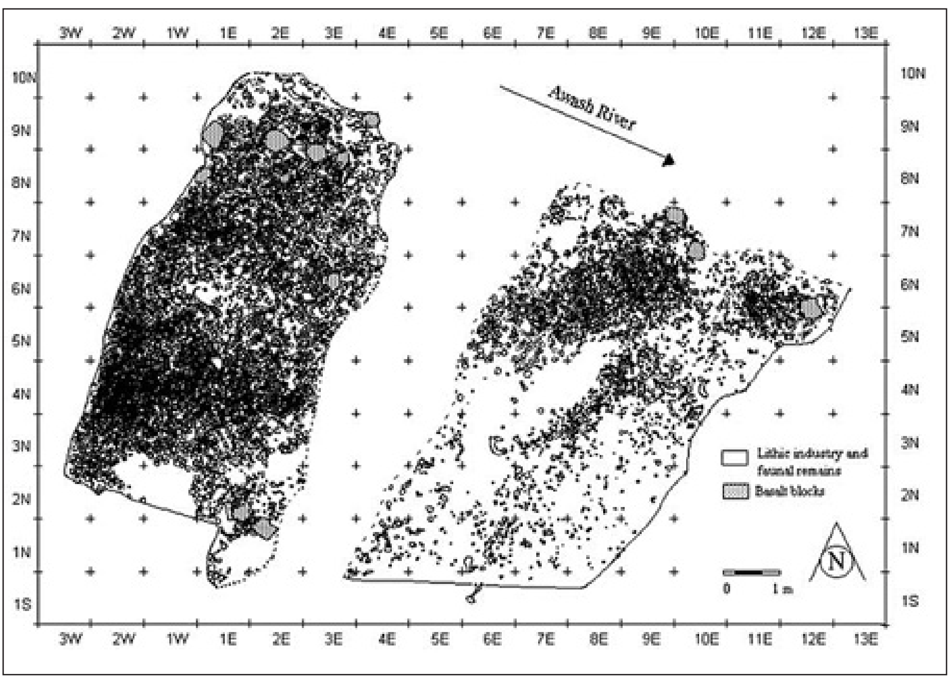
Due to its location close to the right bank of the Awash, the northern part of the site has been destroyed by erosion for an unknown extension, while the excavated area has been divided by a small gully into two sectors (the western and the eastern sectors).

The distribution of the archaeological material on the level D is not uniform. Remains are more intensively accumulated in the western than in the eastern sector of the excavation. High concentrations of materials can be observed in several parts of the excavated area. Two of these concentrations are located in the northern part of the eastern sector, the first one near the eastern bank of the excavation and the second one along a strip about 2.5 m long and 1 m wide, oriented SW/NE. In the western sector, the highest frequency is found in the central part, especially along the western bank, where more than 500 finds are presents in a single square meter (Fig. 12).

Furthermore, the whole paleosurface is strewn with pebbles of basalt and other volcanic rocks, with the exception of obsidian. They do not show any utilization or intentional modification marks, while their distribution approximately corresponds to that of the lithic and faunal remains and they are scattered on the entire thickness of the level. It seems possible to conclude that at least part of them was brought by the hominids and either used as a raw material nearby source for making tools (Fig. 13a) or for some kinds of activities which did not leave any utilization marks on the surface of the pebbles.

An important feature of the site consists on several large blocks of basalt, weighing several tens of kilos each, probably brought here by the hominids.

*Fig. 12. Garba IV D. Distribution of the lithic and faunal remains and of the large basalt blocks.*



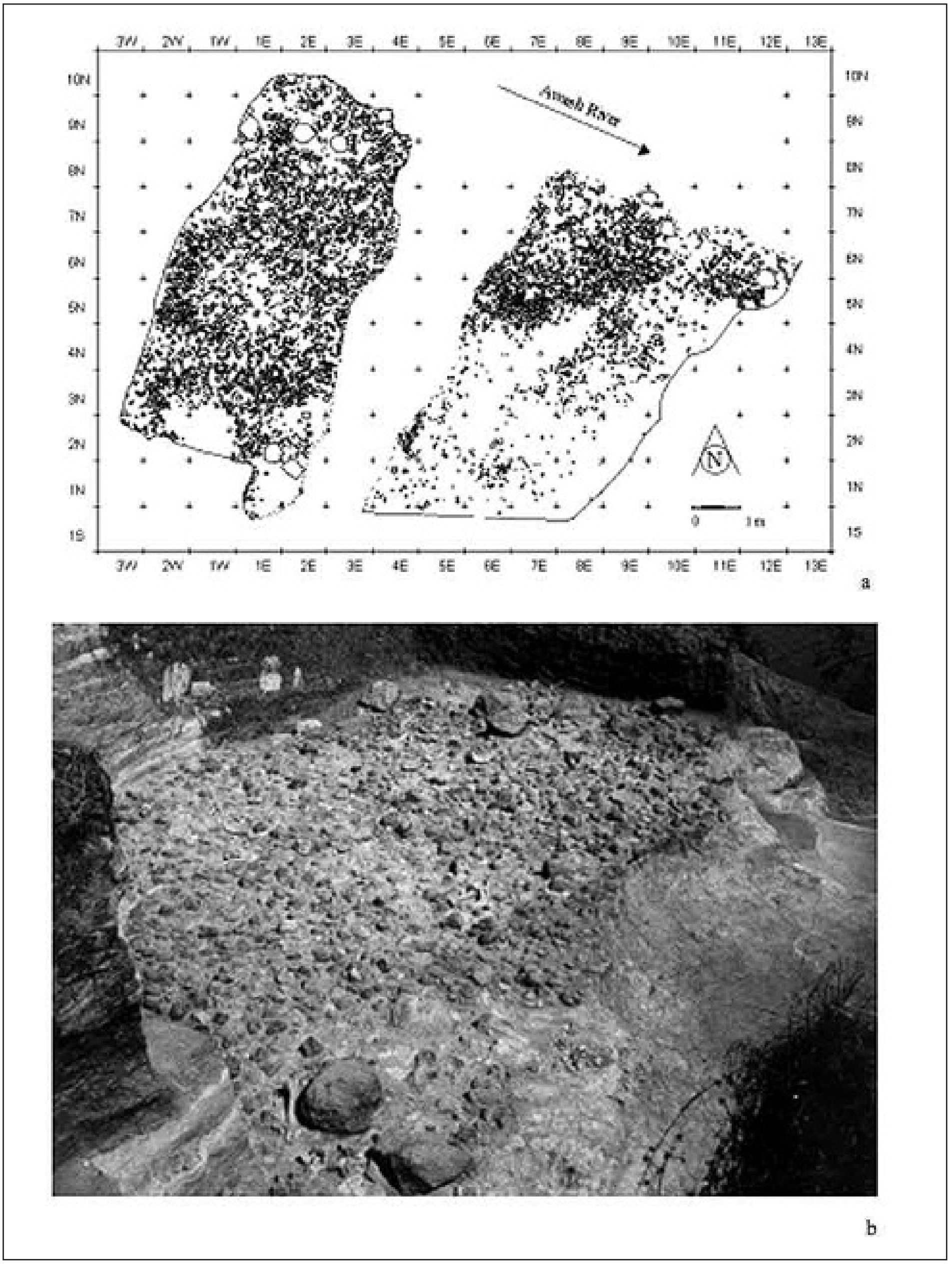



*Fig 13. Garba IV D. Distribution of the unmodified pebbles (a); a detail of the western sector (b).*

Most of them are located in the northern part of the western sector, two in the southeastern part of the same sector (Fig. 13b), and three of them in the northern part of the eastern sector.

Particular evidence as to their significance could lie in the fact that all the blocks are surrounded by large sized faunal remains such as pelvis, jaws, horns, and large bone fragments (Fig. 14 a, b); on the basis of this recurrent association a possible functional destination of these areas to the sharing of food can only be speculated.

A few areas in both sectors yielded no archaeological and paleontological remains. The most interesting area from a taphonomic point of view is an approximately circular area, large about 1.5 m, close to the southern limit of the excavation in the western sector, completely surrounded by lithic and faunal remains (Fig. 14 c,d). A less distinct area in the eastern sector, measuring about 3 x 1 m, is also partially delimited by lithic tools and fauna. The distribution of the 3,000 faunal remains recovered over the site reiterate the same pattern of the lithic remains (Fig. 15).

Another interesting aspect is the relatively high number of antelope horns (about 100) scattered all over the surface, but with a significant concentration in areas also showing the highest density of obsidian artifacts, near some of the large basalt blocks.

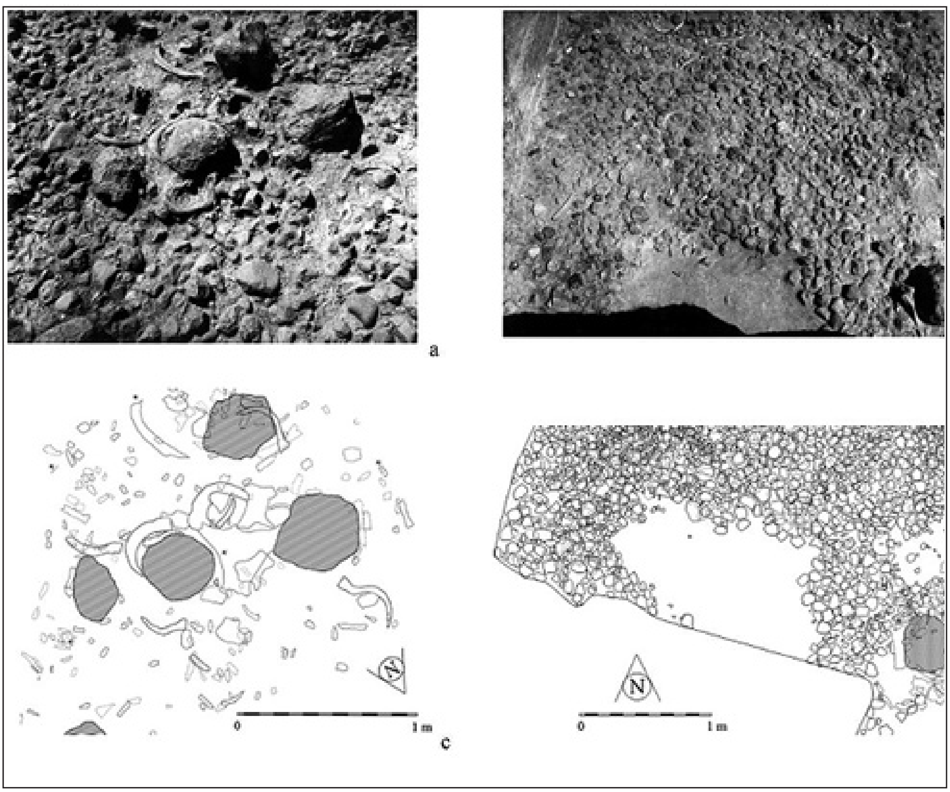
The lithic tools (about 10,000 pieces) as well as the others finds are scattered without significant concentrations (Fig. 16). The high number of objects makes often difficult to interpret the thematic maps. The visualization of the density or dispersion of remains has been simplified by creating frequency maps with objects grouped by value range using SQL (Standard Query Language).

The remains have been grouped and counted by grid square, using either the excavation grid square (1x1 square meters) or smaller squares (50x50 $cm^2$) for more detailed studies of especially significant areas.

The comparison of the total distribution of finds with that of lithic tools on one hand and of faunal remains on the other indicates that the pattern of the spatial distribution of the finds is very similar (Fig 17). But, if we consider the relationship between obsidian tools and basalt ones, it is possible to observe that the density of obsidian in the eastern sector is clearly higher than in the western one, where basalt, tuff, and trachyte prevail (Fig. 18).

It is possible to observe a high concentration in the northern and in the central-western part of the western sector, but, in particular, the distribution seems to indicate that one area in the eastern sector was devoted to the working of this raw material.

*Fig 14. Garba IV D. Large basalt blocks surrounded by faunal remains in the northern part of the western sector (a, b); detail of the semicircular area without remains in the southern area of the western sector (c, d).*



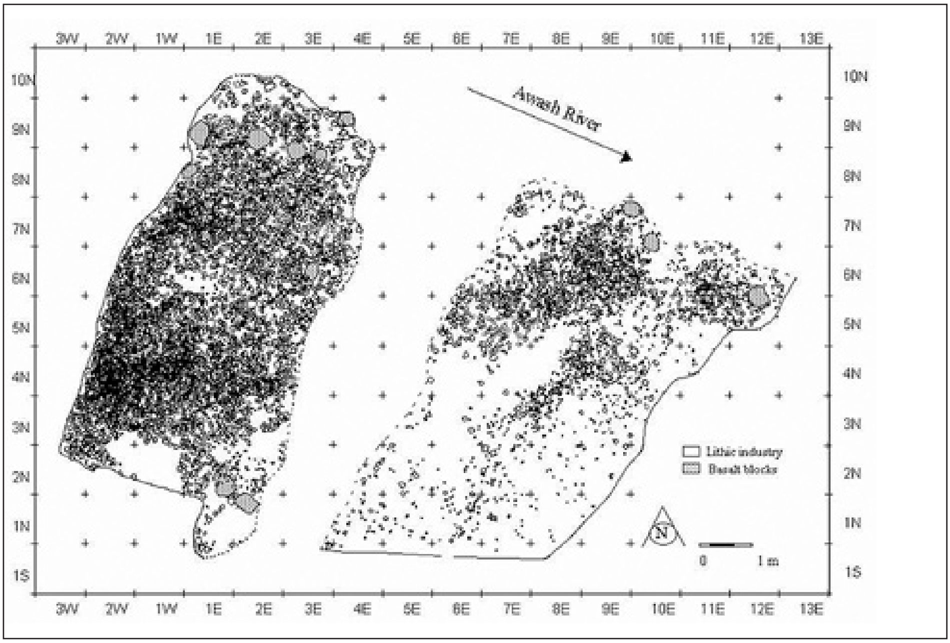



*Fig. 15. Garba IV D.  Distribution of the faunal remains and of the large basalt blocks.*
*FIg. 16. Garba IV D.  Distribution of the lithic industry and of the large basalt blocks.*

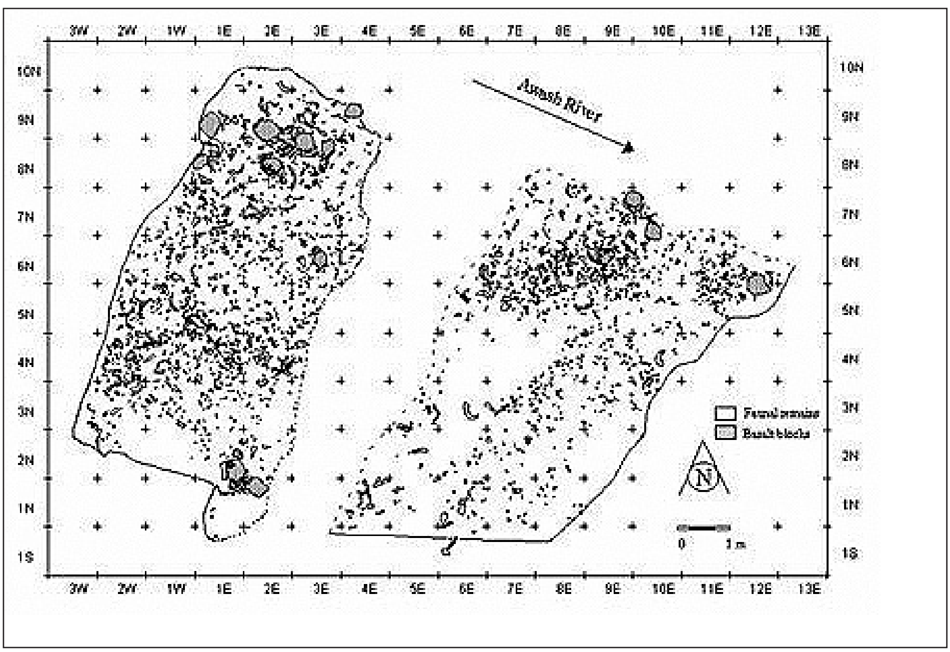


*Fig 17. Garba IV D. Frequency of the lithic and faunal remains (a); frequency of the unmodified pebbles (b); frequency of the lithic industry (c); frequency of the faunal remains (d).*

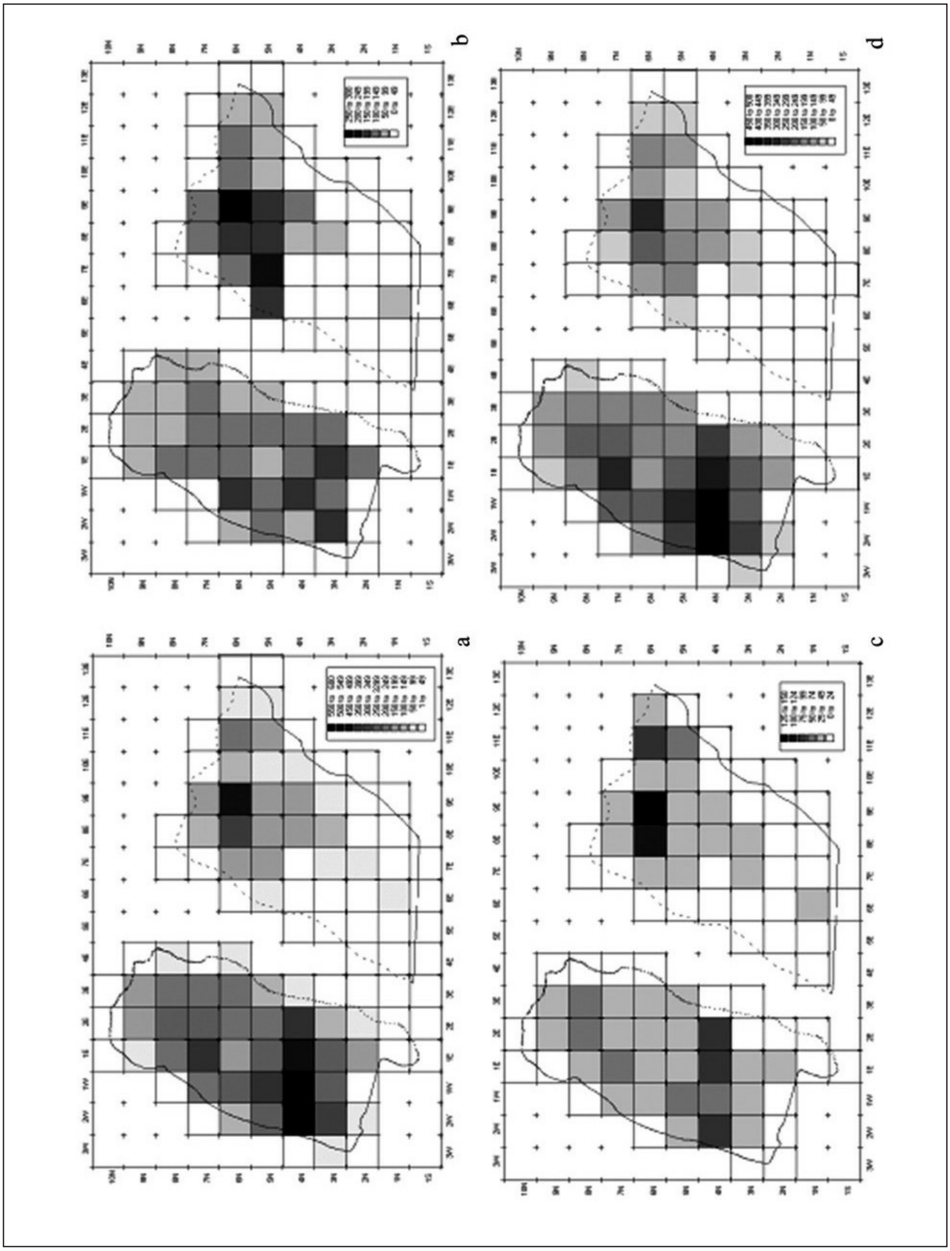
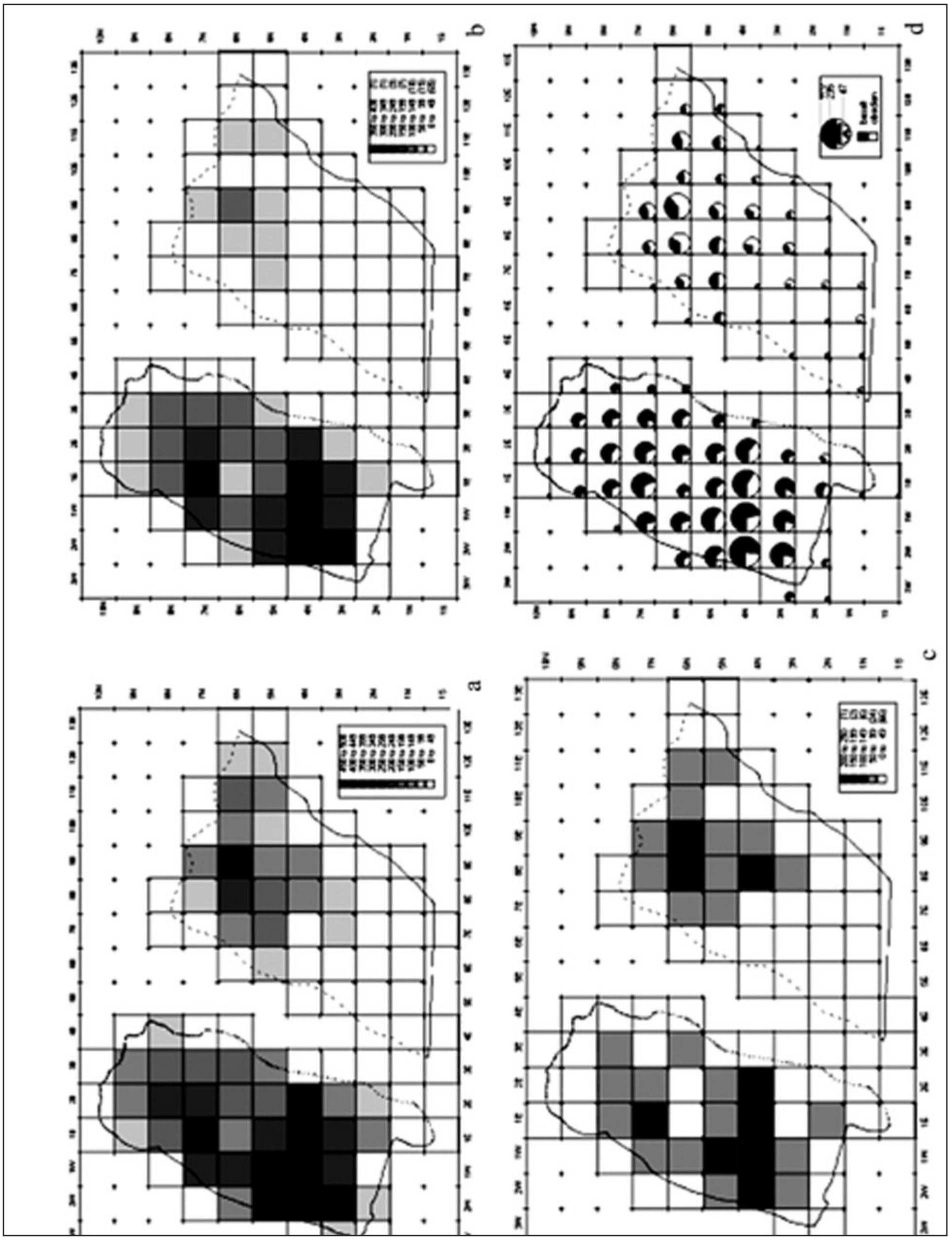


*Fig 18. Garba IV D. Frequency of the lithic remains (a); frequency of the basalt industry (b); frequency of the obsidian industry (c); relationship between basalt and obsidian industry (d).*



In this area, the density of obsidian wastes, flakes and cores, is much higher than the rest of the paleosurface, and also higher than that of non-obsidian flake and pebble industries within the same area.

