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Techno-Typological Analysis of “Developed Oldowan”/Early Acheulean Assemblages from Garba IV Levels C and D, Melka Kunture (Upper Awash), Ethiopia.

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Techno-Typological Analysis of “Developed Oldowan”/Early Acheulean Assemblages from Garba IV C and D, Melka Kunture (Upper Awash), Ethiopia.

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In Partial Fulfillment of the Requirements For the

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This is to certify that the thesis presented by Niguss Gitaw Baraki entitled: Techno-Typological Analysis of “Developed Oldowan”/Early Acheulean Assemblages from Garaba IV Levels C and D, Melka Kunture (Upper Awash), Ethiopia submitted in partial fulfillments for the Degree of Master of Arts in Archaeology compiles with the regulations of the university and meets the accepted standard with respect to originality and quality.

Signed by the examining committee.

External examiner-----Signature-----Date-----

Internal examiner-----Signature-----Date-----

Adviser-----Signature-----Date-----

Abstract

This thesis conceives of an analysis of Early Stone Age collections from Melka Kunture, particularly at Garba IV levels C and D. They were excavated between 1972 to 1985 and are today stored at the Authority for Research and Conservation of Cultural Heritage. In spite of ongoing researches conducted at these localities, raw material influence on the knapping process of the knappers and the technological features of the previously nominated artifact traditions called “Developed Oldowan” is poorly understood. Methodologies like typological classification, measurement of the technological axis, width, depth and so forth, identification of raw material, understanding of thickness evennes along the technological line of artifacts were employed to address the problem. The production techniques were influenced by the type of raw material. Although large flake productions are not large in number, their appearance is an essential indicator about the emergence of the Acheulean. The low number of Large Cutting Tools is determined by the original size of the unworked material. On account of this, not only frequency of Large Cutting Tools, but also understanding various technological innovations of an artifact has been found to be important in characterizing Early Acheulean site. Therefore, the artifact tradition called “Developed Oldowan” was not understood to be independent technologicaly. It, rather, bears an evidence of technological similarities with the Early Acheulean.

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List of Abbreviations

AF-Angular Fragment

ARCCH-Authority for Research and Conservation of Cultural Heritage

BT-Blank Type

CV-Coefficient Variations

DR-Dorsal removals

EN-Extraction Number

EPA-External Platform

FRSN-Flake Removal Surface Number

FT-Flake type

G-IV C/D-Garba IV C or D

I-Impurities

MD-Maximum Dimensions

MD-Per-Maximum Dimensions Perpendicular

MER-Main Ethiopian Rift Valley

MFSL-Maximum Flake Scar Length

MFSW-Maximum Flake Scar Width

ML-Maximum Length

MT-Maximum Thickness

MT-Mean of Thickness

MW-Maximum Width

MW-Maximum Width

NHT-Number of Hinge Terminations

PC-Preservation Code

PFC-Platform Cortex

PF-Platform

PFT-Platform Thickness

PFW-Platform Width

RC-Rounded Cobble

RM-Raw Material

SDT-Standard Deviation of Thickness

SSN-Striking Surface Number

SS-Split and Snap

T-25-Thickness at 25%

T-50-Thickness at 50%

T-75-Thickness at 75%

Ter.Type-Termination type

TL-Technological Length

TR-Triangular Cobble

TTVT-Total of the Three Values of Thickness

TW-Technological Width

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Chapter one: Introduction

1.1. Background

Melka Kunture, located at about 50 kilometers from Addis Ababa, is a pre-historic site in the Upper Awash River Valley of Ethiopia. It has rich lithic collections ranging chronologically from the Early to the Late Stone Age. It was discovered by a hydrogeologist, G. Dekker in 1963. The same year a French pre-historian, G. Bailloud, carried out the first surface surveys and collected important and diagnostic lithic materials and faunal remains (Chavaillon and Piperno, 2004).

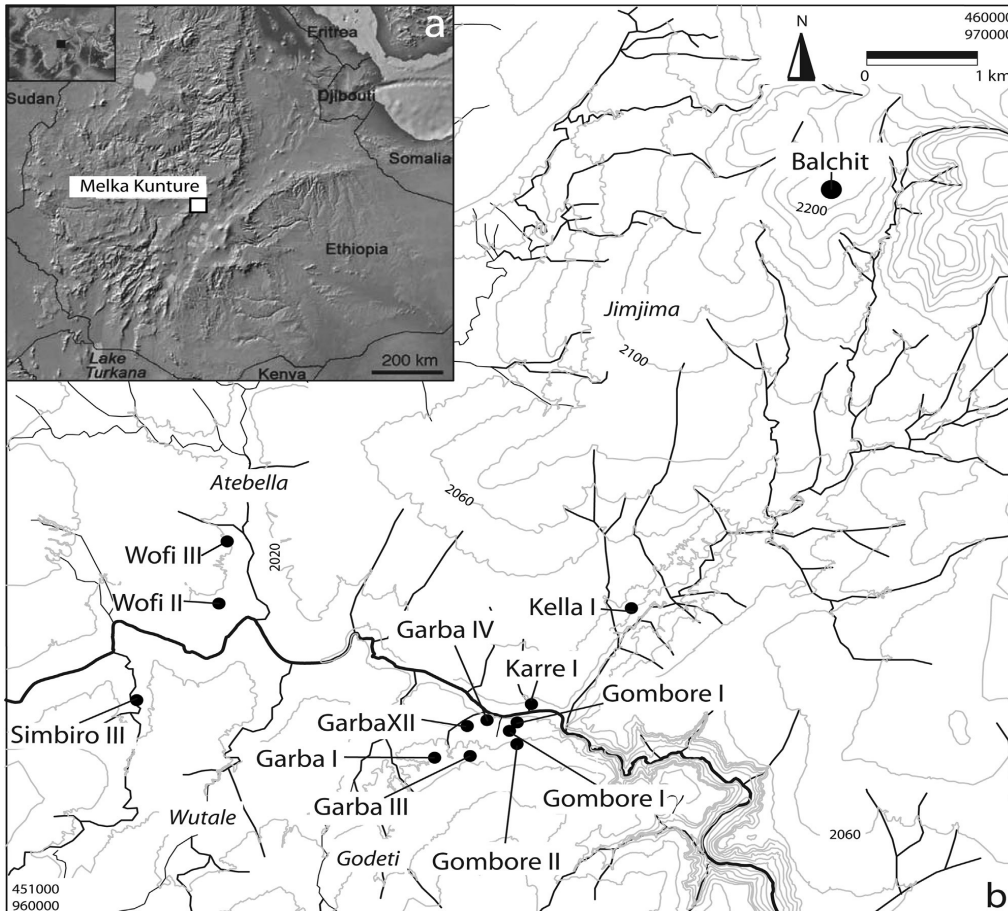


Figure 1. (a) Location of Melka Kunture on the shoulder of the Main Ethiopian Rift in the map of Ethiopia and surrounding countries; (b) map of the Melka Kunture area (vector resolution of the 1:50,000 topographic map) (After Gallotti *et al.*, 2013).

The site have artifact evidences dated between 1.7 million years BP to approximately the last 12 to 10,000 years ago. The dominant raw material in the area is obsidian, which can be extracted from the nearby outcrops of Balchit, 7 to 10 kilometers from the main site. This research is set with the intention of better understanding of the technological variations of “Developed Oldowan” and Early Acheulean. There are large numbers of Early Stone Age collections in the store of the ARCCH (Authority for Research and Conservation of Cultural Heritage), Ethiopia. The stone artifacts collected from Melka Kunture were curated in the ARCCH by researchers of the site but they did not provide a proper inventory and classification, particularly for the Early Stone Age artifacts.

A classification and analysis of such collections shed more light on the Early Stone Age technologies of the Melka Kunture in particular and in Ethiopia in general. Melka Kunture has one of the most abundant and diverse lithic collections in Ethiopia. This thesis reviewed data on technological change in the manufacture of artifacts of “Developed Oldowan”/Early Acheulean collections from Melka Kunture, particularly the Garba IV. It has focused on geological identification of raw material types, morphological, typological and technological variations of the artifacts.

The name “Developed Oldowan” was initially used to describe a technologically “advanced Oldowan” artifact tradition, that preceded the Acheulean industry, by M. Leakey (1971). According to preliminary investigation of the lithic collections of Melka Kunture stored in the ARCCH, the site rendered artifacts belonging to the “Developed Oldowan” and Acheulean (Early, Middle and Late Acheulean). These types of materials have been described as a distinct cultural tradition until very recently. In the 1970s and 1980s, the

emergence of the Acheulean at Melka Kunture (Upper Awash, Ethiopia) was dated to 1 million years ago. Current research results, however, could push the earliest existence of this technology at approximately 1.5 million years ago (Gallotti, 2013).

A detailed techno-typological study of artifacts of this site, using basic scientific techniques including artifact's morphology, measurements, and examining other visible features (such as noting the presence or absence of [cortex](#), for example), have been undertaken to address the current discussion about the presence or absence of a separate artifact tradition called the "Developed Oldowan".

1.2. Statement of the problem

The assemblages I have studied are the "Developed Oldowan"/ "Early Acheulean" collections of Melka Kunture. The main reason I chose this topic is that there are controversies on the hypothesis of a coexistence of "Developed Oldowan" and "Early Acheulean". The presence of "Developed Oldowan" and the origin of the Acheulean are widely debated among scholars in Early Stone Age studies. Currently there are plausible geo-chronological testimonies about the early origin of the Acheulean in East Africa between 1.76 and 1.4 million years ago (de la Torre, 2011b). The emergence of "Developed Oldowan" is, however, poorly understood in the archaeological contexts (Sileshi *et al.*, 2009; Harris 1978).

The bio-cultural evolutionary history of change is also poorly known, despite its significance. Different statements were forwarded at different times by different archaeologists primarily depending on culture-history paradigms about both biological and cultural change (de la Torre, 2013).

Proper, methodologically sound, classification and analysis of the collection have the potential in giving us a clear technological picture of the “Developed Oldowan”/Early Acheulean collections. This research has, therefore, tried to analyze the technological and morphological changes that appeared in the “Developed Oldowan”/Early Acheulean techno-complexes of Melka Kunture.

A credible technological description of the “Developed Oldowan”/Early Acheulean assemblages has assisted in defining the technological and typological attributes of the artifacts under investigations. This research is aimed at identifying the archaeological attributes of the “Developed Oldowan” / ”Early Acheulean” industries of Garba IV, including its typological composition and its raw material strategies, which might serve to characterize it as a cultural stage in the Early Stone Age (ESA) period.

1.3. Working Hypothesis

Controversies are still continuing among pre-history archaeologists about the “Developed Oldowan”. Some researchers have suggested that there is a difficulty in recognizing this artifact tradition as a distinct technological innovation. Other researchers accept the Developed Oldowan as a new innovation in the history of human cultural evolution (Sileshi *et al.*, 2009).

Whether the “Developed Oldowan” is a technology that should be considered as a technological transition between Oldowan and Acheulean and whether there is any technological similarity or difference between “Developed Oldowan”/Early Acheulean has been tested at the final stage of the study, along with trying to address the above controversies.

1.4. Objectives of the study

In an attempt to gain better understanding of the entire lithic technological process, the research will have the following general and specific objectives.

1.4.1. *General objective;*

The thesis has a general objective of evaluating the technological abilities of Melka Kunture knappers and to associate them with the present hot issue of the earliest evidence of the Acheulean and its possible co-existence with an artifact tradition termed as “Developed Oldowan” at the study area.

1.4.2. *Specific objectives;* In addition to the above general objective, this research has the following specific objectives.

*To reason out if there is any difference in the production technique of some of the artifacts at Melka Kunture in relation to the raw material difference.

*To understand whether or not the “Developed Oldowan”/Early Acheulean were contemporaneous technologies to each other,

*To understand the technological characteristics of “Developed Oldowan”/Early Acheulean,

*To realize the evidence for the Early Acheulean at Melka Kunture and discuss its unique attributes.

1.5. Materials and Methodologies

A methodology has been established to address the goals set above. The artifacts selected for analysis are divided into two general categories. These include the “Developed Oldowan”/ Early Acheulean.

1.5.1. Methods

1.5.1.1. Review of previously written documents

Reviewing previously undertaken research results is often the first step in archaeological research. This research uncovers the written records associated with the study area. I have reviewed articles that have been prepared by other archaeologists who studied this area. These reports describe what was found in this area during any previous archaeological investigations.

1.5.2. Sampling

Among the various localities found at Melka Kunture Garba IV levels C and D (sites where “Developed Oldowan”/Early Acheulean artifacts found) are chosen for analysis. While selecting artifacts for analysis the following procedures have been taken into consideration; *The artistic characteristics of the artifacts were found to be essential during the selection process of artifacts for investigation. Poorly produced artifacts are not easy for analysis without advanced technological methodology. The artistic characteristics are defined in terms of the presence of retouches, point of impacts and wholeness of the artifact under investigation. The artifact should at least possess some of the major features of an artifact. Hence artifacts of such types (lacking artifact features) are not part of the analysis. Abraded artifacts are not part of the study. Hence, they are excluded in the analysis. Because the

presence of such artifacts might be hard for technological investigation; such as in a condition where features of flakes are impossible to identify.

I have chosen very few samples compared with the general catalogue number of artifacts. On account of this, entirely concluding about the presence or absence of an artifact tradition called “Developed Oldowan” is difficult. Therefore, this thesis has provided the results and features of the artifacts' possible characterization in the Early Stone Age study. It is also done to have a general understanding of the title under investigation and to exercise and have the experience of dealing and working with lithics.

1.5.3. Typological Classification

What is known as the “typological approach” is a common approach widely applied in the study of artifacts by archaeologists (Sharon, 2006).

In setting up a general typological classification, the researcher has followed the Isaac's artifact classification system (Isaac *et al.*, 1997). Although there are various classification methods that have been forwarded and applied into the analysis of artifacts typology by different scholars of the field, I have chosen Isaac's way of classification because it describes artifacts in a general and qualitative pattern of lithic reduction. Hence they can be grouped into the subsequent universal categorization.

1. Flaked pieces (FPs): A nucleus or mass of rock from which flakes are struck off and bear their sign of removal. This is often considered an objective piece that functions primarily as a source for detached pieces. The cores are further classified into various groups. I have followed the typological categorization of cores applied by Chavillon and Piperno (2004) in classifying artifacts from Melka Kunture. They are important to have a

generalized classification of cores by avoiding ambiguity. Hence they are classified into the following groups;

1 - Unipolar core: Types of cores from which flakes have been removed from a single edge towards the same direction.

2 - Bipolar core: Type of a core from which flakes have been removed from two edges. These two edges are mostly found opposed to each other, though, there are also some located on different planes. The flakes may meet each other in their distal end or not. One or several flake scars can be found in each edge.

3 - Centripetal core: Type of a core whose removal starts on the edge and approach towards the center. The flakes can be removed from the entire core surface or only from some parts.

4 - Pyramidal core: Type of a core whose removal starts on the edge and approach towards the center and maintains the shape of a pyramid. Objects in this category are often quite elaborate and provided a relatively large number of flakes.

5 - Polyhedral core: Type of a core from which flakes have been removed in several directions from several edges.

6 - Prismatic core: Type of a core whose flake removals have been struck from the same platform by rotating the core. The platform can be used either in its natural surface or a fracture. It can be also a previous large removal.

7 - Shapeless core: These cores that cannot be grouped into no one of the above core typologies.

2. Pounded pieces (PPs): A rock used as a hammer stone to detach flakes from an objective piece. These usually show signs of impact damage such as crushed edges.

3. Detached pieces or *débitage* (DPs): A portion of rock removed from an objective piece by percussion.

4. Unmodified pieces (UNs): These are manuports transported to sites.

Toth (1985) types of artifact classification are also employed to understand the technological reduction technique of the hominins. These are grouped into six; Type I, Type II, Type III, Type IV, Type V and Type VI. Type I has a cortical platform and dorsal surface while type II is cortical platform and dorsal surface with part cortical. Type III is cortical platform and dorsal surface without cortex. Type IV has a non cortical platform and cortical dorsal surface. Type V and VI have non cortical platform, but differs that the former has half cortex on its dorsal surface and the later does not (Toth, 1987).

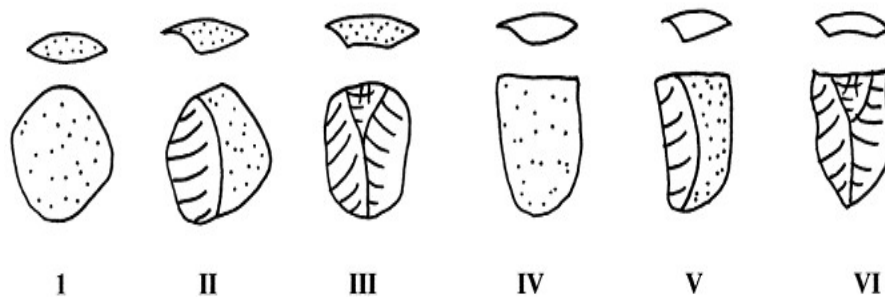


Figure 2: Flake types (after Toth, 1985).

1.5.4. Attribute Analysis

Each of the classifications applied to classify artifacts is analyzed depending on some diagnostic attributes. The attributes can be metric measurements, weight, circumference and the length of the cutting edge of the artifacts. The qualitative attributes include such

descriptive information as the raw material, state of weathering, patination and location and nature of any breakage (Sharon, 2008).

The type of blank used in the artifact procurement, the number and location of flake scars on a tool's face, the direction of the flaking technique and the nature and location of retouch are also attributes considered in analyzing artifacts. Attribute analysis is very important to set a criterion that constitutes the basis for classifying lithic as distinct typology (Andrefsky, 2005).

The analysis process encompasses both qualitative and quantitative methods. Qualitative attributes includes like flake scar counts and quantitative attributes are the linear measurements, angles and weights.

1.5.5. Metric measurement

Measurements of artifacts are also part of the methodology that have been applied in the process of this study. Digital caliper was used to measure the various sizes of artifacts. Technological length, width, depth, maximum dimensions, external platform angle, platform width and thickness were measured.

1.5.6. Raw Material Identification

In identifying the type of the raw materials used for artifacts productions of “Developed Oldowan” and Early Acheulean, rough visual observation have been conducted. Previously published materials were also among the inputs employed in the process of raw material identification for this research.

It is clear that raw materials played an important role in structuring variability in artifact assemblages and that the identification of raw material sources can provide additional information on issues such as hominin use of the landscape, mobility, and planning depth.

1.5.7. Flake Scar Count

Flake scars are important marks of technology that are produced in the process of artifact production. They help us to easily understand the sequential stages of artifacts manufacture. The amount of scars and their structure of production can tell us about the knapping method used, the time span taken in producing the artifacts, and at the same time the quality of the artifact (Sharon, 2006).

1.5.8. Digital Archive of Artifacts

Both the ventral plan view and dorsal view of the artifacts are photographed using a digital camera of Nikon D70 model, 6 megapixels (3,008 x 2,000).

1.5.9. Variable selections

To understand variation in core reduction strategies reflected in the whole flakes from the Garba IV levels C and D collections, I collected data associated with some of the variables suggested by Presnyakova *et al.*, (2015). These technological variables include the following;

a). External Platform Angle: EPA is an angle measured between the platform surface and the dorsal surface of the flake. A goniometer was used in measuring the EPA. Experimental data revealed that EPA has a determining factor in the production of flakes with diverse types of flake size and morphology (Magnani *et al.*, 2014).

b). Platform Depth: It is a measurement between the point of impact and the point where the platform surface and dorsal surface meet. According to some experimental evidences platform depth can play a significant role in the final size of a flake. The larger the platform depth the larger the mass of the flake (Dibble, 1997).

c). Thickness evenness coefficient: This is important in that it give us the thickness of a flake along its technological length axis at 25 %, 50 % and & 75 %. The standard deviation was initially calculated to figure out the thickness evenness. This standard deviation divided by the mean value of the three thickness measurements gives us the coefficient variance of the thickness. While the low values tells us the existence of low variations along the technological axis, high values, on the other hand, signals the presence of high variations along the technological axis of the flake. Hence, Mode 2 flakes (the Acheulean industry) are thought to have low values compared with the Mode 1 artifacts (the Oldowan) (Presnyakova *et al.*, 2015).

In general, the analysis include; measuring the size of artifacts and observing change in morphology and the chronological sequence in time line. In addition, raw material type, tool dimensions platform and cross section typology and the nature of retouch were studied in laboratory. According to Kurashina (1978), this type of artifact examination is helpful to understand the technological patterns.

1.6. Scope of the study

As it is more of laboratory work, the research depends on examination of attributes of the “Developed Oldowan”/Early Acheulean artifacts collected from Garba IV levels C and D, Melka Kunture. This research has extracted as much useful information as possible from the collections available at the ARCCCH, Ethiopia.

This research did not go beyond the period at which the “Developed Oldowan”/Early Acheulean is believed to be appeared in the study area. The width of the study is also

confined to the understanding of the technological change of “Developed Oldowan” / Early Acheulean.

1.7. Significance of the research

Significance of the study primarily rests on the current state of knowledge of the transition from Oldowan to Acheulean technology. There is a blurred evidence of “Developed Oldowan” technology in Africa. So the results of this research will hopefully provide an additional source of inspiration for other researchers. This research come up with practical evidence as far as the discrepancies that appeared about the co-existence of ““Developed Oldowan”” and Early Acheulean in Ethiopia in general and at Melka Kunture in particular is concerned.

Chapter Two-Literature Review

2.1. An Overview of the African Stone Age

There are three main categories of Stone Age periods in Africa. These are Early Stone Age (ESA), Middle Stone Age (MSA) and Late Stone Age (LSA), as the name indicates they represent from earliest to the recent period. The ESA of Africa is further sub divided into two elements; the Oldowan and the Acheulean artifacts. The former category of the ESA is the first and earliest human beings artifact manufacture evidence, whose testimony first appeared in East Africa, particularly at Olduvai Gorge, Tanzania. Later on the womb of Ethiopia led to the discovery of the earliest ever artifacts with an age of 2.6 million years ago at Gona (Sileshi *et al.*, 2009). This artifact tradition is known for the fabrication of artifacts on flake production and is believed to be contemporary with the first appearance datum of the genus *Homo* (Leakey, 1971).

