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Dissertação final:

Terminal Pleistocene Lithic Technology and Adaptation from Bulbula River B1s4 Site, Ziway-Shala Basin, Ethiopia

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Abstract

Archaeological excavation which had been conducted in 2009 and 2010 in the Ziway-Shala Basin, close to the Bulbula River Canyon at B1s4 site, has yielded lithic assemblages and few faunal remains. Two human occupation horizons (PS1 and PS2) were identified which are separated by an occupational hiatus at the very end of the terminal Pleistocene. Analysis of debitage on both unit levels indicates the presence of similar features that lead us to assume that B1s4 lithic industry was oriented towards the production of blades and bladelets. But, this site shows strong technological and industrial variabilities to early Holocene sites which are very close to B1S4. The microliths, which are widely discovered at early Holocene sites-and to a lesser extent sites dated to Pre-Maximum Glacial Maximum-are hard to find at B1s4.Alike Paleoenviromental records in the Ziway-Shala basin and other parts of Ethiopia and Eastern Africa, B1s4 has proved that terminal Pleistocene was characterized by fluctuating weathering conditions that might have forced hunter-gatherers in the region to practice diverse adaptive strategies.

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Chapter One

Introduction and Research Objectives

1.1. Background

The archaeological survey and excavation which had been conducted by Late Stone Age Research Project in Ethiopia from 2007 -2010 had revealed human occupation horizons at Bulbula which were dated to early Holocene, Terminal and early Pleistocene period (Bon *et al.*, 2013). The study site, B1s4, from Bulbula 1 locality is part of this project and it was first discovered in 2008. Charcoal sample from the lower paleosol (PS1) level of B1s4 were taken for radiocarbon dating and dated to 12,040 ± 50 (14,045-13,755 cal BP) using AMS dating. Therefore, the earliest occupation at B1s4 site is belongs to the Late Stone Age, particularly for the Terminal Pleistocene period (Ménard *et al*., 2014) which was characterized by fluctuating climate conditions such as an increasing temperature and moisture, but it was mainly interrupted by an abrupt return to the arid condition and probably Younger Dryas climatic reversal (Kiage and Liu, 2006: 644). This fluctuating climatic condition during the terminal Pleistocene increasingly modified the cultural and subsistence strategies of the hunter-gatherers. Chronologically, the terminal phase of the last glaciation in East Africa had prevailed after 12,500 BP and had continued into the onset of the Holocene (Kiage and Liu, 2006: 644).

Moreover, during this period the cultural and environmental interaction and contact of hunter-gathers is a focus of many archaeological researchers in the field who are interested to understand human adaption. During this period, hunter-gathers may have been forced to design certain adaptive strategies to cope up with the changing environment which finally brought district lithic technology in some regions (e.g. South Africa) (Ambrose, 2002: 12:13).

Therefore, my thesis project focused on the analysis Terminal Pleistocene lithic materials from B1s4 site which had been excavated and collected by the project of Late Stone Age Sequence in Ethiopia directed by François Bon (Université de Toulouse, France) and Asamerew Dessie (ARCCH, Ethiopia).

1.2. Research Objective

The main objective of this research was to understand technological adaptation of B1s4 Bulbula hunter-gatherers to the major resources and environmental changes that took place during the Terminal Pleistocene. The specific objectives of this research are the following:

1. To understand characteristic features LSA lithic technology at B1s4 and how Terminal Pleistocene hunter-gatherers at B1s4 organized and used the surrounding landscape during this period;
2. To investigate how the cores were exploited during the manufacture of flakes;
3. To understand the subsistence strategy of hunter-gatherers of B1s4 based on evidence found on lithic and faunal remains;
4. To understand technological and typological traditions as well as behavioral and social changes that prevalent during the end of the Pleistocene and the onset of the Holocene at Bulbula (B1s4);
5. To compare and contrast the typological and technological features of Bulbula B1s4 lithic assemblage from local and regional site such as B1S4, DW2S1, DW2S2 at Bulbula and FEJx2 at Lake Besaka and others;
6. To understand better late quaternary archaeology and paleoenvironment of the study area.

1.3. The significance of the study

The terminal Pleistocene, which is characterized by fluctuating and turbulent climatic conditions, has been the concern of archaeologists who have been working on this period. In Ethiopia, this period spans from c. 18,000-12,000 BP and culturally has been understood by few stone artifacts uncovered from Lake Besaka (Brandt, 1982) and Bulbula B1s1 (Ménard *et al.*, 2014; Habte, 2014). Yet, there is a lack of data to understand the technological aspect, subsistence strategy and adaptation behavioral aspect of hunter-gatherers who were living during this terminal Pleistocene period. So, this thesis would generate additional data which are useful for understanding paleoenvironment, cultural behavior and economic subsistence of hunter-gathers of the terminal Pleistocene period.

1.4. Statement of the Problem

Despite several attempts had been made to establish the chronology and techno-typology pattern of LSA industry of the Horn of Africa, yet this period remains poorly understood. There is no general consensus about the definition and the chronological boundaries among the researchers working in the region. It is 'catch-all concept' which depends on different kind of contexts and industries dated between MIS3 and Late Holocene (Ménard *et al*., 2014). Researchers such as Brandt (1982) characterized LSA dominantly by the existence of backed microlithic tools and blade-core technology. Others said that LSA culture is apparent by the production of blade and miniaturization (Ménard *et al*, 201. All agree that archaeological reality is much more complex, and widely accepted that the existing archaeological data is not sufficient enough for understanding hunter-gatherers technological behavior in the region because the temporal and technological changes that occurred during this period were limited by lack of stratigraphic sequence and reliable radiocarbon data (Brandt, 1982).

Despite several research projects has been conducted in order to establish the chronology and typology of LSA in the Horn of Africa, the available data did not produce enough information and yet this period remains poorly understood. Hence, in order to generate more data useful for understanding the chronology and the nature of technological and environmental changes in the LSA period in general and the Terminal Pleistocene in particular, more data are needed sites like Bulbula. Therefore, the data from Bulbula (B1s4) has the potential to yield important information to understand Terminal Pleistocene hunter/gatherers cultural development in the Ziway-Shala basin, which is located in the Main Ethiopian Rift. My research project therefore focused to understand the adaptive strategies of the Terminal Pleistocene hunter-gathers in Bulbula (B1s4) through close examination of the technological innovation, land use and mobility pattern, and subsistence strategies.

1.5. Development of the Research Interest and the selection of the study site

My research interest on the study of lithics developed in 2013 when I have started to work on analysis of lithic materials collected from Mezber by Eastern Tigray archaeological Project (ETAP) near to Adigrat town. The reason for selecting B1s4 for study is related to the importance of the site for yielding information about the technological and behavioral adaptations of the hunter-gathers of the Terminal Pleistocene period as the areas is preserved important water bodies of the Ziway-Shala basin that may provide resources during the bottle neck period faced the Last Glacial Maximum hunter-gathers. In addition, the B1s4 has preserved important sedimentary formations of two paleosols in which one of it was securely dated and could provide data to answer hunter-gather adaptive strategies of the new environment they encounter during the Terminal Pleistocene and also it offers me an opportunity to compare to other post-LGM site of Bulbula like B1S1 studied by Habtie (2013)and DW2S1 and DW2S2 (Ménard *et al*. (2014).