Furthermore, there is an evident correlation between high concentrations of fauna and high concentrations of obsidian artifacts, and between high concentrations of basalt pebble tools and high concentrations of basalt flakes (Fig 19). The use of a finer grid (50 cm) brings further confirmation to this observation (Fig. 20).

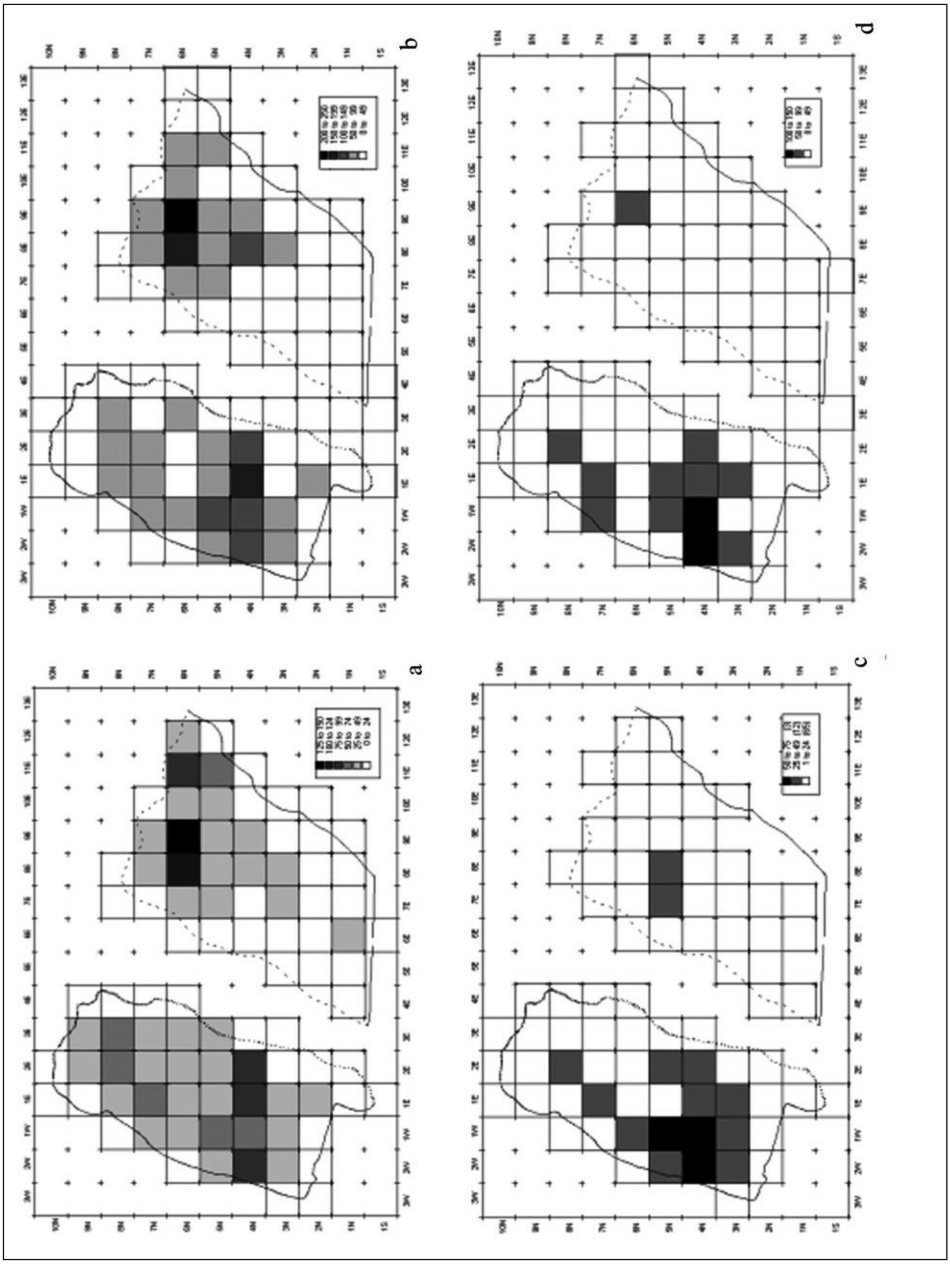
A correlation between the distribution of obsidian artifacts and faunal remains is also perceivable in the north-central portion of the eastern sector, near the basalt blocks surrounded by large faunal remains (Fig. 21a). This is a recurrent association at Garba IV D, which can also been observed in the northern part of the western sector (Fig 21 b).

Further taphonomic investigation of level D at Garba IV was carried out by analyzing the vertical distribution of finds in transversal and longitudinal sections, on which the altitude of all the remains was projected.

The topological functions characterizing GIS allowed the extrapolation of spatial coordinates for each find (x and y); by ranging on the abscissa the values of x or y, respectively, for the transversal and longitudinal sections, and on the ordinate the depth values, it becomes possible to visualize archaeological sections of any portion and over any extension of the excavated area. Each object is represented with a point, because it is impossible to reconstructed the real volume and the real form of the pieces and, as for the plan, it is possible to obtain thematic sections using the information contained in the database.

It is clear that such topological operations will be extremely helpful in reconstructing the modalities and phases of the formation of the site, as well as its post-depositional processes; it is also

*Fig 19. Garba IV D. Frequency of the faunal remains (a); frequency of the obsidian flakes, tools and cores (b); frequency of the basalt pebble tools (c); frequency of the basalt flakes and tools on flakes (d).*



possible to highlight specific associations or distributions through the interfacing of data from different thematic sections with the horizontal maps.

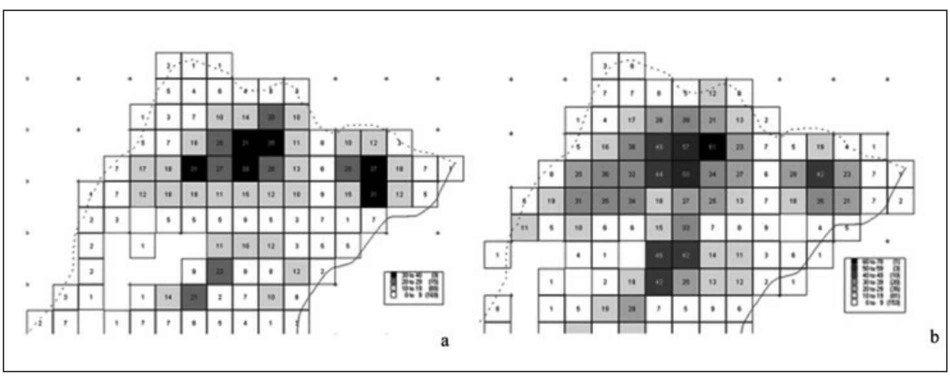
The thickness of the level D is about 50 cm, with a weak slope from the eastern to the western sector. If we observe the thematic section of the distribution of the lithic industry according to the different kind of raw material, we reach the same conclusions as for the horizontal spatial analysis.

The presence of obsidian in the eastern sector is higher than in the western sector with no particular vertical distribution based on the raw material.

The longitudinal section shows the same distributions. It is interesting to note that the horizontal concentrations correspond to a greater thickness in the section (Fig. 22).

Two main features can be highlighted when considering the lithic industry on the base of raw material and typology: the great accumulation in the central part of the western sector and the higher density of flake industry, above all on obsidian, located in the northern part, where several large basalt blocks are surrounded by faunal remains (Fig. 23).

*Fig 20. Garba IV D. Central-northern area of the eastern sector. Frequency of faunal remains (a); frequency of obsidian flakes and tools (b).*



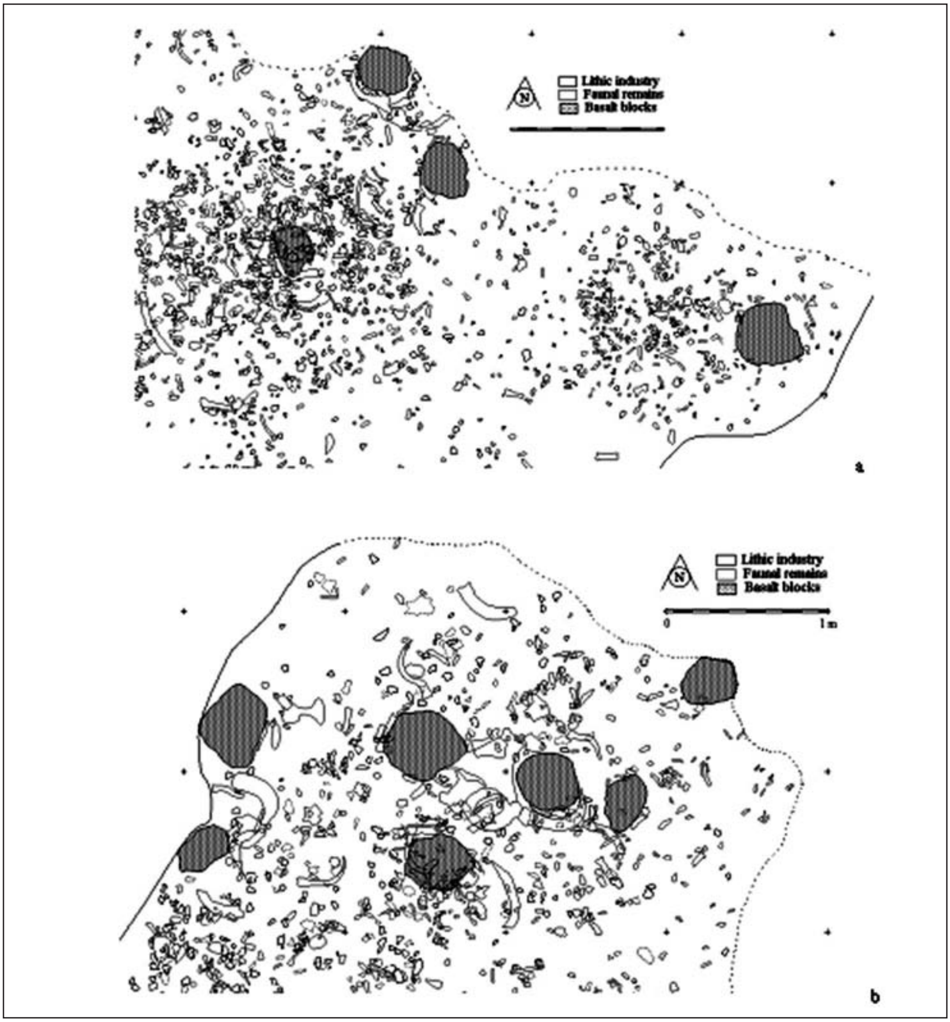



*Fig 21. Garba IV D. Distribution of faunal remains, blocks of basalt and obsidian flakes, cores and tools in the eastern (a) and in the western sector (b).*

A similar distribution pattern can be observed in the eastern sector with the recurrent association between the large basalt blocks surrounded by faunal remains and obsidian tools and flakes. In the transversal section of the eastern sector this recurrent association is even more evident.

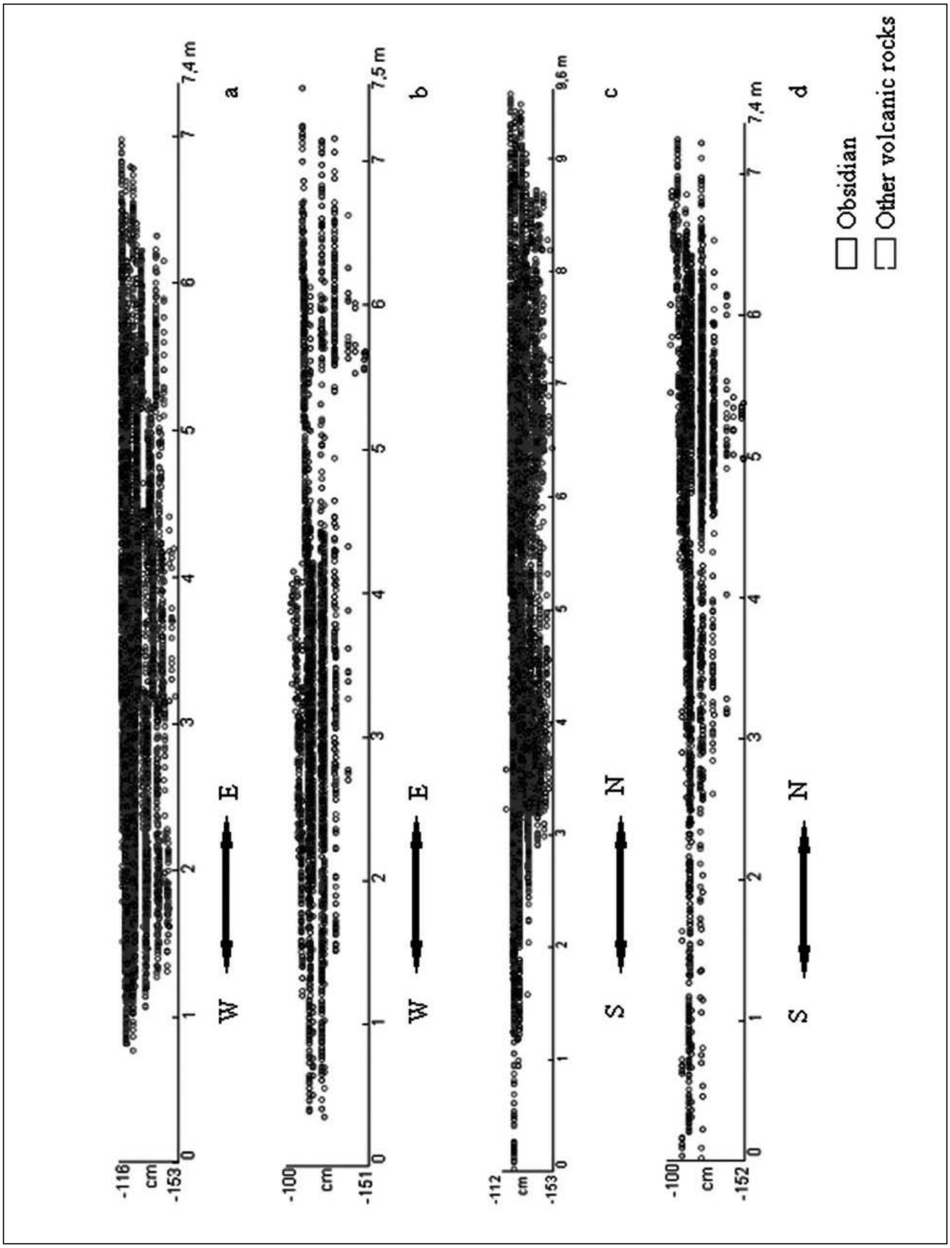



*Fig 22. Garba IV D. Distribution of obsidian and other volcanic rocks flakes and tools. Transversal section in the western (a) and in the eastern sector (b); longitudinal section in the western (c) and in the eastern sector (d).*

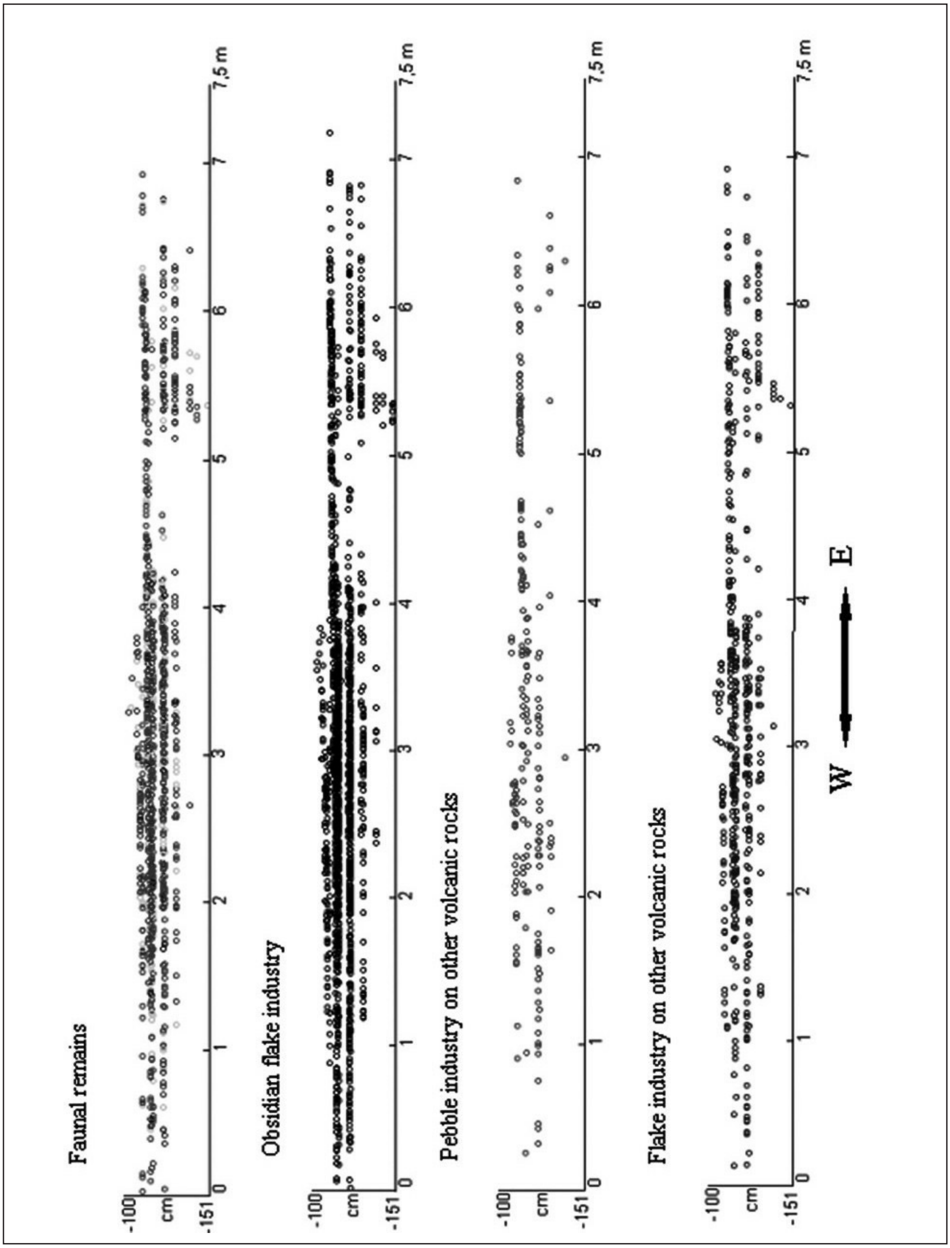



*Fig 23. Garba IV D. Transversal section of the eastern sector.*

In fact the areas with large basalt blocks, high number of faunal remains and obsidian flake industry, though one close to the other, are nevertheless clearly separated by areas characterized by a slow number of remains.

The realization of thematic and general sections is useful not only for the analysis of the associations, but also for the interpretation of eventually distinct phases of frequentation of the site by hominids.

At least three different layers can be distinguished in these sections. In order to confirm this observation, we realized a tridimensional reconstruction of the paleosurface; the use of a vertical exaggeration factor allowed to highlight the vertical distribution of finds. As well as for the plan and section, also for the tridimensional reconstruction it is possible to obtain thematic maps using the information contained in the database.

The next steps of this research will consist in the widening of the analysis of each layers using different methodologies. Thanks to the GIS application, it becomes possible to visualize the horizontal distribution of each layer and to point out to eventual association patterns comparing the results with those obtained until now.

It will also be very helpful to use the refitting method to test if these layers could be eventually correlated to distinct settlement phases. Moreover this method will allow us to give the right weight to the post-depositional processes which led to the formation of these paleosurfaces.

The same system has been actually applied to the other Oldowan sites of Melka Kunture, Gombore I and Karre I, in order to control the results of their interpretation with the taphonomy of Garba IV D. When the data of all these sites will be compared, we could have interesting information about the spatial organization during Oldowan times at Melka Kunture.

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# THE ARCHAEOLOGY OF THE PENINJ "ST COMPLEX" (LAKE NATRON, TANZANIA)

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*Ignacio de la Torre,*
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## Introduction

Presently, research at Peninj (West of Lake Natron, Tanzania) is being carried out in three geographical areas: North Escarpment (NE), South Escarpment (SE) and Type Section (Figure 1). The first two areas are more distant to the former paleo-lake than the latter. In those two areas, sites devoid of fauna and containing Acheulian stone tools have been discovered. Type Section is, conversely, situated in a deltaic paleoenvironment close to the former lake shoreline. Sites in Type Section preserve dense concentrations of bones and lithic tools adscribed to the Oldowan industry.

Previous publications (Isaac 1965, 1967; Dominguez-Rodrigo et al. 2001a) have paid special attention to the Acheulian sites discovered in the region, and recently to the lithics (de la Torre et al. 2003) and zooarchaeological and taphonomic characteristics (Domínguez-Rodrigo et al. 2002) from the ST Site Complex at Maritanane (Type Section). This paper is presented as a synthesis of the works at the ST Site Complex, that is composed of a pene-contemporary cluster of 11 archaeological sites, which share the following properties: similar stratigraphic position on the same paleosol, similar taphonomic conditions and topographic proximity, since all these sites appear in a reduced area.

Radiometric dating (Manega 1993; Isaac & Curtis 1974), paleomagnetic dating (Thouveny & Taieb 1986, 1987), and bio-stratigraphic correlations (Geraads 1987; Denys 1987) place these archaeological sites in the 1.6-1.4 Ma interval (Dominguez-Rodrigo et al. 2001a, 2001b, 2002).

## Geology of the ST Site Complex

*Introduction: Regional geology*

The Peninj Group is a Plio-Pleistocene sedimentary unit exposed on the south-western section of the Magadi-Natron basin in the south of Kenya and in the north of Tanzania. The exposures appear on the Tanzanian sector of the basin in the form of extensive areas of outcrops on the Sambu and Sanjan tectonic escarpments in the current semi-graben to the west of lake Natron (Figure 1). During the formation of these sedimentary exposures between 2.0 and 1.0 Ma, the lake basin showed a substantially different aspect, since the 400-meter-high western tectonic escarpment of the Rift Valley (Nguruman Escarpment) did not exist.

The relief was formed by volcanic cones and the distant precambric highlands of Oldoinyo Ogol. The basin is situated to the north of the point where the Gregory rift system is divided into three branches: Eyasi, Manyara and Kilimanjaro. It is also in a region of high volcanic activity known as the northern volcanic province of Tanzania (Dawson & Powell, 1969). The current configuration of the Rift in this area ocurred at about 1.0 Ma.

The Plio-Pleistocene deposits of Peninj were initially described by Isaac (1965, 1967). Isaac made a stratigraphic synthesis of these sediments due to their importance in the study of the archaeological sites discovered in 1963. The deposits are 80 m. thick. They are composed of lacustrine and alluvial sediments with interbedded volcanic tuffs.