The earliest archaeological record for the use of artifacts by our ancestors comes from indirect evidence from cut-marks (Braun, 2014). An inflicted mark of artifacts on bones has been reported from the Sidi Hakoma Member of the Hadar Formation at Dikika, although they are not widely accepted. The tuffs are dated between 3.42 and 3.24 Ma, based on an application of $40^{Ar}-39^{Ar}$ dating method. It is self-evident that a close observation of the bones using an environmental scanning electron microscope reveals the presence of artifact cut-marks at this time (McPherron *et al.*, 2010). Recent archaeological team working at Lomekwi 3, West Turkana, Kenya, has found chipped stone artifacts. These artifacts gave a new archaeological record and are dated back to 3.3 million-year-old. They are 700,000 years older than the oldowan and the archaeologists named it as “Lomekwian” (Harmand *et al.*, 2015).

The Acheulean technology, the second subdivision of the ESA, embarked a great departure of technological and intellectual evolution in Human Evolution (Sileshi *et al.*, 2009). Its main features include different large bifacially worked artifacts like cleavers, handaxes and picks (Yonas *et al.*, 2013). The earliest discovery so far, dated back to approximately 1.8 Ma, came from some East African sites (Berhane *et al.*, 1992; Yonas *et al.*, 2013; Leper *et al.*, 2011). In South Africa this artifact techno-complex can be dated between 1.7 and 1.4 million years ago (Chazan *et al.*, 2008). According to Lepre *et al* (2011) the Acheulean stone artifact tradition might have been initially existed at the same time with *Homo erectus*.

Unlike the Early Stone Age, the Middle Stone Age lacks large bifaces. It is mainly characterized by the dominance of Levallois technology and points, the main characteristics of modern human behavior (Marean and Assefa, 2005). Late archaic *Homo sapiens* are responsible for the manufacture of Middle Stone Age artifacts (Lahr and Foley, 2003).

2.2. A Brief statement of Hominin Evolution during “Developed Oldowan”/Early Acheulean period

The research of hominin evolution in the Pleistocene epoch is a dynamic field of study (Sharon, 2006). Several important events in human evolution took place during the Pleistocene epoch. Fossil localities in Africa such as Olduvai Gorge, Tanzania, the Turkana Basin of Kenya and Ethiopia, and Olorgesailie, Kenya, contain many bones and artifacts of fossil humans (Leakey, 1971). In addition, human fossils are found throughout the Old World, because the Pleistocene represents the time of the first recorded human migrations

out of Africa. All these remains provide valuable information on how our ancestors lived and interacted with their environment (Chauhan, 2004).

The 1960 archaeological exploration at Olduvai Gorge, Tanzania, revealed the discovery of a 1.25 million years ago partial cranium of *Homo erectus* by Louis and Mary Leakey. After this time its discovery continues at Olduvai Gorge and at other pre-history sites including in East, South, and Northwest Africa. Another researchers led by Richard Leakey uncovered an approximately complete young boy remains of *Homo erectus*, dating to 1.6 Ma, in 1984 at Nariokotome on the western side of Lake Turkana. It is usually referred to as the "Turkana Boy" (Leakey, 1971).

The remains of this species have been documented out of Africa too, as it is found in Asia and Europe. For instance in 1990s *Homo erectus* skulls were found at Dmanisi in Georgia dated to 1.75 Ma. These fossils resemble with the African *Homo ergaster*. The earliest *Homo erectus* lived for thousands of years at the same time with the late *Homo habilis* in East Africa. This contemporaneous existence of the two species could indicate that *Homo erectus* (which evolved into our species, *Homo sapiens*) was evolved from *Homo habilis* (de la Torre *et al.*, 2012).

In order to study the information found at localities such as these, many specialists including volcanologists, geologists, archaeologists, physical anthropologists, and paleontologists team up to integrate different types of field and laboratory data. *Homo erectus* (literally "*upright human*") came to occurred into the paleoanthropological record during the Pleistocene at about 1.9 million years ago in Africa. Various fossils of this hominin have been documented in Java, China, Europe, and all over the African continent. The discovery of these fossils is important in that they provide ample evidence about the

paleoenvironment and landscape of the Pleistocene (Cachel and Harris 1995; Kidder and Durband, 2004).

According to some paleoanthropologists this *Homo* is divided into two species; *Homo ergaster* (literally "working human") and *Homo erectus*. The former species have been found in almost many parts of Africa, unlike the later documented all over the world including Africa, Europe and Asia. The earliest records of Acheulean artifacts are contemporaneous with the earliest appearance of *Homo ergaster* at about 1.8 million years ago (Cachel and Harris 1995). The Acheulean artifact traditions were also made by *Homo heidelbergensis*, a species thought to be evolved from *Homo ergaster* (Kidder and Durband, 2004).

The Acheulean industry is traditionally associated with *Homo erectus*, whereas the Oldowan artifacts are linked with *Homo habilis*. However, there are currently new evidence about the probability of the existence of *Homo erectus* before the earliest Acheulean time period and, on the other hand; *Homo habilis* might have been also lived with the earliest occurrence of the Acheulean. Therefore, there is a blurred evidence about the link between *Homo erectus* and Acheulean as well as their relation with Oldowan and *Homo habilis* (de la Torre *et al.*, 2012). After the discovery of *Australopithecus garhi* and cut marks at bouri, Ethiopia, the responsibility of producing the Oldowan artifacts is much more associated with this species than *Homo habilis* (Berhane *et al.*, 1999).

The introduction of a newly invented technological change during the Acheulean period is, therefore, a significant indicator about the radical change in the brain capacity of the Pleistocene *Homo*. Furthermore, the selection and production of the Acheulean Industrial Complex, which is mainly characterized by the manufacturing of Large Cutting Tools,

preparation of cores, and bifacial flaking techniques, during the Pleistocene hominins, reveal the increasing cognitive capacity of the then hominin groups (Chauhan, 2004).

It is usually supposed that the presence of remains of hominins in a particular section in association with Early Acheulean artifacts in Africa is deemed to be the species as neither *Homo habilis* nor *Paranthropus boisei*. On account of this they are alleged to be either *Homo ergaster* or *Homo erectus* (Larick and Ciochon, 1996).

In general, despite the fact that so many ideas are suggested, it seems plausible to accept the fact that the first appearance of *Homo erectus/Homo ergaster* at ca. 1.8 million years ago in Africa is strongly associated with the emergence of the Acheulean, which is coeval with *Homo erectus/Homo ergaster* earliest occurrence. Archaic *Homo sapiens*, believed to be evolved from *Homo ergaster*, is supposed to be responsible for making the later Acheulean phase (White *et al.*, 2003). However, in Europe, *Homo heidelbergensis* is thought to have been developed from *Homo erectus*. This *Homo* was discovered in association with Acheulean assemblages at about 0.5 million years ago (Klein, 1999).

As it was concluded by Chavaillon and Berthelet, the evidence at Garba XII of Melka Kunture suggest that *Homo erectus/ergaster* is the hominin responsible to occupy and made the Acheulean artifacts. The characteristics of the site's spatial organization with a region reserved for crushing, grinding and cutting are archaic (Chavaillon and Berthelet, 2004).

In general, the combination evidence from Konso (Ethiopia) and West Turkana (Kenya) seems a strong reference for the association of early *Homo erectus* with the earliest Acheulean (Yonas *et al.*, 2013). Until it was re-dated very recently between 1.65 and 1.7 million years ago (Suwa *et al.*, 2007; Lepre *et al.*, 2010), the most well preserved *Homo*

erectus skeletal remain, KNM-ER 3733 (from Kenya) was dated back to 1.87 million years ago (Feibel *et al.*, 1989). The initial age of the specimen, 1.87 million years ago, laid it as predate of the Acheulean for years. However, the recent re-analysis of the chronology (dated back from 1.65 to 1.7 million years ago) suggest the possible co-existence of the early Acheulean with early Homo *erectus* (Yonas *et al.*, 2013).

2.3. Origin and Distribution of “Developed Oldowan” /Early Acheulean in Africa

The recent past paleoanthropological research has contributed a lot to our understanding of the evolution of humanity by uncovering a range of Early Stone Age sites in Africa. Despite such prominent discoveries, however, little is known about the technological ability and change of our early ancestor during the late Pliocene and Pleistocene period (Harmand, 2007).

The onset of the Acheulean tradition in the evolution of human culture is a paramount technological advancement compared with its cultural ancestor, the Oldowan (Sileshi *et al.*, 2009). The artifact tradition called “Developed Oldowan” is thought to be a transitional industry between Oldowan and Acheulean (Klein, 1999). After its initial nomenclature by Leakey (1971), this artifact has been used for various Early Pleistocene assemblages in Africa (Chavaillon *et al.*, 1979; Clark and Kurashina, 1979). However, its designation, as an intermediate between Oldowan and Acheulean, is not accepted by some archaeologists (de la Torre and Mora, 2005; Sileshi *et al.*, 2009). For Seleshi *et al.* (2009) the artifacts classified as “Developed Oldowan” at Olduvai are much more similar with the earliest occurrence of the acheulean than intermediates between the Oldowan and Acheulean.

The earliest Acheulean occurrences have been difficult to clearly understand (Lepre *et al.*, 2011). Until the discovery of Acheulean artifacts at Konso Gardula, South Ethiopia (Yonas, 2003; 2013) and at Kokiselei on the west of Turkana, in Kenya, the earliest undisturbed record for the Acheulean has been difficult. These sites are dated to 1.75 million years ago (Yonas *et al.*, 2013).

Setting a clear and definite demarcation between the end and the emergence of Oldowan and Acheulean respectively, is an issue of controversies among prehistorians (Leakey, 1971; Gowlett, 1986; de la Torre and Mora, 2005; de la Torre *et al.*, 2008; Sileshi *et al.*, 2009; de la Torre, 2011b).

The earliest occurrences of the Acheulean artifact tradition are dominantly reported from East and South Africa. Bearing in mind the presence of age variation among the various sites, this technological innovation have been found at Konso-Gardula (Berhane *et al.*, 1992; Yonas *et al.*, 2013), Melka Kunture (Gallotti, 2013), Peninj (Domínguez-Rodrigo *et al.*, 2002), Olduvai Gorge (Leakey, 1971), Kariandusi (Gowlett and Crompton, 1994), Olorgesailie (Potts *et al.*, 1999), and Kilombe (Crompton and Gowlett, 1993).

The first appearance datum point of the Acheulean differs from site to site for various factors. For instance there are lithic sites assigned into the early Acheulean artifact occupation at Gadeb, Sterkfontein, may be Swartkrans, Peninj, Olduvai and the Chari member of Koobi Fora (which are discussed below). The age of these sites comprises between 1.5 and 1 million years ago (Leakey 1971; Clark and Kurashina 1979; Kuman 1998; de la Torre and Mora 2005; de la Torre *et al.*, 2008; de la Torre 2011b).

Assemblages are thought to be occupation sites of Acheulean in the presence of various preconditions. For example an archaeological spot should at least contain 40% of bifaces from the total lithic assemblages to be called as an Acheulean site (Leakey, 1971). However, Leakey later on changed her idea as far as the designation of an assemblage of Acheulean site is concerned.

On account of this, Large Cutting Tools should be taken as an important factor while classifying an assemblage as Acheulean locality. As a result, she was forced to reclassify collections into the Acheulean which were initially grouped into the “Developed Oldowan”, without giving much attention her former idea of 40% incorporation of bifacial artifacts (Leakey, 1975).

Misra (1987) asserted that Early Acheulean artifacts are characterized by the occurrence of different core artifacts like handaxes, choppers, polyhedrons and spheroids. Misra, further, added that Early Acheulean assemblages only have a few cleavers and flake artifacts, no Levallois techniques, with a frequent use of hammer stone technique. The Acheulean in African stayed for at least 1 million years. These artifacts are found all over the continent. However, the most plausible and sound chronological information comes from both East and South Africa (Stiles, 1979).

The earliest Acheulean in West Turkana, Kenya, are dated back to approximately 1.8 million years ago (Lepre *et al.*, 2011). In South Africa, the earliest Acheulean is recorded with an earliest age of 1.6 million years ago (Chazan *et al.*, 2008; Gibbon *et al.*, 2009; Matmon *et al.*, 2012). This will be discussed in the following topic.

2.3.1. East Africa

The need to clearly understand and produce a sensible conclusion as far as the origin of the Acheulean technology is now the tenet center of interest among researchers of human cultural evolution (de la Torre *et al.*, 2003; de la Torre *et al.*, 2014).

The early appearance of Acheulean into the archaeological record also remains difficult to be certain until recently. Thanks to current researchers, it seems now that its earliest origin is recognized globally. Its emergence understood in the archaeological contexts after the discovery of large cutting tools like cleavers, picks and handaxes, its main characteristics (Yonas *et al.*, 2013).

Accordingly, based on geochronological study, the most primitive evidence of Acheulean is recorded in East Africa from 1.76 to 1.4 million Years Ago (Leakey, 1971; Berhane *et al.*, 1992; Roche *et al.*, 2003; de la Torre *et al.*, 2008; Sileshi *et al.*, 2009; Lepre *et al.*, 2011; Yonas *et al.*, 2013), which in turn brought an up to date technological system of dealing with the early stone age assemblages (Harmand, 2007; Braun *et al.*, 2008; de la Torre *et al.*, 2008; Braun and Hovers, 2009; de la Torre and Mora, 2009; Stout *et al.*, 2010). It is after its earliest discovery in East Africa that this technology dispatched to the rest of Africa and Europe (de la Torre *et al.*, 2012).

Acheulean industries at Konso, Southern Ethiopia, are dated back to 1.75 Ma, and hence are among the earliest discoveries for the earliest Acheulean in the world. Large flake blanks were used to produce crude and pick bifacial/unifacial artifacts at Konso (Yonas *et al.*, 2013).

From the later early Acheulean (ca. 1 million years ago) to the late Acheulean have been recorded at Middle Awash, Afar, Ethiopia. Cut marks on fauna were discovered and studied.

However, an *in situ* archaeological assemblage of early Acheulean occurrence come from the Daka member of the Bouri Formation with in an alluvial deposit dated back to 1.04 million years ago (Schick and Clark, 2003). At Gona, there is also an evidence of the early Acheulean technology dated back to 1.6 million years ago (Quade *et al.*, 2004).

There are some critiques about the designation of a site as an Acheulean occupation and, in fact, about the “Developed Oldowan” artifact tradition. Some of the criticisms include the difficulty of accepting (1) the impossibility of assigning an assemblage as Acheulean without a high frequency of handaxes and (2) the designation of “Developed Oldowan” as an independent cultural entity, hence reclassified into the early Acheulean industry (de la Torre *et al.*, 2008; Sileshi *et al.*, 2009; de la Torre, 2011b).

Nowadays, there are archaeologists who argue the labeling of such artifact tradition as an intermediary between Oldowan and Acheulean lacks a clear technological tradition. According to Sileshi *et al.*, (2009) the artifact study at Gona together with some experimental works and based on the review of the current Early Stone Age literatures the DOA (Developed Oldowan A) does not entail an independent technology rather bear a similarity with oldowan.

Because of the absence of a pragmatic evidence of technological shift from the earlier manufacturing methods, the DOA (Developed Oldowan A) should not be classified as an isolated entity of human cultural tradition rather should be grouped into the Oldowan (de la Torre and Mora, 2005).

The Acheulean is believed to be heralded by the appearance of bifacially worked handaxes. However, the Early Acheulean assemblages also contain unifacially modified artifacts with the ventral surface hardly worked or not worked. It must be underlined that the Early

Acheulean appearance should not be limited by the onset of bifacially worked handaxes. It, rather, should contain both unifacial and bifacial Large Cutting Tools (handaxes, cleavers and knives) and heavy duty tools (core axes and picks) (Yonas *et al.*, 2013). The Gona Acheulean artifacts are dated back to 1.6 million years ago (Quade *et al.*, 2008).

The Olduvai Gorge, located in the Northern part of Tanzania, is thought to be a good site to have some indications about the transition from Oldowan to Acheulean in Africa. The study of de la Torre and Mora on the previously excavated lithic assemblages by Mary Leakey at Olduvai Middle and Upper Bed II has opened the way to re-examine both biological and cultural proof in the modern view of the origin of the Acheulean in Africa in general and at Olduvai Gorge in particular (de la Torre *et al.*, 2014).

The study and explanation of archaeological situations and their technological interpretation of two assemblages at the site of Peninj, located on the western margin of Lake Natron (Tanzania), by de la Torre, Mora and Matinez-Moreno (2008) has revealed these artifacts as the earliest Acheulean. The two assemblages, RHS-Mugulud and MHS-Bayasi, are dated from 1.5 to 1.1 million years ago. They use both collections stored at the National Museum of Dar-es-Salaam, Tanzania (Glynn Isaac's excavations between 1960s-1980s) and those unpublished data and documents found at Smithsonian Institution in Washington, in addition to their excavation inputs at the site of RHS-Mugulud (de la Torre *et al.*, 2008).

The so called "Karari scraper" cores with a single platform came to exist in the archaeological record in Kenya (Isaac *et al.*, 1997). Karari scrapers, identified from the basal Okote Member at Koobi Fora, Kenya, are dated between 1.6-1.5 million years ago. Their production technique comprises a removal of various flakes from around the

circumference of a given cobble and large flake. This method of artifacts manufacture is believed to be important to have a predetermined morphological feature of a flake and it as well helps to get useful artifacts. In Kenya, there are also other Acheulean industries at a site called Kokiselei 5, West Turkana, dated back to 1.65 million years ago (Roche, 2003). The “Developed Oldowan” sites at Koobi Fora, east of Lake Turkana, are dated back to 1.6 million years ago; the same is true to the Olduvai Gorge middle and upper Bed II more or less dated between 1.6 and 1.4 million years ago (Isaac, 1997).

In the west of Turkana, Kenya, at a site called Kokiselei, from the Nachukui Formation, the FAD (First Appearance Datum) of the early Acheulean is currently pushed back to 1.76 million years ago. The assemblages contain quadrangular picks and unifacial/bifacial crude handaxes . This is the earliest record of the Acheulean. A possible coexistence of Oldowan with Acheulean is also recognized (Lepre *et al.*, 2011; Yonas, 2013).

The Acheulean large cutting tools, particularly the handaxes, show a gradual progress from their first appearance at about 1.7 million years ago to the later Acheulean time, which is after 0.6 million years ago. In their first existence, the handaxes were poorly manufactured compared with the later Acheuleans which include better made handaxes (Leader IV, 2009). This technological advancement is a prominent evidence for our understanding of the progress of hominin knapping skills (McPherron, 2000). In Eritrea Acheulean handaxes dated between 125,000 and 70,000, based on U-Th dating of coral, were found at the site of Abdur (Bruggemann *et al.*, 2004; Walter *et al.*, 2000).

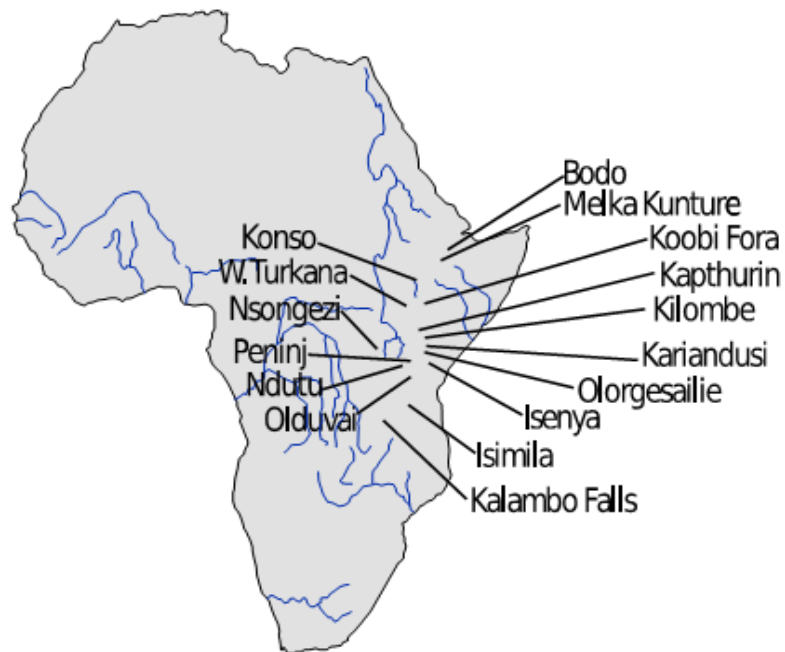


Figure 3: Location of some Early Acheulean and Developed Oldowan sites in East Africa (Produced by David Braun and Niguss Gitaw).

2.3.2. South Africa

The earliest record of the Acheulean at South Africa has been recognized as a restricted distribution until very recently. Based on a recent absolute dating method, however, some of the sites suggest the presence of an early Acheulean hominin occupation. Sterkfontein is among the prominent palaeoanthropological sites found in South Africa. Member 5 of this site is dated to between 1.7 and 1.4 Ma. At Kromdraai A there are artifacts that can be classified into the Early Acheulean techno-complex (Kuman, 2007). Some Acheulean

bifaces have been also found at another South African site called Swartkrans with an age of 1.5 million years ago (Brain, 1993).

The study of Leader (2009) on the artifact assemblages of Reitputs 15, located at about 15 Km far from the modern Vaal River, revealed another possible Early Acheulean site in South Africa. This site is dated from 1.57 to 0.22 million years ago based on cosmogenic nuclide burial dating of an ancient alluvial deposit of the Vaal River. Individual sample dating also reveal to be between 1.89 ± 0.19 to 1.34 ± 0.22 million years ago (Gibbon *et al.*, 2009). Furthermore, the Wonderwerk Cave, dated back to 1.6 million years ago using OSL (Optically Stimulated Luminescence) and paleomagnetism, is another early Acheulean site in South Africa (Chazan *et al.*, 2008).

Various biface artifacts scattered along the coarse gravel part of the Reitputs site can be classified as an Early Acheulean artifacts, which are in fact the best radiometrically dated data about the earliest presence of the Acheulean techno-complex in South Africa. These chronological data entails that handaxe using hominins might have been lived in South Africa in contemporary with the East African hominids. Hence the contemporary existence of the Acheulean technology in various sites of Africa by 1.6 million years ago could indicate both the radical technological advancements and the extensive use of Large Cutting Tools (LCT) in the continent (Gibbon *et al.*, 2009).