1.6. Research Methods

1.6.1. Data Analysis

During classifying and analyzing lithic artifacts, researchers employ different approaches and often determine the methodologies based on the type of question they would like to address. According to Vanpool and Leonard (2011), both qualitative and quantitative methods are important for the analysis of lithic assemblage. The qualitative and theoretical perspective tells us which observations are important to make and how explanations are constructed. On the other hand, quantitative methods and statistical techniques play an important role in archaeological analysis because archaeologists rely on heavily on fragmentary archaeological samples that time and the vagaries of environment (including human activities) allowed to be preserved. These quantitative methods and statistics were employed for data analysis which were collected by systematic observation and analysis of the lithic assemblages. Bearing this in mind, the lithics assemblages derived from B1s4 were analyzed using both qualitative and quantitative methodological approach.

Qualitative data analysis would be organized using the lithic assemblages uncovered during excavation as well as referring the draft notes taken during the field work. In order to develop standard classification system, first levelled the artifacts on the table at the laboratory room available by Authority for Research and Conservation of Cultural Heritage (ARCCH). This would be useful for me to be apparent for the different form of tools variability and for the first few days I tried various classification schemes with different analytical procedures until I came up with the classification scheme and a standard descriptive system that would be capable of dealing with the observed variability, yet would be easy to understand and relatively fast to record.

The analysis of lithics begins with the identification and classification of lithic assemblages. Classification plays a great role for the summarization of data for descriptive purpose. It plays also a role as a heuristic device (Andrefsky, 2005). According to Whittaker (1994:270), there are four factors that govern the shapes of the lithic artifacts. These factors include 1) the raw material of which the tools are manufactured, 2) the technology employed during the production of the artifacts, 3) the function or purpose of the artifacts, and 4) the style of characteristic mode of tool form current among the people making the object. During the analysis of B1s4 lithic assemblages, the raw material choice and the technological employed were systematically examined and used to develop a classification scheme for my data analysis (based on both qualitative and quantitative method) as well as to achieve my research goals. The prehistoric hunter-gathers from B1s4 were totally produced their lithic artifacts from obsidian which are available near to the site. In addition, the techniques applied and the technologies practiced at B1s4 were traced by analyzing individual debitages, cores and tools. The stage of manufacture and the manufacturing techniques exhibited on each artifact provide evidences to understand the technology employed during the production of artifacts. So, taking in account this, individual lithic artifacts from B1s4 would be carefully classified and examined in order to determine an artifact was as cores, tools and debitages in one hand and to reconstruct the technical and technological procedures of a given assemblages on the other hand. For debitage analysis, decortications of debitage analysis, tool debitage analysis, and hierarchical analysis were employed. To understand core reduction sequence, both core and flake assemblages were analyzed.

1.6.2. Debitage Analysis

Most prehistorians who study lithics have given much attention for cores and tools relatively compared to flakes and debris, collectively they are called debitage, during the classification and the analysis of lithic assemblages (Fish, 1981: 374). Debitage are flaked products removed by either pressure or percussion techniques. They tell the whole process which includes wide variety of activities and varies stages of process of the raw material from the original to the finished stages (Inizan *et al* 1999; Fish, 1981: 374). The analysis of debitage can be differed from one to another depending on the purpose of lithic studies (Gang, 1997). But, whatever such variations exists among researchers, the methods of debitage analysis can be largely divided in to two classes: individual flake analysis and flake aggregate analysis (Anderfsky, 2005; Ahler 1989:86 *cited* in Gang, 1997: 89). The individual flake analysis comprises decortication or core reduction debitage analysis, tool debitage analysis and hierarchical analysis (Gang 1989:89).

During the analysis of B1s4 lithic artifacts, I used individual methods of debitage analysis particularly for whole flakes, blades, bladelets, cores and tools. On the other hand, angular wastes, broken flakes, chips and shatters were analyzed in aggregate or mass analysis system. According to Gang (1989: 106), during mass or aggregate analysis, individual artifacts are not investigated, instead this debitage analysis method favors counting and weighting of the total artifacts in a given artifact sample. For individual debitage analysis, the basic and common debitage attributes such as the size and shape of every whole flakes (maximum length, width and thickness), artifact type, platform type, cross-section, the presence or absence of cortex, nature of retouch (for scrapers), completeness and physical condition were considered. Then based on these attributes, an attribute table on excel program was prepared and data entered into the computer. The same attribute analysis table is used for tools and cores. This attribute table is adopted and modified from Brandt (1982; 2012).

1.6.3. Core Analysis

Researchers employ different methodological approach for core analysis. Morphological description, technological analysis or graphical representations of technological attributes are some of the methodological approaches often used by researchers. These methodological approaches of core analysis provide information about temporal relationships between flake removals. It also offers spatial information and gives information useful to know different stages of reduction sequence and movement of abandonment of reduction process.

Specific core industries such as blade and bladelet constitute a small part of the lithic assemblage of B1s4 and in order to understand reduction sequence of the assemblage, all of these cores were analyzed from morphological and technological point of view. Experimental archaeology has provided useful data for the understanding of reduction sequence of cores. In their early stage, cores are mostly characterized by large and heavy features and exhibit few scars on the major removal face and simple scar pattern. When it reaches at middle stage, both core size and removal surface area on cores reduced. At this stage, the negative features of the core manifests complex features both in terms of scar count and pattern which resulted from the previous scar pattern. In final and latter stage, reduction of core often characterized by amorphous shape and very complex scar pattern and high scar counts (Baumler 1987:27; Munday, 1976:120 *cited* in Gang, 1989).

1.6.4. Tool Analysis

According to Anderfsky (2005: 76), tools "are considered to be all those chipped stone objective pieces that have been modified by intentionally altering their form and those detached pieces that show signs of modification as a result of use". Tools can be identified either by the task for which it was produced or the type of choice made by the makers among several equally valid and feasible options. The task of every tool is measured by its functional attributes, but the type of choice of the material is related to stylistic attributes. For this thesis, the lithic assemblage from B1s4 is investigated by dividing into shaped and unshaped tools. Shaped tools comprise scrapers, retouched flakes, backed pieces, while unshaped tools include irregular modified pieces and lithics with utilized edge.

1.6.5. Exploratory analysis

Further analytical tools would be employed and the data on the attribute table were represented visually using for example frequency distributions like histogram, bar chart, pie chart etc. Then, the data summarized in the graphical representation were again further described by using numerical form of descriptive statistics which can be based on a single variable. This numerical characterization of the data allows a more formal means of both describing a distribution and comparing two or more distribution. These numerical descriptions of distribution are termed either statistics or parameters depending on whether they describe a population or a sample. Statistics are descriptions of the characteristics of a statistical sample, whereas parameters refer to the characteristics of statistical population Vanpool and Leonard (2011).