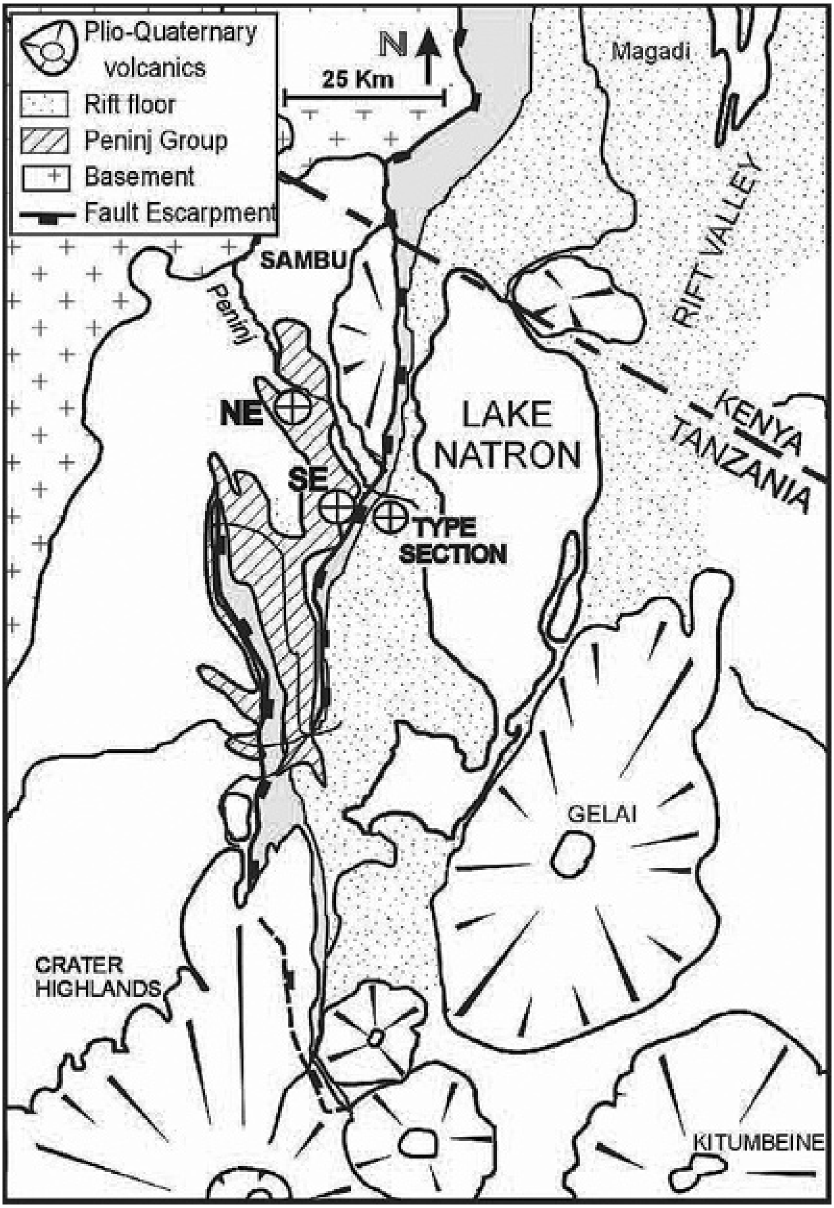


*Fig. 1. Location of the Plio-Pleistocene deposits of the Humbu Formation in the Peninj area. Key: NE(North Escarpment); SE (South Escarpment), and Type Section. The ST site complex is located in Type Section (Maritanane).*

The Peninj Group was formed on a 400 m. thick lava basement (the Sambu lavas) dated to 2.0 Ma, 1.9-1.77 Ma. and 3.5 Ma (Isaac 1967; Isaac & Curtis 1974). This basalt deposit together with the nephelinite and phonolite Pliocene deposits overlay a precambric quartzite stratum belonging to the Mozambique Belt (Lubala & Rafoni 1987). Both in the middle and at the top of the Sambu lavas, sediments similar to those of the Peninj Group appear. They have been called Naikuruku and Hajaro beds respectively (Isaac, 1965).

The Hajaro beds are overlaid by a 10 m. thick basaltic flow showing reverse paleomagnetic polarity and a radiometric date (K/Ar) of 2.0 Ma (Thouveny & Taieb 1987). These beds are the base of the Peninj Group (Isaac 1967). Isaac (1965, 1967) divided the Peninj Group into two units (Figure 2): the Humbu Formation (approximately, 40 m. thick and mostly alluvial) and the Moinik Formation (between 30 and 40 m. thick and basically of lacustrine facies).

Fossils have appeared so far mainly in the alluvial facies of the Humbu Formation. This formation was also divided into three members.

The first of them is the basal sands with clays (BSC), which constitute the initial detritic infill of the basin. They show mid-fan facies and proximal alluvial fan facies which fill the tectonic basin which was limited by the proto-escarpment of Sambu (approximately 20 m. high). The second member is the Main Tuff (MT), constituted by basaltic tuffs originated in a small volcanic cone situated to the south of the modern Peninj river delta. The third member is the Upper Sandy Clays (USC), deposited in a flat landscape with hardly any noticeable relief. They show distal and intermediate alluvial facies to the north and lacustrine facies to the south. They contain most of the fossils and stone tools discovered thus far.

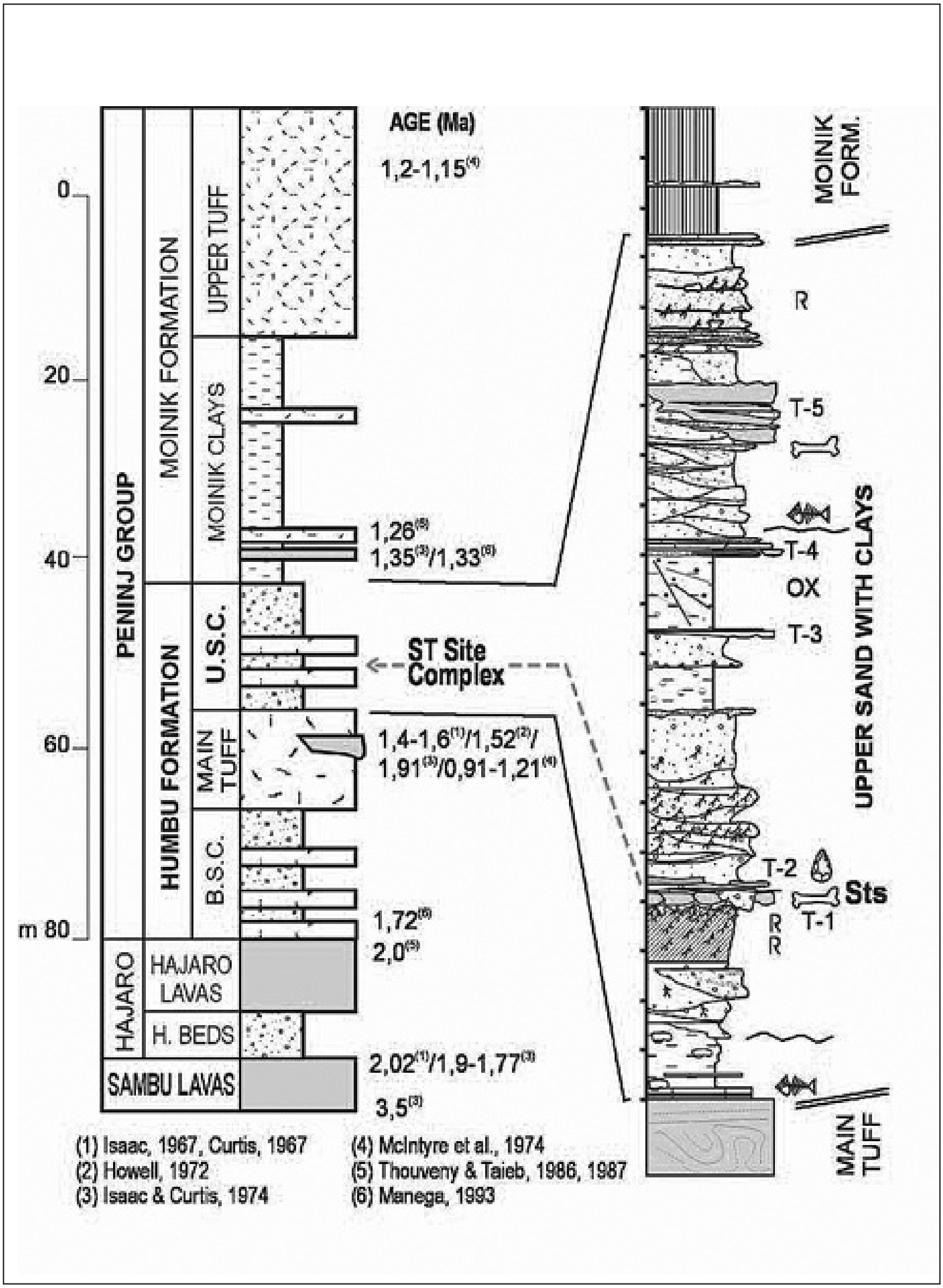


*Fig. 2. Stratigraphic sequence of the Peninj Group with the current dates available.*

The age of these deposits is controversial, although they have been dated by K/Ar and Ar/Ar as well as by paleomagnetism. The reason for controversy is that the tuffs appear altered by diagenetic zeolitization of volcanic crystals.

The base of the Peninj Goup would be younger than the Hajaro lavas (dated at 2.0 Ma) (Isaac 1965, Isaac & Curtis 1974). A basaltic tuff interbedded into the Main Tuff (Wa Mbugu basalt) shows normal polarity and has been dated to 1.4-1.6 and 1-9 Ma (Isaac & Curtis 1974; Howell 1972; McIntyre et al. 1974). It is temporarily assumed to represent the Olduvai subchron in the Matuyama phase (Thouveny & Taieb 1987) dated between 1.9 and 1.78 Ma (Walter et al. 1991; McDougall et al. 1992; Valet & Meylander 1992).

A basaltic tuff situated at the base of the Moinik Formation has been dated to 1.33-1.4 Ma (Isaac & Curtis 1974; Manega 1993). This tuff corresponds to the end of the USC sedimentation process. Also at the base of the Moinik Formation and overlying the previous tuff, Manega (1993) has dated another tuff to 1.26 Ma, which reinforces the validity of the date of the underlying tuff (Intra-Moinik tuff). After the Moinik Formation, the Peninj Group sedimentation ends at about 1.2-1.15 Ma (McIntyre et al. 1974).

The most complete outcrop series of the Peninj Group is found in what Isaac (1965) called Type Section. It is an area situated at the foot of the modern escarpment by the current delta of the Peninj river. This area has been strongly modified by tectonics and erosion has created a complex of gullies exposing fossiliferous sediments.

The abundance of archaeological sites in Type Section has made us define the ST site complex. The Type section embodies Kamare, Maritanane and Kipalagu. Most of the outcrops are contained in the Maritanane area and so is the ST site complex.

*The Upper Sands with Clays (USC)*

The USC member is widely distributed along most of the exposures of the Peninj Group. It overlays the Sambu Escarpment (North and South) and is also found along all the Type Section outcrops (Figure 3).

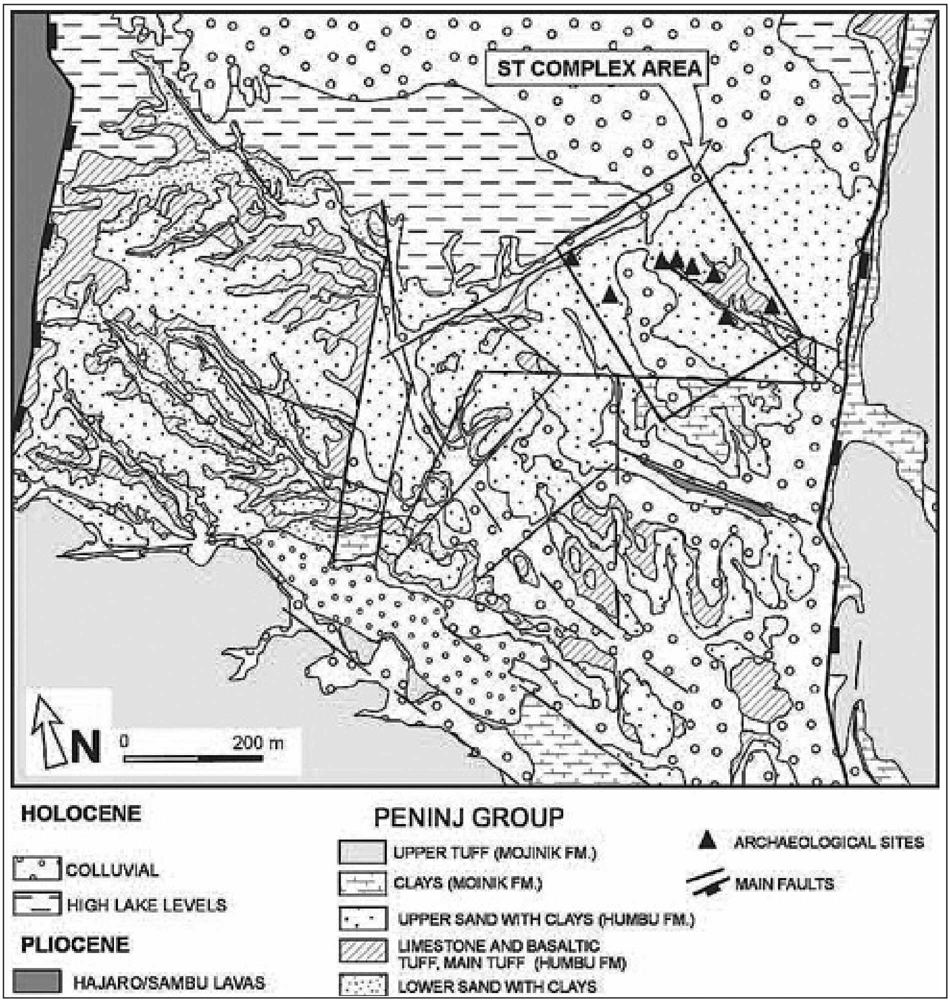


*Fig. 3. Geomorphological map of the Peninj Group in Maritanane, Type Section, and location of the ST site complex.*

The thickness of the USC varies between 4 m. to 20 m. In Type Section, the USC represents a proximal alluvial facies towards the west and a distal alluvial facies towards the east and the south. The materials that constitute the USC in this area are lacustrine-swampy dolomitic carbonates, clays and silts, sands ranging from fine grained to coarse grained and interbedded volcanic tuffs. The sedimentary structures observed show the intervention of geological processes of different origin, such as the variation of the lake shoreline, the volcanic activity and tectonic movements which produced periods of erosion, sedimentation and edaphic processes.

The paleoenvironmental evolution of the USC at the ST site complex level can be documented in the modification of the alluvial facies. Around the ST site complex, the evolution of the landscape can be summed up in the following description. Lacustrine carbonates were deposited on the surface of the basaltic tuff of the Main Tuff. These carbonates contain abundant bioturbation due to the activity of boring organisms. On the lacustrine facies, mudflat lacustrine facies appear interbedded with marshy carbonated sediments containing carbonate nodules. This indicates variation in the base level as a result of fluctuations in the lake shoreline. Gradually, these sediments incorporated fine grained sands with root casts and oxidation processes in a paleoecological setting of a distal alluvial fan.

Then, the first phase of channel formation occurred due to a decrease in the water level of the lake and a progradation of the most proximal deltaic facies. This change might have been tectonically induced. The channels show their greatest development to the north of the ST site complex area, but are visible along most of the outcrops, eroding the fine grained underlying sediments. The channel infill is constituted by coarse grained sands showing a horizontal and crossed lamination. After this filling phase, fine grained sands and sandy clays containing isolated root casts are deposited again.

Oxidation processes intervene afterwards, as shown by the presence of reddened sediments. After this period, proximal alluvial fan facies erode the anterior substrate.

These deposits are constituted of coarse grained sands with abundant clayish and zeolitic matrix, showing important bioturbation by the presence of a compact web of root casts. This facies is very cemented. After this sediments were deposited, a volcanic eruption was responsible for the deposition of  a tuff (T1), which is 20 cm thick on average. In some areas it becomes 40 cm. thick. After the eruption, the area appears sealed by the tuff. Then, a new fluvial incision phase erodes the tuff, which in some spots shows signs of important subaerial weathering (cracking of the surface, formation of split blocks). In some parts, the faulting created by posterior tectonic dynamics can be observed. This sin-sedimentary tectonic activity can be documented by the presence of material sismically slumped which formns part of the Main Tuff.

This process ended when there was a new rising of the base level with the creation of crusting in the channels because of carbonate precipitated by algae. Later, the channels were filled with coarsed grained sands and the surface ressembled the previous one deposited prior to the formation of T1. During this period, most of the ST archaeological sites were formed both on the edges of channels which excavated and eroded the tuff (T1) as well as on the well-cemented tuff surface including a sandy and clayish matrix.

Not long afterwards, a new tuff was deposited (T2). This tuff is laminated and is adapted to the landscape relief. It is also affected by tectonic processes and eroded as a result of the continuation of the formation of channels. The alluvial sedimentation was discontinuous, with the incision of channels and the sedimentation of river deposits with coarse grained sands and clays in sheetflow and channel fill deposits. During this time, there was a very widespread and intense drainage system. After this phase, a new lacustrine transgression took place, depositing a dolomitic limestone layer overlaid by fine grained sands and clays. Then the delta expanded again. At the base of the Moinik Formation, the lake covered most of the area because of either a climatic change or a tectonic tilting of the lake basin towards the west.

*The ST site complex*

Maritanane (formely called Type Section by Isaac, 1967) comprises about 1 km2 of Plio-Pleistocene sedimentary exposures. The northeastern section of Maritanane is occupied by two gullies, which contain the greatest density of fossil bones and artefacts retrieved so far from the whole area. Within these gullies, archaeological remains are distributed more or less regularly (Figure 4), with higher density spots which were formally called sites (ST2A, ST2C, ST2D, ST2E, ST2G, ST3, ST4, ST6, ST15, ST30, ST31 & ST 32). The sediments exposed in between these sites are also littered with archaeological remains, though in smaller amounts, which makes artifact and archaeofauna distribution a continuum in this reduced area.

The archaeological ocurrences are situated in the Upper Sands with Clays (USC) of the Humbu Formation, directly overlying a volcanic tuff and covered with carbonated sands. The tuff is widely exposed in most of the outcrops, over an area comprising almost 75% of Maritanane. The archaeological materials appear on a paleosol right on the surface of the tuff in most of the area, except when the tuff is eroded or cut through by river channels. Many materials appear exposed but encrusted to the tuff by the effects of carbonate.

ST2. This big site, divided by small modern gullies (ST2A, ST2C, etc) is found at the top of a small slope in the northeast of the ST complex in a fine and coarse grained sandy matrix right above the tuff (T1).

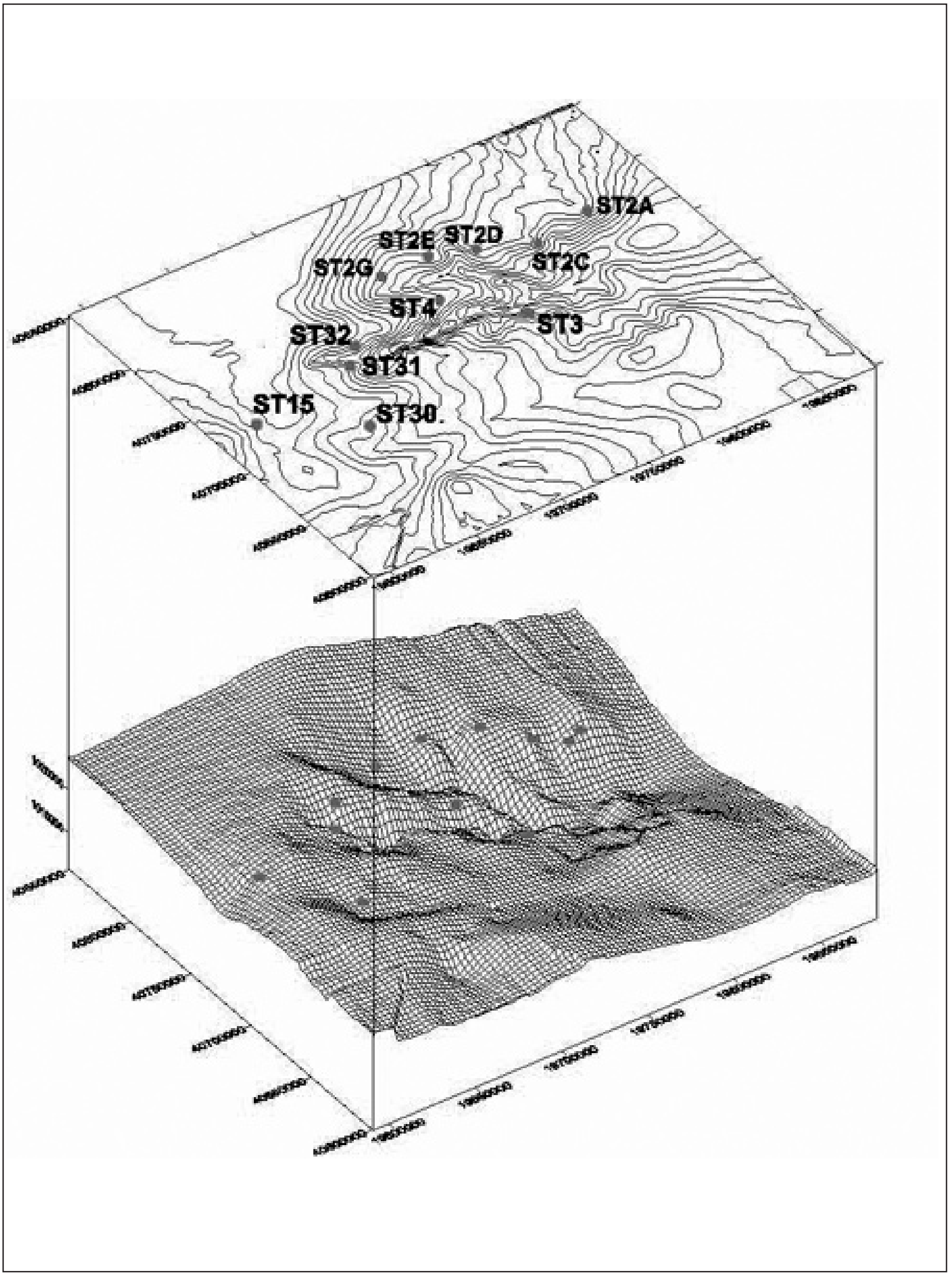


*Fig. 4. 3D reconstruction of the modern topography of the St site complex showing the sites distributed around the main gully.*

The sandy sediments covering the fossiliferous deposit are 10 cm thick. The archaeological remains appear on the top of the tuff surface, covered by greenish sands and clays and a reduced sand infill in a channel structure overlying clayish lacustrine and distal alluvial sediments. The site is situated about 2.8 m above the Main Tuff. In a part of the exposed outcrop, the tuff (T1) appears eroded because of the presence of a small channel. The erosion is very straight and could be conditioned by a fault which follows a 105º-107º E direction.

ST3. This site is situated in the Eastern margin of the ST site complex. Archaeological remains are mainly found at the base of the sand deposit of a river channel. The base of the channel presents a bio-precipitated laminated carbonate, where some faunal specimens and stone tools are found. Other archaeological remains appear on the non-cemented sides of this carbonate and even underneath.

The channel described follows a west-east direction and was formed on brown sands with root casts. Under these sands, coarse grained sands containing basaltic blocks from the tuff are found. The site is about 1.5 m above the Main Tuff.