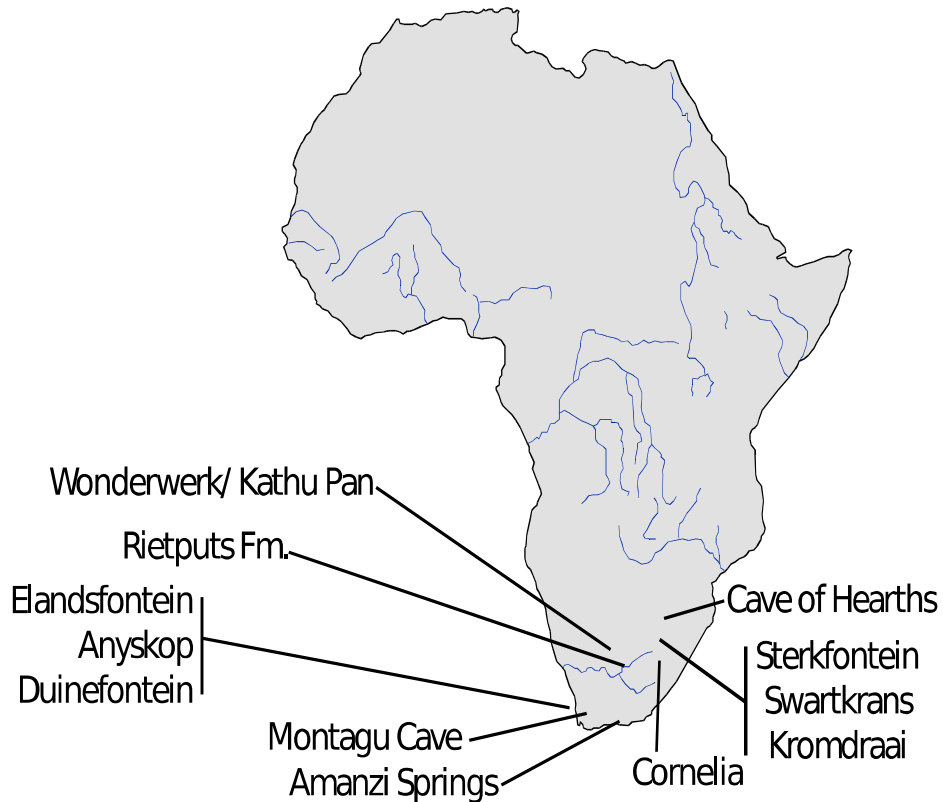


Figure 4: Location of some Early Acheulean and Developed Oldowan sites in South Africa (Produced by David Braun and Niguss Gitaw).

2.3.3. Earliest occurrences of Acheulean Out of Africa

After its first appearance in Africa in general and east Africa in particular, the Acheulean techno-complex widespread into India (Pappu *et al.*, 2011) and Near East (Bar-Yosef and Goren-Inbar 1993).

Acheulean sites outside Africa, for example at Ubeidiya in Israel, are dated as early as 1.4 million years ago (Bar-Yosef and Goren-Inbar, 1993). The recently dated archaeological site of Nahal Zihor in southern Israel might be the earliest Acheulean occupation. The fluvial and lacustrine deposits of this site is dated back to ~1.6 (Guralnik *et al.*, 2010). It

comprises two groups; Group A and Group B. The morphological analysis of these handaxes suggest the classification of the former into the Early Acheulean and the later into the Late Acheulean techno-complex (Grosman *et al.*, 2011).

The earliest European Acheulean is recorded in particular in Southern Europe dated back to between 0.6 and 0.8 million years ago (Scott *et al.*, 2009). There are also Acheulean sites with an age of 0.5 million years ago documented in this continent (Briant *et al.*, 2009).

Furthermore, the Acheulean techno-complex has been documented in India dated to 1.1 million years ago at the site of Isampur Quarry. The Early Acheulean bifaces, discovered in South Asia, are characterized by an irregular shape having a large and wide butt. The flake scars are also, like the butt, large and bold. This might have been resulted in as a result of hard hammer percussion technique (Chauhan, 2004).

2.3.4. Occurrences of “Developed Oldowan”/ Early Acheulean at Melka Kunture

Our understanding of the Acheulean industries of Melka Kunture is ambiguous. What is known about these industries is based on the 1970s and 1980s studies (Chavaillon and Piperno, 2004). The earliest discoveries of Acheulean artifacts at Melka Kunture, based on the analysis carried out at Garba XII J lithic assemblages, have been dated to 1 million years ago in the 1970s and 1980s. Oldowan and “Developed Oldowan” sites were also recognized including; Karre I, Garba IV and Gombore I with an age between 1.7 and 1.5 million years ago. On account of this, the gap between Oldowan and Acheulean occurrences was understood as not exceeding 0.5 million years ago (Gallotti, 2013).

Since 1967, Chavaillon discovered various artifacts belonging to Oldowan and Acheulean at different sites of Melka Kunture (Chavaillon *et al.*, 1979; Berthelet and Chavaillon,

2004; Chavaillon and Berthelet, 2004). Garba IV, situated on the right bank of the Awash River along the outlet of the Garba stream, was among the localities uncovered by Chavaillon in 1972 (Piperno and Bulgarelli, 2004). The excavation area of Garba IV, about 100 m², is divided into Eastern Sector (excavated from 1972-1975) and Western Sector (excavated from 1975 to 1982). Its northern part was destroyed by the Awash River, in which the stream of Garba washed away the central portion of the archaeostratigraphic level D (Piperno and Bulgarelli, 2004), the level with paramount collections among the Garba area. About 19,055 finds, of which 9821 are lithic artefacts and 6654 unworked lithic materials, have been exposed. The remaining 2580 are faunal remnants (Gallotti and Piperno, 2004).

Chavaillon conducted the first excavation in 1973. A year later, the responsibility of carrying out archaeological investigations at this site was transferred to Marcello Piperno together with Grazia Maria Bulgerelli up to 1982 (Chavaillon *et al.*, 2004). This locality was traditionally classified as the occupation of “Developed Oldowan” artifact traditions. These industries' classification into the “Developed Oldowan” was primarily depend on the presence of large number of retouched flakes, choppers with a mixture of structures, and the existence of some cleavers and bifaces (Chavaillon and Piperno, 1975).

Gombore Iy is alleged to be a ‘Developed Oldowan’ site. Garba XII, Garba XIII, excavated since 2007, and Simbiro III are localities of Early Acheulean (Morgan *et al.*, 2012). Artifacts from Garba XII are considered to be transition between Oldowan and Acheulean techno-complexes (Chavaillon and Berthelet, 2004). The transition from Acheulean to the Middle Stone Age is thought to be found at Garba III. The presence of high frequency of

large stones (Manuports) and busted pebbles coincides with the Oldowan sites of Garba IV and Gombore I (Chavaillon, 1980).

The Early Acheulean at Melka Kunture has long been accepted to appear at about 1.0 million years ago at Garba XII, (Chavaillon *et al.*, 1979). This date, compared to its neighboring early Acheulean sites dated between 1.76 and 1.4 (for example Yonas *et al.*, 2013; Lepre *et al.*, 2011), is younger (Gallotti, 2013). According to Chavaillon and Berthelet (2004) Garba IV level D represents the earliest occupation of Acheulean technology at Melka Kunture.

However, recent study by Gallotti suggests the emergence of Acheulean at Melka Kunture can be pushed back to 1.5 million years ago at Garba IV level D. The lithic assemblages found at this locality are, thus, among the richest in the discovery of the Early Stone Age artifact series in Eastern Africa. These technological traits are shared by the contemporaneous sites in East Africa and are considered to be typical of the Early Acheulean. This suggests an older origin for the Acheulean at Melka Kunture, 0.5 million years ago than previously inferred (Gallotti, 2013).

2.4. Brief introduction of discoveries and Archaeological Research in the study area

The site, discovered by Gerard Dekker in 1963, was surveyed by Gérard Bailloud in 1964, and then systematically explored by a French mission directed by Jean Chavaillon (1965-1982 / 1993-1995). Since 1999, an Italian mission directed by Marcello Piperno from the Italian Ministry of Foreign Affairs and the University of Rome “La Sapienza” has worked

at the site in agreement with the ARCCH of the Ethiopian Ministry of Culture and Tourism and the Oromia Culture and Tourism Bureau (Chavaillon and Piperno, 2004).

In 1963, the prehistorian Gérard Bailloud lived in Addis Ababa to assess some archaeological sites in the country. He was initiated by Joseph Tubiana to investigate the prehistory of the Horn of Africa, particularly Ethiopia. In the same year, Gérard Bailloud was, after he received a permission from the then Institute of Ethiopian Archaeology (IEA), which was established in 1952 to take care of the heritages of the country, and on the will of the Ministry of Culture, ready to begin his operation in Eastern Ethiopia (Chavaillon and Piperno, 2004).

In 1963 a Netherlands hydro geologist and a friend of L.S.B. Leakey, G.Dekker, was also living in Addis Ababa. This person had an ardent desire to conduct pre-history research. He spent his weekends driving out of Addis Ababa with an intention of discovering pre-history sites. On account of this, he conducted a survey on the ford of Awash, i.e. Melka Kunture. While he was on the way to the Awash village, Dekker recognized and marked an eroded small outcrop. It was a promising discovery with a spectacular alluvium (Chavaillon and Piperno, 2004). Before 1963, the prehistory of Melka Kunture was unexplored.

Gerrard Dekker was so excited by his discovery and he decided to protect the site by announcing for the concerned body of the country. It was after his broadcast that authorities from the Institute of Ethiopian Archaeology, Francis Anfray and Gerrard Bailoud together with Gerrard Dekker visited the site of Melka Kunture, during which the archaeological importance of the site confirmed (*Ibid*).

Gerrard Bailoud had a plan to undertake investigations around Harar. However, his project did not stay long. This was because; he understood the great significance of the Early Stone Age site of Melka Kunture compared to the Harar region. His initial survey enabled him to collect a large number of artifacts on the surface. The Acheulean site of Gombore (the current Gombore II, locality 1) was also one of the sites discovered by Gerrard Bailoud and he was able to collect artifacts from the surface and occasionally on their original context. His first work was published in a small book which was edited in Addis Ababa (*Ibid*).

Mary D. Leakey and Glyn Ll. Isaac, after they were invited by R.W. Seymour, who was a geologist at Addis Ababa University and interested in both geological and archaeological study, were highly fascinated to study the geology and archaeology of the site. The first archaeological excavation and investigation was conducted by Jean Chavaillon after he was asked by André Parrot, President of the Commission of excavations for the Foreign Office, in 1965. During his field campaign, Chavaillon discovered a layer full of rounded pebbles together with mammal bones and flaked pebbles at Gombore (Chavaillon and Piperno, 2004).

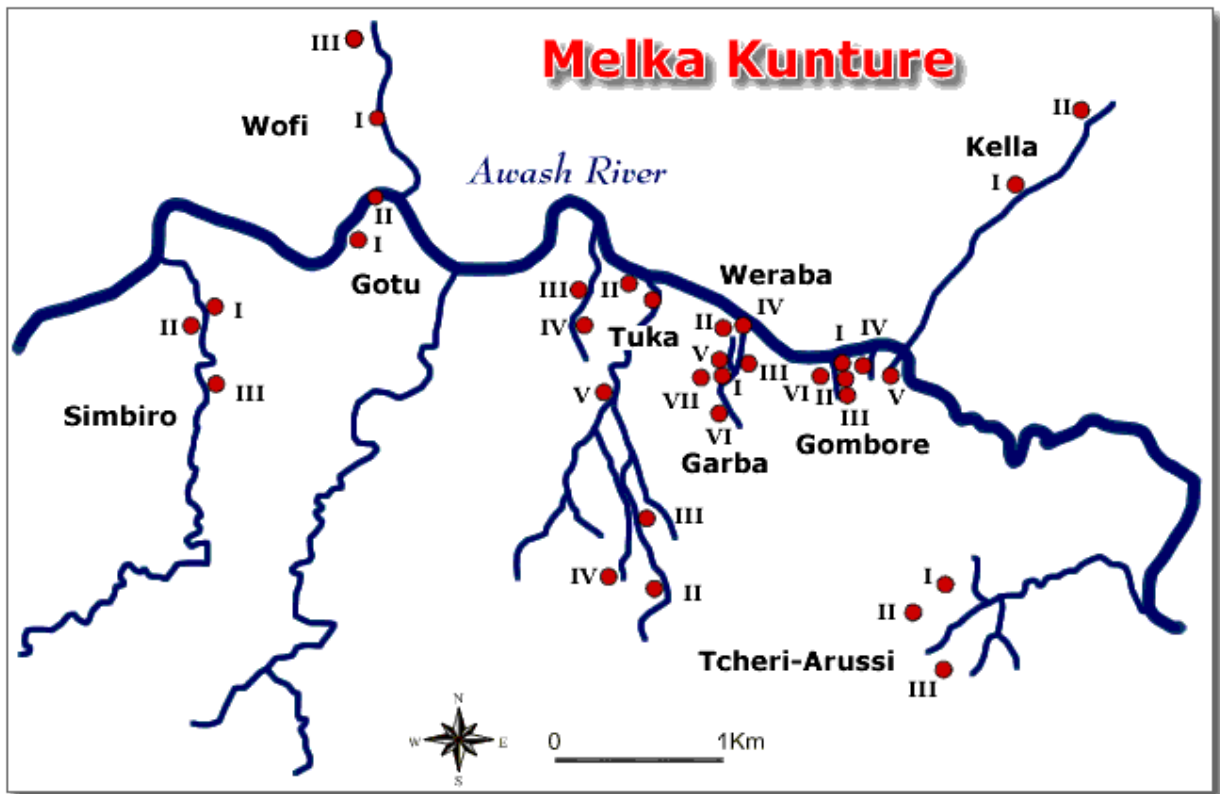


Figure 5. Location of different archaeological sites of Melka Kunture (After Chavaillon and Piperno, 2004).

From 1965 to 1982 an in depth archaeological excavations had been undertaken. However, after 1982 there was no opportunity to conduct an archaeological excavation, because of the unwillingness of the then government, until its resumption in 1993. In 1992 the previously discovered materials were studied in Paris and Rome. The field work exploration of 1993, conducted by A. Berthelet, J. L. Boisaubert, J. Chavaillon and M. Piperno, was concentrated at the main site of Gombore II, the late butchery site of hippopotamus. In 1999, Marcello Piperno took the responsibility of directing and undertaking the archaeological exploration at Melka Kunture. Starting from this period, he conducted

fieldwork and laboratory studies together with Italian and French teams (Salvini *et al.*, 2012; Chavaillon and Piperno, 2004).

2.5. Discoveries of Hominins and Fauna

As the paleontological study revealed, high frequency of Hippopotamus amphibus, Suids, Bovids (*alcelaphini*) Equids (*stillohipparion*), have been uncovered. A fragment of distal humerus, belonging to Homo cf. erectus, was discovered at this site. Biological evolution evidence, together with cultural evolution, has been discovered within different localities of Melka Kunture, all belonging to the genus *Homo*. One probably archaic *Homo sapiens* and four *Homo erectus* specimens have been unearthed. *Homo erectus* humerus and partial infant mandible have been discovered at Gombore I and Garba IV respectively. The humerus of *Homo erectus*, found at the Oldowan site of Gombore I (dated between 1.7 and 1.6 Ma), seems something strange, as Oldowan sites are associated with *Homo habilis* and Acheulean sites with *Homo erectus*. However, the robust features of this fossil cannot support for classifying it as *Homo habilis*. Its characteristics strongly fit with *Homo erectus* than *Homo habilis* (Coppens, 2004).

As far as the abundance of faunal remains is concerned, the richest site in Melka Kunture is Garba IV, which was excavated by Marcelo Piperno, followed by Gombore IB, excavated by Jean Chavaillon (Geraads, *et al.*, 2004). The site of Garba IV is most significant for its fauna and artifacts discovery with a long chronological sequence (Piperno, *et al.*, 1974-1975).

2.6. Archaeological Sequences and Main Cultural Subdivisions at the study area

At Melka Kunture more than 70 archaeological levels have been identified so far. This sequence is only comparable with the archaeological record at Olduvai Gorge and span the times of the Oldowan, Acheulian and early MSA. The excavators suggest that there is good evidence for a general continuity in the development of technological and other cultural patterns during the whole sequence. This essential behavioral continuity seems also to correspond to the paleoanthropological evidence at Melka Kunture: human remains associated to the Oldowan at Gombore I and to the “Developed Oldowan” at Garba IV have been both referred to *Homo erectus* (Chavaillon *et al.*, 2004).

The earliest findings at Melka Kunture includes from the Oldowan to the Late Stone Age. The Early Stone Age collections of Melka Kunture include Oldowan, “Developed Oldowan” (like Garba IV and Gombore I) and at the same time Acheulean (from sites Gombore II) (Chavaillon and Berthelet, 2004). The Oldowan sites include Karre I, Gombore I, Gombore Ig, Garba IVG-E, while Garba IV level D, Garba XII, Simbiro III, Gombore II, Garba I are Acheulean sites. The Oldowan site of Karre is dated back to between 1.6-1.7 Ma, using K/Ar dating method. This site can be correlated with the level B of Gombore I, located on the right side of River Awash (Chavaillon and Berthelet, 2004).

At the site of Gombore II an evidence for the presence of Middle Acheulean, dated to 0.8 million years ago has been recorded in the chronological sequence of Melka Kunture. The Late Acheulean is well represented at the site of Garba I with an age ranging between 0.5 and 0.4 million years ago. This extended artifact tradition might have been stayed not later than 0.2 million years ago, and is represented in Melka Kunture at Garba III (Chavaillon

and Piperno, 2004). The Middle Stone Age is represented by Garba IIIA. Wofi II, Wofi III and Kella I are Late Stone Age sites. All sites from Early Stone Age to Middle Stone Age are found on both banks of the Awash River (Gallotti, 2013).

A later Acheulian is well represented in the stratigraphic sequence of Melka Kunture, at the locality of Gombore II dated to 0.84 million years ago, exhibiting twisted handaxes, while the extremely rich Upper Acheulean at Gombore II is dated to 0.5 and 0.4 million years ago. Unlike the earliest phase of the Eastern African Stone Age, known as Early Stone Age (ESA), which is studied better, the latest phases, i.e., Middle Stone Age (MSA) and Late Stone Age (LSA), have not been studied intensively at Melka Kunture particularly the East African Later Stone Age is poorly documented at Melka Kunture, being represented so far by some finds at Wofi and Kella (Chavaillon and Berthelet, 2004).

Chapter Three

Geology and Paleoenvironment of the study area

3.1. Geology and Geo-chronology

The pre-history site of Melka Kunture is geologically located in a lateral branch of the Rift Valley. It is a valley site that extends 5 km in both left and right banks of the Awash River. It is formed from fluvial sediments. The sedimentation process at this site is broken as a result of volcanic activities. The products of the volcanic activities such as tuff and lava are imperative to have a vivid understanding of the stratigraphic relation between the various archaeological localities of the site. Hence the volcanic deposits, which are about 100 meter thick, are important chronological markers of the site (D'Andrea, *et al.*, 2002).

Geological development at Melka Kunture has been understood as a result of rifting and volcanic processes. Archaeological sites of Melka Kunture are mainly situated on a regional normal fault (A type of geological fault where the hanging wall has moved down ward relative to the foot wall as a result of pulling apart of the rocks). Part of this fault is packed by volcanic and sedimentary deposits of Pleistocene. The overall geological succession at Melka Kunture covers from Late Miocene to the Holocene (Salvini *et al.*, 2012) (See Figure 6). The Garba IV sediments, dated back to 1.5 million years ago with a radiometric dating method, incorporate fine gravels and sand (Gallotti, 2013).

Melka Kunture is a river valley with fluvial depositions of pebbles and clay. These depositions undergo various erosion processes associated with sedimentary cycles as a result of climatic fluctuations. Various geological depositions with different age are revealed one after the other; its thickness reach up to 30 meters if some of the layers were

not lost due to erosion. These fluvial deposits positioned with volcanic tuffs are important for absolute dating. These geological formations bear an evidence of both biological (example remains of fossilized bones) and cultural (example, lithics) human evolution record. Besides, different human made features ranging from the earliest (i.e, before 1.5 million years ago) to the later are documented in these geological depositions (Chavaillon *et al.*, 1979).

3.2. Paleoenvironmet of the study area

In an attempt to reconstruct the paleoenvironmental situation of Melka Kunture during the Early and Middle Pleistocene in depth investigations have been carried out. Paleobotanical, Micro paleontological and paleontological studies have been employed to understand the then environmental situation. On account of this study, paleoenvironmental change has been attested in the highlands of Ethiopia, during the time when the archaeological data is reflected to be apparent in the site (Piperno, 1999).

This environmental change was the result of more or less oscillation in arid or moist climate, which is the main diagnostic feature of the Pleistocene epoch in southern hemisphere. This environmental rise and fall played a significant role in opening the way for the expansion of some arboreal species. Animals adapted to dry conditions, such as several species of Bovids and Equids were highly concentrated on arid savannah environments, while animals like Hippopotamus, Elephant and *Phacocerus*, were adapted to woodland savanna during humid phases. The same situation is also indicated at Melka Kunture by the faunal associations found during extensive excavations in chronologically different sites, where the presence of mammals adapted to more or less humid or arid

conditions is proposed in terms of statistical frequency of one or another species rather than as an alternative frequent of different mammals in the Ethiopian Highlands (*Ibid*).