1.6.6. Use Wear Analysis

Use wear analysis is the study of the function of tools based on the complex analysis of all traces of use, including macro-deformations, micro-linear traces and polishes (Peterson, 2015). This study can be investigated by using both low-power or high-power microscope technique. By the request of the author of this thesis, a small use wear study was conducted by Elizabeth Peterson (PhD candidate from Simon Frazer University, Canada), up on a selection of

14 shaped obsidian tools classified as different types of scrapers from B1s4. According to here report, the method used within the analysis is the standard low-power use wear method developed by Dr. George Odell (1977). Before evaluation, each stone was washed carefully in water and then lightly bathed in 50% acetone to clear away any hand grease that could be confused as polish under microscopic inspection. The tools were then each evaluated under a stereomicroscope of 6 to 80X magnification, tracking the location, type, and frequency of the different wear attributes.

1.7. Definitions Retained for this Study

1.7.1. Artifact Typology

Artifact type is a subjective, macro-level assessment based on presence or absence of specific features on each artifact (e.g. lateral retouch, butt morphology, and overall artifact length, width, and thickness).

1.7.2. Completeness

Completeness is determined based on whether or not the artifact was broken during use-related activates or during production or post-depositional processes. When an artifact had a bulb of percussion or unbroken proximal end, intact lateral edges, and intact distal tip or bit, it was coded as complete. Other codes, for example, like *proximal flake* and *distal flake fragment* were used if the artifact had an intact proximal end and lateral edges and distal end and lateral edge respectively.

1.7.3. Length, Width, and Thickness

Length, Width, and Thickness was recorded in millimeters (mm) and measured maximum limits of each artifact. Each artifact was held perpendicular then parallel during the measuring process. Measurements were recorded with one electronic digital caliper that measures to the hundredth of a millimeter (0.00 mm).

1.7.4. **Presence or Absence of Cortex**

Cortex was measured only viewing the dorsal surface of the artifact and was recorded either the presence or absence of cortex.

1.7.5. **Dorsal Scar Pattern and Scar Counts**

Dorsal scar patterns can indicate particular reduction sequences and illuminate standards in production or reduction of stone tools. For example artifacts may have parallel or convergent dorsal arrises indicating unidirectional core flaking. On the other hand scar counts are refer to the number of flake scars evident on the on the dorsal face of the flake.

Chapter two

Cultural and Environmental Background

2.1.Contextual Data

2.1.1. Features of the Ziway-Shala basin, Main Ethiopian Rift

The Ziway-Shala basin is located in the Main Ethiopian Rift (hereafter called MER), which is part of the northern extension of East African Rift System. Its northern limit extends to the Red Sea and Gulf of Aden rift system (Gasse and Street, 1978: 280). The study area, B1s4, is found in the Ziway-Shal Basin and it is located at 07°49.125' N and 038°41.909' E close to the edge of Bulbula canyon and to the north of Bulbula 1 locality (figure 1 and figure 2) (Bon *etal*., 2013). It is part of the Bulbula Plain which is situated between Lake Ziway and Lake Abijata and extends 28 km in length and 10 km in width. This wider plain area varies in elevation ranging between 1640 and 1700 m a.s.l. In the eastern and western part, the Bulbula plain is bounded by Alutu volcano and, the Waso and Macho hills respectively (Di Paola, 1972).

Figure 1: Photo showing location of study area (B1s4) in the Bulbula plain with some addation (Bulbula 1 locality). Courtesy of F. Bon. and C. Ménard.

The Bulbula River connects the two most northern lakes (Lake Ziway and Lake Abijata). Lake Abijata receives water from in its northern end from the Bulbula River that discharges from Lake Ziway. The Bulbula Rivers flows in deep gorge which is flanked by a cliff measures about 30-35 m in height. Bulbula is part of the Ziway-Shala basin which is located 7-8°30'N latitude and 38°30'E longitude with an elevation ranging from 1558 to 1636 m a.s.l. near the highest part of its floor. Approximately it is 150-210 km away south of Addis Ababa, the Ethiopian capital (Gasse and Street, 1978; Le Turdu *et al.*, 1999: 136; Benvenuti *et al.*, 2002: 247).