ST4. This site is located in the intermediate zone of the ST site complex, on top of a slope which follows a west-east direction. It is constituted by coarse grained sands in a channel fill formed in a clay matrix which might have followed a northwest-southeast direction. The channel includes blocks from the tuff and presents a carbonate layer on the basal erosive surface. On the base, volcanic blocks have been retrieved which have a diameter of approximately 0.5 m and which are covered by algae-deposited carbonate. The base of the channel is situated only 0.4 m. from the top of the Main Tuff. The proximity of the channel to the Main Tuff could confuse the actual stratigraphic location of the channel by placing it in the channel deposits found at the bottom of the USC.

However, the existence of the carbonate level at the bottom of the channel, the upper contact with the greenish sands and the existence of basaltic blocks from T1 prove that the formation of the channel took place after the deposition of T1 which the channel itself eroded. This site was strongly altered by tectonic movements, showing some variation in the disposition of the archaeological materials, ranging from 0.2m. to 0.4 m. due to faulting.

ST6. This site is found on the same slope as ST4 about 20 m. to the west. Archaeological remains are found on the tuff surface (T1) in the cemented greenish sands. A few meters away T2 can be observed, a little displaced by tectonic dynamics, but stratigraphically above the archaeological deposit. In this zone, T1 is 0.4 m thick. It is not easy to determine the situation of the site with respect to the Main Tuff, because it was highly modified by tectonic faulting but it ranges between 2.5 m and 3.5 m.

ST15. This site is the westernmost locality of the ST site complex. It is situated on a slope about 1.8 m. above the Main Tuff. The archaeological level is situated in strongly cemented sandy sediments and right on the surface of T1 which appears highly altered. At the same point, an erosional front can also be observed. It cuts the tuff at the level of formation of a small stream channel with coarse grained sands. The channel infill appears laminated and its base is close to the top of the Main Tuff. A few meters south of the site the tuff is observed continuously with 1.2 m of underlying sand sediments and 0.4 of clays with carbonate nodules above the Main tuff.

ST30. This site is situated on a small platform formed in between two small gullies. It is the southernmost site in the ST site complex. Its surface is practically horizontal. Laterally, T1 can be observed to the south. It is highly weathered on surface. To the north, the greenish sands with root casts are found. The facies where archaeological materials appear is composed of cemented sands.

The archaeological level corresponds to the level of the paleosol where the other sites are located. From the southern outcrop of the locality it can be deduced that the site is situated 5 m. above the Main Tuff.

ST31. This site is located at the beginning of the gully that separates ST4 and ST3. The archaeological horizon is located on the surface of T1 in a sandy matrix and under the fill deposit of a shallow paleochannel (0.3 m. thick). T2 overlays this channel. The base of the sequence is covered with sediments. Thus, the distance between ST 31 and the Main Tuff is uncertain. Under T1, there are a few cms of greenish sands.

ST32. This site is similar to ST31 and both sites are separated by an erosional gully. It is directly on the tuff surface. However, there is more than 1 m of sedimentary sequence between T1 and T2, which could indicate that there was a posterior subsidence movement or that T2 was deposited on an elevated paleorelief. The site is 3.5 m above the Main Tuff.

*Geological Interpretation of the ST Site Complex*

The redundant stratigraphic situation of all the archaeological sites of the ST complex on the surface of a tuff (T1), suggests that all the sites were deposited on the same paleosol. The eruption of a volcanic cone to the south of the lake created the deposition of T1 on an alluvial fan environment. Sedimentation stopped at a certain time. Then erosion proceeded to weather, crack and shatter the tuff. Then, the lake briefly covered the area forming a laminar carbonate layer in the lowest areas because of the action of algae and stromatolites. Afterwards, sedimentation by a deltaic system followed the regression of the lake and sands and clays were deposited on the carbonate and tuff surface. In the initial phase of this deltaic process with the combination of large and several small and shallower channels, early hominids occupied the area and created the ST site complex.

The paleorelief of the area (Figure 5) has been obtained by measuring the distances of sites to the Main Tuff (after considering recent tectonic changes but not those that ocurred after the deposition of the Main Tuff and before the formation of T1). The data were obtained along an extended area where the outcrops have allowed us observe the thickness among different stratigraphic units (Figure 6). The most elevated zone is situated to the south and west. A channel, which originated in the northwest, goes across ST4 and by ST3. Other smaller streams joined this main channel. The direction of relief is north-south, similar to those currently observable, which indicates the reactivation of the faulting.

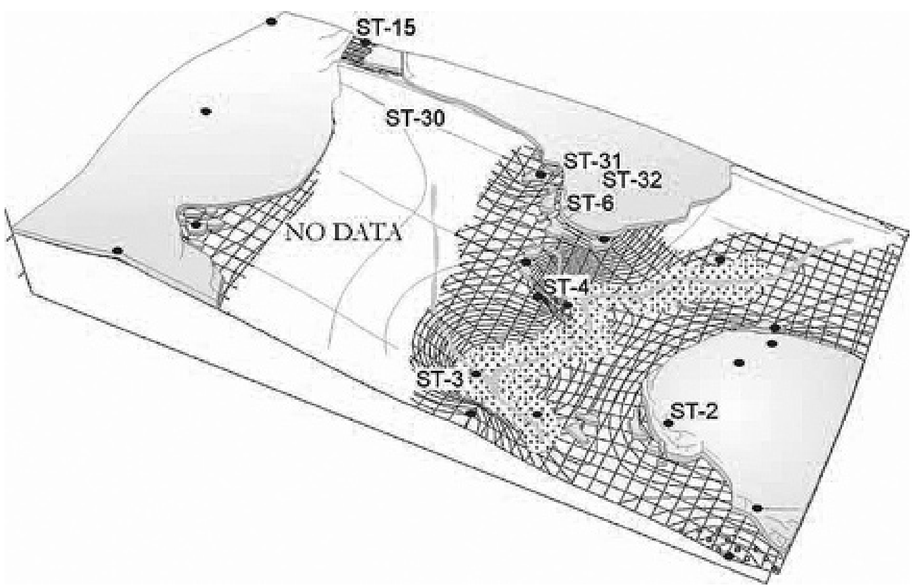


*Fig. 5. Location of the archaeological sites in the ST site complex on the paleotopography of the area and showing the paleoecological landmarks.The shaded area shows the zones where T1 has been preserved. White areas show the erosive processes created by channel fills.*

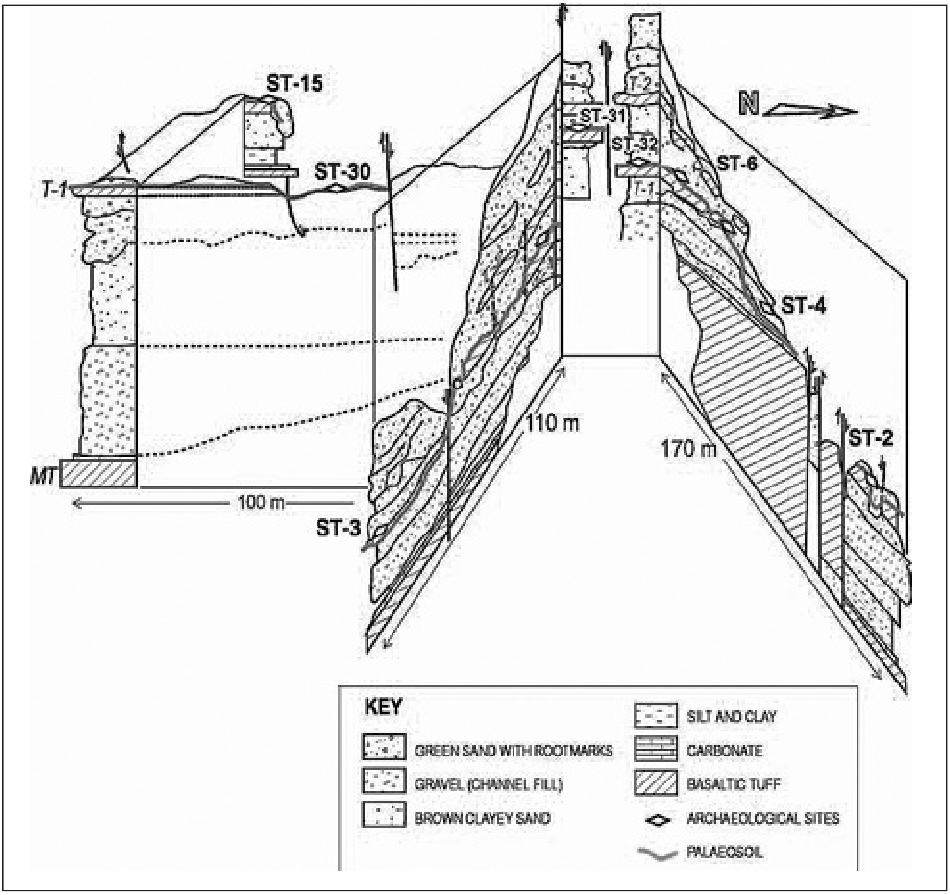


*Fig. 6. Isometric stratigraphic reconstruction of the St site complex with the main lithological features shown.*

According to these data, the most depressed parts of the ST site area correspond to the zones where T1 has been eroded and channel deposits are well represented. This could indicate that T1 was eroded and even the older deposits were also eroded to incorporate the channels. The most elevated areas are situated on well preserved tuff (T1). The disposition of the deposits supports the paleotopographic reconstruction, with a minor relief exposed showing a 4 m difference between the lowest and the highest point.

The larger channel would flow southeast or south by the zones where ST4 and ST3 are located. Smaller shallow channels appear nearby also eroding T1. The overall impression is that hydraulic energy did not play a major role in the final configuration of archaeological sites.

The side channels are too small and the situation of ST4 and ST3 on the edge of the channel supports the contentions that most of the materials were not transported by water. Judging by the size, if seasonality was as marked as it is today in modern savannas, most of these streams in the areas where archaeological materials were deposited might have been dry or the water level might have been low at the time hominids were foraging in the area.

## Data Collecting Method

Most sites in the ST complex are located on individual slopes, except ST2 (comprising five slopes: A,B,C,D,E, G, most of them with archaeological materials). T1 is exposed along the whole area connecting all the slopes that constitute the main gully. Most sites contain sediments overlying the archaeological horizon, varying from thick strata (ST3) and moderately thick strata (ST4 & ST30) to thin deposits (ST2A, ST15 & ST32), and lack of overlying sediments (ST31 & ST2B,C,D,E).

Test excavations have yielded the same kind of carbonated materials adhered to the tuff surface. In all these sites, archaeological materials also appeared on the surface of the slopes due to erosion. These surface materials were also documented as belonging to these sites because of the following reasons:

In Maritanane, clusters of surface archaeological materials are spatially restricted to the localities where sites have been documented to exist *in situ* through excavations.

Therefore, there seems to be a lack of significant transportation due to erosive processes. The densities of the material observed on the surface are similar to those documented through excavation in the same localities.

In the whole area of Maritanane, no archaeological materials have been retrieved above the horizon documented on T1 in the USC. There is no difference whatsoever in raw material types, technology and morphology of the artifacts collected on the surface from those unearthed through excavation. Most of the materials (both faunal and lithic) appear fresh, without any traces of erosion from exposure.

Despite these observations, to further ensure that the archaeological remains on the surface belonged to the same archaeological horizon identified on T1, only those remains observed on the upper parts of the slopes, right under T1 were included in this study. The ST6 site was not included in the present analysis, because even if faunal remains and stone tools have been documented in it, none of it has been collected so far.

Archaeological materials included in this study, thus, come from three sources: surface, *in situ* on the tuff paleosol exposed and *in situ* through excavation. Test excavations were carried out at all sites (except ST6, ST31 and ST32) to establish relationships between materials unearthed and those adhered to the paleosol surface exposed. These relationships were expressed in terms of density, taphonomy (preservation stages of fauna, types and sizes of bones represented, orientation, abrasion, polishing, taxonomy), technology and raw material types used in the elaboration of the artifacts discovered. The sedimentological and taphonomical analyses of the carbonate surfaces of the tuff exposed proved that the archaeological materials were adhered to the tuff in the past and not as a result of recent re-elaboration and carbonating of sediments.

In some cases, anatomical parts of the same animal were found both in the horizon covered by sediments and the horizon exposed on the paleosol surface exposed. The carbonate sediment on top of the tuff was indistinguishable from that documented under the sedimentary deposits. The same density of materials and the same taphonomic results were obtained in both buried and exposed archaeological contexts, further supporting their common provenience.

Bone preservation in the ST complex is not very good. A significant amount of the bone sample contains specimens with cortical surfaces damaged by carbonate crusts, water etching and weathering. A smaller amount of specimens show better preservation, especially around ST4. Only the bones with intact or well preserved cortical surfaces were used for the analysis of bone surface modifications.

The distributions of artifacts and faunal remains was plotted by using a laser theodolite. A careful topographic map of the main gully and the surrounding area embodying the ST site complex was made to plot archaeological materials more accurately. All the main geological features, especially the web of faults of the gully were also recorded. This allowed a 3D reconstruction of the paleotopography of the area, featuring the main characteristics of the paleolandscape and site distribution therein (Figure 5).

## The Oldowan Industry

### *Raw materials*

The difraction X-ray analyses and the mineralogical analyses have resulted in the identification of several types of basalt (basanites, aphiric basalts, hawaian basalts and aphitic basaltic tuffs), as well as piroxenic nephelinites and quartz.

Nevertheless, only three types of raw materials are clearly differentiated de viso: basalt, quartz and nephelinite. Quartz is the most difficult raw material, of those represented, to be transformed through an organized knapping process.

A large variability in the properties of the basalts that hominids used in Type Section has been documented. Some artefacts were elaborated from very fine-grained basalts, which are very apt for flaking. Other basalts are very porous, thick-grained and with internal irregularities. Conchoidal fractures would have been very hard to obtain from this type of basalts. Nephelinite must have been highly appreciated by hominids, since it is fine-grained and produces very sharp-edged tools without internal vesicular irregularities. Thus, nephelinites and some basalts were the most adequate raw materials for tool elaboration.

Raw material sources have not yet been precisely identified. As pointed out previously, Type Section is composed of deltaic sediments. Depositional energy is, thus, very low and the sedimentary matrix is fairly fine-grained, missing conglomerate deposits. So far, no gravel or conglomerate level exposed during the formation of the Humbu Formation has been discovered.

Basalt is the predominant raw material type in the ST Site Complex industry, comprising 74.3% of the total number of stone artefacts. Nephelinite is represented by 16.9% of all the lithic tools. The presence of quartz is smaller (8.6%), although in some sites, such as ST2E or ST3, it is more abundant than nephelinite (Table 1). With respect to the representation of raw materials according to artefact type, quartz seems to have been used mostly for hammerstones.

The remaining tool types are evenly made in basalt and nephelinite. Detached pieces (flakes, debris and flake fragments) are mostly made of basalt (75.4%), nephelinite (18.4%) and quartz (5.3%).

| % | NEPHELINITE | BASALT | QUARTZ |
|---|---|---|---|
| ST30 | 14,5 | 75,8 | 9,7 |
| ST15 | 16,7 | 83,3 | - |
| ST31 | 17,1 | 82,9 | - |
| ST32 | 43,8 | 56,3 | - |
| ST3 | 15,6 | 62,5 | 18,8 |
| ST4 | 16,3 | 67,3 | 16,3 |
| ST2A | - | 100 | - |
| ST2C | 18,3 | 80,5 | - |
| ST2D | 66,7 | 33,3 | - |
| ST2E | 11,5 | 73,1 | 15,4 |
| ST2G | - | 80 | 20 |
| TOTAL N | 60 | 263 | 29 |
| TOTAL % | 16,9 | 74,3 | 8,2 |

*Table 1: Percentages of the representation of the diverse raw material types in the St Site Complex.*

*Table 2. Percentages of artefact types in the ST Site Complex.*

| % | Unmodif pieces | Hammer-stones | Cores | Retouched Flakes | Flakes | Flakes Frags | Chunks | Chips | Total |
|---|---|---|---|---|---|---|---|---|---|
| ST30 | 11,3 | 4,8 | 8 | 4,8 | 14,5 | 32,3 | 19,4 | 4,8 | 17,5 |
| ST15 | - | - | 16,7 | 16,7 | 16,7 | 33,3 | 16,7 | - | 1,7 |
| ST31 | 4,9 | 4,9 | 17* | - | 14,6 | 43,9 | 12,2 | 4,9 | 11,6 |
| ST32 | - | 6,3 | 18,8* | 6,3 | 25 | 31,3 | 12,5 | 6,3 | 4,5 |
| ST3 | - | 6,3 | 9,4 | 15,6 | 25 | 25 | 9,4 | 9,4 | 9 |
| ST4 | 6,1 | 2 | 12,2 | 6,1 | 24,5 | 26,5 | 10,2 | 12,2 | 13,8 |
| ST2A | - | - | - | 16,7 | - | 50 | 33,3 | - | 1,7 |
| ST2C | - | - | 2,4 | 9,8 | 24,4 | 30,5 | 30,5 | 2,4 | 23,2 |
| ST2D | - | - | - | 33,3 | - | 33,3 | 33,3 | - | 0,8 |
| ST2E | - | - | 5,8 | 7,7 | 26,9 | 23,1 | 25 | 11,5 | 14,7 |
| ST2G | - | - | - | 20 | 40 | 20 | 20 | - | 1,4 |
| **TOTAL N** | **12** | **9** | **29** | **28** | **76** | **108** | **70** | **23** | **354** |
| **TOTAL %** | **3,4** | **2,6** | **8,2** | **7,9** | **21,5** | **30,5** | **19,8** | **6,5** | **100** |

Light-duty tools are also distributed, according to raw material type, in similar percentages: basalt (77.8%), nephelinite (18.5%) and quartz (3.7%). Cores are made in basalt (72.4%), nephelinite (24.1%) and quartz (3.4%). Therefore, raw material use in the ST Site Complex is similar to its distribution in the landscape. Basalt is the most abundant rock type. Nephelinite and quartz are more geographically located and limited in distribution. Their exploitation by hominids, thus, was more ocassional.

*Tool types*

Detached pieces are the most abundant tool type (Table 2) in all the lithic assemblages from the ST Site Complex. They make up 66.4% of the total number of artefacts. Flake fragments are predominant (30.5%), followed by complete flakes (21.5%). Debris (6.5%) is scarcer, supporting a slight taphonomic bias in the preservation of lithic component of the assemblages in the ST Site Complex. Cores are represented by 8.2% of all the artefacts retrieved, and retouched flakes constitute 7.9%. Approximately 22% of these retouched pieces were made from complete flakes. The remaining retouched artefacts were made on flake fragments. The size of these retouched tools is similar to the average size of regular flakes (**Table 3**). Light-duty scrapers (*sensu* Leakey, 1971) are the most abundant retouched elements (71.4%), followed by notches (17.8%) and endscrapers (7.1%) (Figure 7).

Flakes are 40 mm long on average (Table 3). Their quadrangular shape is even in all the assemblages from the ST Site Complex. This is indicative of both similar flaking processes and homogeneous core volumes in all these sites. Pieces showing cortical surfaces are rare. Only 20.6% of flakes and flake fragments show some cortical areas and none of them belong to the initial flaking stage. Knapping and tool making is supported by the presence of cores, hammerstones and rejuvenation flakes.

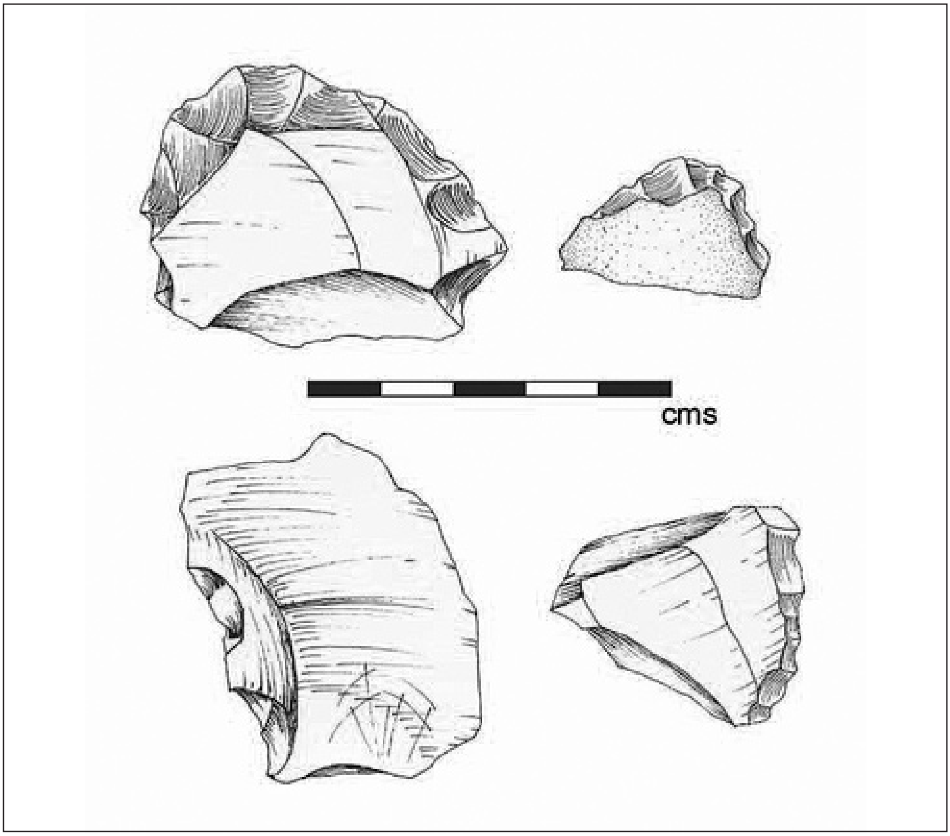


*Fig. 7. Some light duty scrapers of the ST site complex (Drawn by Noemi Morán).*

| | Length (mm) | Width (mm) | Thickness (mm) | Weight (gr) |
|---|---|---|---|---|
| Unmodified pieces | 82,42 | 70,42 | 61,92 | 529,83 |
| Hammerstones | 67,29 | 58,29 | 53,71 | 435,22 |
| Cores | 59,43 | 70,20 | 61,80 | 423,00 |
| Retouched Flakes | 42,54 | 37,36 | 15,50 | 33,89 |
| Flakes | 40,49 | 36,63 | 12,30 | 24,93 |
| Flake Frags. | 35,60 | 32,36 | 12,53 | 20,06 |
| Chunks | 31,46 | 21,57 | 11,06 | 15,76 |
| Chips | 16,83 | 13,91 | 4,87 | 1,52 |

*Table 3. Mean sizes of the artefacts from the St Site Complex.*

However, the paucity of cortical elements indicates that the initial flaking of cores took place somewhere else outside.The technological attributes of flakes also supports this. Approximately, 90.9% of the striking platform of flakes show no cortex at all. This indicates that either the striking platform was prepared before flaking or that previous flakes had been obtained in the same direction. Striking platforms are mostly uni-facial (79%), although bifacial (8.4%) and multi-facial (3.5%) striking platforms are also documented, suggesting that there was a redundant care in the extraction of flakes with determined characteristics. The analysis of the dorsal surfaces of flakes is also relevant to reconstruct the technological strategies used by hominids.

More than 70% of the flakes analysed show 3 or more negative scars from previous flaking. The presence of these previous flaking does not show *per se* the complexity of the knapping process. However, the high percentage of flakes this type indicates that hominids were repeatedly exploiting the same flaking surfaces.