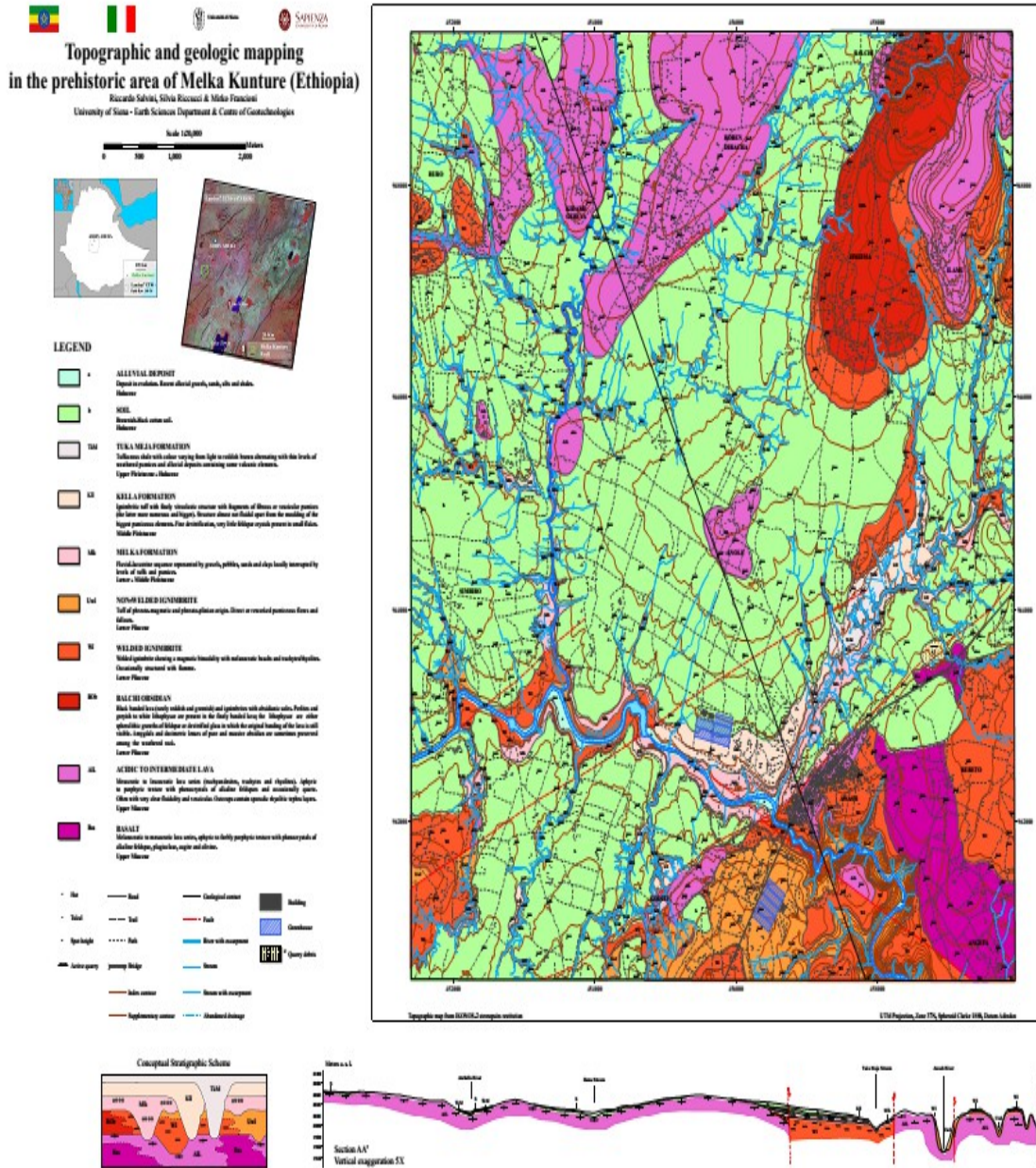


Figure 6. Topographic and Geological map of Melka Kunture (Taken from Salvini *et al.*, 2012).

Chapter- Four

Analysis and Results

4.1. Assemblage Overview

A total of 199 artifacts were investigated during the process of the analysis work from Garbe IV levels C and D. 76 whole flakes, 33 cores, 82 broken artifacts and 8 pounded pieces were studied (Table 1). The type of raw material is dominantly obsidian in level C assemblages. Level D has obsidian, ignimbrite, rhyolite and basalt materials. To clearly understand the technology of the materials a critical and sound measurement was undertaken (Table 2).

Table 1: Total number of studied assemblages

Category	Garba IV level C	Garba IV level D	Total
Whole Flakes	27	49	76
Cores	8	25	33
Broken Artifacts	39	43	82
Pounded pieces	6	2	8
Total			=199

4.2. Techno- typological Classifications

One of the fundamental archaeological methodologies is classification of materials into different categories based on some attributes such as; morphological similarity, lithic raw material characteristics, size of the artifact, function of the artifact and so forth. This type of classification enables the researcher to summarize data for further detail description. Classification and identification should be undertaken at the beginning of artifacts analysis (Andrefsky, 2005).

On account of this every artifact was categorized into pounded pieces (cobbles used as hammer stones etc), detached pieces (flakes and fragments) and flaked pieces (like cores); artifact classifications introduced by Isaac (1997) before further investigation is carried out. Flaked pieces are artifacts from which flakes struck off. Detached pieces are artifacts removed from the core. These were further subdivided into whole flakes, split flakes, angular fragments, snaps and split and snaps.

A flake is said to be snapped if and only if it is broken more or less parallel to the striking platform. The breakage could be in either the distal or proximal side of the artifact. A split flake is a broken flake along the flaking axis, perpendicular to the striking platform. Only half of the bulb of percussion remains in a split flake (Hovers 2009; Toth *et al.*, 2006). This type of flake usually occurred as a result of the use of hard hammer percussion in the process of stone artifacts production (Inizan *et al.*, 1992).

4.3. Technological Attribute Analysis

To have robust information about the analysis of stone artifacts under investigation, a proper registration form has been completed before doing the main analysis. Each artifact was given an identification number to facilitate the study based on various attributes, usually determined by the type of flake. Cortex percentage, weight, raw material type and maximum dimensions are among the attributes applied for every artifact, without artifact type considerations.

4.3.1. Whole flakes: These are detached pieces with clear diagnostic features including striking bulb, visible removal surfaces and striking platform (Appendix 2). These artifacts are the most significant sources of information as far as hominin knapping skills and the technological features of Early Stone Age are concerned (Sileshi 2000, Braun *et al.*, 2003). 76 artifacts were identified as whole flakes during the analysis. Among these artifacts only 27 were from the level C of Garba IV. The rest 49 belong to Garba IV level D. The whole flakes analyzed from level C are obsidian. Unlike the raw materials identified in level C which are the same source of materials, level D of the Garba IV comprises obsidian and basalt, ignimbrite and rhyolite whole flakes. 18 whole flakes produced from obsidian have been analyzed in level D together with 31 artifacts whose source is basalt, ignimbrite and rhyolite. Most of these artifacts are found in a good state of preservation.

Table 2: Dimensions of whole flakes at Garba IV levels C and D (measurements are in mm except the weight which is in grams. Length measured along the technological axis and both width and depth measured at 50% of the flake following its technological axis).

Site		Maximum dimension	Minimum dimension	Mean	Standard deviation	Total Number of artifacts
Garba IV Level C	Length	80.25	18.28	38.74	14.24	27
	Width	97.62	15.12	40.04	17.93	
	Depth	20.18	5.55	12.4	4.32	
	Weight	113.83	3.39	29.81	31.04	
Garba IV level D	Length	134.2	23.62	56.05	23.44	49
	Width	84.78	17.75	48.39	17.55	
	Depth	37.24	7.34	16.99	7.92	
	Weight	473	5.27	79.56	96.41	

Various information were gathered while analyzing whole flakes by measuring and studying the following attributes; weight, cortex (dorsal and platform cortex), dorsal removals, termination types and external platform angle (EPA). Measurements like maximum dimension, maximum dimension perpendicular, maximum width, platform width, platform depth; technological length and technological width were undertaken. In addition, measurement of depth was applied at different levels of the whole flakes; at 25 %, 50% and 75%. Measurement of depth at different levels is a new methodology proposed by Presnyakova *et al.*, (2015).

Measurement of dimension and weight is significant in that it plays a prominent role in telling us size and shape of the flake (Sileshi, 2000). Technological length is measured from the point of percussion/ the striking point into the point at which the flake terminated. As elements of measurement systems are incorporated into my research study, it is indispensable to show a brief way of measuring some of the measurement methods (Figure 7).

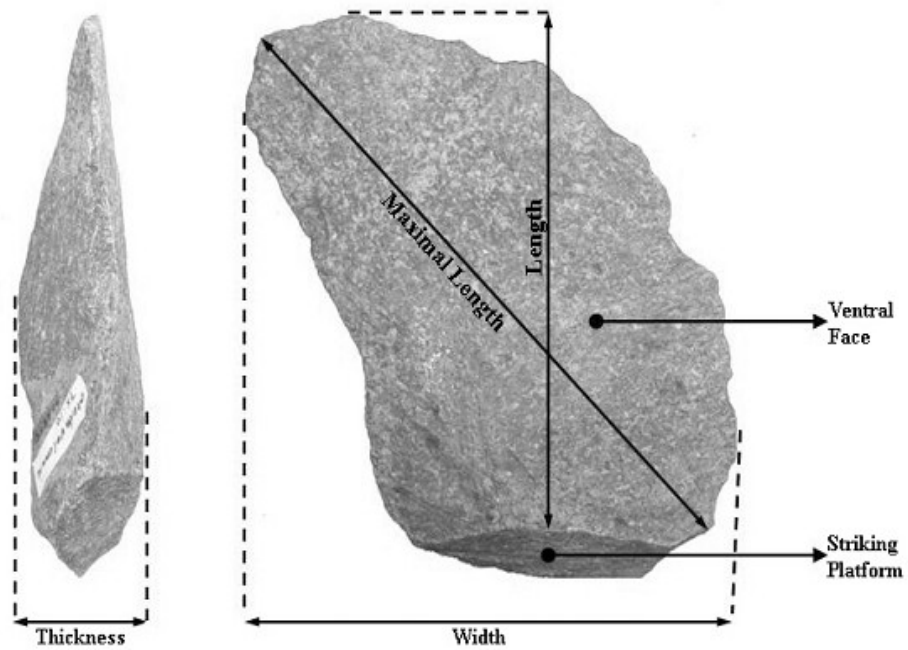


Figure 7: a picture showing some of the types of measurements in whole flakes (After Sharon, 2006).

4.3.2. Core typology and analysis

Core classification is very important in that it provides vivid evidence about the manufacturing technique of a given stone technology. This became clear when someone tries to investigate the frequency of flaking surfaces, flake direction, the angle between the striking platform and the flaking surface of the core. Understanding whether the pre-historic man used the core with or without preparing its platform, is also significant in opening the way for recognition of the knapping technology (Gallotti, 2013).

A total of 33 cores were studied (Figure 9 and Appendix 3). 25 of them are from Garba IV level C and the remaining 8 are from the same locality of level D. Most of them were produced from rounded cobbles with a few materials worked from triangular cobbles. Cores were analyzed based on measurements of maximum length, maximum width and maximum depth (Figure 8). Coverage of remaining cortex was analyzed in percentage. As a result most of the cores have cortical surfaces between 40-60%. Only one material has been found with a cortical surface and a single core was identified as non cortical. Striking surface number, flake removal surface number and extraction numbers were also analyzed to understand availability of the raw material source and its quality. The presence of more removals on a core may indicate both good quality of the material and scarcity of the raw material, which directly relate with cognitive capacity of the knapper. Maximum length and width of the cores were measured. The highest maximum length is 150.12 mm and 32.44 is the lowest (Mean=93.07). Maximum width ranges between 27.69 and 120.44 (Mean=70.75). Maximum depth measurement have been also included, with the highest depth measurement 120.44 and lowest measurement of 27.69 (Mean=51.21) (Table 2).

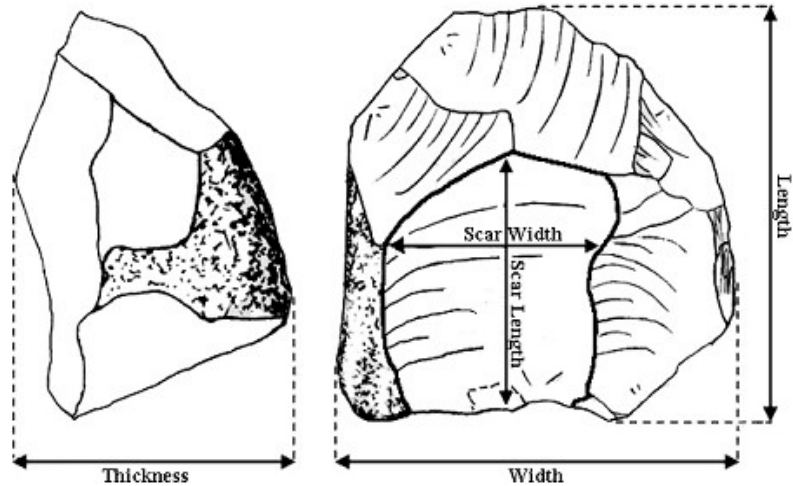


Figure 8: Measurement of cores and their largest removals (After Sharon, 2006).

Weight unit of the materials was measured in grams. Measurement of weight is taken as a good indicator of reduction intensity (Amick *et al.*, 1988). Among the whole removals in each core the largest flake scar was measured. Maximum length and width of largest scars, based on the line of the removal, were recorded in each core, with a maximum length ranging between 113.74 mm and 26.33 mm. The maximum width of the longest removal on cores lied between 104.72 and 10.74 mm. Termination and interaction of the largest removals were identified. Most of them are terminated as feathered with some hinged ones.

Total Number of Studied Flaked Pieces at Garba IV Levels C and D

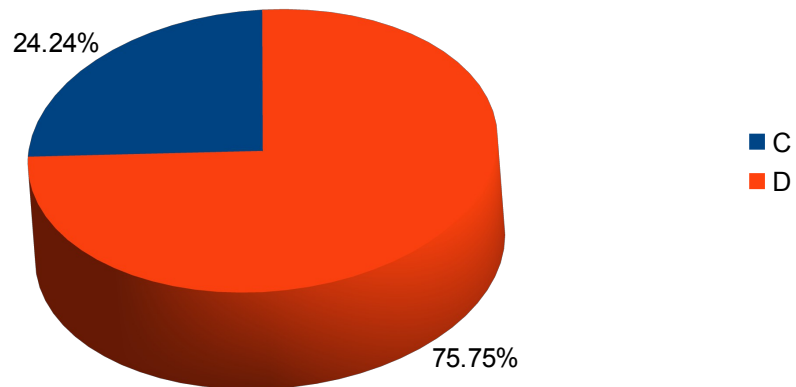


Figure 9: Number of studied flaked pieces where,

C = Garba IV level C

D = Garba IV level D

The cores were grouped into various types of core typological classification systems applied by Chavaillon and Piperno (2004) in classifying stone artifacts from Melka Kunture. Unipolar, bipolar, polyhedral (Figure 10), unipolar (Figure 11) and pyramidal core types were identified (Table 3). No centripetal types were found in the assemblages I have studied. There were also cores which were difficult to classify into none of the core typologies.

Table 3: Core typologies

Core typology	Number of artifacts	Garba IV level C	Garba IV level D
Unipolar	8	1	7
Bipolar	7	3	4
Polyhedral	10	37	7
Prismatic	0	0	0
Pyramidal	1	0	1
Core fragments including those unidentifiable and shapeless cores	7	0	7



Figure 10: Polyhedral core type



Figure 11: Unipolar core type.

4.3.3. Analysis of broken artifacts: These were analyzed by applying weight, maximum width dimension measurements, raw material type, remaining cortex in percentage, flake types and termination types (Appendix 1). Because of the absence of technological reference point, the length and width were defined as the maximum dimensions. External platform angle was also measured only for flakes that preserve the platform. Platform depth and width was part and parcel of the measurements (only for artifacts that do have the platform, hence it excludes angular fragments). Flake types were defined as split (longitudinal fracture), snaps (transverse fracture, but with the striking platform maintained), angular fragments (with a broken platform) and a combination of split and snap in one flake. A total number of 82 artifacts were analyzed (Figure 12).

Total number of Broken Artifacts at Garba IV Levels C and D

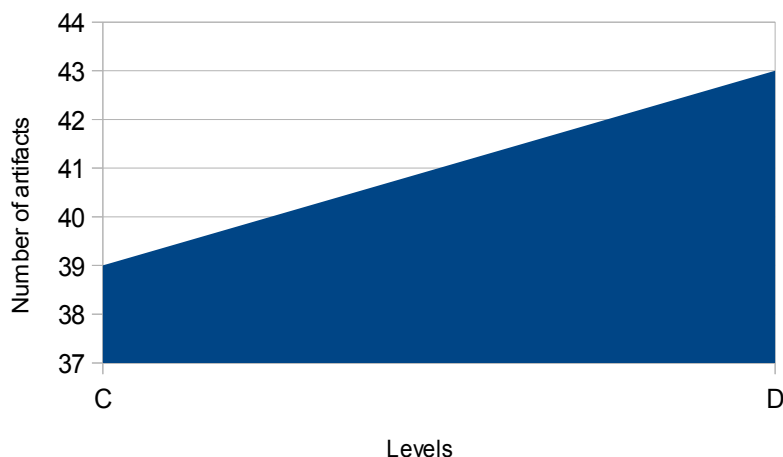


Figure 12: A graph showing the total number of studied broken artifacts

4.3.4. Pounded pieces: pounded pieces were analyzed for raw material type, weight, number of pounded surfaces and cortex. A total number of eight materials have been analyzed, six from Garba IV level C and the rest two from Garba IV level D (Figure 13). Their pounded surfaces range between two and four. Two artifacts were identified with two pounded surface, and three artifacts with three pounded surfaces during the analysis (Table 4 and Appendix 4). They are medium sized hammer stones with elongated and spherical shape. Their cross section is plano-convex and bi-convex. The impact surfaces are located along their edges and at the central part.

One hammer stone is found to bear evidence about the use of the material for both percussion and source of flake. It has some removals both before and after it was used as a pounded material. The previous removal is known because it has currently a pounded

surface with a visible removal. And the later removal is known because the removal surface does not have any evidence about its use as a hammer stone; only a fresh removal was attested.

The raw materials are dominantly obsidian (from Garba IV level C) and other materials like ignimbrite, basalt and rhyolite (from Garba IV level D) rocks. Their weight ranges between 126 to 744 g, from Garba IV level C and Garba IV level D, respectively. Compared to obsidian raw material, aphyric rocks are more resistant and difficult to break. Gallotti (2013) asserted that hominins were deliberately selecting homogeneous rocks, like aphyric and subaphyric basalts, which are dense and fracture resistant at Garba IV level D.

Table 4: pounded surfaces and the corresponding number of artifacts.

No.	Pounded surfaces	Number of artifacts with pounded surfaces
1	Two	2
2	Three	3
3	Four	3

The blank type is dominantly rounded cobbles with a few rounded cobbles. As far as cortex is concerned most of them have from 60-90 % non cortical surfaces, which might suggest the use of the materials very often as a hammer stone. One of the hammer stone seems to have been used for both a hammer stone and core. This is because there is a removal on its some part and a pounded surface on the other. There are also two different

types of removals. The presence of a battered removal surface in one of its removal side could indicate that the removal might have been appeared before it was used as a hammer stone. You can still see both the removal and the battered surface together.

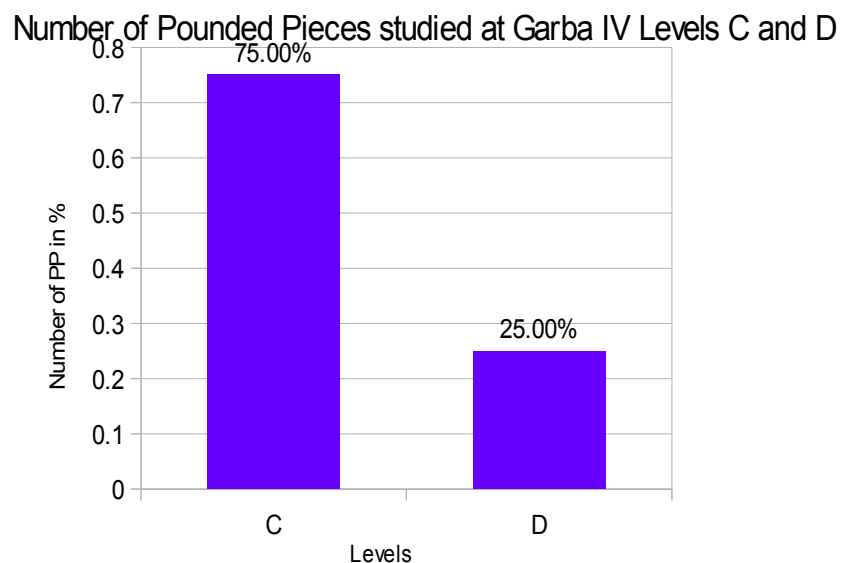


Figure 13. A graph showing the total number of studied pounded pieces

4.4. Platform Analysis

4.4.1. EPA Analysis: Exterior platform angle was measured using goniometer which is expressed in degrees. External platform angle (EPA) is measured from the striking point to the dorsal surface of the flake (Figure 17). Measuring EPA is not an easy thing as the presence of curved artifacts makes it difficult to clearly measure. To avoid this type of confusion I have measured the artifacts at the point of low thickness of the platform. Platform depth and external platform angle are, according to experimental results, decisive

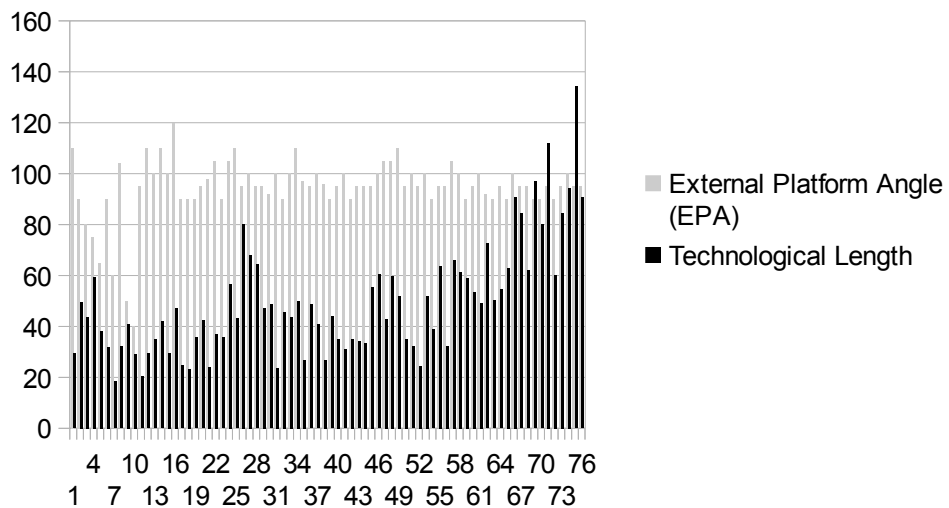
factors in the final size of a flake (Dibble and Whittaker 1981, Kooyman, 2000). The larger the flake, the higher the depth of the platform is. The size of EPA is determined by size of the flake. The increasing value of EPA can be the result of large flake. The presence of large size flake weight is the result of an increment of platform depth and EPA (Dibble, 1997). The EPA measurement shows the presence of greater than and less than 90° flakes (Figure 16).