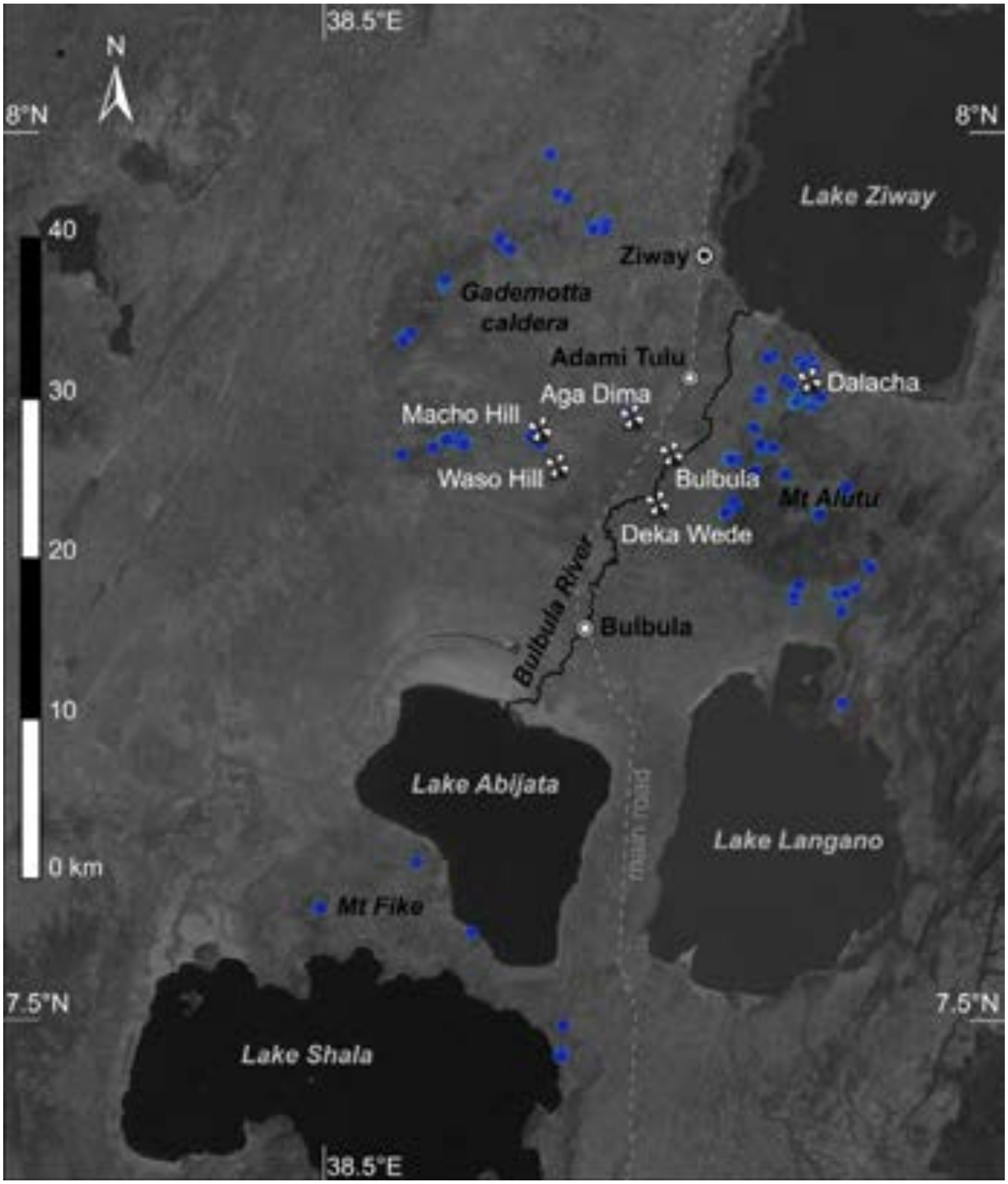


Figure 2: satellite image (Landsat) of the Ziway-Shala basin showing the location of main LSA sites (windmills) and sampled obsidian sources (blue dots) (after Ménard *et al*., 2014: 57).

As it has presented in figure 2, the Ziway-Shala basin comprises rift-bounded chains of four different lakes (Ziway, Langano, Abijata and Shala) which were different times connected and formed a single lake during the late Pleistocene and Holocene (Benvenuti *et al*. 2002: 247; Street, 1979; Chernet 1982). These lakes measure an area of about 14,640 km^2 and they are hydrologically closed, but surface water network connects the three northernmost lake of Ziway, Langano and Abijata (Le Turdu *et al*., 1999: 138).

The Ziway-Shala basin in the MER is bounded by steep border fault escarpment of 70-80 km apart. These escarpment border the Ethiopian plateau to the west and the southeastern part to the east. It is surrounded by trachytic shield volcanoes of Pliocene shield age that includes Mount Chilalo (4006 m), Mount Badda (4170 m) and Mount Kubasa (3760 m) in which these mountains overlook the Ziway-Shala lake basin system from the east. The Ziway-Shala basin has preserved the relics of several dormant silicic caldera volcanoes of Mount Bora (2293 m), the Alutu Caldera (2328 m), the O'a Caldera (1960 m), and the Corbetti Caldera (2320 m) which rises above the rift floor (Le Turdu *et al*., 1999).

2.1.1.1. Geology and Geomorphology of Bulbula River

The MER divides the 1,000-km-wide uplifted Ethiopian volcanic province symmetrically into the northwest and southeast plateaus. The whole area of MER divided geographically into northern, central and southern sectors (WoldeGabriel, 1990; 1991) which is bordered by the Ethiopian Plateau to the west and the Somalian Plateau to the east (Benvenuti *et al*., 2002: 248). Distribution of volcanic rocks along the MER boundary faults shows a discontinuous sequence ranging in age from the Oligocene to the Quaternary (WoldeGabriel, 1990; 1991). Huge volcanic eruption especially in the southern and central MER has started in the Late Eocene-Early Oligocene by a basaltic eruption, associated with an early stage of rifting characterized by uplifting and faulting. Series of alternating half-grabens were the results of the early phase of Late Oligocene to Early Miocene times. Then, this phase was followed by the development of full symmetrical grabens and rift-in-rift structures (WoldeGabriel *et al*., 1990; Le Turdu *et al.,* 1999; Benvenuti *et al*., 2002).

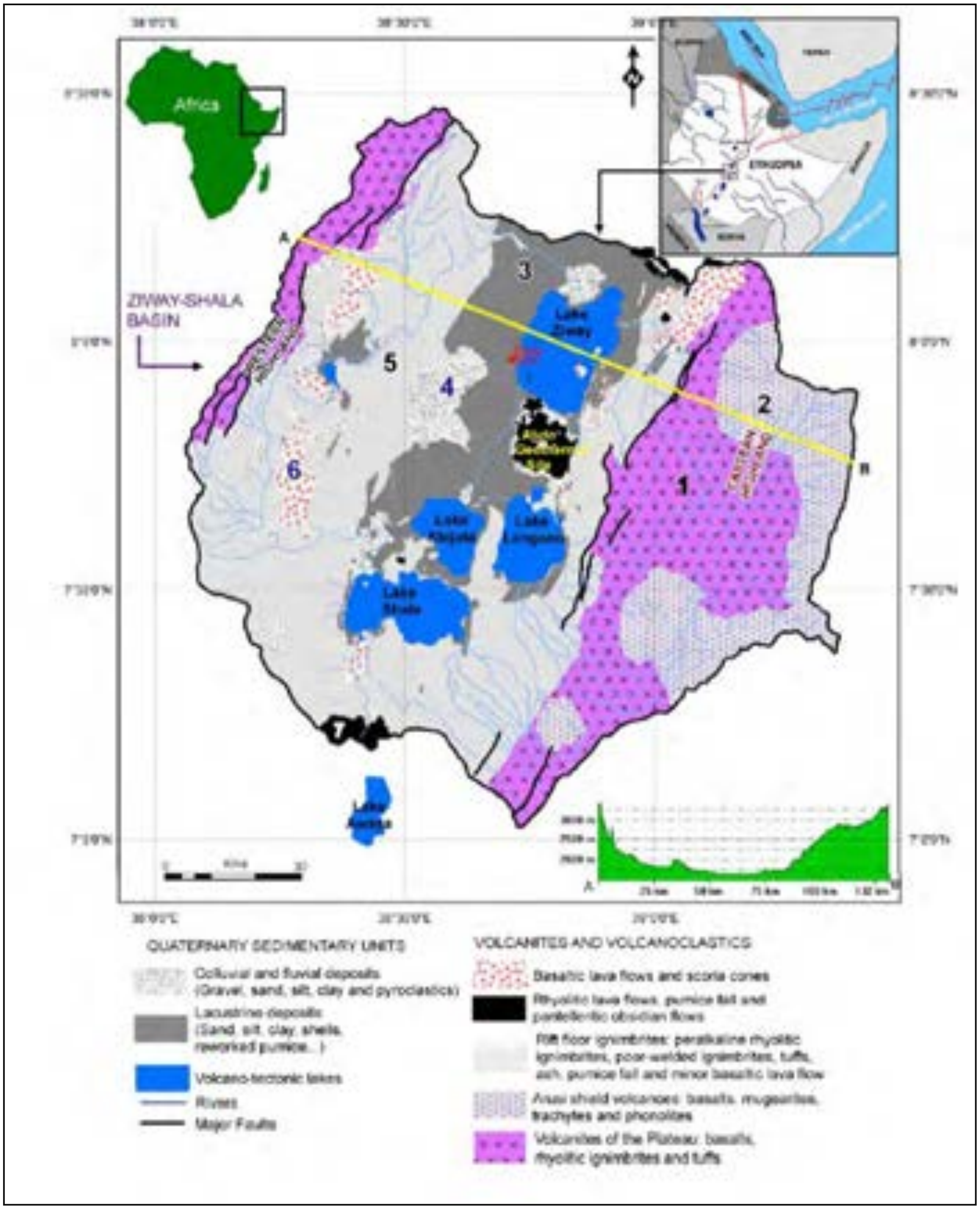


Figure 3: simplified geologic map of the study area (Ziway-Shala basin) (after Rango, 2009: 35).