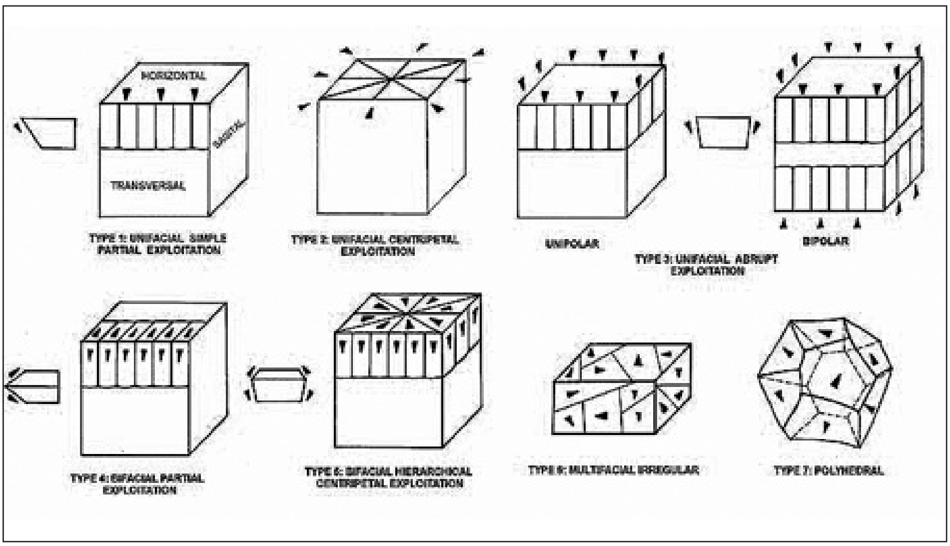


*Fig. 8. Ideal schemes of the exploitation methods documented in the ST site complex.*

*Core types*

Our core classification (de la Torre et al. 2003) is based on the consideration of cores as geometric volumes in which, at least, six schematic surfaces have been differentiated.

Flaking on these surfaces and the resulting interaction among them result in unifacial, bifacial, trifacial and multifacial systems. The directionality of flaking allows the distinction of unipolar, bipolar and centripetal strategies. The angle formed by the intersection of the different exploited surfaces can be described as simple or as abrupt.

Considering all these attributes together, the exploitation strategies followed by hominids and documented in the ST site lithic assemblage are (Figure 8):

<u>Type 1</u>. Unifacial simple partial exploitation. It is represented by choppers. Flaking takes place on a surface generated by the natural or cortical plane. The striking platform and the flaking surface adopt an acute angle; that is, the edge appears only on part of the perimeter of the core.

<u>Type 2</u>. Unifacial centripetal exploitation. It consists of the exploitation of the horizontal plane from both the sagittal and transversal planes. Flaking is carried out from unprepared striking surfaces. It is differentiated from Type 1 in the development of the edge, which now occupies all the perimeter of the core. In addition, the only exploitation (flaking) surface is generated through radial flaking.

<u>Type 3</u>. Unifacial abrupt exploitation. It can also be defined as the exploitation of the transversal and/or sagittal plane from one or two of the horizontal planes. Thus, from natural or prepared striking platforms, parallel and longitudinal flakes are obtained. The flaking surface forms a straight percussion angle with respect to the striking platform.

Type 4. Bifacial partial exploitation. It is the strategy documented for chopping tools or bifacial choppers. The negative scars of flaking on one plane are used as the striking surface to flake the adjacent plane. A configuration edge is obtained this way with a simple angle. The edge occupies only a determined area of the piece and not all its perimeter.

Type 5. Bifacial hierarchical centripetal exploitation. The geometric volume of these cores is divided into two asymmetrical convex surfaces which share an intersection plane. The surfaces are hierarchical; the subordinate surface acts as a preparation plane to obtain the radial flakes that characterize the main surface. Besides, the striking surface is oriented with respect to the flaking surface in a way in which the edge created by the intersection of both surfaces is perpendicular to the knapping axis of the centripetal flaking.

Type 6. Multi-facial irregular exploitation. This group is constituted by the cores that present several exploitation surfaces without a clear organization in the reduction process. In the ST Site Complex, cores of this category are always small-sized and with hardly any cortex. This suggests that they may be overexploited cores which could have been more systematically flaked in a previous stage of the reduction sequence.

Type 7. Polyhedral exploitation. It is similar to type 6. It consists of cores exploited from several planes or striking surfaces. However, in this case, it is supposed that the striking surfaces are intentionally chosen to shape the artefact or, at least, there is a tendency for cores to become spherical.

Even if the hierarchical centripetal exploitation is the most common strategy used by the Peninj hominids (30%), type 3 (unifacial abrupt) is also frequently represented (20%), as well as type 6 (multi-facial irregular) (20%) and type 2 (unifacial centripetal) (16.7%). Unifacial choppers (type 1), bifacial choppers (type 4) and polyhedrons (type 7) are poorly represented (3.3%, 6.7%,and 3.3%, respectively).

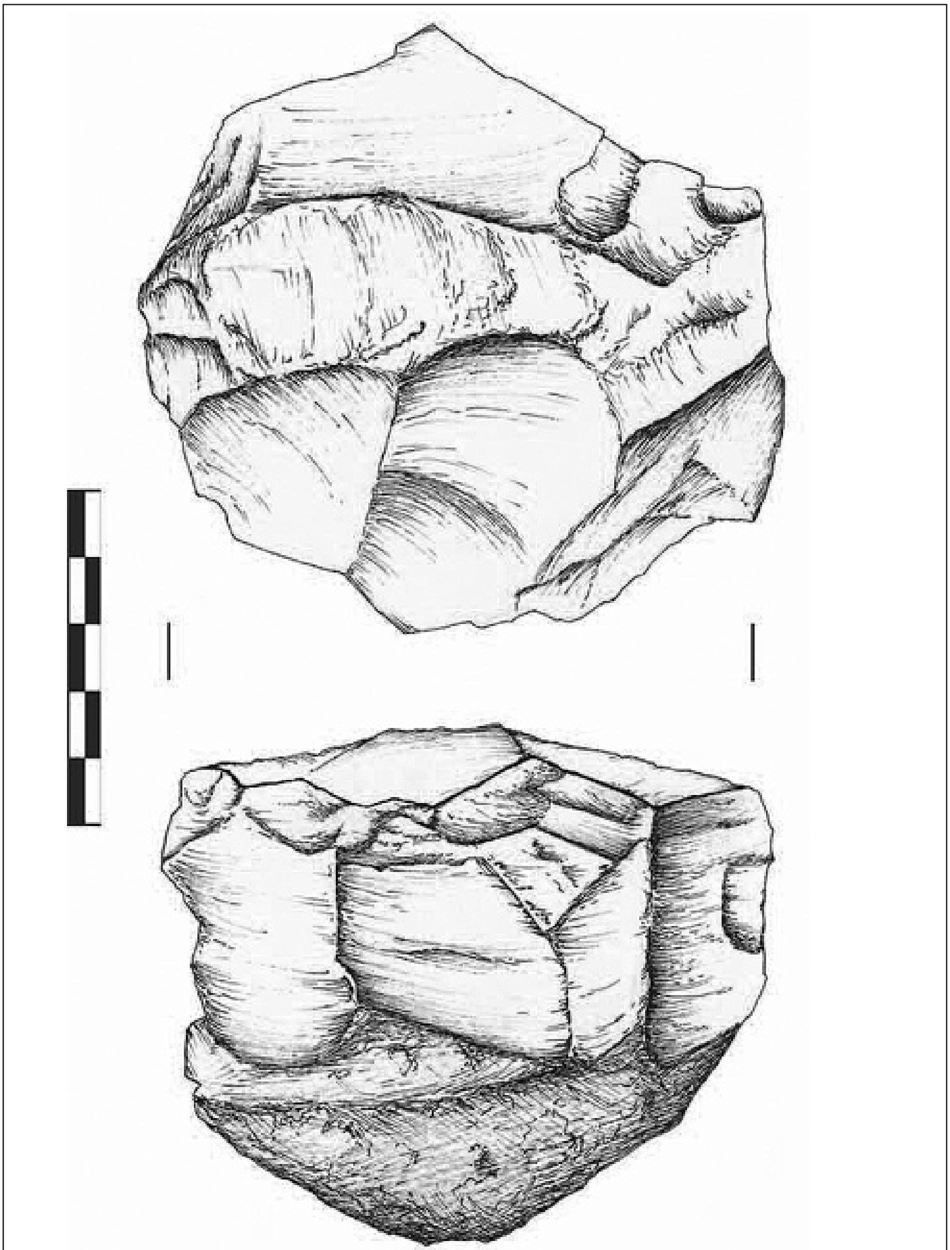

*Fig. 9: Hierarchical bifacial centripetal core from the ST site complex in a initial reduction stage (Drawn by Noemi Morán).*

Basalt has been more extensively used in all the exploitation strategies. The only exception in which nephelinite becomes more abundant than basalt is in the representation of the multi-facial irregular cores, with 50% and 33.3% respectively of the cores of this category.

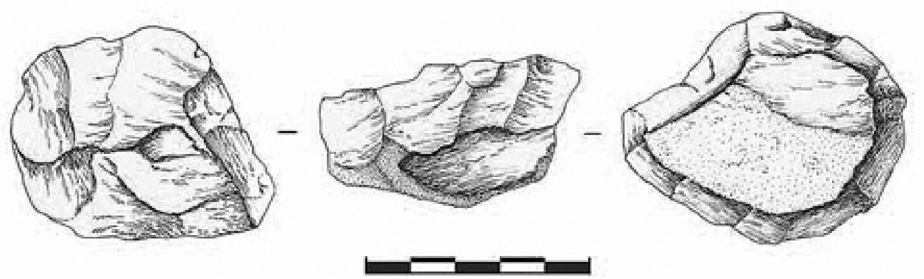

*Fig. 10. Exhausted hierarchical bifacial centripetal core from the ST site complex in a final reduction stage.*

*Table 4: Total number of faunal specimens recovered in the ST site complex.*

| | ST30/31/32 | ST15 | ST3 | ST4 | ST2 |
|---|---|---|---|---|---|
| Macromammals | | | | | |
| Identifiable | 55 | 58 | 39 | 296 | 129 |
| Skull | 6 | 8 | 9 | 54 | 15 |
| Axial | 5 | 17 | 8 | 53 | 26 |
| Appendicular | 44 | 33 | 22 | 189 | 88 |
| Non-identifiable | | | | | |
| Axial | 26 | 18 | 22 | 118 | 167 |
| Appendicular | 22 | 54 | 48 | 71 | 43 |
| Total macromammals | 103 | 130 | 109 | 485 | 339 |
| Chelonia | 4 | 19 | 36 | 43 | 51 |
| Reptilia | 3 | 0 | 2 | 13 | 7 |
| Aves | 1 | 0 | 0 | 0 | 0 |
| Pisces | 212 | 0 | 0 | 0 | 0 |
| Crustacea | 0 | 0 | 0 | 6 | 6 |
| TOTAL | 323 | 149 | 147 | 547 | 547 |

The bifacial hierarchical centripetal strategy of core exploitation (type 5, our classification) is fairly complex, since a bifacial flaking process is obtained through the creation of an artificial edge of configuration, keeping this structure throughout all the flaking process (Figure 9). This bifacial structure is not maintained by simply alternating the impacts on both sides (discoid method), but through the configuration of one of the surfaces as a subordinate plane used to exploit the principal surface.

The maintenance of the adequate convexities of such a surface is a key part of the process. This explains the redundancy in creating rejuvenation flakes used to recreate the necessary angles and to continue reducing the core until its exploitation is not feasible anymore (Figure 10). This process is documented by several examples from the ST Site Complex and reveals that Peninj hominids had the capabilities to undertake complex reduction processes from a bifacial edge and to keep them through the whole flaking sequence.

## Faunal Analysis

The total number of faunal specimens recovered from the ST site complex is summarized in Table 4. The specimens are distributed in the area exposed. The higher number of specimens documented in ST4 is due to a more prolonged and extensive excavation that has taken place at the site.

Because of this reason, the information provided by the analysis of  the faunal remains from this site is presented separately from the remainder of sites, where only test trenches have been carried out.

The taxa identified so far in the ST site complex archaeofauna are: *Ceratotherium simum, Hipparion* cf. *cornelianum, Equus* sp., *Sivatherium maurisium, Giraffa* cf. *pygmaea, Synceros* sp., Tragelaphus *strepsiceros, Megalotragus kattwinkeli, Connochaetes taurinus, Damaliscus niro, Hippotragus* sp., *Aepyceros melampus, Sylvicapra* sp., *Antidorcas* cf. *recki, Gazella* sp, *Kolpochoerus* sp., *Metridichoerus compactus* and *Theropithecus* sp. (Geraads 1987; our fieldwork).

A taphonomic study of the fauna based on specimen size distribution, skeletal part representation and bone abrasion and polishing was conducted to evaluate the influence of water in the bone accumulation at all these sites. Most specimens do not show the abraded and polished surfaces and edges typical of water transport. More than 95% of the specimens do not seem to have undergone any significant transport beyond local rearrangement.

The only exception seems to be the bone assemblage recovered from ST3. There, as many as 19% of the specimens show polishing on some of the edges and moderate abrasion on the surfaces typical of water modified assemblages. In this case, either hydraulic transport or local water erosion seem to have been operating in the site. Some of these specimens are located in a coarse-grained sand deposit in a river channel indicating a high energy context.The distribution of specimen sizes also indicates lack of transport. Most ST archaeological sites show a percentage of specimen sizes similar to experimental assemblages that have not undergone any water transport and also similar to some archaeological sites in low-energy depositional environments for which non-significant hydraulic transport is inferred.

The high percentage of small-sized specimens (between 20 and 50 mm.) indicates that most of the faunal assemblage was deposited by non-hydraulic agents in the same are from which it was recovered. Further support for this statement comes from the types of elements represented. Axial, cranial and appendicular elements appear associated in the same sites, despite the differences in density factors.

From the 1544 identifiable mammal bone specimens, a total Minimum Number of Elements (MNE) of 306, belonging to different anatomical parts, has been documented. MNE identification for long limb bones was made within each animal group by examining bone specimens individually and using the following criteria: animal size, cortical thickness according to bone section, overlap of homologous parts, differences in size and morphology.

There is a small number of limb bone epiphyses, so most of the diagnostic criteria were applied in identifying the abundant shaft fragments. Specimens were compared against one another to make sure they belonged to different elements before using them as valid MNE indicators. These estimates very likely underestimate the total number of bones originally present in the bone accumulation at the ST sites.

By transforming the MNE obtained in the different ST sites into Minimum Animal Units (MAU), an overall underrepresentation of animal units according to the MNI (Minimum Number of Individuals) can be observed in the bone assemblage.

When the percentage of these animal units (% MAU) is calculated, the axial parts of the skeleton (vertebrae and ribs) and the small compact limb bones (carpals, tarsals and phalanges) appear underrepresented.

This situation is documented in all the sites irrespective of animal size. Pelves and scapulae are also moderately represented. Long limb bones are dominant, when skull remains are ignored. Upper limb bones (ULB) (humeri and femora) and intermediate limb bones (ILB) (radio-ulnae and tibiae) are represented by similar number of elements, although ULB seem to be more abundant in most animal size categories.

Metapodials are, comparatively, underrepresented. Curiously, forelimbs seem to be more abundant than hindlimbs. This situation was documented in all the ST sites.

| | Smaller mammals | | Larger mammals | | TOTAL | |
|---|---|---|---|---|---|---|
| Tooth marks | N | % | N | % | N | % |
| Upper limb bones | 2/46 | 4.3 | 1/12 | 8.3 | 3/58 | 5.1 |
| Intermediate limb bones | 1/51 | 1.9 | 1/11 | 9.0 | 2/62 | 3.2 |
| Lower limb bones | 2/28 | 7.1 | 0/4 | 0 | 2/32 | 6.2 |
| Total | 5/125 | 4.0 | 2/27 | 7.4 | 7/152 | 4.6 |
| Percussion marks | N | % | N | % | N | % |
| Upper limb bones | 12/46 | 26.0 | 3/12 | 25.0 | 15/58 | 25.6 |
| Intermediate limb bones | 11/51 | 21.5 | 3/11 | 27.2 | 14/62 | 22.5 |
| Lower limb bones | 1/28 | 3.5 | 0/4 | 0 | 1/32 | 3.1 |
| Total | 24/125 | 19.2 | 6/27 | 22.2 | 30/152 | 19.7 |

*Table 5: Total numbers and percentages of tooth and percusión marks (shaft specimens).*

The low representation of ribs, vertebrae, compact limb bones, the low epiphisis:shaft ratio and the significant tooth marking of epiphyseal fragments support the hypothesis of significant carnivore involvement in the formation of the faunal assemblages at the ST site complex.

*Bone weathering*

Given the structural difference of axial, cranial and appendicular bones, long limb bone weathering analyses in the ST site complex were focused on shaft fragments from long limb bones alone.

From the sample of bones that had not been affected by diagenesis, specimens from the ST4 showed the largest amount of best preserved surfaces with stages 0 and 1 being predominant. ST2 showed a wider variety of weathering stages, being stage 1 predominant and with some specimens showing stages 2 and 3. ST3 is similar to ST2. ST15 showed mostly fresh bone surfaces with only 25% of the specimens showing weathering stage 2 features.The ST30, ST31 & ST32 complex showed a curious distribution. Most of the bones analyzed for weathering purposes from these sites came from ST30.

Bone specimens range between fresh O stage (43%) and weathering stage 3 (57%). In this case, it can be clearly observed that the fresh bones belong to small fauna and the more weathered specimens are from larger fauna, especially the postcrania of a Bovini.

This would rule out differential preservation in bones of the same carcass and would support an interpretation of weathering in this site as an indicator of the time of the total bone accumulation.

Most of the bone assemblage from ST4 and ST15 would have been accumulated in relatively little time, whereas ST2, ST30, ST31 and ST32 seem to have spanned a longer period, probably involving several occupational episodes.

An alternative explanation would be that the bones representing weathering stages 2 and 3 are a small part of the sample, which could result as a background scatter from previously to the hominid intervention in the area. Future research will grant further support to either interpretation.

*Bone surface modifications*

Results from the analysis of bone surface modifications and their anatomical distributions are presented in table 5. Tooth marks have been observed in almost one out of two epiphyses from limb bones and one out of three rib fragments. Tooth marks occur in a fairly low percentage (4.6%) on limb shaft fragments, with a moderately higher percentage in large-sized carcasses (Table 5). Metapodials appear tooth marked at a higher rate than meat-bearing bones.

Percussion marks occur in all limb bone types. The contrast of their occurrence in meat-bearing bones compared to metapodials is fairly marked. Percussion mark rates are broadly similar in both carcass size categories.

Both percussion marks and tooth marks at the ST site complex support the hypothesis that hominids had primary access to carcass resources, both meat (low tooth mark percentages) and marrow (percussion mark percentages).

Tooth mark occurrence on shaft fragments appears in the lower range of variation of the Hominid-Carnivore dual-patterned experimental model (Blumenschine, 1988, 1995: Capaldo, 1995, 1998).

Cut mark patterns also support this behavioral inference: From the 154 bone fragments showing weathering stage O, several were smaller than 50-40 mm and hard to identify to element type (i.e., humerus or femur), even when limb section (i.e., upper limb bones) could be ascertained in several cases.

Overall cortical thickness and a reduced section of the shaft rendered the differentiation between intermediate and lower limb bones difficult to identify in several specimens smaller than 5 cms. A total of 90 shaft bone fragments showing weathering stage 0 were classified to element type. The resulting cut mark pattern shows a high proportion of cut marked upper limb bone shaft specimens, followed by intermediate and lower limb bone fragments.

Both in smaller mammals and larger mammals, the cut mark patterns are broadly similar. Furthermore, mid-shaft specimens are cut marked in a much higher percentage than limb bone ends. Only two epiphyses (two proximal radii from size 3 carcasses) bear cut marks on the near-epiphyseal section. The remainder of the cut marks have been documented on mid-shaft sections.

Further, a large portion (>75%) of meat-bearing mid-shaft specimens are cut marked in both carcass sizes. This is indicative of intensive defleshing (Dominguez-Rodrigo 1999). If taken together, the bone surface modification evidence reflects primary hominid access to fleshed carcasses as modeled in Hominid-Carnivore experimental scenarios (Dominguez-Rodrigo 1997, 1999).

The main difference observed between these experiments and the ST archaeofauna -which for the analysis of cut marks comes mostly from the well-preserved bone assemblage excavated at ST4- is the scarcity of cut marked limb ends. Therefore, the only carcass processing activity that can be reconstructed with the current information available is carcass defleshing, but not disarticulation. This could be a reflection of hominid behavior or sampling bias. Cut marks have been observed in all the ST assemblages (except ST3), although in smaller amounts than in ST4.

## Conclusions

The paleosol exposed horizontally at Maritanane, spanning an area close to 1 km2, offers a unique opportunity to assess hominid behavior across a paleolandscape. Although small scatters of archaeological remains have been discovered in some spots of this paleolandscape, most archaeological materials are concentrated in the ST site complex area.

The detailed geological analysis of the area shows that the ST sites were situated in an alluvial setting in a deltaic environment at the intersection of several river channels. Although isotopic analyses should confirm it, the abundance of fossil root casts from plants bigger than grasses suggests some degree of closed vegetation.The widespread nature of all the archaeological materials at the ST sites contrasts with the discrete densities documented at Koobi Fora (Kenya) and Olduvai Gorge (Tanzania).

The existence of spatially differentiated bone concentrations, the different degrees of weathering on limb bone shafts and the overall low densities of materials (both of stones and bones) supports the interpretation that the ST site complex represents an overlaping set of loci in the alluvial landscape of Maritanane that hominids created by repeatedly visiting the area.

Carcasses may have been obtained in or near that alluvial setting. Remains bearing cut marks and belonging to large-sized animals such as rhinoceros and *Sivatherium* suggest that hominids obtained carcasses in the same area. The *Sivatherium* remains at ST4 indicate that they belonged to the same individual, which was complete when processed by hominids.

If the alluvial area was not very open, the abundance of antilopini and alcelaphini would be indicative of their transport by hominids from the nearby more open areas. Regardless, most game could have been obtained very close to the ST sites given the overall open nature of the landscape (Dominguez-Rodrigo et al. 2001a).

Most likely, carcasses were fully fleshed when transported to sites, as indicated by the percentages and distribution of cut marked and tooth marked bone specimens. Based on a landscape taphonomy study in the area, there was a high degree of carnivore competition in Maritanane during the formation of the paleosol.

This contradicts the widely accepted scavenging scenarios proposed to account for early hominid behavior. In fact, the ST site complex at Peninj suggests that hominids were obtaining and transporting fleshed carcasses to certain areas and then, leaving these places after processing the carcasses. The behavior reconstructed implies a substantial degree of complexity, planning and dynamic interaction with the environment to obtain carcasses, in which predatory strategies on small and middle-sized animals should seriously be considered.

The analysis presented in this work also suggests that the industry from the ST Site Complex of Peninj corresponds mostly to flaking activities carried out at sites. This is inferred by the predominance of flakes and cores.

The initial stages of the operational chain (raw material obtainment, initial core flaking) are absent. These unrepresented phases were probably carried out outside the ST Site Complex area. This process must have included not only the initial debitage of cores, but also posterior flaking stages, since the percentage of flakes showing some cortex is always low. However, flaking activities *in situ* are clearly documented as suggested by the presence of split fractures, the abundance of flakes and cores and the presence of hammerstones.

These flaking activities were very likely related to carcass processing behaviors, as indicated by the close spatial association of bones and stone tools and the presence of cut-marked bone specimens.Indeed, the technology displayed by the Peninj hominids is fairly complex; the aim of this technical process is the preparation of the extractions on the main flaking surface of the cores, in order to obtain predetermined flakes.