EPA is a determining factor in influencing the final shape and size of the flake. It might be also controlled by the knapper, because of which morphology of the flake varies. Because of the convexity structure of the dorsal surfaces of some of the materials studied, it was too difficult to precisely measure the EPA. Andrefsky (1998) and Dibble (1997) stated the difficulty of measuring the EPA of artifacts with a convex dorsal surface.

Platform dimensions (both depth and width) were also measured, as they are important indicators of flake size (Dibble, 1997). Width of the platform is the distance from one lateral margin to the other along the striking platform. Platform depth was measured the distance from ventral to the dorsal surface of the flake along the platform surface (Andrefsky, 2005).

According to Kooyman (2000), EPA influences various types of flake characteristics. These include; termination and both length (Figure 14) and depth of a flake. A decrease in the EPA resulted into a feathered termination. Regarding the relation between EPA and the length of a flake Speth (1972) stated that an increase in the exterior platform angle can be resulted into an increase in the length of the flake.

Relationship between Technological length and EPA

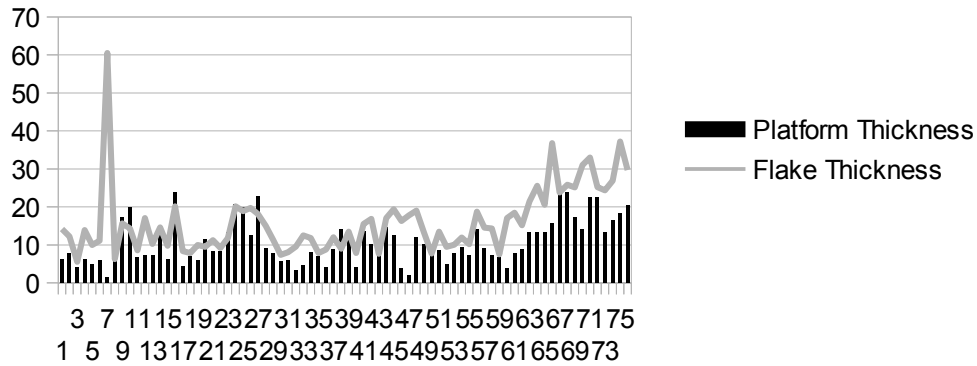


Where, X represents the technological length and Y represents EPA.

Figure 14: Relationship between EPA and Technological length.

The relation between EPA and flake length seems an indirect relationship (See figure 14). platform thickness and flake thickness have relatively direct relationship. The higher the platform thickness, the higher the flake thickness (See figure 15).

Relation between Platform thickness and Flake thickness



Where, X represents Platform thickness and Y represents flake thickness.

Figure 15: Relationship between Platform thickness and flake thickness.

4.4.2. Platform Depth: This is an important factor for the variation of flake morphology. It is measured from the dorsal to the ventral surface of a flake, along the striking platform excluding the bulb of percussion (Kooyman, 2000). Together with EPA, depth of the platform determines length and depth of the flake. They have a direct relationship. The length and depth of a flake increases as the platform depth increases (Dibble and Whittaker 1981; Speth 1972; Bonnicksen 1977).

EPA and their frequency at Garba IV C and D

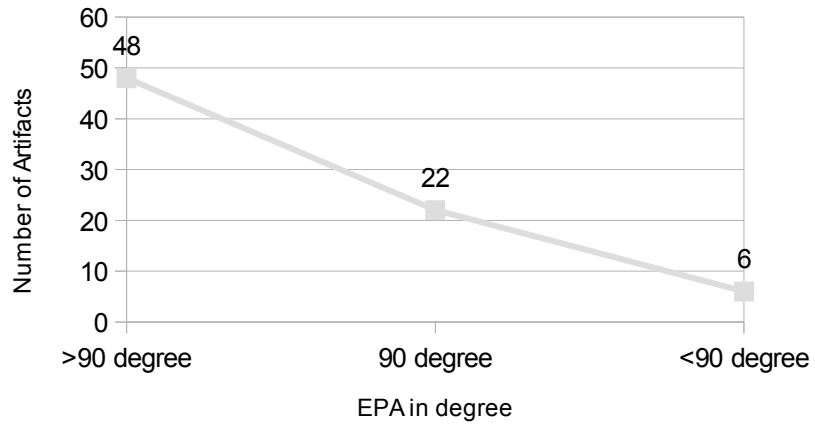


Figure 16: Frequency of EPA.

Measurements of EPA in the whole flakes indicate that artifacts with greater than 90 degree are large in number followed by flakes with equal to 90 degree and less than 90 degree (Figure 16).

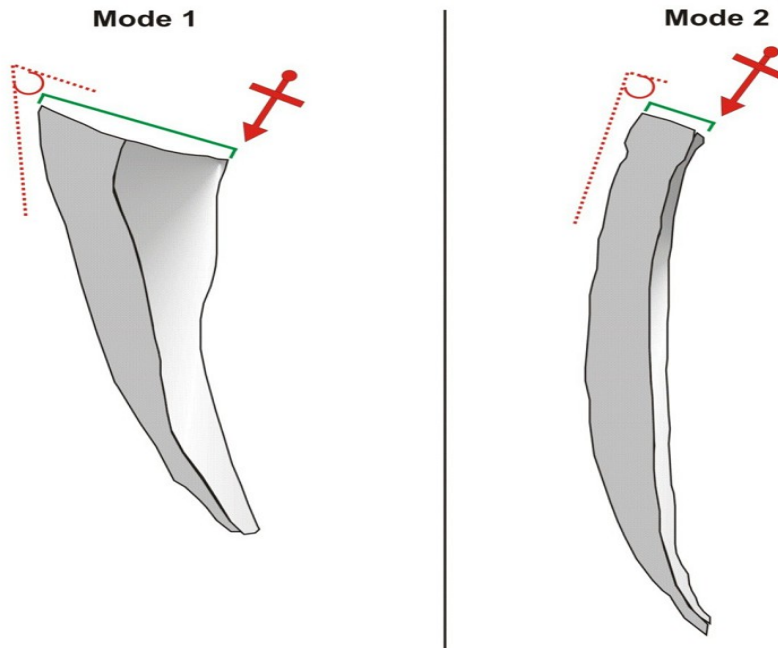


Figure 17: External platform angle and platform depth. Dashed line: EPA; solid line: platform depth; arrow: point of percussion.

4.5. Analysis of scars

4.5.1. Dorsal Flake scars: Negative flake scars on the outer part of a flake are good indicators of the previous technique of removal from a core. It is also significant in that it tell us about the intensity of core reduction. According to experimental studies the presence of non cortical artifacts in an assemblage revealed the extensive reduction of the core (Marwick, 2008). Count of dorsal removals on whole flakes of Garba IV levels C (N=27) and D (N=49) indicate that the hominin were both active and passive in extensively using the objective pieces (Figure 19). This is because there are materials that do have many removals on their dorsal surface while some of them do not. The number of dorsal flake

scars are related either with size of the flake or reduction intensity (Mauldin and Amick, 1989).

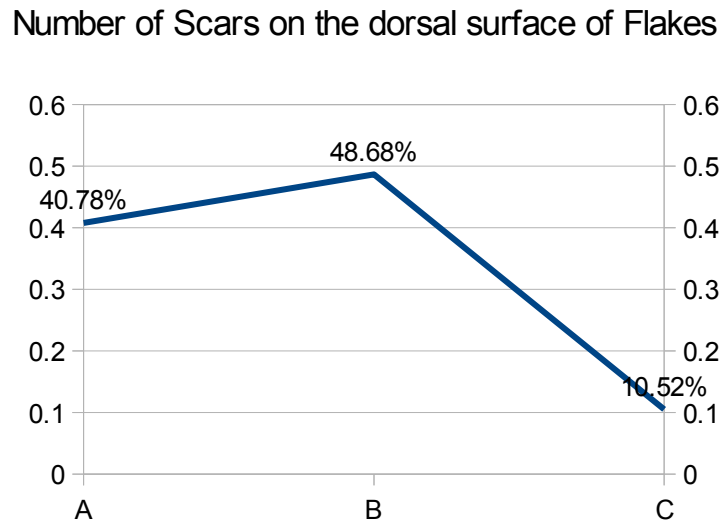


Figure 18: A graph showing numbers of dorsal removals from flakes.

Legend

A=Flakes with dorsal removals between 0 and 2

B=Flakes with dorsal removals between 3 and 4

C=Flakes with dorsal removals between 5 and 7

4.5.2. Extractions from cores:

Removals from each core were counted and investigated (Figure 19). Measurement of the longest extraction was made. Its length and width were measured.

“A more technologically oriented measure of the size of a core is the length of the longest flake scar on its surface, that is, the length of the longest flake detached from the core before it was abandoned. This measure provides a basis for considering the sizes of cores

in terms of the sizes of complete flakes in the same assemblage” (Holdaway and Stern 2004:186).

Both the hominins' knapping skill and local raw material availability can affect reduction intensity (Toth *et al.*, 2006). The presence of large number of smaller scars on a core, compared to other flakes produced from the same raw materials, can imply reduction of the core more intensively. Large extractions, on the other hand, could indicate to the reverse. Most of the cores have large number of scars which can suggest the extensive use of the material. This can be the result of the following factors;

- 1.The raw material quality might have played a determining role in intensively using a single core as a source of various detached pieces. No matter whether there are various sources of raw materials close to their production site, the hominins can select materials with a good quality of fracture and durability. In this case, the issue of cognitive capacity can be understood in line with the ability of the hominins in selecting raw materials with a good attribute.

2. Availability of raw material source can affect the use of materials. The absence of raw materials nearby the production/occupation site can force hominins to repeatedly utilize the raw materials close to them.

- 3.The dominance of the same types of raw materials in the area the hominins occupy can also be taken as another factor for the use of the same type of core for flake removals. If they have the same quality they cannot be switched as a replacement of an already extractions started material by a new one can waste time and energy to get a suitable surface of extractions, particularly for cores that needs platform and extraction surface

preparations.

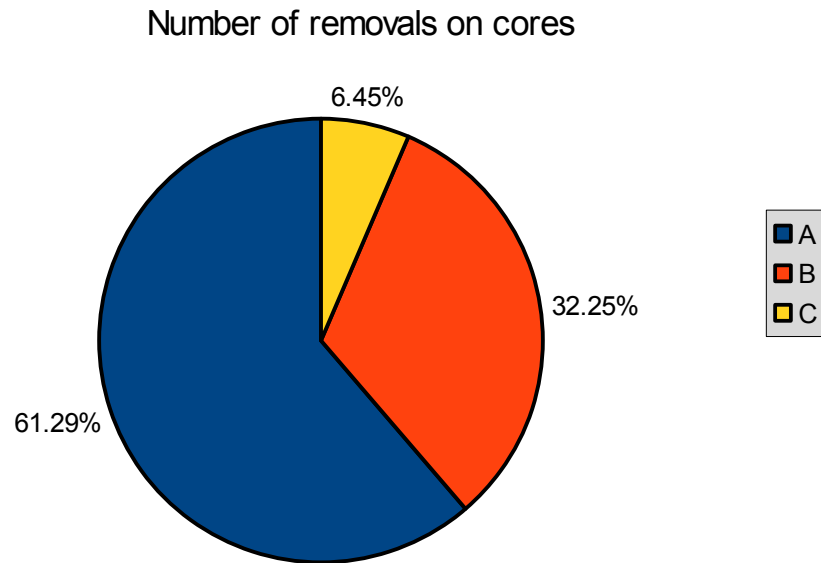
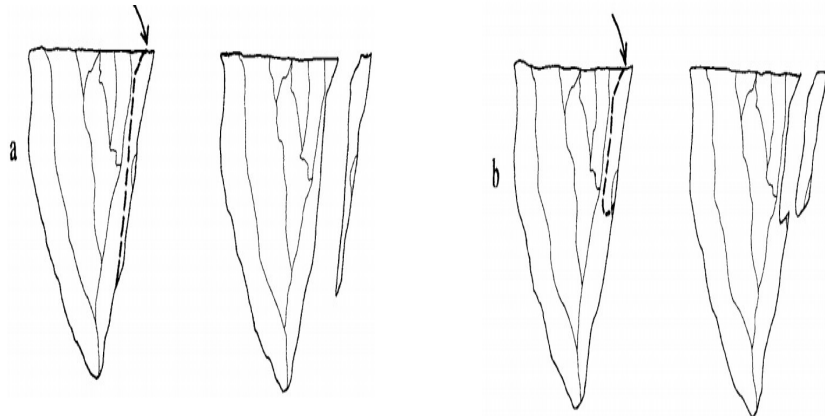


Figure 19: Number of removals from cores. A=Cores with removals between 2 to 5, B=Cores with removals between 6 to 9, and C=Cores with removals between 10 to 13



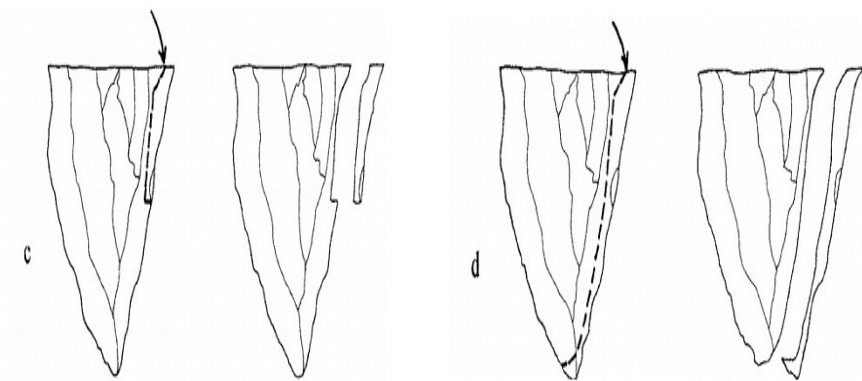


Figure 20: Schematic representation of termination types; a) Feather, b) Hinge, c) Step and d) Overshot (After Andrefsky, 2005).

4.6. Flake Terminations: The distal end of a flake is termed as a termination, a point at which the original blow of force terminates. They can be feather, hinge, step or overshoot (Figure 20). Feather terminations are smooth and feathered distal end. Sometimes the flake can terminate as a breakage. In this case, the termination is called step termination. Whenever the force rolls towards the detached pieces (going away from the core) it is known as a hinge termination. The other termination type is overshoot. It appears when the force goes down into the core (Andrefsky, 2005). The various types of terminations can be determined by raw material types, size and weight of the materials and the types of percussive tool used for striking (Hovers, 2009).

4.6.1. Termination types of whole flakes at Garba IV level C

Most of the whole flakes of this level have feather terminations, followed by hinge and overshoot (Table 5). Step fracture is infrequent. Flakes with feathered terminations are the

most desired types of artifacts. They are also considered as indicators of good flaking capacity of the knappers. The more you know how to knap correctly the more feathered or close to feathered flake terminations you will have (Whittaker, 1994).

Table 5: Termination types of whole flakes and their numerical representation at Garba IV level C

Termination types	Number of representations
Feather	14
Hinge	6
Overshot	6
Step	1

4.6.2. Termination types of whole flakes at Garba IV level D

Like the level C whole flakes, feather terminations are dominantly represented at level D materials. Hinge and step fractures are the least represented terminations after overshoot (Table 6). These terminations are not desirable and happen usually as a result of some mistakes from the knapper. This error can occur because of various faults. The way the core is stricken can produce either a flake with a feather termination or with step and hinge terminations, depending on the ability of the hominin.

The blow of forces (outward and downward forces) should be proportional to have a good flake. The outward force is the force that helps to pull away the flake from the core and the downward force is the force that goes along the direction of the flake length. When the outward force is too high there is usually a possibility to have a flake with a stepped fracture. This is because the application of too much force on the outward force can facilitate the flake to be pulled rapidly. If the external platform angle is closer to 90 degrees

step and hinge fractures can occur. The absence of enough force while striking can also force the flake to terminate shortly, without going down. Existing hinge and/or step fracture can create the same type of termination (Whittaker, 1994).

The application of insufficient force while striking a core can result into a step termination (Hovers, 2009). Hinge terminations usually occur near the surface of cores with relatively rounded and blunt end. Cores with a flat surface have high possibility to produce a hinge fracture (Cotterell and Kamminga, 1987). Hinge termination can happen in the absence of handling a proper relationship between the hammer stone, the external platform angle and the core. The higher the platforms angle the high possibility to have a flake with hinge and/or overshoot terminations (Dibble and Whittaker, 1981).

Table 6: Termination types of whole flakes and their numerical representation at Garba IV level D

Termination types	Number of representations
Feather	37
Hinge	3
Overshot	6
Step	3

4.6.3 Termination types of broken flakes at Garba IV level C

As these are broken artifacts, it is only some of them with diagnostical features of termination that are identified their termination types. Overshot termination is hardly represented at this level of Garba IV, unlike feather terminations which represents for almost all broken artifacts (Figure 21).

Termination types of broken flakes at Garba IV levelC

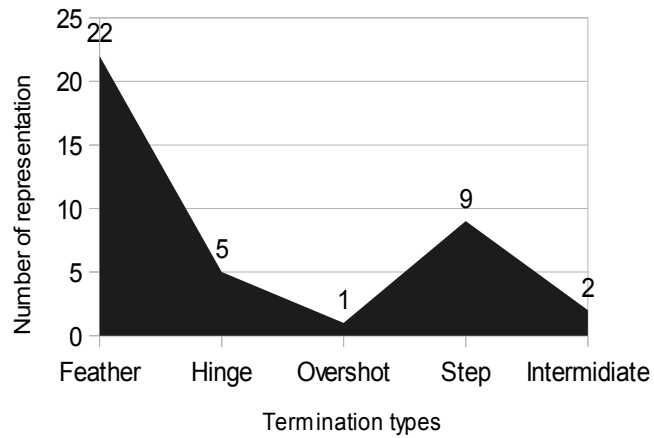


Figure 21: Frequency of termination types from Garba IV level C broken flakes.

4.6.4. Termination types of broken flakes at Garaba IV level D

Feather, step and hinge terminations are common in this level. The former is the leading termination types represented most often. No overshoot fracture was recorded (Table 7).

Table 7: Termination types of broken flakes at Garba IV level D

Termination types	Number of representations
Feather	23
Hinge	10
Overshot	0
Step	10

4.7. Toth types of whole flakes classification

This classification system was applied to have a clear understanding of the knapping technology, phases of artifact production in whole flakes. This is based on the presence/absence of cortex on both the dorsal surface and platform of a whole flake.

Whole flakes are more important than large core flakes because they provide ample evidence about the technology of the early hominins. Accordingly, Toth classified them into six categories. These are; type I, type II, type III, IV, V and VI (Toth, 1985, 1987). From type I to type III the platform is cortical. The dorsal surface cortex decreases as we go from type I to III. The last three types; type IV, type V and type VI have a platform surface without cortex. Cortex of their dorsal surface increases as we count from type VI to type IV. These types are summarized in the following table (Table 8).

Table 8: Toth types of whole flake classification.

Toth types (1985, 1987)	Description
I	Cortical platform/Cortical dorsal surface
II	Cortical platform/Part cortex dorsal surface
III	Cortical platform/No cortex dorsal surface
IV	No cortex platform/Cortical dorsal surface
V	No cortex platform/Part cortex dorsal surface
VI	No cortex platform/No cortex dorsal surface

On account of these classification schemes the materials from Garba IV levels C and D have been studied deeply. Both types II and VI and both types II and V are dominantly found at Garba IV level C and D respectively. Type I and IV are uncommon at level C. Type I, III and IV are poorly represented at Level D (Table 6). The dominance of types II and VI at Garba IV level C can be interpreted as the presence of frequent use of raw materials by the hominins, particularly the existence of the later type. Type II appears to be one of the dominant types represented at level D after type V, which indicates extensive use of the materials (Table 9).

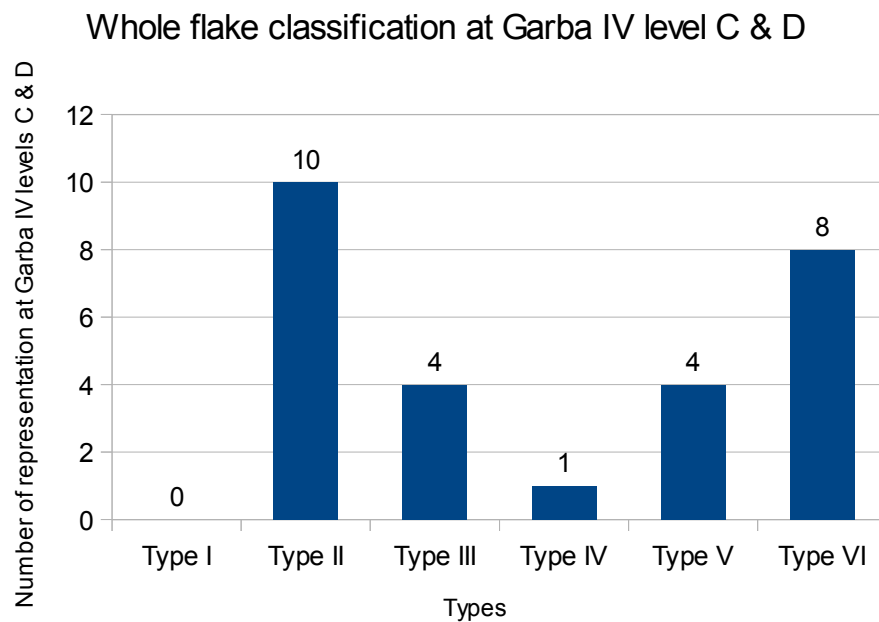


Figure 22: Both types of artifacts classification at Garba IV level C.

Table 9: Frequency of Toth's (1985, 1987) whole flake classification at Garba IV level D

Toth types	Number of representations at Garba IV level D
Type I	3
Type II	15
Type III	3
Type IV	1
Type V	20
Type VI	7
Total	49

The highest and the lowest maximum dimension size of the whole flakes ranges between 141.77 mm and 29.3 mm respectively (Table 2).

4.8. Thickness evenness coefficient

The results of thickness evenness values range quite substantially. The result shows that they range between 1% to 30% thicknesses variations. There are some flakes that demonstrate the presence of evenly distributed thickness values along the technological line. In contrast flakes with high variation of thickness values are also present. Some of the flakes with evenly distributed thickness values have only 1% of variance throughout the length of the flake. Up to 30 % of thickness variations along the technological axis were also documented from other thickness values.