The Ziway-Shala basin in the central sector of the MER was formed by the erupted voluminous flow of rhyolitic ignimbrites and collapsed calderas during early Pliocene tectonic event. This central sector of the MER and its shoulders are made of volcanites and pyroclastic rocks, whereas large areas of the rift floor are covered by volcano-lacustrine and fluvio-lacustrine deposits (WoldeGabriel *et al*., 1990). Compared to the previous periods, the Late Pleistocene–Holocene time interval appears to be characterized by minor tectonic deformation. During these periods, Wonji Fault Belt (WFB), which formed part of the central sector of MER and eastern marginal graben of the Ziway-Shala basin, and the Silti Debre Zeit Fault Zone (SDZFZ) were the two main areas in the sector of MER dominantly affected by tectonic and volcanic events (Benvenuti *et al*., 2002). Volcanic activities continue from the Middle Pleistocene to the present in WFB and are marked by the development of fluvio-lacustrine basins. Successive Fluvio-lacustrine basins have been also formed in the Pleistocene-Holocene in an extensive area of the MER floor (Le Turdu *et al*., 1999; Benvenuti *et al*., 2002). This was also a time when joint history of sedimentation in the Ziway, Langano, Abijata and Shala lake basins have started in the central MER (Le Turdu *et al.*, 1999).

Figure 4: Fluvio-lacustrine sediment, east of Lake Shala (after Rango, 2009:36)

Figure 5: Pumice deposit, northeast of Lake Ziway (after Rango, 2009: 36)

Lacustrine sediments were formed by non-volcanic activities in portions of the rift. This lacustrine formation in the portions of the rift valley covered a large area of about 4000km^2 and whose thickness is sometimes considered range from about 40 m in Bulbula River and 50 m in Boru and Maky River up to more than 100 m between Modjo and Koka. These lacustrrine sediments were formed when the big lakes were formed when lakes were filled with water drying up in the area where in the past occupied the floor of the rift valley. Lakes Ziway, Langano, Abijata and Shala in fact, are the remnants of the ancient large water basin. The lacustrine deposits are marked by the presence of cemented volcanic sands, and ashes, transported pumice, silt, clay and diatomites (Di Paola, 1972).

The Late Pleistocene-Holocene deposits of the Ziway-Shala basin have revealed three lithostratigraphic units. The first two, the alluvial and fluvio-lacustrine deposits, formed the lithostratigraphic unit of Meki Formation. Evidence of this formation is recorded on the fluctuation marks identifying in the Meki River base-level (Benvenuti *et al*., 2002). The other lithostratigraphic unit, which is called Bulbula Formation, was recorded in the Ziway-Shala Basin. Lacustrine diatomaceous marls and calcareous sands formed this lithostratigraphic unit. This formation is dominated by a thick (about 30 m) volcaniclastic Latest Pleistocene unit which preserves erosive surfaces and paleosols used as reference for the transition from Upper Pleistocene to Holocene deposits (Gasse and Street, 1978). The last stratigraphic unit is called the Ajewa Formation which is comprised the eastern shore of Lake Shala. This unit is composed of Late Pleistocene and Holocene deep to shallow lucustrine, shoreface, alluvial and colluvial deposits (Benvenuti *et al*., 2002).

With regards to geomorphology, striking geomorphological evidences of lake fluctuations and soil formation process have been identified in the Ziway-Shala basins in a form lacustrine recessional still stands, such as terraces and stranded plaeo-shorelines (figure 6). Evidences of lucustrine terraces (V-I from higher to lower) are recognized around Lake Ziway (Benvenuti *et al*., 2002). Relict shorelines were also identified and they are mainly developed in the southern basin of the MER. Evidences of terraces has continued to develop during the early phases of the Holocene and a single lake had existed during the development of terrace IV dated between 9600 and 9400 BP, with a subsequent flooding at about 5400-5100 BP (Benvenuti *et al*., 2002).