This predetermination is similar to the Levallois method, which modifies raw materials from a volumetric conception of cores. The cognitive processes, the technical knowledge and the manual dexterity behind both strategies are very similar.

Assuming the complexity of the Levallois method and its similarities with the strategies observed in Peninj, it seem necessary to revise the technology of traditional Oldowan industries and the cognitive and behavioural inferences for Plio-Pleistocene hominids drawn thereof.

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# Technological Developments in the Oldowan of Koobi Fora: Innovative Techniques of Artifact Analysis

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## Introduction

The wealth of new information on the Early Stone Age (Kimbel et al. 1999, Kibunjia 1994; Semaw et al. 1997; Plummer et al. 1999) has led to recent discussions on the nature of Oldowan hominid technology (Kibunjia 1994; Semaw 2000; Roche et al. 1999; Roche 2000). The tempo and configuration of technological change in the Plio-Pleistocene has risen as a key factor in understanding early human behavior.

However, the study of early human technology is hindered by the limited ability of contemporary methodologies to tease apart the complex set of influences affecting artifact morphology. The rich history of research in the Oldowan has focused almost exclusively on variation within various forms of Mary Leakey's (1971) typological framework. New manifestations of this landmark work have modified the original typology to rid analysis of a priori functional or cultural assumptions (Isaac 1984; Rogers 1997; Rogers et al. 1994). However, the smallest unit of analysis has usually remained at the level of counts of artifacts within these categories.

To more fully understand behavior in the Plio-Pleistocene it is necessary to explore the ecological clues within hominid technologies. This requires studying technology beyond the inferential level of typological classification.

A study of the complex interaction of hominids and their physical and natural environment would prove very difficult through the filter of typology. We hypothesize that quantifiable differences in the morphotechnical attributes of artifacts represent behaviorally significant changes in resource utilization. This hypothesis implies that access to resources that were vital to the survivorship of Plio-Pleistocene hominids is manifested in variation within the form of artifacts. Hominid technology represents a conduit between the hominid and access to resources such as meat and marrow. The morphology of artifacts is the expression of selection pressures on hominids to gain access to these resources muted by availability of stone on the landscape.

Therefore, to study the ecology of hominids through artifact analysis it is necessary to include factors such as paleoecology and paleogeography. It is also necessary to focus on subtle complexities of form that reflect changes in hominid ecology. Rather than representing artifact form as a nominal attribute (e.g. chopper vs. discoid, or even flaked piece vs. detached piece) it is imperative to study artifact form as a metric attribute.

In this way more complex patterns within hominid technology can be elucidated. Although we do not condone analyses done within a vacuum of typology, we believe that more complex patterns within hominid technology can be elucidated using more finite methodologies.

Here we employ digital image analysis, previously explored in younger archaeological assemblages (McPherron and Dibble 1999), to analyze aspects of Oldowan technology at sites from the Karari Ridge region of the Lake Turkana Basin in the Koobi Fora Formation. The sites in this study (FxJj 1, FxJj 3, FxJj 10, FxJj16, FxJj 18GL, and FxJj 20M) were excavated by a team of archaeologists from University of California, Berkeley during the 1970s under the supervision of one of us (JWKH) and the late G. Ll. Isaac (Isaac and Harris 1997).

The application of modern recovery techniques and unbiased selection make this one of the largest and most informative collections of Plio-Pleistocene archaeological material. We apply this new methodology to questions of technological evolution in the Lake Turkana Basin and outline a model for understanding resource use by Plio-Pleistocene hominids.

## Background

To test the previously stated hypothesis, assemblages chosen for study must have rich paleoecological contexts. Very few archaeological sites have been subjected to the full suite of paleoecological analyses that allow a complete picture of the environments of early human adaptation. Yet, the large interdisciplinary research projects of the 1970s and 1980s have provided a wealth of information about a handful of archaeological sites (Howell et al 1987; Isaac and Harris 1997).

We chose to test our hypothesis about the morphology of Oldowan artifacts on assemblages from the Koobi Fora Formation on the east side of Lake Turkana in northern Kenya. The Plio-Pleistocene sediments have been under almost continuous study since the late-1960s when Richard Leakey first discovered the region (Leakey 1970). Of particular relevance are the paleogeographical studies conducted by C. Feibel and F. Brown in the 1980s and 90s (Feibel 1988; Feibel et al. 1989; Brown and Feibel 1986).

These studies set the framework for the analysis of hominid behavior in this study. Their research dispelled the previous conception of a lake existing in the Turkana basin over the entire course of hominid occupation in the region (Rogers et al. 1994; Isaac and Harris 1997).

The current paleogeographical interpretation details that although a lake was present for part of the Plio-Pleistocene, a large river (i.e. Proto-Omo) was the major sedimentological agent in the basin. This study focuses on the sub-region known as the Karari/Abergaya Ridge because of the extensive database of information about sites from this area of the basin. Paleogeographic reconstructions posit that during the two main stages of hominid occupation, the east side of Lake Turkana had very variable landscapes (Brown and Feibel 1986; Feibel 1988; Feibel et al. 1989).

These two time periods, which are the focus of this study, are the KBS Member (1.89-1.65 Ma) and Okote Member (1.65-1.39 Ma) of the Koobi Fora Formation. During the Okote Member the Karari Ridge region was host to an oscillating system where a large meandering river gave way to a braided river system.

The KBS member represents a mosaic of landforms, with a large meandering river splaying into an extensive delta front against the shoreline of a diminutive proto-Lake Turkana. It is against this dynamic landscape that the Plio-Pleistocene archaeological evidence from the Koobi Fora Formation has been found.

The variation of archaeological entities within these 600,000 years has been the basis of important findings on ranging patterns, land use, and technological developments by Plio-Pleistocene hominids (Isaac 1976a,b; Harris 1978; Rogers et al. 1994). Initial descriptions of the archaeological material from the Abergaya/Karari Ridge focused on the nature of the archaeological record in this one area through time and across space.

Isaac (1976a,b, 1977, 1978, 1981) used the assemblages from the KBS Member to articulate perspectives on the nature and tempo of technology at the dawn of cultural evolution. Harris (1978; Isaac and Harris 1978) concentrated on the Okote Member, defining the Karari Industry and providing description for a period of the archaeological record that was previously understudied.

These two archaeological collections provide a framework for the current study of technological change in the Lake Turkana Basin. The variation between these two archaeological entities represents technological change which is the focus of our analysis. The sites from the KBS Member (FxJj1, FxJj3, and FxJj10) were excavated out of sediments that reflect the interface between a fluvial and lacustrine environment (Isaac and Harris 1997). The present paleogeographical reconstruction of the Turkana Basin suggests that these sites were situated in small channels that were part of a back delta swamp (Feibel 1988; Rogers et. al. 1994) (figure 1).

The Okote Member sites (FxJj 16, FxJj 18GL and FxJj 20M) were found in a variety of contexts (Harris 1978; Isaac and Harris 1997) but all are situated in an area further from basin axial sediments than the KBS sites. During Okote Member times lacustrine conditions were minimal (Feibel 1988; Rogers et al. 1994). The sites in the Okote Member are often associated with ephemeral stream sediments that had their headwaters on the eastern margin of the basin (Feibel 1988) (see figure 2).

The archaeological character of the two temporally separated groups of assemblages also emphasizes this dichotomy. Previous analyses call attention to the disparity in artifact density between these two groups (Rogers 1997; Rogers et al. 1994). The KBS Member excavations had very low artifact densities (figure 3). Comparatively the Okote Member excavations produced densities almost two orders of magnitude higher than their KBS counterparts.

The techno-typological character of these time periods is also notable. Original descriptions of the Okote Member assemblages underscored the prevalence of the characteristic "Karari Scraper" form (Isaac and Harris 1978; Harris 1978). Various chopper forms dominate the KBS assemblages. Large flake scrapers are rarely present in KBS Member assemblages, and when they appear they do not conform to the technological characteristics of the "single platform core" (Ludwig and Harris 1998).

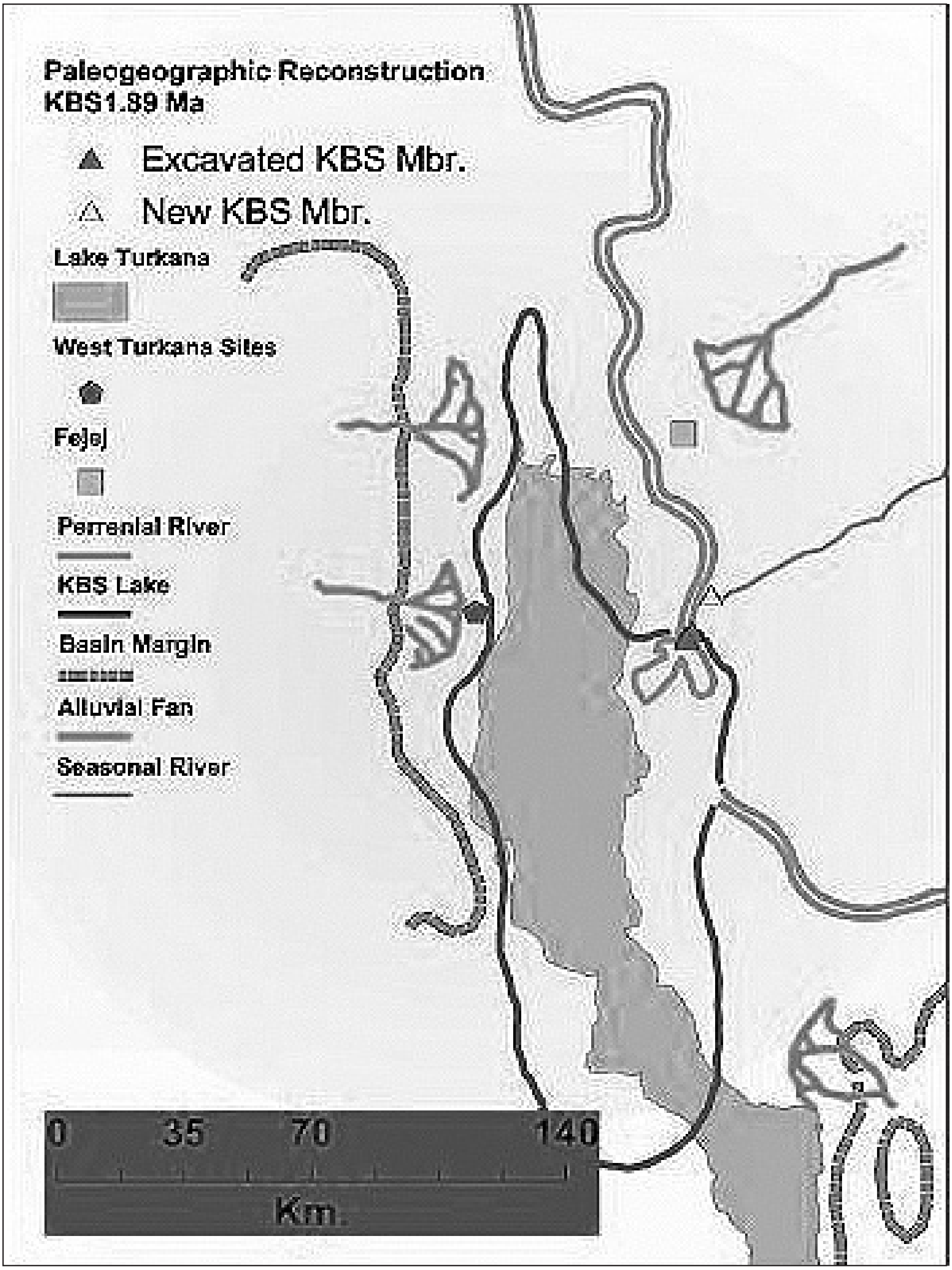



*Fig. 1 The present paleogeographical reconstruction and archaeological sites of the Turkana Basin from the KBS Member. Adapted from Feibel 1988.*

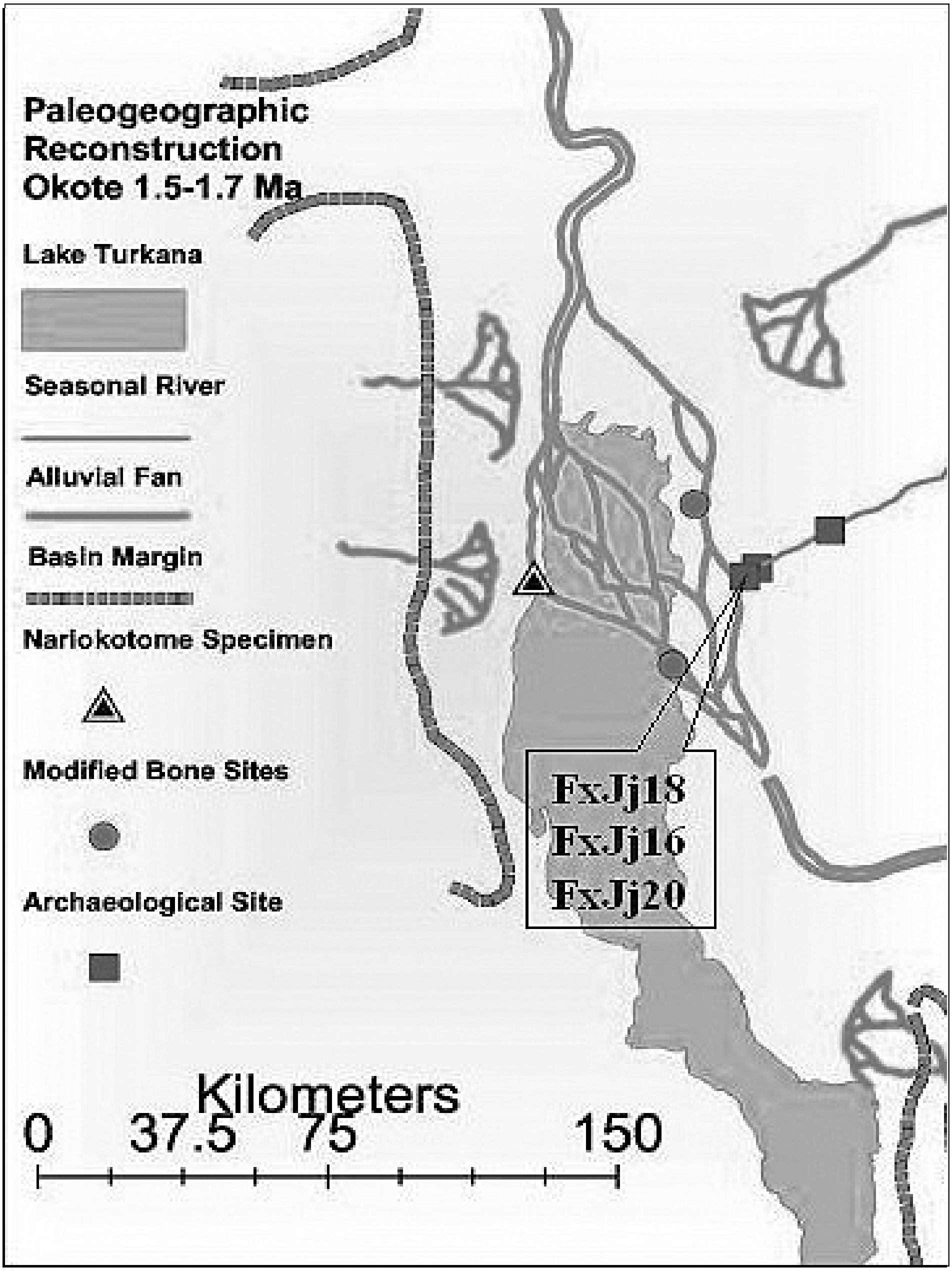



*Fig. 2 The present paleogeographical reconstruction and archaeological sites of the Turkana Basin from the Okote Member. Adapted from Feibel 1988.*

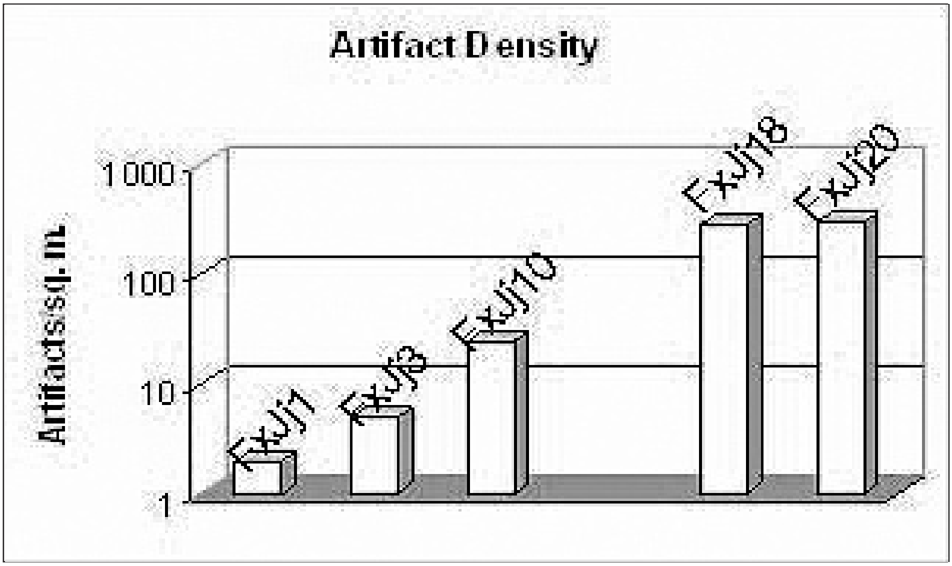
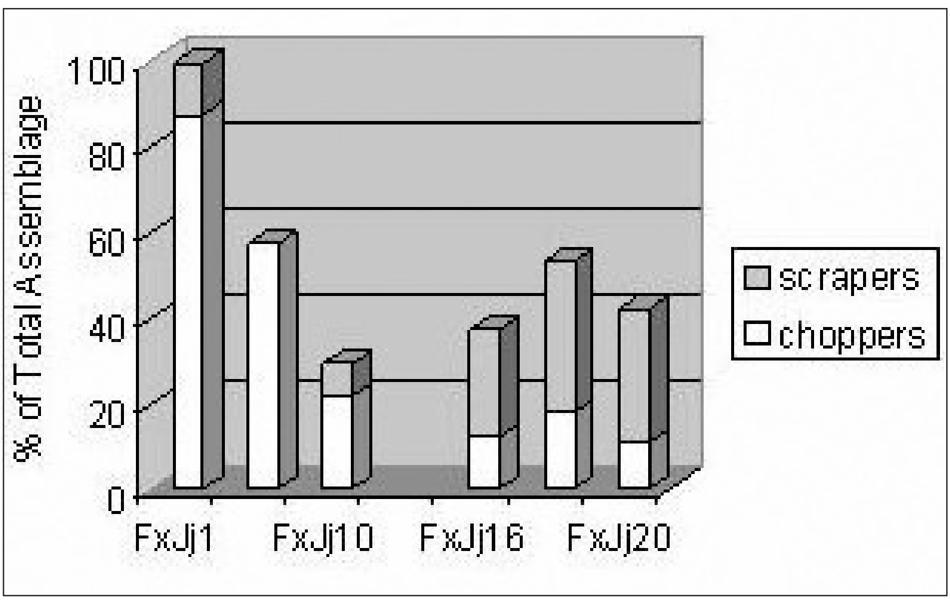



*Fig. 3. Artifact Density in different KBS and Okote sites. From Rogers et al. 1994.*

*Fig. 4. Ratio scrappers/choppers in different KBS and Okote sites. From Isaac 1997.*



A ratio of flake scrapers to chopper forms in sites from Koobi Fora reflect this difference (see figure 4).The archaeological assemblages from the Okote member represent a different pattern of behavior than that seen in the KBS member. It is precisely this variation that makes the Koobi Fora Formation a suitable setting for testing hypotheses on the coincidence of hominid behavior and morpho-technical patterns in the stone artifact record.

We believe that the differences in the archaeological record represent separate ecological contexts in the KBS and Okote Members. Artifacts represent the interface between hominids and their environment. Therefore artifact morphology should reflect the reorganization of the relationship between hominids and their natural and physical environment.

## Materials and Methods

### *The Case for Flakes*

In this study we focus exclusively on whole flake assemblages from six sites in the Koobi Fora Formations housed in the National Museums of Kenya in Nairobi. This analysis focuses on flakes exclusively because:

1) Whole flakes represent the most abundant artifact class of these Oldowan assemblages;

2) Whole flakes are likely one of the most functionally significant classes in the Oldowan toolkit (see below Toth 1986);

3) Whole flakes represent a singular technological event. In contrast to whole flakes, flaked pieces (FPs i.e. core tools) may be transported and successively modified and therefore may represent several different ecological contexts (i.e. resource availability Binford 1979).

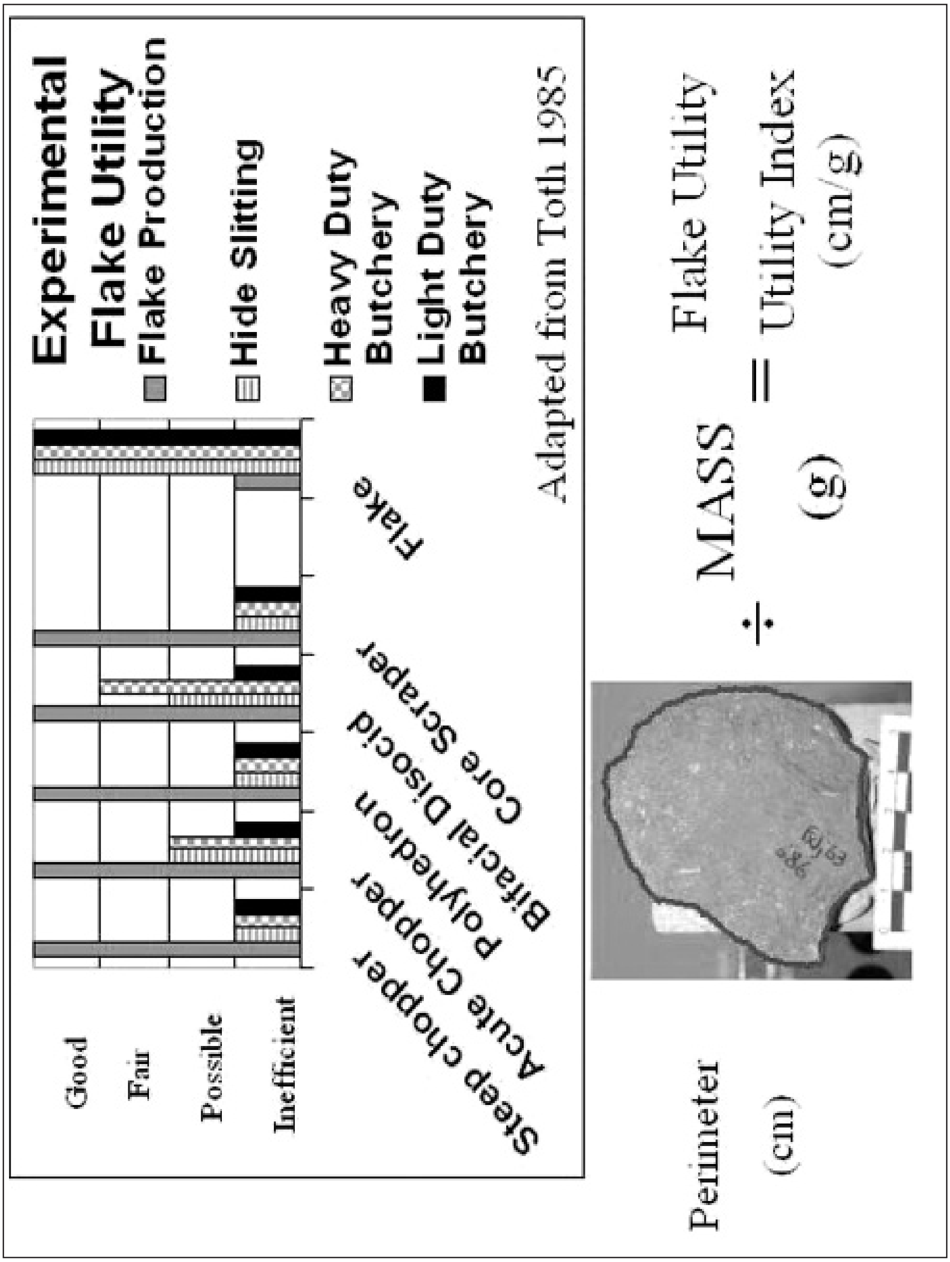



*Fig. 5. Experimental flake utility and functional significance of Oldowan tools Adapted from Toth 1985.*

In Isaac's (1977) inspection of early hominid technology he investigated the ecologic reason for the origins of cultural behavior. He described this behavior as a "least effort solution" to a sharp edge (Isaac and Harris 1997: 263).