This thickness variation is found to be influenced by the types of raw materials. The relatively low variation of thickness values of flakes are dominantly obsidian. Flakes that

do have a high percent of variation on their technological line, on the other hand, are basaltic materials, ignimbrite and rhyolite. Most of the rhyolites are relatively green in color.

The study of archaeological and experimental artifacts demonstrates that thickness evenness is the most determining factor for identification of Oldowan and Acheulean whole flakes (Presnyakova *et al*, 2015).

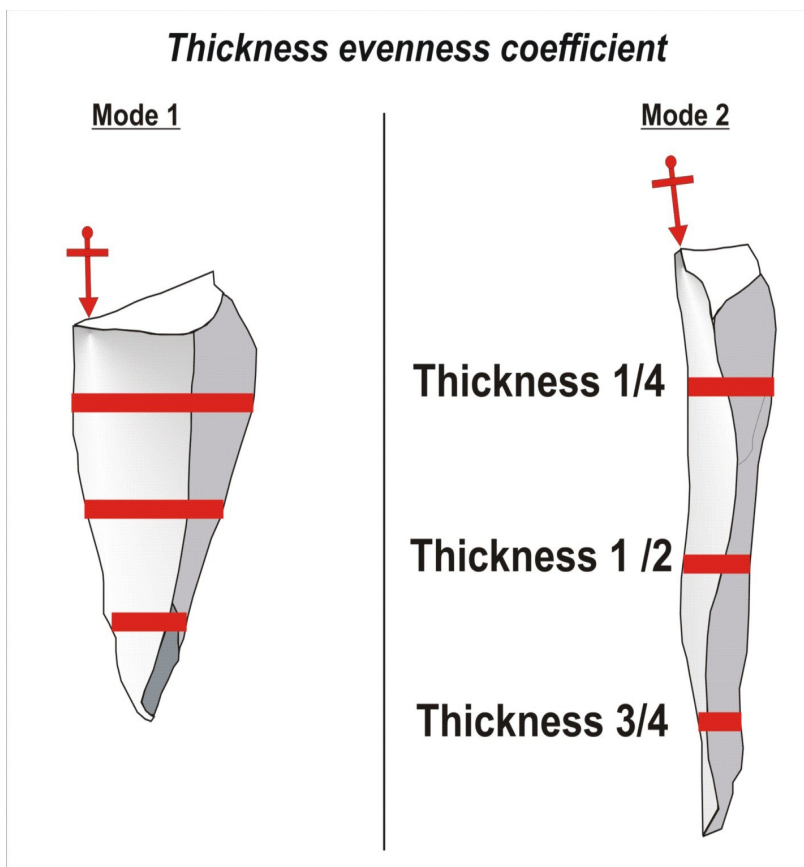


Figure 23: Thickness evenness coefficient measured at 25%, 50% and 75% along the technological axis.

4.9. Raw material identification, selection system and analysis

Raw material determination was very difficult because of some reasons. One important factor is that the impossibility of investigating the materials based on their outer surface. Some of them are sticky to identify by simply looking their surface, without opening them. On account of this, the raw materials were classified in a general and rough way and depending on some of the previously written articles.

The possibility of the Early Stone Age knappers ability to select based on the raw material quality is not given much more attention (Isaac *et al.*, 1997) until very recently. Current studies at Nachukui Formation, since 2.3 Ma, shows those hominins were competently able to select raw materials based on their knapping quality and technological planning (Harmand, 2007). During the early Pleistocene obsidian was extensively exploited at Melka Kunture (Piperno *et al.*, 2009), and during the late Pliocene at Hadar, Ethiopia (Goldman-Neuman and Hovers, 2012) which might be related with the selection capacity of the hominins based on various factors. The earliest obsidian exploitation in the archaeostratigraphic level D of Garba IV, during the lower Pleistocene, symbolizes the most systematic utilization as well as a highly organized chaîne opératoire (Piperno *et al.*, 2009).

The dominant utilization of obsidian at Melka Kunture since the Oldowan and continued for more than 1.7 million years ago is an exceptional occurrence in the history of ancient hominin culture in Eastern African Oldowan sites. Early Stone Age sites (e.g. Kare I, Gombore I and Garba IV), Middle Stone Age sites (e.g. Garba III) and the Acheulean sites such as Simbiro III bear an evidence of high concentration of obsidian materials in their

assemblage. Other materials of volcanic rocks such as ignimbrites, basalts, trachytes and trachybasalts were utilized by the then hominins as well (Piperno *et al.*, 2009). Obsidian also became the leading source of raw material during the Late Stone Age and recent times (Chavaillon *et al.*, 1979).

Balchit, positioned at 8° 46' N and 38° 37' E, is an outcrop which is the source of obsidian raw materials for the pre-history hominin habitats of Melka Kunture (Gallotti, 2013). It is located more or less 10 km far from Melka Kunture with an elevation of 2140 meter above sea level (Agazi *et al.*, 2006).

Obsidian is to be found at different sites of Melka Kunture. However, the highest frequency of this raw material is found at Garba IV, which accounts twice greater than the representation of the sum of other raw materials (Piperno *et al.*, 2009). Obsidian was the prominent raw material utilized for making the artifacts from Garba IV level C (Figure 24). Even in various literatures it is reported that the majority of the artifacts from level C were made from obsidian. The artifact assemblages from Garba IV levels C and D incorporate both types of *chaîne opératoire*, that is, production of small-medium flakes and large flake productions.

The quality of raw material together with its accessibility is a determining factor about what kind of shape and size can be obtained at the end of the tool production and as well as about the assemblage variety (Whittaker, 1994).

Obsidian (n=77), Garba IV C

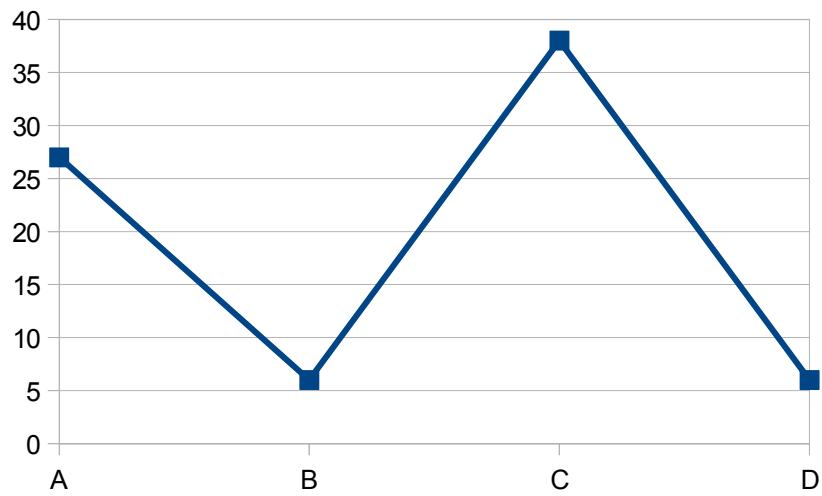


Figure 24: Frequency of Obsidian at Garba IV level C.

Legend: A=Whole Flakes, B=Cores, C=Broken Artifacts and D=Pounded Pieces

Table 10: The entire studied raw material assemblages

Raw materials	Levels	Numbers	Total=110
Obsidian	C	77	
	D	33	
Others (Ignimbrite/Basalt/Rhyolite)	C	3	Total=89
	D	86	
Total	=		199

As the data in the above table (Table 10) demonstrate the large number of raw material is represented by obsidian. The rest are a combination of basalt, ignimbrite and rhyolite.

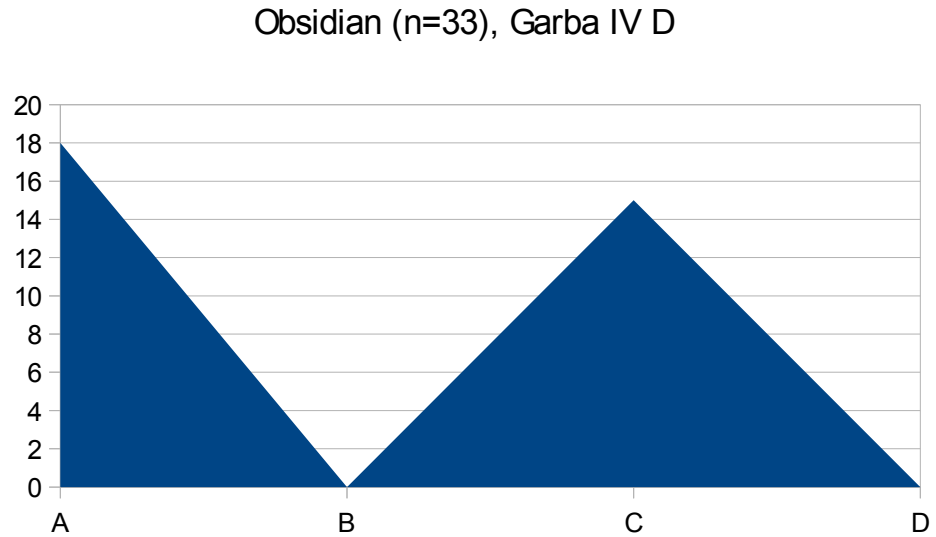


Figure 25: Frequency of obsidian at Garba IV level D.

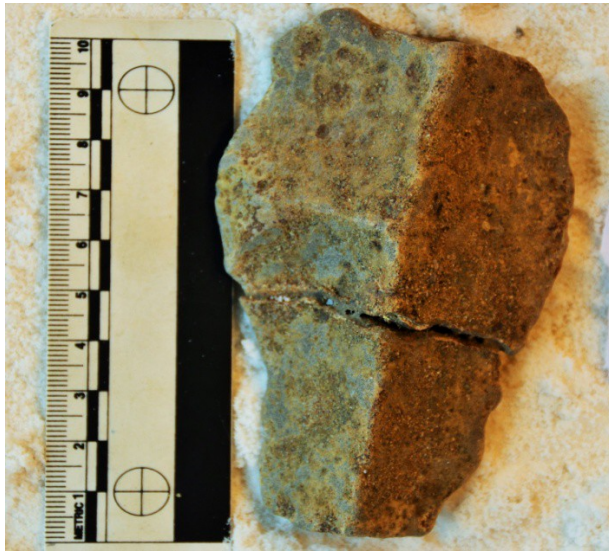
Legend: A=Whole Flakes, B=Cores, C=Broken Artifacts and D=Pounded Pieces.

Obsidian is highly utilized material resource by Garba IV level D knappers (Figure 25).

This gives us an idea about the domination of obsidian during the quaternary alluviums (Kieffer *et al.*, 2004).

4.10. Technological structure of the assemblages

4.10.1. LCT production: Production of large flakes and LCT technology are not common at the archaeostratigraphic level C and D of Garba IV in Melka Kunture. In her study of Garba IV level D materials, Gallotti identified only 1.5% of the artifacts belonging to large flakes and LCT technology. She added that this *chaîne opératoire* includes the selection of only two raw materials; obsidian and Melka Fault lava for the manufacture of LCTs. Despite the low number of representation in the entire lithic materials at Garba IV level D in relation to the small *débitage* flakes, its appearance (even if with less frequency) has a paramount qualitative importance to compare intra- and inter site techno-economic behaviors (Gallotti, 2013). The LCTs at Garba IV are produced from large flakes.



A



B



C



D

Fig 26: Examples of large flake productions at Garba IV (A and C are in their dorsal view, B and D are in their ventral view).

Handaxes are not common at Garba IV. Their presence at Garba IV is very low, not more than 10 materials were reported from the catalogue. Only 5 handaxes were investigated by Gallotti in her study of the Garba IV level D Early Acheulean artifacts. The presence of

Large Cutting Tools in small number has a major role in revealing the introduction of a new technological group (Early Acheulean) into the site. The low number of Large flakes/LCTs appearance at Garba IV apparently entails the technology is in its infant phase; meaning it is just beginning, that is, the Early Acheulean. Probably it is possible to argue here that the presence of high number of LCT in an assemblage is not both plausible and a determining factor to assign a site as Early Acheulean occupation. A site should not contain more than 50 % of LCTs/ large flake production in its assemblages to be considered as Early Acheulean site. A site that comprises more than 50 % LCTs and large flake production is definitely an Acheulean site, which is obvious, but should not be considered as an Early Acheulean occupation.

The low frequency of LCT and large flake manufacturing, on the other hand, is probably the most crucial factor to identify Early Acheulean site. The smaller the presence of large flake productions in an assemblage, the most probable it is an Early Acheulean site. A site should include both the preceding and the evolving technologies to be accepted as Early Acheulean site. The preceding technologies should not be less than the introducing industries in frequency. They should be at least higher than the developing technologies by some percentiles. The early stage of something starts with a gradual process of development. Therefore, it is both credible and probable that a site is going to be assigned into the Early Acheulean technology on the grounds of quantity relationship between the developing and the already existed technological tradition.

The Early Acheulean appeared at different time period in different sites. The East African Early Acheulean sites range between 1.76 and 1.40 million years ago, suggesting the intra- and inter-site variability. Only three artifacts were identified as LCTs at Gadeb 2E with in 761 artifacts assemblages (de la Torre, 2011b). As Gallotti (2013) pointed out from Chevrier (2012), among 191 artifacts found at Kokiselei 4 site, West Turkana, in Kenya, 28 (15%) were identified as proto-handaxes, handaxes and picks together with small *débitage* production . As it is mentioned in the literature review portion of this thesis, the Kokiselei 4 site is dated back to 1.76 million years ago (Lepre *et al.*, 2011).

At Kokiselei 5 only one large flake production have been recorded with in a total assemblage of 1766 stone artifacts, most of which were in the operational sequence of small-medium sized flakes.

4.10.2. Small *débitage* production: This method of operational sequence is the most dominant at the study area of the selected assemblage samples. Obsidian and rhyolite rocks are used in large numbers in both core and flake production. The core size distribution is similar at Garba IV level D (Gallotti, 2013). Most of the materials found in this type of techno-economic pattern are obsidian. Ignimbrite, rhyolite and basalt raw materials are also recognized in this type of lithic production system, albeit they are less represented compared with the obsidian (Figure 27).

In general, there are flakes with curved shape which is the indicator of the mode 2 artifacts; the Acheulean industry (Figure 28). Most of these materials are small-medium sized. Curvature is a variable based on a reasoning of how the core surface is maintained. Core

surface maintenance significantly affects the morphology of a flake detached from it (Magnani *et al.*, 2014). Shaped artifacts are directly related with curved profiles (Goren-Inbar and Sharon, 2006). Oldowan flakes, on the other hand, have either convex or flat profile because of the absence of shaping (Presnyakova *et al.*, 2015).

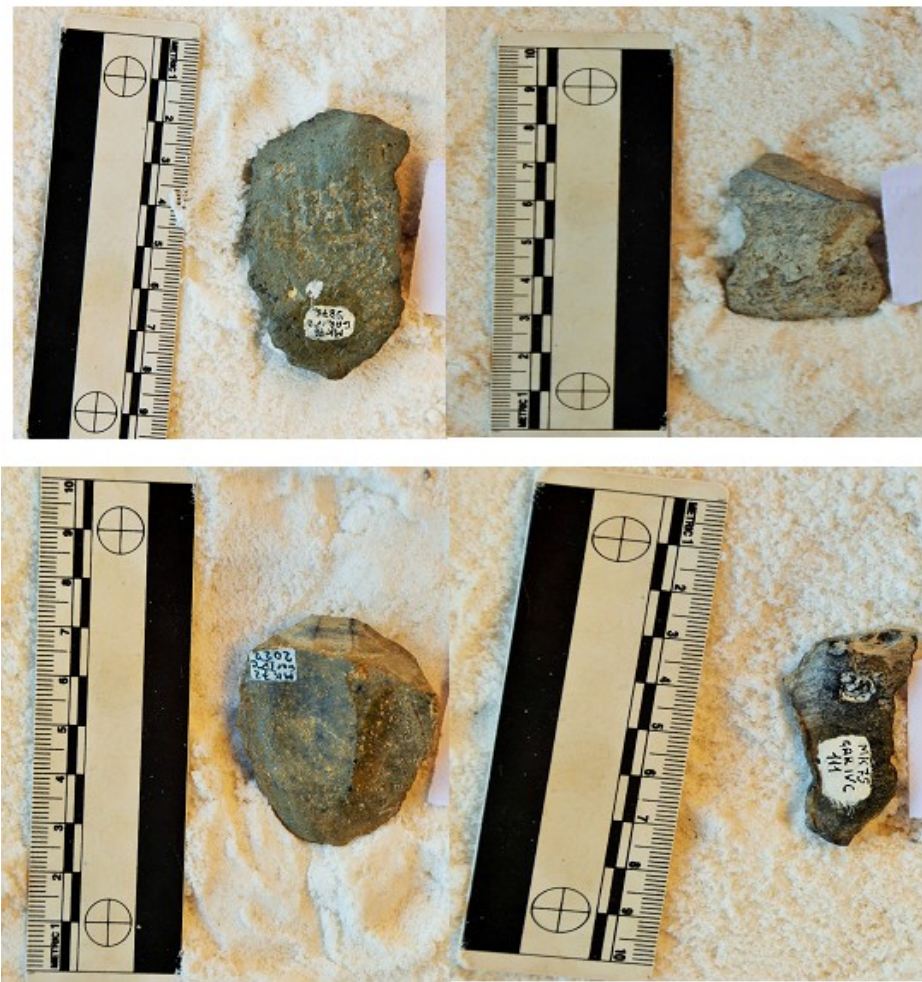


Figure 27: Examples of small-medium sized flakes.

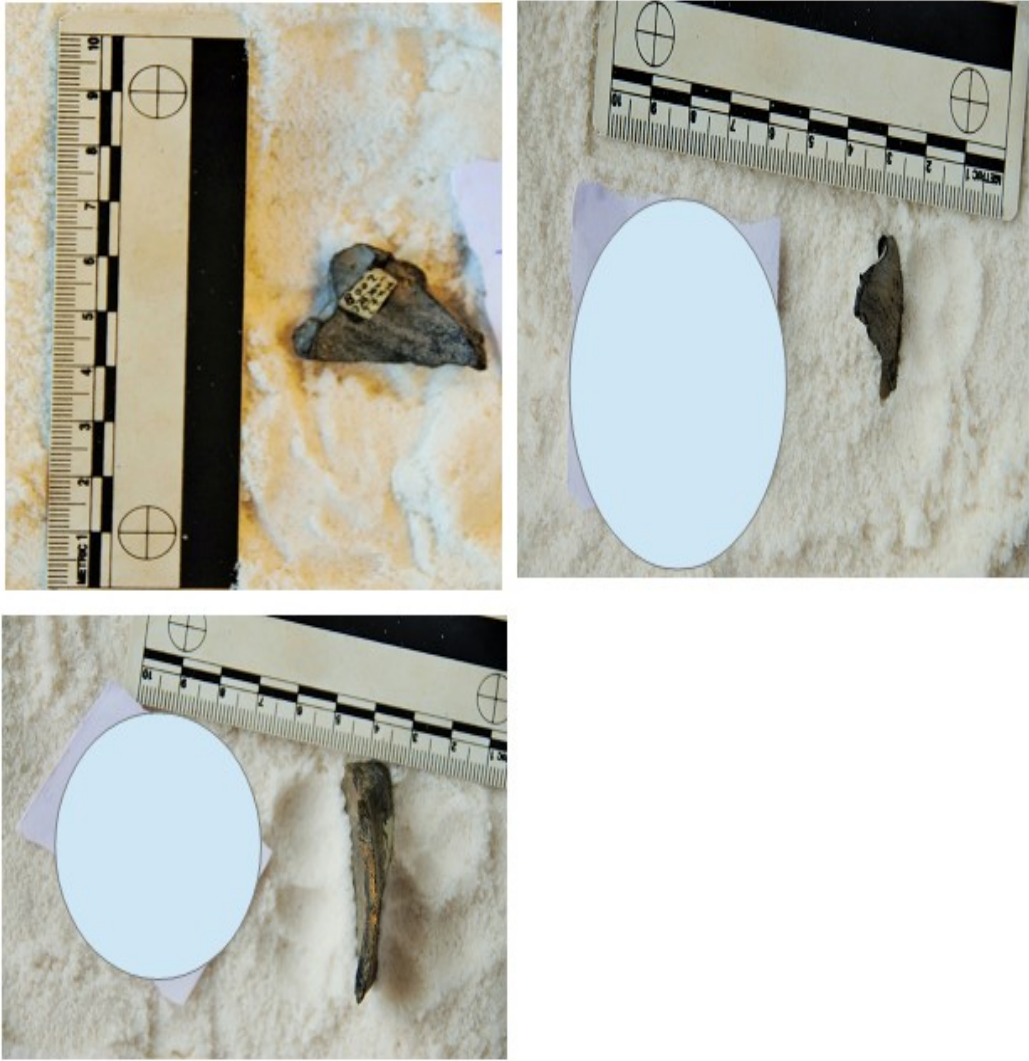


Figure 28: Flakes with curved shape.

Chapter Five

Discussion and Conclusion

5.1. Discussions

As far as the emergence of Acheulean is concerned, Isaac (1969) stated that the presence of large flake production is a significant indicator its earliest appearance. Unlike in the Acheulean technology where there is an evidence of large flakes detachment, large flake production is uncommon in the Developed Oldowan (Leakey, 1975).

However, detached pieces found in Acheulean assemblages, no matter whether they are by-products of LCTs or not, have an important technological substance as far as variability in the Acheulean industry is concerned (Turq *et al.*, 2013; Isaac *et al.*, 1997). In the absence of LCTs, evidence of large flake production is taken as crucial signal of Acheulean technology in a given assemblage (Goren-Inbar and Sharon, 2006). Sites that do not have evidence of LCTs such as FC West at Olduvai and Kokiselei 4 at West Turkana have been classified into the Acheulean simply by the presence of large flake production (de la Torre and Mora 2005; Roche *et al.*, 2003). At the site of Gesher Benot Ya'aqov in Israel there is no evidence of bifaces, but was identified as Acheulean just because of technological characteristics of the assemblages (Goren-Inbar and Sharon, 2006). Neither handaxes nor cleavers have been found at Kromdraai A, South Africa. Nevertheless it is believed to be an Acheulean site (Kuman *et al.*, 1997). Technological features like sophisticated small *débitage* techniques are important clues to characterize Early Acheulean artifacts (de la Torre, 2009).