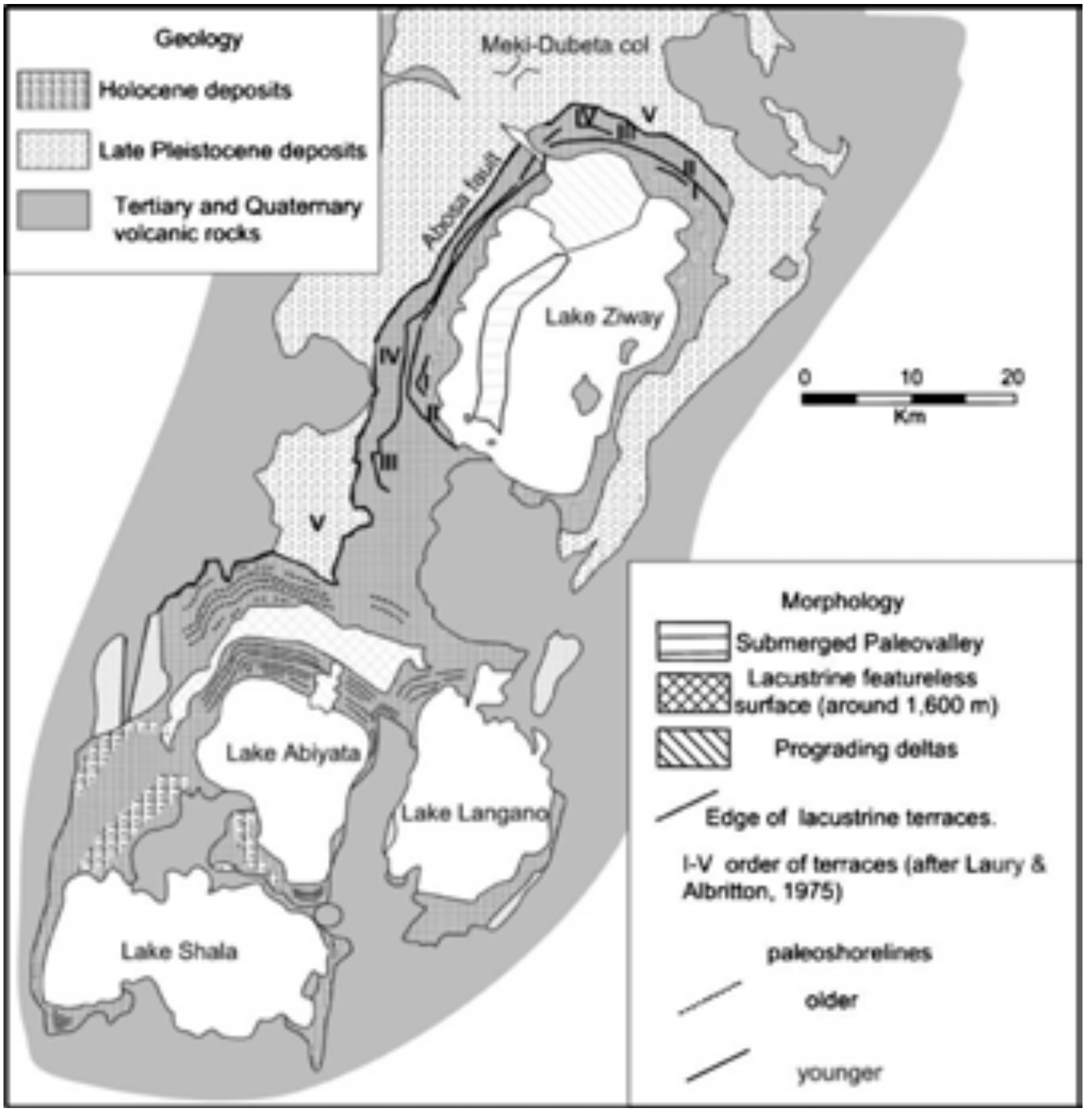


Figure 6: synthesis of the main geomorphological features related to Late Quaternary lake fluctuations (after Benvenuti *et al*., 2002:251).

Morphological evidence of lake-level lowering and complete desiccation was recorded in the Ziway-Shala basin. This desiccation is represented by N-S trending depression, 2 km wide and 15 km long, about 2 m deeper than the average lake Ziway bottom, interpreted as a submerged paleovalley (Benvenuti *et al*., 2002).

2.1.1.2. Climate and Vegetation of the Ziway-Shala Basin

The Ziway-Shala basin modern climatic data has shown a considerable climatic variation within a short distant difference. Mainly, it is marked by alternating wet and dry seasons following the annual movement of the Intertropical Convergence Zone (ITCZ) which separates the air streams of the northeast and southeast monsoons. In the region, the average annual rainfall ranges from 600 mm at the vicinity of lake Ziway to 1200 mm in the high margins (3000 m contour) of the MER. The rainy season (*Kiremt*) of the study area is in the summer (from June to September), and get about 50-70 % mean annual total rainfall (Degefu, 1987). From October to February, hot and dry weather (*Bega*) is predominant. This is the season when the ITCZ lies in the southern Ethiopia. At the Ziway area for Example, the average monthly minimum temperature ranges from 9 °C in December to 6 °C in July. On the other hand, the average maximum temperature ranges only from 25 °C in February and July to 29 °C in May (Wendorf and Schild, 1974: 110). In general, in the Ziway-Shala basin, the mean annual temperature is less than 15 ºC in the highlands and more than 20 ºC in the lowlands. Evaporation ranges from more than 2500 mm on the rift floor to less than 1000 mm in the highlands (Le Turdu *et al*., 1999: 138).

The modern vegetation cover of the Ziway-Shala Basin ranges from open woodland to bushed grassland on the rift floor. Bushed grasslands is identified on the rift shoulders, and then remnants of dry, montane forest and, from 3200 to 3500 m, ericaceous scrub and Afroalpine moorland (Le Turdu *et al* 1999: 138).

2.2. Archaeological and Historical Background Bulbula

The MER, as part of the East African Rift System, contains important paeoanthropological sites where important fossils and cultural remains of hominids have been uncovered. It comprises well know paleoanthroplogical and archaeological sites such as Konso-Gardula, Gademotta, Gedeb, Melka Kunture and Kesem-Kebena (WoldeGabriel *et al*., 2000).

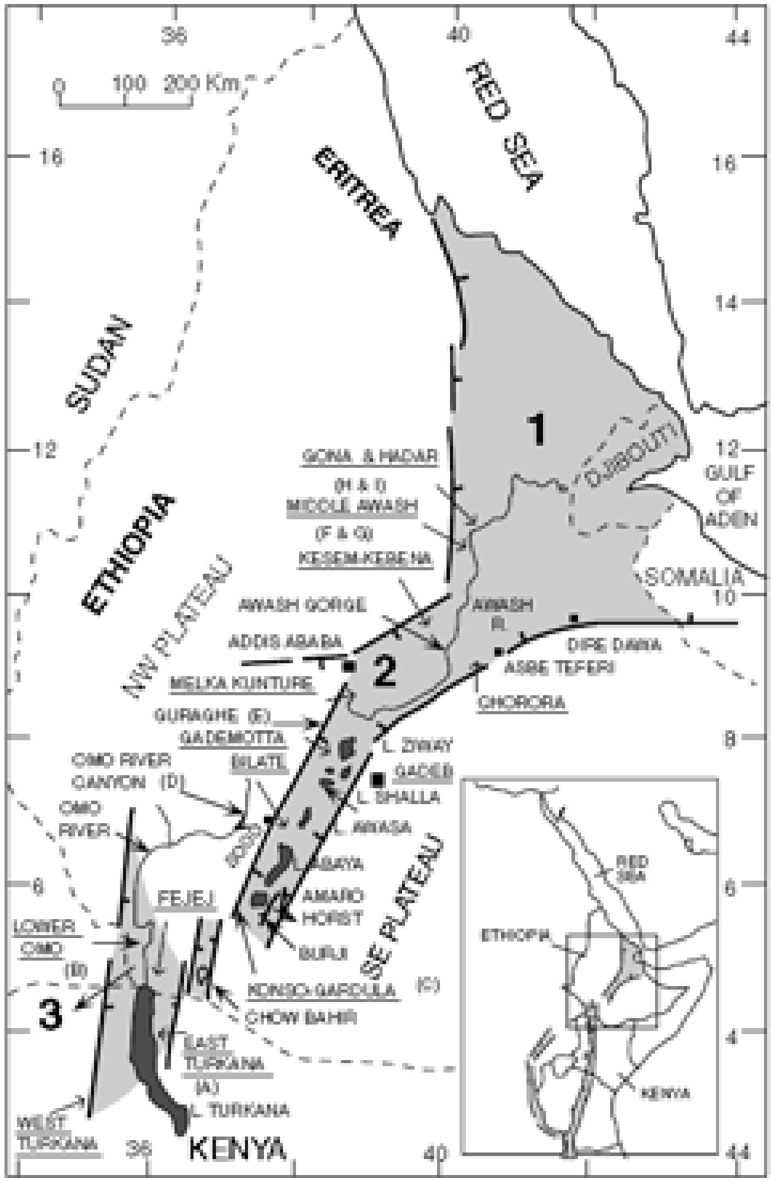


Figure 7: Main paleoanthopological sites and geographic features in the northern part of the East African Rift System. (after WoldeGabriel *et al.,* 2000: 84).