Toth's (1986) work in the Koobi Fora Formation further developed this assertion and provided one of the earliest experimental perspectives on early hominid behavior. Toth's work provided an initial functional qualification of M. G. Leakey's typology (Leakey 1971). Toth's (1986) experiments suggested that although large core tools were an important aspect of early hominid technology, whole flakes were likely the most significant part of the early hominid toolkit.

Toth's experimental work provided a loose framework for understanding the functional significance of Oldowan tools. Toth ranked different tools according to their effectiveness in conducting certain tasks (see figure 5). Whole flakes score the highest in all of Toth's experiments. It is therefore likely that whole flakes represented a significant aspect of early hominid technology.

The importance of whole flakes in the Oldowan tool kit suggests that morpho-technical aspects of these artifacts will be very sensitive to changes in ecology of Plio-Pleistocene hominids. To identify these changes we focused on that aspect of flakes that is most closely tied to the functional impact of these artifacts: the edge (Sheets and Muto 1972).

To investigate edge production we standardized our measurement of flake edges by the mass of the artifact. The resulting formula is simplistic but possibly represents an easy quantification of the meaning of a flake to an early hominid: (flake edge (cm)) / (flake mass (g)) = ("flake utility" (cm/g)). Measures similar to this utility measure have been used experimentally (Sheets and Muto 1972) and in younger assemblages to measure increases in mobility (Roth and Dibble 1998).

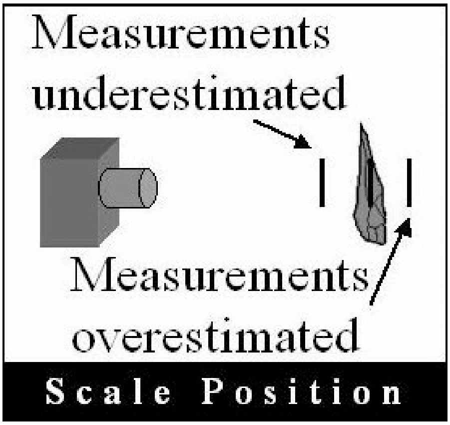
*Digital Image Analysis*

The formula for flake utility is simple yet it reflects very subtle differences in artifact form that are likely significant in the life of early hominids. As artifacts effectively represent access to resources on the Plio-Pleistocene landscape, they are vital to the survival of their makers. Stone tools represent a risk abatement strategy that separates hominids from failing to procure required energy needs (Torrence 1983, 2001; Bamforth and Bleed 1997).

Therefore those hominids that employ adaptive strategies of tool manufacture and use have the potential of defraying resource deficits. A technology that can consistently delay the risk of failing to meet dietary requirements will provide the employers of this technology with increased genetic fitness.Therefore slight differences in technological patterns (e.g. flake utility (cm/g)) that can increase the utility of a given resource (i.e. stone) projected over several hundred artifacts could represent significant differences in individual fitness.

Considering the potential effect on hominid ecology of subtle changes in the "flake utility" attribute, it is necessary to accurately and consistently quantify this attribute. We chose to quantify this measure using digital image analysis. The use of digital images to capture information about artifacts has recently received attention. The decrease in cost of high quality digital cameras and the availability of software to analyze these images allows large amounts of information to captured relatively easily with an acceptable amount of error (McPherron and Dibble 1999).

In our analysis we used an Olympus 2500L Digital Camera to capture 2.6 megapixel images of the ventral surface of 847 flakes from 6 sites housed at the National Museums of Kenya. Our emphasis on perimeter measurements forced us to curb analysis to only those whole flakes, which did not display damage or chipping that would have modified measurements of the edge of a flake.



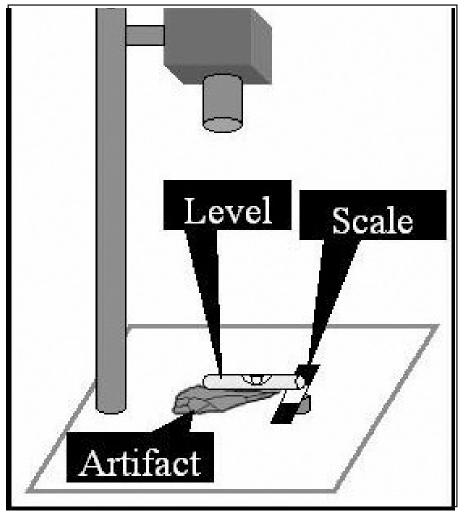




*Fig. 6 Photogrametry technique implemented during capture of images*

Analysis of the edge was conducted using the image analysis program called ImageJ 4.0. Images were digitized using an Intuos Tablet at 2 to 4 times magnification.

Several techniques suggested by McPherron and Dibble (1999) were implemented during the capture of these images. In close range photogrammetry problems of lens distortion (parallax) can be subtle enough not to be readily noticed yet can cause dramatic differences in measurements.

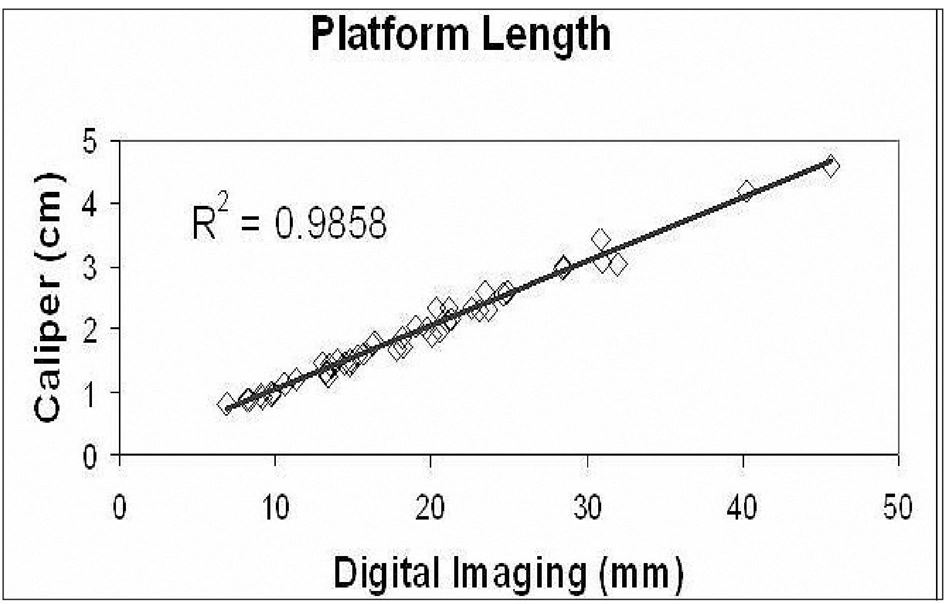
Parallax affects the edges of the image more drastically than the center of the image. To counter the affects of lens distortion, images of the artifacts were captured so that the artifact under analysis only comprised the very center of the image. This considerably reduces the effects of lens parallax. Another confounding factor in digital image photogrammetry is the use of a photographic scale as the reference point for all measurements.

The scale must be in the same plane as the objects being measured or else measurements will be consistently over- or underestimated. In our analysis we overcame this potential source of error by mounting the camera above the specimens and placing one end of a bubble level on the internal surface of the flake and the other end of the level on the reference scale (see figure 6).

To insure that these techniques are factoring out potential photogrammetric sources of error a reference disk that is 1 cm in diameter was periodically photographed and analyzed (as suggested in McPherron and Dibble 1999).

To further assess the accuracy and reliability of the digital imaging technique, measurements were also conducted using a digital caliper (Brown and Sharpe M700). Platform length (as described by Debenath and Dibble 1995) was measured with both techniques. The digital imaging technique is highly correlated to the caliper measurement (r2 = .985, p > .001 see figure 7).

*Fig. 7 High correlation on mesures of platform length by caliper and digital imaging.*



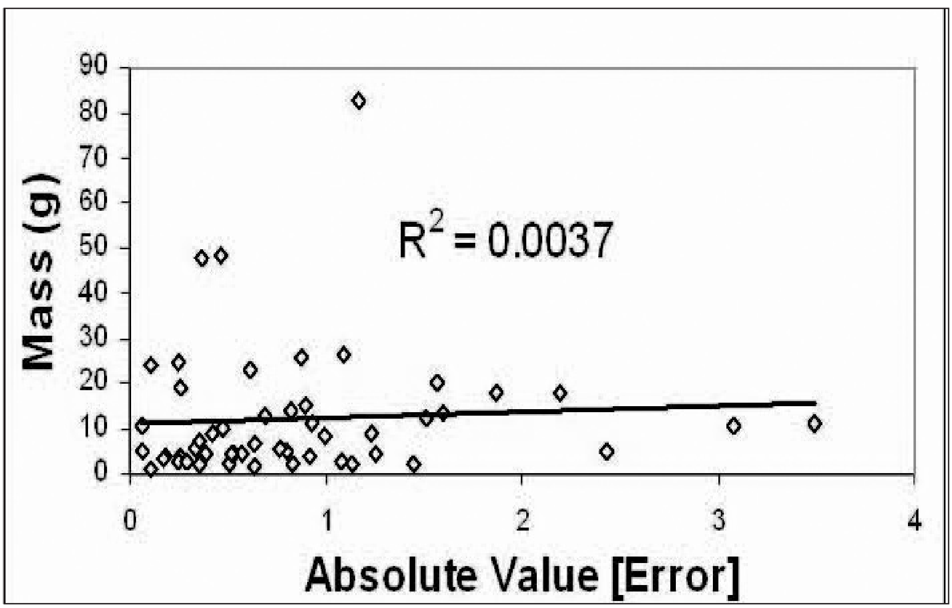
Although there are differences between the two measurement techniques, the error (i.e. Absolute Value [Platform Length (Digital Imaging) – Platform Length (Caliper)]) is not correlated to the mass of the piece (see figure 8).This is an important distinction because in digital imaging techniques the basis of measurements is pixels. If there is an error in the assignment of the reference scale to a specific number of pixels it will be too small to recognize on small objects. However, this error will be greatly magnified in large objects.

## Results

### *Flake Utility*

A comparison of flake utility measures between the KBS and Okote Member flake assemblages reveals significant time-transgressive technological change in the Koobi Fora Formation.

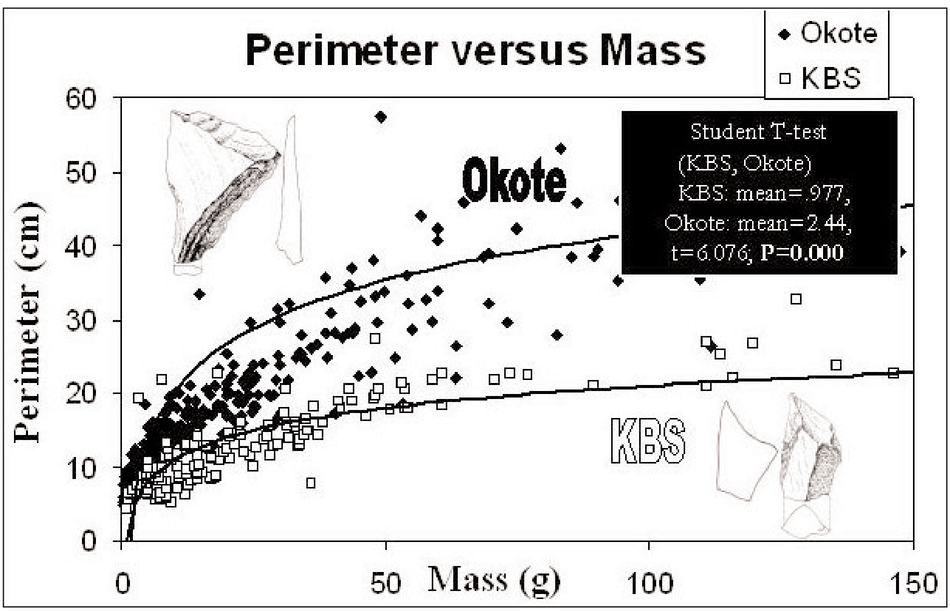
*Fig. 8 Low correlation on mesures on mass and absolute error*



The Okote member flakes display a mean of 2.4 cm of edge per gram of mass, while the KBS member flakes display .977 cm of edge per gram of mass. A plot of mass and perimeter show the clear separation between these two technological systems (figure 9; Student's T-test t=6.076, p<.001).

Although this difference is compelling, there are complications in comparing two measures of size that increase at different rates (i.e. mass increases as a cube and perimeter increases as a square). In order to accurately represent the differences between Okote and KBS members and to separate the affects of flake size it is necessary to represent perimeter and mass values as a natural logarithm. Furthermore, in analyzing data that has a range greater than one order of magnitude (as perimeter and mass have in this analysis) a logarithmic scale is more appropriate. The resulting data set shows a more complete separation between the two technological patterns (figure 10).

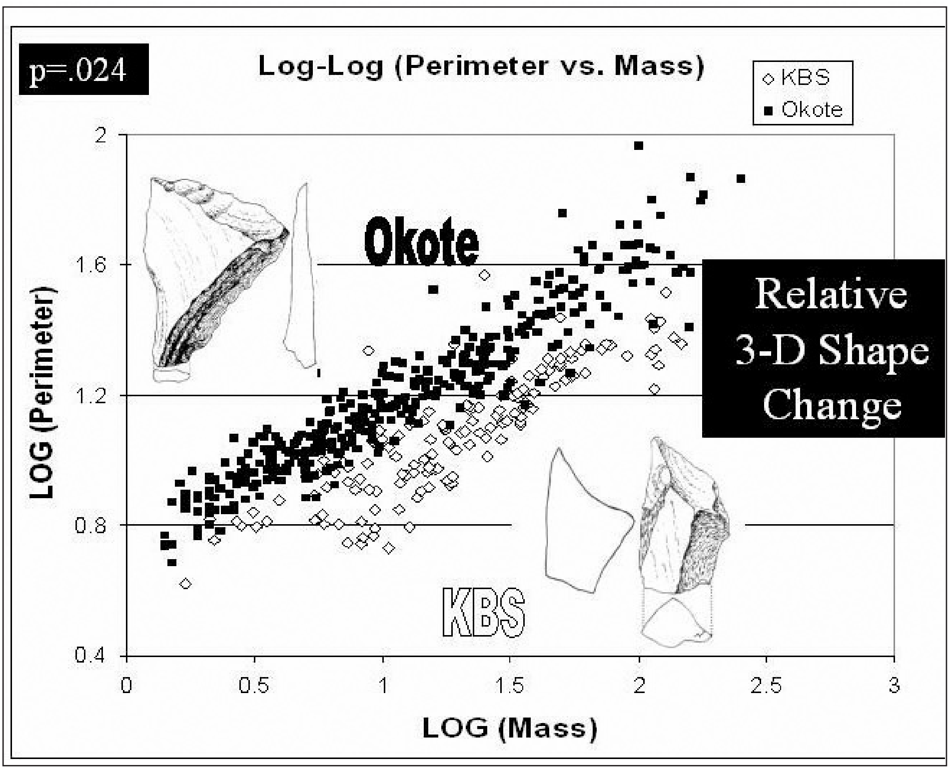
*Fig. 9 Comparation perimeter versus mass in the flakes from KBS and Okote sites*



To further emphasize the fact that the difference between these technological patterns is not merely an artifact of flake size and proportions, the average mass of flakes was plotted within different perimeter size categories. This shows that flakes of the same perimeter are consistently heavier in the KBS (figure 11; Student's T-test t = 3.11; df = 4; p < .05). The pattern displayed here shows that flake utility (perimeter/mass) is consistently lower in the KBS member as compared to the Okote Member.

This corroborates data presented by Roth and Dibble (1998) that as flake size increases not all dimensions must necessarily increase at the same rate (also see Kuhn 1994).

*Fig. 10 Log Perimeter vs Mass and relative 3 D shape change observerd on KBS and Okote flakes*



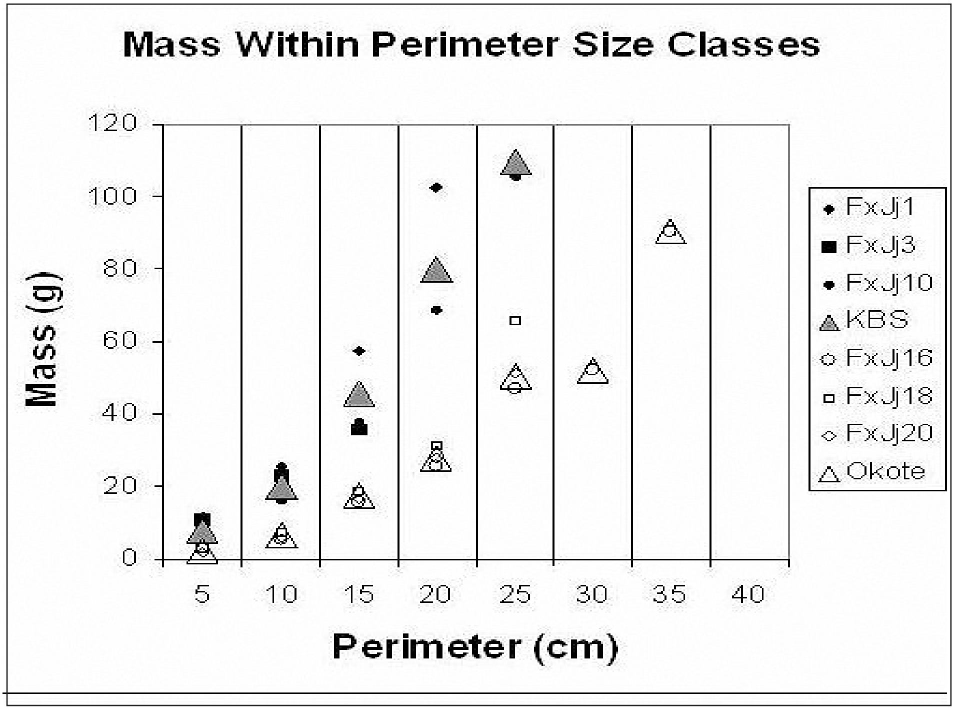



*Fig. 11 Mass within Perimeter size classes in different archaeological Oldowan sites.*

*Core Reduction Strategies*

This technological pattern is interesting because it suggests that hominids in the Okote Member were able to increase the utility of their technology by following a consistent pattern of increasing the perimeter of the flake while minimizing the impact on stone resources by keeping the overall mass (i.e. volume) of the flakes lower. However the actual impact of this technological strategy on hominid behavior lies in the implication of "flake utility" on core reduction strategies.

Numerous studies have suggested that core reduction strategies are often attempts to circumvent constraints on technological design (Boëda 1995; Bietti and Grimaldi 1991; Brantingham 2000).

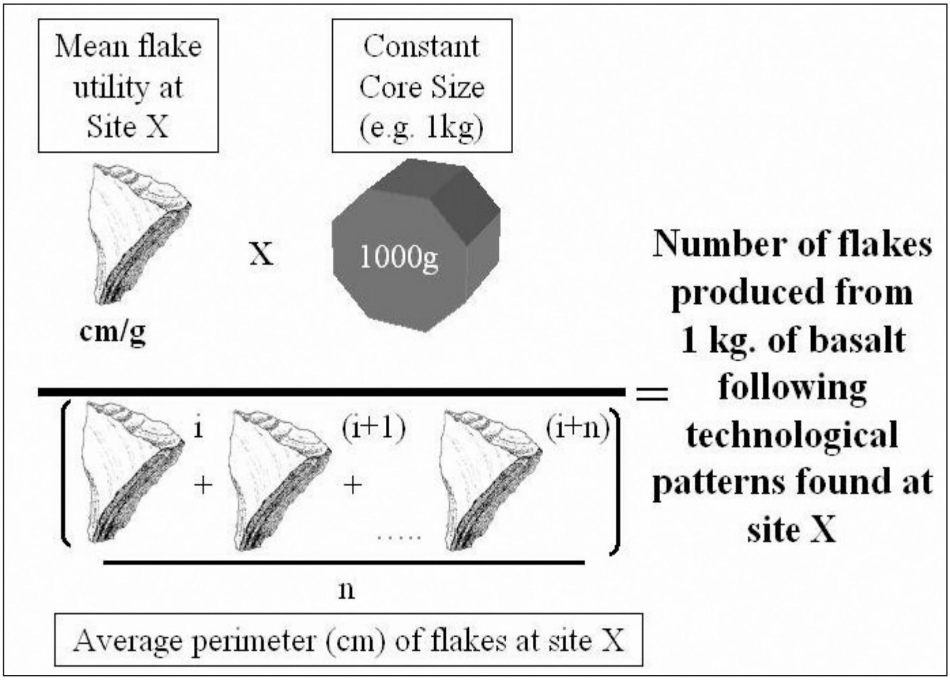



*Fig. 12 Number of flakes produced from 1 kg of basalt.*

It is possible that the "flake utility" variable is influenced by a core reduction strategy that attempts to maximize edge per volume of raw material. Since the flake utility measure incorporates aspects of both flake size and mass, a model can be derived that measures the number of flakes produced from a given mass (see figure 12). If mass is held constant (e.g. 1 kilogram core) it is possible to calculate the perimeter produced by following the KBS Industry pattern.

By dividing the total perimeter produced from 1 kilogram of raw material (Average "flake utility" value (cm/g) for a KBS site x 1000 g) by the average perimeter for whole flakes at the same site (i.e. the sum perimeter of all the whole flakes at a KBS site divided by the number of flakes at the site) it is possible to model the number of flakes produced from a 1 kilogram core.

| KBS Member Sites | | Okote Member Sites | |
|---|---|---|---|
| Site | # of flakes | Site | # of flakes |
| FxJj 1 | 3.33 | FxJj 20Main | 19.15 |
| FxJj 3 | 3.62 | FxJj 18GL | 10.32 |
| FxJj 10 | 6.79 | FxJj 16 | 9.84 |

*Table 1. Modeled Number of Flakes Produced from a 1 Kilogram Core.*

Calculations of this flake production model show that technological strategies implemented during the Okote Member produced anywhere from double to six fold the number of flakes produced using technological patterns displayed in the KBS Member assemblages (see Table 1).

## Conclusion

In this paper we have attempted to show that hominid behavioral patterns that have been described using land use patterns and typological characteristics can be further elucidated using metric analysis of attribute variables. We would emphasize that although the behavioral patterns that were under investigation in this study were initially identified through more conventional typological analysis, technological analyses that focus on metric data has the power to explain variability.