Artifacts are called LCTs if they are not less than or equal to 10 cm (>10 cm) in dimension: width and length (Kleindienst, 1962), that distinguish them from flakes and retouched flakes (Sharon, 2010; de la Torre, 2011a; Yonas *et al.*, 2013). LCTs incorporate structured flaking and deliberate shaping (Sileshi *et al.*, 2009). The presence of large flake productions in Garba IV assemblages might be taken as a prominent indicator about the hominins' preparation to shape them into large cutting tools, main characteristics of Early Acheulean. Isaac(1986) pointed out that the emergence of large flake productions appropriate for shaping into handaxes is a pivotal technological innovation of the Early Acheulean.

The cultural transformation from Oldowan into the Acheulean is still a controversial issue of discussion among professionals; as whether biological or cultural evolution is the prominent explanation about its change through time. These two evolutions are independent to each other. Biological evolution can be a pretext for the introduction of new cultures, and cultural change can play a significant role for the appearance of an evolved biological intellect and/or a new taxonomic group. It is, however, repeatedly claimed that cultural change come out as a result of increment in cognitive capacity (i.e, biological evolution) (Mithen 1999, Wynn 2004). For Stout (2011), combinations of biological and cultural evolution are responsible for the replacement of one technology by a new technological conception during the ESA.

In summary, the technological assessment of the Garba IV level C and D revealed the presence of the same type of small cores. In addition, there are some retouched artifacts along their edges. These all are good indicators of the artifacts classification into the Early Acheulean than “Developed Oldowan”. The total numbers of samples I have studied are

not, however, adequate enough to address such a very controversial issue. Hence, by extending the total number of samples and applying various methodological techniques of a combination of palaeoecological and palaeo-environmental, it might be possible to, at least, reach into one solid and independent conclusion.

5.2. Are the so called “Developed Oldowan” artifact traditions intermediate between Oldowan and Acheulean?

The “Developed Oldowan” artifact traditions were traditionally recognized as a transitional artifact technologies believing that they bears more advanced knapping skill compared to the heir predecessor, Oldowan (de la Torre *et al.*, 2011b). These artifact traditions have been accepted by some archaeologists as a transitional technology between Oldowan and Acheulean (Chavaillon *et al.*, 1979). There are, however, archaeologists these days who argue the labeling of such artifact tradition as an intermediate between Oldowan and Acheulean are not an appropriate decision, as a result of its poor technological features to be considered as an independent technology. This is because these artifact classifications lacks a clear and independent technological characteristics (Sileshi *et al.*, 2009); suggesting the difficulty of recognizing them as an autonomous technologies.

The transition from Oldowan to Acheulean have been traditionally believed to appear at about 1.7 million years ago, during which time *Homo ergaster/erectus* came to evolve. It was at this time a radical change of population increment in Acheulean sites and shaping of bifacial artifacts (*Faconnage*) started (Roche *et al.*, 2009).

Leakey's classification of this artifact tradition as "Developed Oldowan" A, B and C faced a number of critics; as this classification method have some constraints on its technological attributes. The size and morphology of bifacial artifacts and frequency of handaxes were taken as determining factors to assign artifacts either into "Developed Oldowan" or Acheulean (Leakey, 1971). Sileshi *et al.*, (2009) asserted that the stone artifact study at Gona, Afar, Ethiopia, together with some experimental investigations and based on a review of the current Early Stone Age literature, the "Developed Oldowan" A does not entail as a self-reliant technology rather bears a similarity with the Oldowan.

In addition, de la Torre and Mora (2005) claimed that the absence of a pragmatic ground of technological transformation from the earlier manufacturing methods, the "Developed Oldowan" A should not be assigned as a self-directed human cultural tradition other than the Oldowan.

Some of the artifacts from Garba IV levels C and D clearly show that the hominins were knapping artifacts from both a large and small size cobbles. The later is common than the former. This method differs according to the raw material types. Although, there are a few obsidian large sized cobble cores from level C most of them belong to small sized cores. The materials from level D are, on the other hand, relatively large sized cobbles compared with level C. There are some artifacts that are greater than 10 cm in size, particularly the cores and some of the whole flakes. Some of the artifacts that are in most cases on the way to be modified into LCTs are important signals about the onset of the Acheulean technology at Melka Kunture. The very standardized morphology of the artifacts is an essential indicator about the mental planning of the hominins during the knapping process.

As far as tool frequency is concerned, different researchers provide different reasons for the must and must not be of tool frequency as an essential method through which an assemblage is identified into a given technological category. Kleindienst (1962) asserted that an assemblage should contain 40% of handaxes to be regarded as an Acheulean site. Gowlett (1986), however, did not give recognition about Kleindienst's claim. He, rather, pointed out the invalidity of handaxe frequency by stating the similarity of one handaxe with forty handaxes. For him it is quality that matters in human technology, not quantity. de la Torre (2011b) also supports Gowlett's idea. The existence of a handaxe in any assemblage suggests the same technological and cognitive capacity of the knappers, as it is in an assemblage where plentiful handaxes are present (Lemonnier, 1990). de la Torre (2011b) argue that both handaxe frequency and LCT morphology should not be taken as a sole mechanism of differentiating “Developed Oldowan” from Early Acheulean.

The materials from Garba IV do not have large number of handaxes. As it is stated above only 10 handaxes were found at this site. However, the small number of handaxe representation cannot limit our understanding of the appearance of the Acheulean at the site. Hence, it has a robust suggestion about its existence at different times in different areas. The Acheulean tool types have similarities all over the world. It does not mean, however, they are entirely akin. The shape, size, method of production, raw material usage and assemblage composition of the Acheulean indisputably differs from region to region (McPherron, 2000; Potts *et al.*, 1999).

Production of large flakes and LCT technology are poorly represented at the archaeostratigraphic level C of Garba IV. Only a very small number of the artifacts belong

to large flakes. Only one raw materials was used for their production; obsidian. As far as selection of cobble size for knapping stone artifact is concerned, Sileshi *et al.*, (2009) states that Oldowan tool makers prefer fine-grained cobbles that are suitable to make sharp edged flakes for processing carcasses and for cutting, usually using a hand held percussion technique. Early Acheulean tool makers, on the other hand, were interested in large size cobble blanks so as to struck large flake blanks, usually greater than 10 cm.

Yonas *et al.*, (2013), furthermore, underlined that occupations of Early Acheulean technology are characterized by the presence of large flake blanks with sizes measuring from 10 to approximately 20 cm which finally modified into artifacts typologically similar with picks, handaxes and cleavers. According to Isaac (1981) the location of “Developed Oldowan” around lake shore and Early Acheulean at an inland-riverine environments clearly suggest the practice of different activities by the same hominins in varied environmental settings. Chavaillon *et al.*, (1979) stated the presence of similar type of settlement occupation at Melka Kunture like some of the Early Stone Age sites, close to rivers. Some localities at Melka Kunture including Garba IV levels C and D, Gombore IB and Gombore I are situated along the Palaeo-Awash bank.

However, the association of “Developed Oldowan” with lake shore environmental settings and Early Acheulean close to fluvial ecology is somewhat ambiguous (de la Torre, 2008, 2011a), as some Early Acheulean sites like Konso (Yonas *et al.*, 1996) are located at lake shore environment.

The technological and artistic features of these artifacts, both from Garba IV levels C and D, are more close to the Early Acheulean technology than being understood as either an independent artifact tradition or the Oldowan industry. Therefore, the Acheulean technology heralded a radical change both in technology and cognitive capacity from the Oldowan, which clearly shows discontinuity other than a great departure of innovation (Sileshi *et al.*, 2009). The early Stone Age technology is characterized by the increasing social complexity and its interaction between the evolution of human cognition skill (Stout, 2010). Recent studies suggest the influence of models from cognitive neuroscience and developmental psychology for the emergence of various methods of artifact making (Stout *et al.*, 2008).

5.3. Raw material selection and their influence on the production of artifacts and its possible role in signaling about cognitive capacity of the Hominins

Various suggestions have been forwarded by different prehistorians about the procurement of raw materials during the Early Stone Age in Africa, particularly at Olduvai Gorge, Tanzania (Leakey, 1971), in the Nachukui formation of West Turkana (Harmand, 2007) and at Koobi Fora, Kenya (Isaac and Harris, 1978). The presence of varied types of raw materials in the exploitation process revealed that the hominins were capable of selecting materials based on either durability or flaking quality and/or may be another factors that are not yet investigated.

Early Stone Age knappers were capable of selecting raw material types based on their flaking predictability (homogeneity, hardness, elasticity and the brittle nature of the

materials), suggesting to what extent the thinking capacity of the hominins was. Roche *et al.*, (2009: 137) stated that “the ability to intentionally modify a natural homogeneous, isotropic, hard and rigid mineral material (Example, Hard rock) is a technical behavior only shared by humans and their congeneric ancestors”.

Besides, Sileshi *et al.*, (2003) and Stout *et al.*, (2005) declared that hominins were selecting raw materials based on their durability at about 2 million years ago at Gona, Ethiopia. Selecting a particular raw material for the production of a specific type of artifact probably started during the Early Stone Age (Schick and Toth, 1994). Furthermore, during the Early Oldowan (ca. 2.34 million years ago) and the Acheulean (ca. 0.70 million years ago) time hominins were selecting raw materials with good flaking quality; more or less grained phonolites and rhyolites over coarse grained rocks (Harmand, 2007). The ability of raw material acquisition and selection system increases in the Acheulean than its chronologically preceding artifact types (Archer and Braun, 2010).

Obsidian is used as a raw material for the production of artifacts at Melka Kunture together with other raw materials. What is fascinating about the archaeology of Melka Kunture is the frequent use of obsidian by the hominins, even during the Oldowan period at Gombore I and Garba IV (Piperno *et al.*, 2009). It is unusual to find the use of obsidian as a raw material by the Early Stone Age artifact makers in Eastern Africa, although there is evidence of its use in Acheulean sites. The plausible evidence about the use of this raw material in East Africa is during and after Middle Stone Age (Leahey, 1971).

The presence and dominance of obsidian artifacts from other basalt materials at Garba IV levels C and D can be associated with raw material availability and the hominins selection ability. Stiles (1991) proposed that the dominance of a particular raw material type in an assemblage might be related with the availability of raw material. The presence of rock frequency revealed the preferential selection of the hominins during the Early Pleistocene. At Olduvai Gorge, for instance, hominins were transporting for about 13 kilometers to bring raw materials. Hominins responsible for making artifacts from 1.9 million years ago onward were using materials depending on their presence nearby the occupation sites (Isaac *et al.*, 1997). Hence, raw materials with good quality were deliberately selected during the Early Oldowan, Oldowan and Early Acheulean period at the Nachukui Formation. Heavy, resistant and medium sized rounded trachyte objects were selected as hammer stones (Harmand, 2007).

About 10 Early Stone Age artifacts from Gombore I (four artifacts), Garba IV (One artifact) and Gombore II (five artifacts), at Melka Kunture, have been examined to understand their provenance using Energy-Dispersive X-Ray Fluorescence Analysis (EDXRF) by Agazi Negash and his colleagues. As a result, from the Early to Mid-Pleistocene raw materials were supplied from a nearby outcrop. This result, in fact, supports the previously claimed suggestion as the location of the sites close to the raw material sources (Agazi *et al.*, 2006).

Stone artifact sites are mostly located beside raw material sources. Following the Oldowan, however, hominins start to bring materials from a long distance (Rogers *et al.*, 1994), though there are also possibilities of short distance transportation of raw materials. The Omo Shungura Formation archaeological sites entail a distance of several kilo meters

(Plumer, 2004). A long distance transportation of obsidian handaxes at the Early Stone Age site of Gadeb (dated from 1.45 to 0.7 million years ago), about 100 km, is believed to be the earliest evidence of the longest distance distribution of raw materials ever (de la Torre, 2011b).

The original size of unworked materials can influence the final shape of an artifact. LCTs and large flake productions are represented in small amount at Garba IV levels C and D. The technological characterization of the artifacts of Melka Kunture (Garba IV levels C and D) into the Early Acheulean technology should not be denied or ignored simply because of the low frequency of large flake productions and LCTs. The smaller the manuports were the smaller the artifacts would be. However, the larger size of the manuports could be resulted into either large and/or small flake production, governed by the type of technology and its intended use after its final shape. Nevertheless, what we have at Garba IV is a small size of manuports. As far as the the manuports are concerned Gallotti *et al* (2014) asserted that the manuports from which this material found are predominantly small in size, though there appears a small frequency of large nodules. The presences of LCTs in an assemblage have been taken as a significant indicator of Acheulean industries (Klein *et al.*, 1999) for a long period of time. However, understanding various technological innovations of an artifact can play a prominent role in characterizing the earliest appearance of Acheulean technology (Sharon, 2008, 2010).

There is strong evidence about variation of stone artifact production techniques especially governed by the type of raw material and its quality at Melka Kunture locality Garba IV

levels C and D. According to Braun (2009) and Stiles (1991) a number of Early Stone Age studies revealed the crucial role of raw material type in technological manufacturing system. A specific raw material was selected for a particular flake type at Garba IV. At this locality different raw material was used for different flake production type. Some of the rocks like ignimbrite and basalt were, mostly, used both for relatively large flake productions and small-medium sized artifacts. Obsidian, on the other hand, was utilized for small-medium sized flakes. There are a few approximately large sized obsidian materials and small-medium sized of ignimbrite, rhyolite and basalt raw materials.

It does not mean, however, that there are no large or small core and flake artifacts in either type of the raw materials, but what is claimed is based on the high frequency of the artifacts in respective with the type of raw material.

5.4. Conclusions

Technological features of Early Acheulean at Garba IV includes, large flake production and a predetermination of flake manufacturing technique, for instance the existence of Kombewa core method, albeit in small number. The Kombewa core method is a significant indicator of high degree predetermination in the Acheulean blank manufacture. This type of core method has been studied and recorded at various Acheulean sites of Melka Kunture (Chavaillon and Piperno 2004).

At the samples I have studied there are two cores with a Kombewa method. Unlike in other Acheulean sites, the Kombewa core method at this site is represented by relatively small sized artifacts (less than 10 cm in length). However because of its very low frequency it is difficult to discuss more about it and hard to reach into a conclusion, though, it is still a significant signal of the Early Acheulean technological evolution. The earliest appearance of the Acheulean should not be governed only by the existence of high percentage of bifacial artifacts in an assemblage. It should, rather, include investigating the thickness evenness and curvature of the flake tool. An experimental study by Presnyakova *et al.*, (2015) revealed the presence of an evenly distributed thickness value along the technological line of Acheulean flakes. Oldowan artifacts tend to lack an evenly distribution of thickness values. Most of the Garba IV levels C and D artifacts have, hence, an evenly distributed thickness value along their technological length, which is the diagnostic feature of the Mode 2 artifacts.

The appearance of Early Acheulean at Garba IV of Melka Kunture at about 1.5 million years ago is unique because it entails the appearance of the technology at different times in

different areas. Most of the identified Early Acheulean sites in Africa dates back at least earlier than the time they appeared at Melka Kunture. Example Konso and Kokiselei 4 are dated back ca. 1.75 million years ago (Yonas *et al.*, 2013; Lepre *et al.*, 2011). The earliest Acheulean technology appearance at this time is, therefore, crucial to our understanding of its distribution. Therefore, “Developed Oldowan” and Early Acheulean are not, based on their technological characteristics, believed to appear coevally at the study area.

The stone artifact materials from Garba IV level C, which were initially assigned as “Developed Oldowan” artifacts, based on the current technological study, are much more close into the Early Acheulean assemblages of Garba IV level D. Hence, their morphological features including their production techniques and the presence of some standardized methods of knapping are prominent signals of the artifacts' re-classification into the Early Acheulean. In some of the cores I have studied, there is evidence that an organized way of reduction technique have been employed by the knappers. This type of reduction method, according to de la Torre (2011a), is among the agents for the emergence of the Acheulean.

Bibliography

Agazi, N., Shackley, M. S., & Alene, M. 2006. "Source provenance of obsidian artifacts from the Early Stone Age (ESA) site of Melka Konture, Ethiopia". *Journal of Archaeological Science*, **33**: 1647-1650.

Amick, D. S., Mauldin, R. P., and Tomka, S. A. 1988. "An Evaluation of Debitage Produced by Experimental Bifacial Core Reduction of a Georgetown chert nodule". *Lithic Technology*, **17** : 26-36.

Andrefsky Jr., W. 2005. *Lithics: Macroscopic Approaches to Analysis*, 2nd. ed., Cambridge University Press, Cambridge.

Archer, W., & Braun, D. R. 2010. "Variability in bifacial technology at Elandsfontein, Western Cape, South Africa: a Geometric Morphometric Approach". *Journal of Archaeological Science*, **37**: 201-209.

Berhane, A., Yonas, B., Suwa, G., Walter, R.C., White, T.D., WoldeGabriel, G., and Tesfaye, Y. 1992. "The Earliest Acheulean from Konso-Gardula". *Nature*, **360**: 732-735.

Berhane, A., White, T., Lovejoy, O., Latimer, B., Simpson, S., Suwa, G. 1999. "Australopithecus garhi: a new species of early hominid from Ethiopia". *Science*, **284**: 629–635.

Bar-Yosef, O., Goren-Inbar, N., & Gilead, I. 1993. *The lithic assemblages of 'Ubeidiya: a lower palaeolithic site in the Jordan Valley*. Institute of Archaeology, Hebrew University of Jerusalem.

Bonnichsen, R. 1977. "Models for deriving cultural information from stone tools". *Musée National de l'Homme. Collection Mercure. Commission Archéologique du Canada. Publications d'Archéologie. Dossier Ottawa*, **60**:1-332.

Brain, C.K. 1993. *Swartkrans: A Cave's Chronicle of Early Man*. Pretoria: Transvaal Museum.

Braun, D. R. 2014. "Earliest Industries of Africa". In: Renfrew, C and Bahn, P., G (Eds.), *The Cambridge World Prehistory*. The Cambridge Encyclopedia of Archaeology, Cambridge University Press, 65-79.

Braun, D. R. & Harris, J. W. K. 2003. "Technological developments in the Oldowan of Koobi Fora: Innovative Techniques of Artifact Analysis".. In: J. M. Moreno, R. M. Torcal & I. T. Sainz (Eds.), *Oldowan: Rather More than Smashing Stones*. First Hominid Technology Workshop, University of Barcelona Press: Barcelona:117–144

Braun, D. R., Plummer, T., Ditchfield, P., Ferraro, J., Maina, D., Bishop, L., Potts, R. 2008. "Oldowan Behavior and Raw Material Transport: Perspectives from the Kanjera Formation". *Journal of Archaeological Science*, **35**:2329–2345

Braun, D.R., Hovers, E. 2009. "Introduction: Current Issues in Oldowan Research". In: Hovers, E., Braun, D.R. (Eds.), *Interdisciplinary Approaches to the Oldowan*. Springer, Dordrecht, Vertebrate Paleobiology and Paleoanthropology: 1-14.

Briant R. M., Hosfield R. T., Wenban F., Roberts M., Pope, M.2009. "The Archaeological and Sedimentary Records from Boxgrove and Slindon". In: Briant R. M., Hosfield R. T., Wenban-Smith F. F.(Eds.), *The Quaternary of the Solent Basin and the Sussex raised beaches*. London, UK: *Quaternary Research Association*: 96–122.

Cachel, S., and J. W. K. Harris.1995. "Ranging patterns, land-use, and subsistence in *Homo erectus*, from the perspective of evolutionary ecology". In: J. R. F. Bower and S. Sartono (Eds.), *Human evolution in its ecological context*: 51–66. Leiden: Pithecanthropus Centennial Foundation, Leiden University.

Chauhan, P. R. 2004. "A review of the Early Acheulean evidence from South Asia. *Journal of World Prehistory*, **17**: 141-179.

Chavaillon J.,Chavaillon N., Hours F., Piperno M. 1979. "From the Oldowan to the Middle Stone Age at Melka-Kunture (Ethiopia). Understanding Cultural Changes". *Quaternaria, Roma*, **21**: 87-114 .

Chavaillon, J., Chavaillon, N., Berthelet, A. 2004. "Methodology". In: Chavaillon, J and Piperno, M (Eds.), *Studies on the Early Paleolithic Site of Melka Kunture, Ethiopia*. Origines, Firenze: 195-209.

Chavaillon, J., and Piperno, M. 2004. "History of Excavation at Melka Kunture".
In: Chavaillon, J and Piperno, M (Eds.), *Studies on the Early Paleolithic Site of Melka Kunture, Ethiopia*. Origines, Firenze: 3-21.

Chavaillon, J., Berthelet, A. 2004. "The Archaeological Sites of Melka Kunture".
In: Chavaillon, J and Piperno, M (Eds.), *Studies on the Early Paleolithic Site of Melka Kunture, Ethiopia*,. Origines, Firenze, 25-80.

Chazan M, Ron H, Matmon A, Porat N, Goldberg P, Yates R, Avery M, Sumner A, and Kolska Horwitz L. 2008. "Radiometric dating of the Earlier Stone Age sequence in Excavation 1 at Wonderwerk Cave, South Africa: preliminary results". *Journal of Human Evolution*, **55**:1-11.

Clark, J.D., and Kurashina, H. 1979. "Hominid occupation of the East Central Highlands of Ethiopia in the Plio-Pleistocene". *Nature*, **282**: 33-39.

Coppens, Y. 2004. "The hominids of Melka Kunture. Some general reflections".
In: Chavaillon, J., Piperno, M. (Eds.), *Studies on the Early Paleolithic Site of Melka Kunture, Ethiopia*. Origines, Istituto Italiano di Preistoria e Protostoria, Firenze, 685-686.

Crompton, R. H., & Gowlett, J. A. 1993. "Allometry and multidimensional form in Acheulean bifaces from Kilombe, Kenya". *Journal of Human Evolution*, **25**: 175-199.

D'Andrea, A., Gallotti, R. and Piperno, M. 2002. "Taphonomic Interpretation of the Developed Oldowan site of Garba IV (Melka Kunture, Ethiopia) through a GIS application", *Antiquity*, **76**: 991-1001.

de la Torre I., Mora R., dominguez-Rodrigo M., de Luque L., Alcalá L. 2003. "The Oldowan industry of Peninj and its bearing on the reconstruction of the technological skills of Lower Pleistocene hominids". *Journal of Human Evolution*, **44**: 203–224.

de la Torre, I. 2011a. "The origins of stone tool technology in Africa: A historical perspective". *Philosophical Transactions of the Royal Society Biological sciences*, **366**: 1028-1037.