The study area, the Ziway-Shala Basin, is part of the MER and the existence LSA occurrences/sites in the region was identified for the first time by researchers conducting a Pleistocene/Holocene environmental study in the northern Afar Rift and Central Rift Valley

Lakes in the 1970s. During the survey, an exposed section near the Bulbula River was revealed that an occupation horizon embedded within a paleosol dated on charcoal to ca. 27,057 ±1,540 BP (Gasse and Street, 1978; Gasse *et al*., 1980) in which this radiometric data has been considered as the earliest known LSA record in Ethiopia. In addition to the occupation horizons, it was also reported that the site has been littered with obsidian blade industry including non-geometric microliths, scrapers and blades as well as faunal remains which were collected on the surface (Brandt, 1986). Despite its archaeological potential of LSA sequence, no one has conducted a research on the area until the Late Stone Sequence in Ethiopia project took the initiative and started its survey in 2007. This primary survey encompasses different environmental and topographic features including hill tops and paleoshorelines. Among the surveyed areas, the Bulbula river valley attracted the attention of the survey team. This river cuts the sedimentary deposits of the Upper Pleistocene and Holocene formation sediments in which finally the surveyed team recognized two archaeological localities: Bulbula 1 (B1S1,B1S3 and B1s4) and Deka Wede (DW1, DW2S1 and DW2S2) (figure 2) (Ménard *et al.,* 2014).

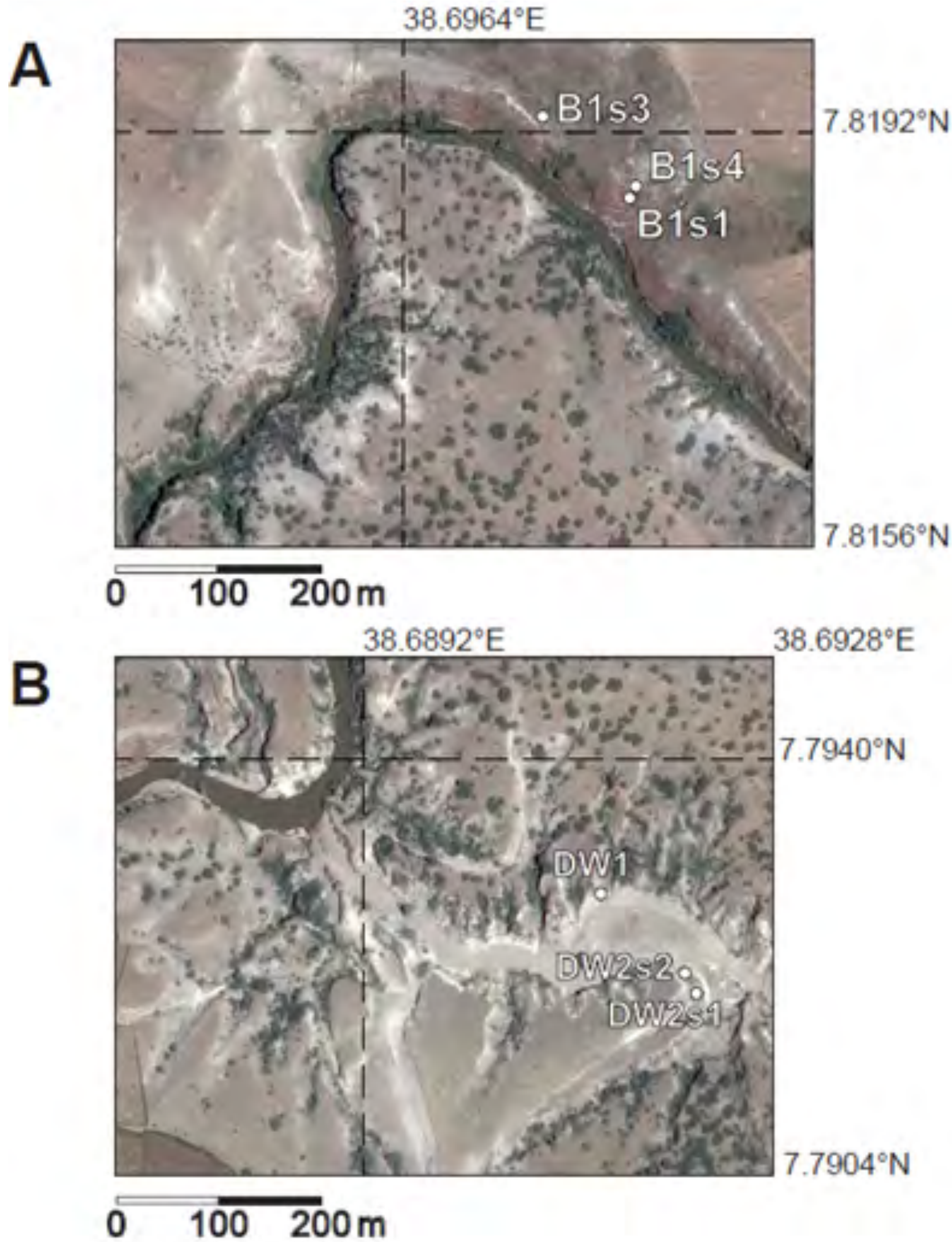
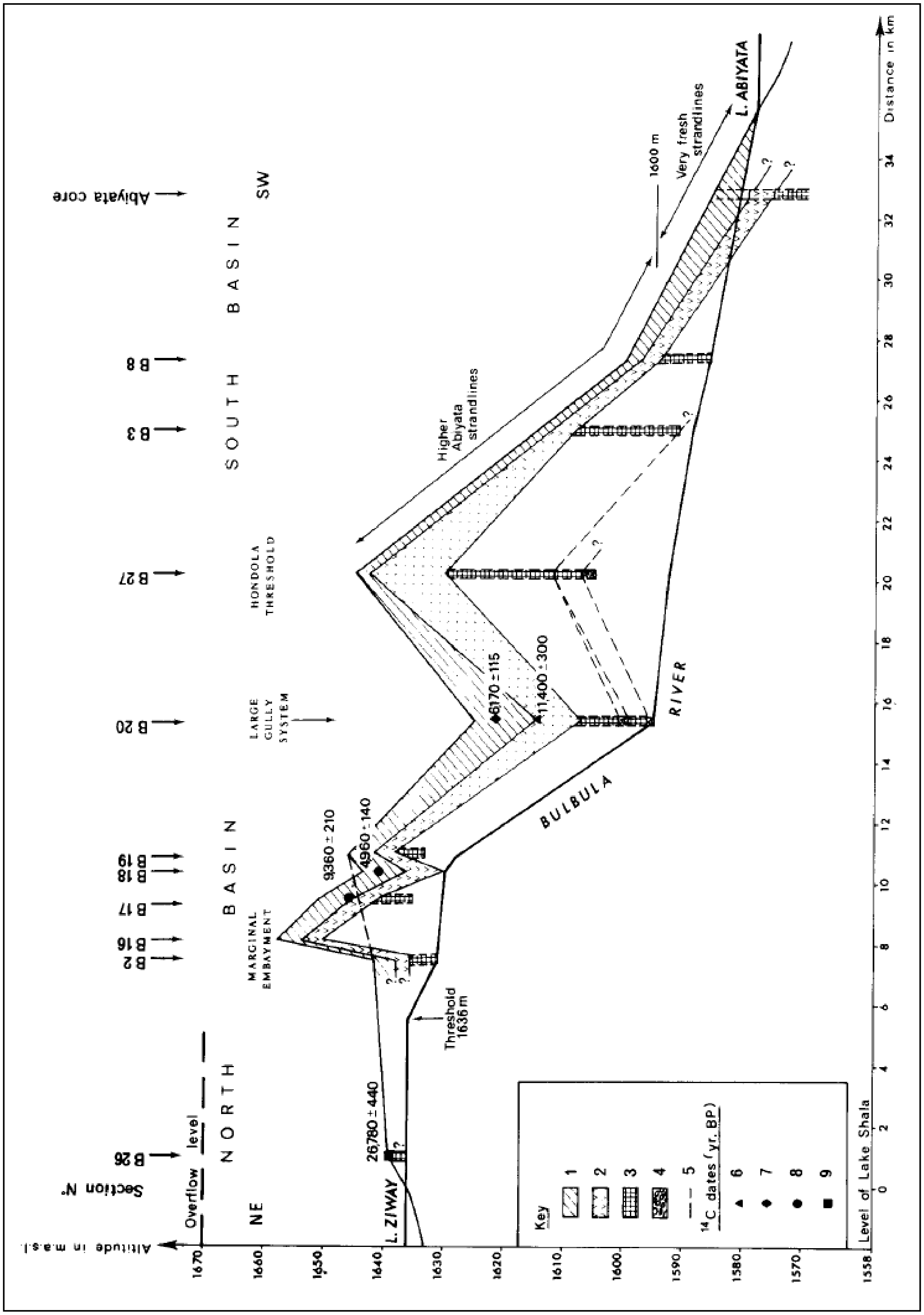