The present analysis not only presents plausible explanations for time transgressive behavioral patterns already described, but also provides further insights into variation within temporal units. While flake utility measures are absolutely higher in the Okote Member than the KBS Member significant variation within the KBS and Okote Member can be seen (e.g. FxJj 10 vs. FxJj 3 or FxJj20 vs. FxJj16). It is likely that these differences are associated landscape scale ecological differences, although more work is needed to explain this variation.

It is important to note that no aspect of this analysis suggests hominids in the KBS Member were incapable of implementing the strategies seen in the Okote Member. It is plausible that the ecosystem that KBS hominids lived in did not necessitate the development of such technological strategies.

Therefore this analysis does not directly impact the discussion of hominid abilities (see Chavaillion 1976; Piperno 1993; Kibunjia 1994; Roche 1989, 2000 vs. Semaw 2000, Semaw et. al 1997; also see Kimura 2002) but rather sheds light on the behavioral variability the that Oldowan comprises. Ecological pressures on technological design of hominid toolkits appear to work at very subtle levels. Perhaps the rather mundane nature of Oldowan variation that is the hallmark of the "technological stasis" model is purely the result of methodologies, which are incapable of isolating ecologically pertinent variables.

Further analyses are needed to test this hypothesis. We believe that finite methodologies, such as the digital imaging analysis described here, are the key to capturing the variation that reflects ecological variability. Analyses that attempt to deflate technological patterns to ordinal or nominal variables (e.g. Kimura 1999, 2002) are unlikely to address patterns of ecology and evolution.

The consistent implementation of a strategy that extracts more flakes from given volume of raw material is an adaptation that Isaac and Harris (1997:263) predicted would develop in the face of raw material scarcity.

Here we have shown that their morphological prediction is correct, although the impetus for this change is still uncertain. Research on Plio-Pleistocene technology has argued for substantial change in the ecology of hominids from the Plio-Pleistocene boundary to the early Pleistocene (Potts 1984, 1991, 1994; Rogers et al. 1994; Rogers 1997; Harris and Capaldo 1993).

Specific hypotheses predict that hominids were tethered to raw material sources early in the development of stone tool technology (Harris and Capaldo 1993; Rogers et al. 1994).

Potts (1991) has suggested that the ability to modify the environment in order to associate stone and faunal resources (i.e. raw material and carcasses with meat and marrow) was an adaptation even more significant than the appearance of stone tool technology.

The "flake utility" measure and the associated flake production model represents a mechanism for hominids to release any tethers from raw materials sources while at the same time reducing the risk of encountering faunal resources (meat and marrow) without adequate technological capabilities to access these resources (see figure 13).

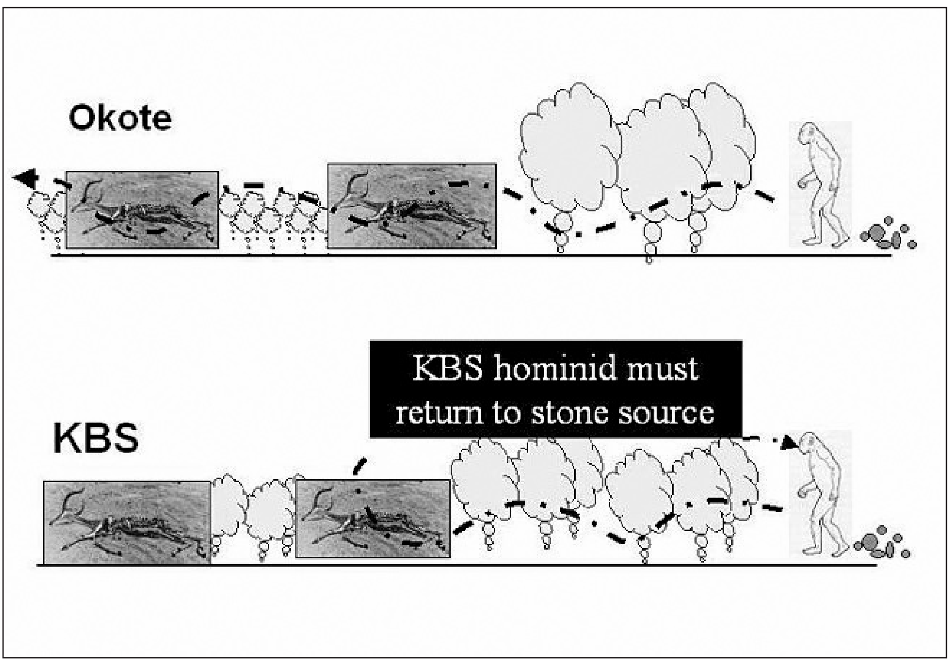



*Fig. 13. Behavioural implications of the "flake utility" model.*

The “flake utility” model suggests that hominids employed patterns that would afford them an adaptive advantage by either opening up areas of the landscape that were previously outside the boundaries of their raw material “tether” or by decreasing the probability of exhausting mobile stone resources (i.e. a transported core) when faunal resources are encountered.

At present it is difficult to tease apart these two different scenarios, although they are not necessarily dichotomous. We suggest that a continuation of these finite analyses coupled with a more rigorous metric approach to technological variation applied to sites within varying environmental settings will provide a better understanding of the nature of technological change.

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# Treading Carefully: Site Formation Processes and Pliocene Lithic Technology

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## Introduction

The appearance of Oldowan lithic technology as an integral part of the Pliocene-Pleistocene hominin record has long been perceived as an adaptive threshold in human evolution (Isaac 1986), because it expanded the ability of early hominids to exploit and modify a variety of raw materials and enhanced the accessibility of high-quality food resources. These resources supported the costly metabolic demands induced by encephalization (Aiello and Wheeler 1995), triggered by -and contributing to- complex social relationships (Humphrey 1988; Aiello and Dunbar 1993; Byrne 1997; Dunbar 1998). Various outcomes of the crossing of this adaptive threshold are modeled and/or tested by hypotheses derived from a plethora of scientific disciplines (e.g., Bunn and Kroll 1986; Speth 1989; Blumenschine 1991; Sept 1992; Aiello and Dunbar 1993; Bunn and Ezoo 1993; Blumenschine et al. 1994; Aiello and Wheeler 1995; Rose and Marshall 1996; Capaldo 1997; Brantingham 1998; McHenry and Coffing 2000; Plavcan 2000; Domiguez-Rodrigo 2002). But it is only from the study of the artifacts that the nature of early stone knapping, and the qualities of the human condition that were necessary to implement it, can be inferred.

Stone knapping is a sequential activity in which stages of reduction follow one another, resulting in artifacts with discrete characteristics. Sequence models are therefore a powerful tool for analyzing lithic production, offering a conceptual basis for linking apparently diverse objects (the discrete lithic artifacts) into patterns that reflect a process in time, and which can themselves be studied in behavioral, cultural or cognitive terms (Leroi-Gourhan 1943; Leroi-Gourhan 1945; Geneste 1985; Boëda 1991; Schlanger 1994; Bleed 2001).

Studies of Pliocene lithic technology apply the concept of sequence modeling, either explicitly or implicitly, when attempting to reconstruct the cognitive abilities of early hominids reflected in the realm of lithic technology.

The sequence of actions involved in lithic production encompasses what might be called strategic planning vs. tactical action. The first stage in the process involved purely abstract processes of decision making, using pre-conceived mental templates of the forms, materials, and imagined sequences of actions as the decision criteria (Pelegrin 1990:118, and references therein).

Whether such high faculties played a part in the lithic technology of early hominids is inferred from patterned variations which are interpreted to reflect depth of planning (e.g., acquisition of appropriate raw material, selection criteria based on shape and size), or from the physical reconstruction of the lithic reduction process by extensive refitting (e.g., Roche et al. 1999; Roche 2000).

On the other hand, tactical, target-specific planning comprises the [mental] structuring of the physical acts necessary for materializing these decisions. It is only at this stage of the knapping process that actual action upon matter takes place. Strictly speaking, the 'archaeological record' that we observe is the direct outcome of this stage of the cognitive process.

Clearly, comprehending lithic reduction at the level of tactical knapping skills bears on our inferences about the higher-level cognitive processes involved in lithic reduction. For this reason, knapping skills should be assessed and reconstructed before inferences about higher cognitive abilities can be attempted.

## Lithic shatter and knapping skills of Plio-Pleistocene hominids

Two different types of human capacities, physical and mental, factor into the knapping skills inferred directly from the archaeological finds. Anatomical characteristics dictate the dexterity of a stone tool maker and his ability to manipulate raw materials of various shapes and forms, and to apply the correct force and direction of blows during the process of lithic reduction.

Technical knowledge, namely, the techniques used in order to implement a mode of lithic production (Roche 2000), sets the objectives towards which manual action is directed. Hence, knapping skills may be hampered by limitations on any or both of these two broadly defined domains.

Anatomical constraints may not have been a limiting factor for the knapping skills of Late Pliocene hominids at Hadar. Whether australopiths were anatomically capable of stone knapping, and if so -which species of australopiths had these abilities, is debatable (e.g., Susman 1991; Marzke 1997; Susman 1998). But early Homo appears to have many (if not all) of the specific elements of precision grip that are necessary for habitual tool-making (Marzke 1997). If the knapping skills of the early tools makers were limited to any extent, the crucial factor would be in cognitive abilities. But which are the archaeological correlates of those cognitive abilities?

## Angular fragments as flaking debris

One category of artifact that has been discussed in this context is 'angular fragments'. Various authors, however, have perceived the term differently. M. Leakey (1971:8) used it to describe pieces "apparently derived from shattering blocks of raw material", which she then coined 'core fragments' in her typology.

From her tacit description it is not clear whether she referred to such items as the results of natural mechanical fracturing or of stone knapping. Isaac and Harris, in their analysis of the Koobi Fora sites, extended the definition of angular fragments to include all flaking debris lacking striking platforms and bulbs, but still attributable to detached pieces (in the terminology of Isaac and Harris 1978) and explicitly differentiated from core fragments (Isaac and Harris 1997:265, table 6.1; 285).

Recently, Semaw (1997:111, 161-163) and Ludwig (1999:43) adopted the latter definition, expanding it to include all fragmented portions of flakes, and any broken pieces on which the point of origin, or the direction, of the blow could not be discerned. Item size is not considered as one of the definitive criteria.

It stands to reason, however, that the majority of these pieces tend to be small (where publications provide sufficient data, the relevant size range appears to be <20 mm; e.g., Chavaillon 1976; Merrick and Merrick 1976; Semaw 1997: table 4.20).

The inclusiveness of the term 'angular fragments' as used by Semaw (1997) and Ludwig (1999) defies the purpose of classification of artifacts in relation to their generative processes. Until the term is redefined in the future, I use here, for the purpose of comparability, the broad definition employed by these two authors.

Angular fragments in Pliocene sites are considered by several workers as the outcome of flaking processes involving the technique of direct percussion with hard hammer. In the Omo localities, these pieces were perceived as the result of nearly random battering of nodules/cores (Chavaillon 1976:571; Merrick and Merrick 1976), a basic mode of lithic production that is integral to the technological repertoire seen in Pliocene lithic assemblages (Roche 2000:102).

Semaw (1997:111), too, includes angular fragments in his category of detached pieces, as do Isaac and Harris (1997), namely pieces that were detached from the core in the course of lithic reduction.

**Angular fragments as the result of site formation processes**

The presence and frequencies of angular fragments in Plio-Pleistocene sites are explained sometimes by invoking hydraulic processes. Where the sites' sedimentological make-up is suggestive of channel bed deposits, water action is claimed to have winnowed a locality of the small-fraction lithics, thus reducing the frequencies of angular fragments, the implication being that their presence on site reflects minimal post-deposition disturbance (e.g., Semaw 1997:161).

Conversely, high frequencies of small, size-sorted artifacts (as well as of bone fragments of similar sizes) may result from transportation by hydraulic agents to sediment traps in floodplains, where the pieces were then embedded (e.g., Merrick and Merrick 1976; Schick 1987; Isaac and Harris 1997:283-285).

The processes of formation of the angular fragments themselves are not necessarily specified in these models. Presumably, these could have been either flaking processes as discussed above, or some natural agency unrelated to human action.

### Finds from A.L. 894 (Hadar, Ethiopia) and their implications

Recent excavations at the late Pliocene (>2.3 Ma) locality A.L. 894 (Hadar, northern Ethiopia), have revealed a few hundred bone fragments and several thousands lithic artifacts in silty-clay deposits of the floodplain of a low-energy stream, dispersed in a ca. 30-cm thick cluster. The lithic assemblage consists mostly of sharp-edged complete and broken flakes, and of angular fragments.

*Fig. 1. A cracked flake in A.L. 894. Identification of these fragments as part of a single flake is possible due to minimal post-depositional disturbance. The actual separation of the frgments from one another occurred only when surrounding sediment was removed during excavation.*

Fig. 2. A cracked flake in A.L. 894, before it was completely exposed in the excavation.

Fig. 3. A snapped flake in situ.

Cores and core tools are present in small numbers (Hovers et al. 2002). Raw materials are cobbles of various volcanic rocks, whose size in relation to the surrounding matrix indicates transport from a source located at least several meters away from the site.

No human remains have been found in A.L. 894. To date, only one hominid taxon, Homo aff. *H. habilis*, has been recovered in the uppermost Kada Hadar Member, at A.L. 666 (Kimbel et al. 1996; Kimbel et al. 1997), which is penecontemporaneous with the A.L. 894 artifact assemblage.

Figures 1-3 document examples of flakes broken in situ as found during the excavation at A.L. 894. They could be recognized as such only because post-depositional disturbance was minimal and did not cause removal of the smaller fragments away from the initial location of breakage. Had this been the case, each of these pieces might have been inventoried several times, as distinct and broken flake(s) and/or as angular fragment(s), unrelated to one another.

The break of the artifact seen in Figure 2 may be an old one, as attested by the silt-filled cracks. The artifacts seen in Figures 1 and 3 had been cracked post-depositinally, but not completely shattered. Removal of the silty sediment at the time of excavation elevated the pressure that had held the pieces together and caused widening of the cracks and final breakage of the artifacts. These photos document, then, examples of formation of angular fragments through purely natural processes, completely unrelated to flaking skills.

Three natural mechanisms may be invoked to explain the occurrences of these (and other similar) items: cracking due to shearing by pedogenic processes (e.g., in clays), cracking and fracturing due to compaction in the sediments, or breakage due to trampling by humans and/or animals.

Pedogenic activity in vertic soils, such as those at AL 894, tends to shear artifacts (or bone) embedded in the sediment, which are then offset along the soil fracture planes (Craig Feibel, pers. comm.). The examples shown here from A.L. 894 are effected by breakage rather than shearing, and the fragments of any single item do not show such dislocation relative to one another.

Several experiments examined the effects of trampling on lithic artifacts made on flint and obsidian. The experiments have shown that breakage is more frequent on harder surfaces, such as the substratum of relatively compact loams and silts (Villa and Courtin 1983; Gifford-Gonzalez et al. 1985; Pryor 1988; Nielsen 1991). Villa and Courtin (1983:279) also noted that elongated pieces had snapped transversally.

Such observations are consistent with finds and with the type of sediment at A.L. 894 (e.g., Figure 3). However, all the trampling experiments documented the formation of edge damage, sometime to the degree that it could be mistaken for intentional retouch (Gifford-Gonzalez et al. 1985; Nielsen 1991; McBrearty et al. 1998).

At A.L. 894, the flakes and angular fragments rarely show secondary modifications. To date, retouch has not been recognized in this site. Possibly, trampling was not the only, or the main, post-depositional process to have caused the presence of angular fragments on the site. To test such ideas, it is necessary to experiment with trampling with the specific raw materials used at A.L. 894 itself.

While one cannot specify at this point the exact nature of the processes leading to breakage and formation of anuglar fragments, the various lines of evidence and reasoning suggest that the occurrence of angular fragments at A.L. 894 is related to natural processes. In this particular site, for one, knapping skills may have played only a secondary role in the occurrence and deposition of angular fragments.

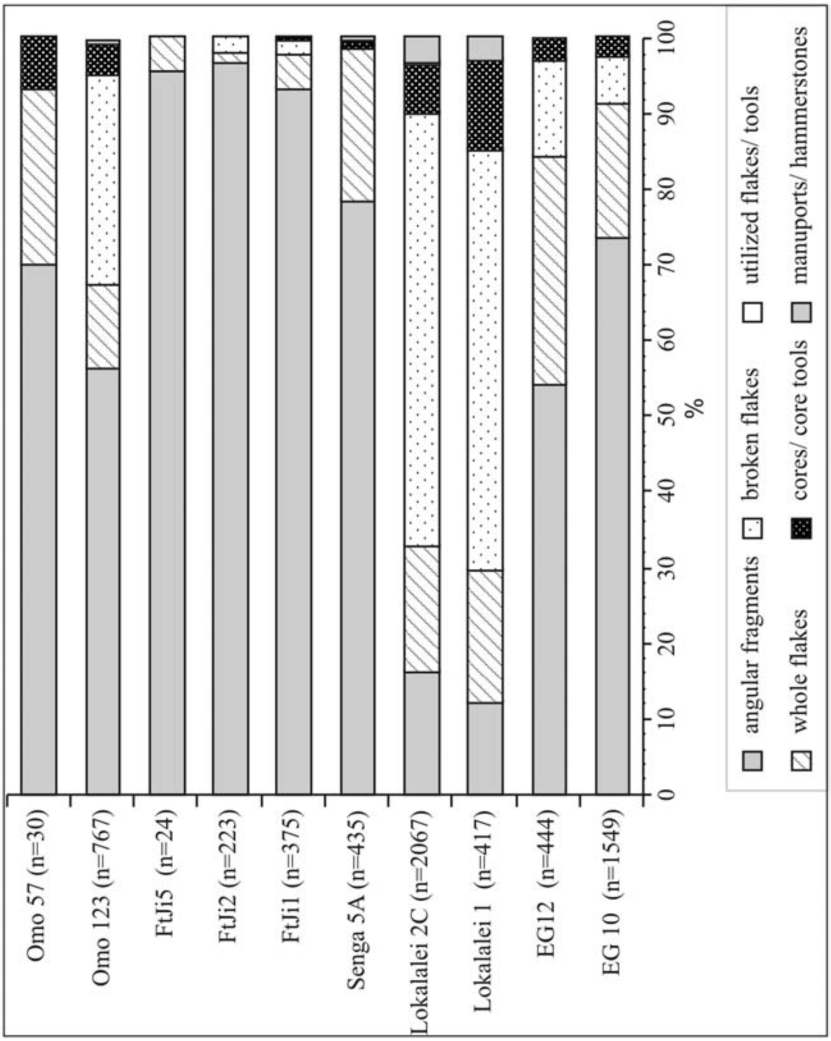


*Fig. 4. Compositions of early lithic assemblages (surface collections not shown). Sources: Omo data after Chavaillon 1976, Merrick and Merrick 1976, Howell et al. 1987. The "Piece" mentioned in the original texts added here to manuports; Senga 5A - data from Harris et al. 1987; Lokalalei 2C -data after Roche et al. 1999. Broken flakes and small flakes originally classified together. Modified pebbles and broken cores are counted here with the cores, unmodified pebbles counted with the manuports; Lokalalei 1 - data from Kibunjia 1994. Broken flakes and fragments larger than 1 cm counted together, only fragments smaller than 1 cm included in angular fragments; Data for Gona from Semaw 2000.*

## Why does shatter matter?

The specific values of fracture mechanics parameters operating on lithic raw material during percussion flaking (see Faulkner 1972; Speth 1972; Speth 1974; Speth 1975; Cotterell and Kamminga 1979; Cotterell and Kamminga 1987; Pelcin 1997 for detailed discussions) are dependent on variables such as the quality of raw material and the size of raw material packages (Merrick and Merrick 1976; Ludwig 1999:107), and on the properties of the hammerstone used (Ludwig 1999:388).

This is seen in Pliocene lithic assemblages, where the knapping of quartz clearly generates high frequencies of angular fragments (Figure 4).

These patterns were related to both raw material properties and the small size of the original nodules, said to have required the application of breakage-prone bipolar flaking (Chavaillon 1976; Merrick and Merrick 1976; Harris et al. 1987; Ludwig 1999). In the case of the Gona assemblages, on the other hand, the occurrence of relatively high frequencies of angular fragments cannot be explained in the same way, since these assemblages were flaked from fair-sized cobbles of fine-grained trachytes (Semaw 2000:1207).

As a general rule, the more skilled a knapper is, the greater his cognitive ability to overcome problems resulting from a material's physical properties, which in turn dictate the material's propensity for breakage and/or shatter. Because the presence of angular fragments in late Pliocene sites can hardly be related to secondary modification by flaking, it bears implications for reconstructing the knapping skills of the early toolmakers. There are compelling indications that these hominids were capable of preplanning the reduction sequences and standardize them to a degree (Roche et al. 1999; Roche 2000).

But the proliferation of shatter in many of the early sites would suggest that early hominids were not highly accomplished in obtaining their knapping goals. The notion that angular fragments resulted from the flaking process in not easily compatible with the view that early hominins had sophisticated understanding of stone fracture mechanics (e.g., Semaw 2000).

If, on the other hand, we accept that the formation as well as frequencies of angular fragments in Pliocene archaeological occurrences are likely due to natural processes, the contradiction becomes more apparent than real. Angular fragments can hardly be considered as reflecting the knapping skills of their makers.

This distinction may seem trivial to the lithic analyst, but has far-reaching implications beyond lithics. In a recent study, Susman (1998) argued that precision grip of Paranthropus in Swartkrans allowed this hominid to use artifacts of various sizes, including very small ones. As an illustration of the smaller artifacts allegedly used by Paranthropus, few flakes and several angular fragments are illustrated (Susman 1998: figure 9). But if at Swartkrans, as in many East African early sites, these are the products of post-depositional processes, they are irrelevant to the question of precision grip in Paranthropus and cannot be relied on as support for this claim.

Similarly, the view that angular fragments originate primarily from natural, post-depositional processes is of interest for understanding the origins of tool making and tool use. In recent years, much evidence has accumulated which documents the diversity of tool-using and tool-making behaviors among chimpanzees in the wild (e.g., Whiten et al. 1999, and references therein; Boesch and Boesch-Achermann 2000).

One particular behavior, cracking of very hard nuts of Panda oleosa, leaves durable, detectable and clear spatial evidence of accidentally-formed lithic artifacts, among which angular fragments are the majority (Mercader et al. 2002a; Mercader et al. 2002b).

Noting the differences between the chimpanzee assemblage and some early Oldowan ones, Mercader et al. (2002b) emphasize nonetheless the similarities between the two assemblage types, indicating that "chimpanzees leave behind a stone record that mimics some Oldowan occurrences".

From here they go on to suggest the possibility that Oldowan assemblages might be interpreted as evidence of hard-object feeding by early hominids. It should be clear from the ongoing discussion that the similarity is more apparent than real, in that angular shatter is a predominant feature in the accidental knapping of chimpanzees but not necessarily a result of early hominid stone knapping as recovered from a prolonged and "dynamic" sedimentological record. To the extent that tentative evolutionary implications of the chimpanzee assemblage are inferred from the superficial similarity between this and hominid-made assemblages, they need to be re-evaluated carefully.

Above all, the previously unsuspected complexities involved in the understanding of the phenomenon of angular fragments in Pliocene sites underscore the importance of combining lithic analyses and refitting of the early stone assemblages with detailed studies of formation processes, sedimentological analyses, and experimental work. This is the only way by which meaningful insights into early lithic technology can be obtained and form the basis for understanding the adaptive impact of Oldowan lithic technology.

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