----- .2011b. "The Early Stone Age lithic assemblages of Gadeb (Ethiopia) and the developed Oldowan\early Acheulean in East Africa". *Journal of Human Evolution*, **60**: 768–812.

de La Torre, I. and Mora, R. 2005. "Technological strategies in the Lower Pleistocene at Olduvai Beds I & II". ERAUL (112). Université de Liège, Liège, France.

-----2009. "Remarks on the Current Theoretical and Methodological Approaches to the Study of Early Technological Strategies in Eastern Africa". In E. Hovers & D. R. Braun (Eds.), *Interdisciplinary approaches to the Oldowan*: 15–24. Dordrecht: Springer.

-----2014. "The transition to the Acheulean in East Africa: an assessment of paradigms and evidence from Olduvai Gorge (Tanzania)". *Journal of Archaeological Method and Theory*, **21**:781-823.

de la Torre, I., McHenry, L., Njau, J and Pante, M. 2012. “The Origins of the Acheulean at Olduvai Gorge (Tanzania): A New Paleoanthropological Project in East Africa”. *Archaeology International*, **15**:89-98.

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

Dibble, H. L., and Whittaker, J. 1981. “New Experimental Evidence on the Relation between Percussion Flaking and Flake Variation”. *Journal of Archaeological Science*, **6**: 283-296.

Dibble, H.L. 1997. “Platform Variability and Flak Morphology: A Comparison of Experimental and Archaeological Data and Implications for Interpreting Prehistoric Lithic Technological Strategies”. *Lithic Technology*, **22**:150–170.

Domínguez-Rodrigo, M., de la Torre, I., Luque, L., Alcalá, L., Mora, R., Serrallonga, J., and V. Medina. 2002. “The ST Site Complex at Peninj, West Lake Natron, Tanzania: Implications for Early Hominid Behavioral Models”. *Journal of Archaeological Science*, **29**:639-665.

Feibel C, S., Brown F, H., McDougall, I. 1989. “Stratigraphic context of fossil hominids from the Omo Group Deposits: Northern Turkana Basin, Kenya and Ethiopia”. *American Journal of Physical Anthropology*, **78**: 595–622.

Gallotti, R., 2013. “An older Origin for the Acheulean at Melka Kunture (Upper Awash, Ethiopia): Techno-economic behaviors at Garba IVD”. *Journal of Human Evolution*, **65**: 594–620.

Gallotti, R., Raynal, J.P., Geraads, D., Mussi, M. 2014. "Garba XIII (Melka Kunture, Upper Awash, Ethiopia): A new Acheulean site of the late Lower Pleistocene". *Quaternary International*, **343**:17-27.

Gallotti, R., Piperno, M. 2001. "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". In: Jorge Martínez Moreno, Rafael Mora Torcal and Ignacio de la Torre Sainz (Eds.), *Oldowan: Rather more than smashing stones*, First Hominid Technology Workshop Bellaterra, 37-75.

Geraads, D., Eisenmann, V., and Petter, G. 2004. "The large mammal fauna of the Oldowan sites of Melka Kunture". In: Chavaillon, J and Piperno, M (Eds.), *Studies on the Early Paleolithic site of Melka Kunture, Ethiopia*: 169-192.

[Gibbon](#), R. J; [Granger](#), D. E; [Kuman](#), K; [Partridge](#), T.C. 2009. "Early Acheulean technology in the Rietputs Formation, South Africa, dated with cosmogenic nuclides". *Journal of Human evolution* , **56**: 152–160.

Goren-Inbar, N., & Sharon, G. 2006. "Invisible handaxes and visible Acheulian biface technology at Gesher Benot Ya 'aqov, Israel: *Axe age: Acheulian tool-making from quarry to discard*, 111-135.

Gowlett, J. A. J. 1986. "Culture and conceptualization: The Oldowan-Acheulian gradient". In: Bailey, G. & Callow, P (Eds.), *Stone Age Prehistory: studies in memory of Charles McBurney*, 243-260. Cambridge, Cambridge University Press.

Gowlett, J. A. J. and Crompton, R.H.1994. “Kariandusi: Acheulean morphology and the question of allometry”. *African Archaeological Review*, **12**:3 - 42.

Grosman, L., Goldsmith, Y., Smilansky, U. 2011. “Morphological Analysis of Nahal Zihor Handaxes: A Chronological Perspective”. *Paleoanthropology*, 203–215.

Guralnik, B., Matmon, A., Avni, Y., and Fink. D. 2010. “¹⁰Be exposure ages of ancient desert pavements reveal Quaternary evolution of the Dead Sea drainage basin and rift margin tilting”. *Earth and Planetary Science Letters*, **290**:132–141.

Harmand, S. 2007. “Economic behaviors and cognitive capacities of early hominins between 2.34 Ma and 0.70 Ma in West Turkana, Kenya”. *Mitteilungen der Gesellschaft für Urgeschichte*, 16:11-23.

Harmand, S., Lewis, J. E., Craig S. Feibel, Lepre, C., J, Sandrine, P., [Arnaud, L.](#), Xavier B, Rhonda L. Quinn, Michel B, Adrian A, Nicholas T, Sophie Ct, Guillaume D, [J. B.](#), Leakey, L., Richard A., [James D.](#), [Sammy L.](#), [Christopher K.](#), [Dennis V.](#), & Roche, H. 2015. “3.3-Million-year-old Stone Tools from Lomekwi 3, West Turkana, Kenya”. *Nature*, **521**: 310–315.

Holdaway, S., and Stern, N. 2004. *A Record in Stone: The study of Australia's Flaked Stone Artifacts*. Aboriginal studies press.

Hovers, E. 2009. “Learning from Mistakes: Flaking accidents and knapping skills in the assemblage of A. L. 894, (Hadar, Ethiopia)”. In: Schick, K., and Toth, N. (Eds.), *The cutting edge: New Approaches to the Archaeology of Human Origins*. Stone Age Institute publication series **3**: 137-150.

Inizan, M. L., Roche, H., Tixier, J., & Reduron, M. 1992. "Technology of knapped stone: followed by a multilingual vocabulary". *Préhistoire de la pierre taillée*.

Isaac G., Isaac B. Isaac G. L., Harris J. W. K., Kroll E. 1997. "The stone artifact assemblages: a comparative study". In: Isaac G., Isaac B (Eds.), *Koobi Fora research project, Plio-Pleistocene archaeology*, 262–299. Oxford, UK: Clarendon Press.

Isaac, G. L. 1969. "Studies of early culture in East Africa". *World Archaeology*, 1: 1–28.

Isaac, G. L. 1986. "Foundation stones: early artifacts as indicators of activities and abilities". In: G. N. Bailey & P. Callow (Eds.), *Stone age prehistory: studies in honor of Charles McBurney*, 221– 241. London, UK: Cambridge University Press.

Isaac, G. L., Harris, J. W. K. & Marshall, F. 1981. "Small is informative: the application of the study of mini-sites and least effort criteria in the interpretation of the Early Pleistocene archaeological record at Koobi Fora, Kenya". Proc. Union Internacional de Ciencias Prehistoricas Y Protohistoricas; X Congress, Mexico City. Mexico, 101–119.

Kidder, J. H., and Durband, A. C. 2004. "A re-evaluation of the metric diversity within *Homo erectus*". *Journal of Human Evolution*, 46: 297–313.

Klein, R.G. 1999. *The Human Career: Human Biological and Cultural Origins*, 2nd edition. University of Chicago Press, Chicago.

Klein, R.G., Avery, G., Cruz-Uribe, K., Halkett, D., Hart, T., Milo, R.G., Volman, T.P. 1999. "Duinefontein 2: an Acheulean site in the Western Cape Province of South Africa". *Journal of Human Evolution*, 37: 153–190.

Kleindienst, M. R. 1962. "Component of the East African Acheulian Assemblage: An Analytic Approach". In G. Mortelmans & J. Nenquin (Eds.), *Actes du IV Congrès Panafricain de Préhistoire et de l'Etude du Quaternaire, Leopoldville*. Tervuren: Belgie Annalen, Musée Royal de l'Afrique Centrale.

Kooyman, B. 2000. *Understanding Stone tools and Archaeological sites*. University of Calgary press, Canada.

Kuman, K. 2007. "The Earlier Stone Age in South Africa: site context and the influence of cave studies". In: T.R. Pickeirng, K. Schick and N. Toth (Eds.), *Breathing Life into Fossils: Taphonomic Studies in Honor of C.K. (Bob) Brain*. Bloomington (Ind.): Stone Age Institute Press, 181-198.

Lahr, M. M., & Foley, R. A. 2003. Demography, dispersal and human evolution in the Last Glacial Period. *Neanderthals and modern humans in the European landscape during the last glaciation*. Cambridge: McDonald Institute for Archaeological Research, 241-56.

Larick, R., & Ciochon, R. L. 1996. "The African emergence and early Asian dispersals of the genus Homo". *American Scientist*, **84**: 538-551.

Leader, G.M. 2009. Early Acheulean in the Vaal River basin, Rietputs Formation, Northern Cape Province, South Africa. Unpublished M.A thesis submitted to the Faculty of Science, University of the Witwatersrand, Johannesburg.

Leah E., Morgan. P., Renne R., Kiefer G., Piperno M., Gallotti R., Raynal J. P. 2012. "A chronological framework for a long and persistent archaeological record: Melka Kunture, Ethiopia". *Journal of Human Evolution*, **62**:104-115.

Leakey, M. D. 1971. *Olduvai Gorge, Excavations in Beds I and II, 1960–1963..*
Cambridge: Cambridge University press.

----- 1975. “Cultural Patterns in the Olduvai Sequence”. In: K. W. Butzer
& G. L. Isaac (Eds.), *After the Australopithecines: Stratigraphy, Ecology, and Cultural
change in the Middle Pleistocene*, 477–493. Chicago: Mouton.

Lepre, C. J., & Kent, D. V. 2010. “New Magnetostratigraphy for the Olduvai
Subchron in the Koobi Fora Formation, northwest Kenya, with Implications for early
Homo”. *Earth and Planetary Science Letters*, **290**: 362-374.

Lepre, C. J., Roche, H., Kent, D. V., Harmand, S., Quinn, R. L., Brugal, J. P., ... &
Feibel, C. S. 2011. “An Earlier Origin for the Acheulian”. *Nature*, **477**: 82-85.

Magnani, M., Rezek, Z., Lin, S. C., Chan, A., & Dibble, H. L. 2014. “Flake
variation in relation to the application of force”. *Journal of Archaeological Science*, **46**: 37-
49.

Marean, C. W., & Zelalem, A. 2005. “The Middle and Upper Pleistocene African
record for the biological and behavioral origins of modern humans”. *African archaeology*,
93-129.

Marwick, B. 2008. “What attributes are important for the measurement of
assemblage reduction intensity? Results from an experimental stone artifact assemblage
with relevance to Hoabinhian of mainland Southeast Asia”. *Journal of Archaeological
Science*, **35**:1189-1200.

Mauldin, R.P., Amick, D.S. 1989. "Investigating patterning in debitage from experimental biface core reduction". In: Amick, D.S., Mauldin, R.P. (Eds.), *Experiments in Lithic Technology*. BAR International Series, Oxford, 67-88.

McPherron S. 2000. "Handaxes as a Measure of the Mental Capabilities of Early Hominids". *Journal of Archaeological Science*, **27**: 655-663.

McPherron, S. P., Zeresenay, A., Marean, C., Wynn, J.G., Reed, D., Geraads, D., Bobe, R., & Be'arat, B.H. 2010. "Evidence for stone-tool-assisted consumption of animal tissues before 3.39 million years ago at Dikika, Ethiopia". *Nature*, **466**: 857-860.

Misra, V.N. 1987. "Middle Pleistocene Adaptations in India". In Soffer, O. (Ed.) *The Pleistocene Old World- Regional Perspectives*. New York: Plenum Press, 99-119.

Mithen, S. 1999. "Imitation and cultural change: a view from the Stone Age, with specific reference to the manufacture of handaxes". In: H. O. Box & K. R. Gibson (Eds.), *Mammalian social learning: comparative and ecological perspectives*, 389-413. Cambridge, MA: Cambridge University Press.

Morgan, E., Paul R., Kieffer, R.G., Piperno, M., Gallotti, R., Raynal, J.P. 2012. "A chronological framework for a long and persistent archaeological record: Melka Kunture, Ethiopia". *Journal of Human Evolution*, **62**:104-115.

Piperno, M. 1999. "The Open-Air Museum of the Early Palaeolithic site of Melka Kunture". *Culture in Sustainable Development. An Italian Strategy*, 34-36.

[Piperno](#), M., [Collina](#), C., [Gallotti](#), G., [Raynal](#), J.P., [Kieffer](#), G., [Bourdonnec](#), F., [Poupeau](#), G., Geraads, D. 2009. "Obsidian exploitation and utilization during the Oldowan

at Melka Kunture (Ethiopia)". In: Hovers, E., Braun, D.R. (Eds.), *Interdisciplinary Approaches to the Oldowan*, 111-128. Springer Netherlands.

Potts, R., Behrensmeyer, A. K., & Ditchfield, P. 1999. "Paleolandscape variation and Early Pleistocene hominid activities: members 1 and 7, Olorgesailie Formation, Kenya". *Journal of Human Evolution*, **37** :747-788.

Presnyakova, D., Archer, W., Braun, D. R., Flear, W. 2015. "Documenting differences between Early Stone Age flake production systems: an experimental model and archaeological verification. *Public Library of Science One*.

Quade, J., Levin, N., Simpson, S.W., Bttler, R., McIntosh. W., Sileshi, S., Klensasser, L., Dupont-Nivet, G., Renne, P., and Dunbar, C.S. 2008. "The Geology of Gona, Afar, Ethiopia". *The Geological Society of America Bulletin*, special paper, **446**: 1-31.

Quade, N. Levin, Sileshi, S., D. Stout, P. Renne, M. Rogers, S.W. Simpson. 2004. "Paleoenvironments of the earliest stone toolmakers, Gona, Ethiopia". *Geological Society of American Bulletin*, **16**:1529-1544.

Salvini, R., Riccucci, S., & Francioni, M. 2012. "Topographic and geological mapping in the prehistoric area of Melka Kunture (Ethiopia)". *Journal of Maps*, **8**: 169-175.

Schick, K. & Toth, N. (1994). "Early Stone Age Technology in Africa: a review and case study into the nature and function of spheroids and subspheroids". In: Corruccini, 109 R.S. & Ciochon, R.L. (Eds.), *Integrative Paths to The Past: Paleoanthrological*

Advances in Honour of F. Clark Howell: 429-450. Englewood Cliffs, New Jersey: Prentice Hall, Inc.

Schick, K. and Clark, J.D., 2003. "Biface Technological Development and Variability in the Acheulean Industrial Complex in the Middle Awash Region of the Afar Rift, Ethiopia". In: Soressi, M., and Dibble, H., L. (Eds.), *Multiple Approaches to The Study of Bifacial Technologies*. University of Pennsylvania, Museum of Archaeology and Anthropology, Philadelphia, 1-30.

Scott G. R., Gibert L. 2009. "The Oldest Hand-axes in Europe". *Nature*, **461**: 82–85.

Sharon, G. 2006. "Acheulian Large Flake Industries Technology, Chronology, Distribution and Significance". PhD Dissertation Submitted to the Senate of the Hebrew University of Jerusalem.

-----2008. "The impact of raw material on Acheulian large flake production". *Journal of Archaeological Science*, **35**: 1329–1344.

-----2010. "Large flake Acheulian". *Quaternary International*, **224**: 226–233.

Sileshi, S., Rogers, M. & Stout, D. 2009. "The Oldowan–Acheulian transition: is there a 'developed Oldowan' artifact tradition?" In: M. Camps & P. Chauhan (Eds.), *Source book of Paleolithic transitions: methods, theories, and interpretations*, 173–193. New York, NY: Springer.

Sileshi, S., Rogers, M.J., Quade, J., Renne, P.R., Butler, R.F., Dominguez-Rodrigo, M., Stout, D., Hart, W.S., Pickering, T., Simpson, S.W. 2003. "2.6-Million-year-old stone

tools and associated bones from OGS-6 and OGS-7, Gona, Afar, Ethiopia”. *Journal of Human Evolution*, **45**: 169-177.

Speth, John D. 1972. “Mechanical basis of percussion flaking”. *American Antiquity*, **37**:34-60.

Stout, D. 2010. “The evolution of cognitive control”. *Topics in Cognitive Science*, **2**: 614– 630.

----- . 2011. “Stone tool making and the evolution of human culture and cognition”. *Philosophical Transactions of the Royal Society B. Biological sciences*, **366**:1050–1059.

Stout, D., Quade, J., Sileshi, S., Rogers, M.J., Levin, N.E. 2005. “Raw material selectivity of the earliest stone toolmakers at Gona, Afar, Ethiopia”. *Journal of Human Evolution*, **48**: 365-380.

Stout, D., Schick, K and Toth, N. 2009. “Understanding Oldowan Knapping Skill: An experimental study of skill acquisition in Modern Humans”. In: Schick, K., and Toth, N. (Eds.), *The cutting edge: New Approaches to the Archaeology of Human Origins*. Stone Age Institute publication series: 247-265.

Stout, D., Toth, N., Schick, K. D. & Chaminade, T. 2008. “Neural correlates of Early Stone Age tool-making: technology, language and cognition in human evolution”. *Philosophical Transactions of the Royal Society B. Biological sciences*, **363**: 1939–1949.

Suwa, G., Berhane, A., Yohannes, H., White, T. I. M., Katoh, S., Gidey, W., & Yonas, B. 2007. "Early Pleistocene Homo *erectus* fossils from Konso, southern Ethiopia". *Anthropological Science*, **115**: 133-151.

Toth, N. 1985. "The Oldowan reassessed: a close look at Early Stone artifacts". *Journal of Archaeological Science*, **12**:101–120.

-----1987. "Behavioral inferences from Early Stone artifact assemblages: an experimental model". *Journal of Human Evolution*, **16**:763–787.

Toth, N., Schick, K., and Sileshi, S. 2006. "A comparative study of tool-making skills of Pan, Australopithecus and Homo sapiens". In: Schick, K., and Toth, N. (Eds.), *The Oldowan: Case studies into the Earliest Stone Age*. Stone Age Institute publication series, 155-222.

Turq, A., Roebroeks, W., Bourguignon, L., Faivre, J.P. 2013. "The fragmented character of Middle Palaeolithic stone tool technology". *Journal of Human Evolution*, **65**: 641–655.

White, T.D., Berhane, A., DeGusta, D., Gilbert, H., Richards, G.D., Suwa, G., Howell, F.C. 2003. "Pleistocene Homo sapiens from Middle Awash, Ethiopia". *Nature*, **423**:742-747.

Whittaker, J.C. 1994. *Flintknapping: Making and understanding stone tools*. University of Texas Press, Austin.

Wynn, T. & Coolidge, F. L. 2004. "The expert Neandertal mind". *Journal of Human Evolution*, **46**: 467– 487.

Yonas, B., 2003. "The emergence and Development of the Acheulean at Konso". *Anthropological science*, **111**: 58.

Yonas, B., Katoh, S., Gidey, W., Hart, W. K., Uto, K., Sudo, M., & Berhane, A. 2013. "The Characteristics and Chronology of the Earliest Acheulean at Konso, Ethiopia". *Proceedings of the National Academy of Sciences*, **110**:1584-1591.

Internet sources

Hall, G., Pickering, R., Lacruz, R., Hancox, J., Berger, L and Schmid, P. 2006.

“An Acheulean handaxe from Gladysvale Cave Site, Gauteng, South Africa”. *South African Journal of Science*, **102**: 103-105. profleeberger.com/files/hallgvhandaxe2006_1_.pdf. (15/01/2015 at 9:15 am).

Stout, D., Hecht, H., Khreisheh, N Bradley, B., Chaminade, T. 2015. “Cognitive Demands of Lower Paleolithic Toolmaking”. <https://scholarblogs.emory.edu/stoutlab/files/2013/.../Stout-et-al-2014.pdf>. (15/01/2015 at 10:00am).

Margheriti, M., Gallotti, R. 2013. “The Emergence of the Acheulean in East Africa – International Workshop, Rome, “La Sapienza” University. *Evolutionary Anthropology Issues News and Reviews*, **23**:126127. DOI: 10.1002/evan.21421. www.researchgate.net/.../Acheulean.../542c281e0cf27e39fa92aa58.pdf. (18/01/2015 at 4:40 pm).

Domínguez-Rodrigo, M., Martín, D., Mabulla, A., Baquedano, Bunn, T., Musiba, C. 2014. “The evolution of hominin behavior during the Oldowane-Acheulean transition: Recent evidence from Olduvai Gorge and Peninj (Tanzania)”. *Quaternary International*, **322-323**:1-6 www.olduvaiproject.org/wp-content/uploads/Intro_QI.pdf. (28/10/2014 at 9:00 am).

Kimura, Y.2002. “Examining time trends in the Oldowan technology at Beds I and II, Olduvai Gorge”. *Journal of Human Evolution Volume 43*:291–321. www.sciencedirect.com/science/article/pii/S0047248402905762.(05/05/2015 at 3:45 pm).

Martín, F., and Eren, M. 2012. “The Early Acheulean in Africa”. In: Domínguez-Rodrigo, M(Editor), *Stone Tools and Fossil Bones; Past Paradgims, Current ideas and Future directions*. Cambridge University Press, Cambridge. ebooks.cambridge.org/chapter.jsf?bid=CBO9781139149327&cid. (21/05/2015at 12:45 pm).

Sileshi, S., Rogers, M., Stout., D. 2013. “Early Acheulian stone assemblages ~1.7-1.6 Ma from Gona, Ethiopia”. International Workshop, The Emergence of the Acheulean in East Africa. http://www.melkakunture.it/research/download/semaw_et_al.pdf.

Parenti, F., Al-Shiyab, A., Santucci, E., Kafafi,Z., and Palumbo, G.1997. “Early-Acheulean-Stone-Tools-and-Fossil-Faunas-From-the-Dauqara-Formation-Upper-Zarqa-Valley-Jordanian-Plateau”.<http://www.isipu.org/wp-content/uploads/2013/10/>.