Figure 8: detailed views of the main areas investigated by the LSA Sequence in Ethiopia project (A. Bulbula, B. Deka Wede), images taken from Google Earth (after Ménard *et al.*, 2014: 58).

2.3. Stratigraphy of the Bulbula River

The sedimentary exposures bordering the Bulbula River provided evidence of two pre-Holocene highstands of the lakes in the Ziway-Shala basin, provisionally named as Bulbula I and Bulbula II. The Cultural stratigraphic record of the Ziway-Shala Lake basin had been dated to Late Pleistocene and Holocene based on the sample taken on a reference section designates as 0738-B20. For this stratgiraphic investigation, the most informative section comes from the quite steeply sloping inner walls of the Shala lake and along the Bulbula River (Gasse and Street, 1978; Grove *et al*., 1975). In Bulbula, the Late Pleistocene and Holocene section is well identified and exposed about 400 m east of Bulbula River in a large gully descending from Mt. Alutu. Two Pre-Holocene highstands of the lakes, provisionally names Bulbula I and Bulbula II, were identified from sedimentary exposures bordering the Bulbula River (Gasse and Street, 1978).

Bulbula I sedimentary deposit was recorded in limited areas and they were found overlying on a fluvial cobble-gravel containing large blocks of tuff and obsidian derived from Mt. Alutu. In Bulbula I, lacustrine sequence begins with thin silt in which a diatomaceous clast provides the only clue to the presence even older lake beds in the area. The basalt silt was overlain by ripple-marked sand containing floated pumice pebbles and very planorbid shells. The upper most and the latest sedimentary deposit are made compact sandy silt which had a thickness from 2.4-4.35 m. This upper most layer of Bulbula I lake bed was unconformobly overlain by fluvial sand pebble-gravel. The upper 20 cm of this sedimentary deposit was made up of a very weakly developed paleosol which preserves abundant worked obsidian artifacts, which probably appeared to be the age of LSA, weathered bone refuses and charcoal. The Charcoal sample has been dated at 27,050 ± 1540 BP (SUA-588) (Gasse and Street, 1978).



Section N°
B 26
B 2
B 16
B 17
B 18
B 19
B 20
B 27
B 3
B 8
Abiyata core
NE
NORTH
BASIN
SOUTH BASIN
SW
Overflow level
MARGINAL EMBAYMENT
LARGE GULLY SYSTEM
HONDOLA THRESHOLD
L. ZIWAY
26,780 ± 440
Threshold 1636 m
9360 ± 210
4960 ± 140
6170 ± 115
11,400 ± 300
BULBULA RIVER
Higher Abiyata strandlines
1600 m
Very fresh strandlines
L. ABIYATA
Altitude in m.a.s.l.
Distance in km
Level of Lake Shala
Key
^{14}C dates (yr. BP)

Figure 9: schematic cross-section along Bulbula River (Ziway-Shala Basin) showing major stratigraphic units. Key: 1) Holocene Lake deposits and surficial colluviums; 2) uppermost Pleistocene pumice deposits; 3) upper Pleistocene lake deposits; 4) upper Pleistocene fluvial gravels; 5) hypothetical correlation; 6-9) ^{14}C dates; 6) non-lacustrine sediments (F.A street, new date); 7-9) lacustrine sediments; 7) F.A street, new date; 8) Geze (1975), approximate location; 9) Laury and Albritton (1975), approximate location. All section numbers are preceded area code 0738 (after Gasse and Street, 1978: 289).

Bulbula II lake beds began with lacustrine mud formation (marl) which was directly resting on the soil. Over the thin marl, ripple-marked or plane-bedded fine sand and silt formed the deposit. This formation is overlain by compact marl which is laminated from 1.5 to 2.0 m and undoubtedly records the lacustral maximum. The upper surface of the marl part were getting smaller slightly before the deposition of the overlying pebbly sands containing occasional *corbicula* shell, which marks a return to shallower conditions. The top part of this pebbly sand sequence is overlying by thin silt bed represent by a brief episode of non-lacustrine pumice laid down during the succeeding arid phase. Finally, the upper most deposits of Bulbula II lake beds are overlain by 7.45 m non-lacustrine pumices which were formed during the succeeding arid phases (Gasse and Street, 1978).

To know the numerical age of the Bulbula I and II deposits Late Pleistocene, an absolute dating system (^{14}C) was employed. The charcoal sample (SUA-494) was taken from a paleosol at the top of the pumice bed and dated to 11,870 ±300 bp (Gasse and Street, 1978). The highest lake deposit was associated with Bulbula II phase at a smaller tributary gully of Bulbula River (0738-B17). The relicts of outcrop measures about 1,641 m. They consist of pumice beach gravel interbedded with waterlaid ash, and overlain by Alutu pumice and then Holocene lake beds.

Shells from the base of the Holocene sediments were dated at 9,360 ± 210 BP on the samples which were taken from the nearby sites (Gasse and Street, 1978).

The Holocene deposits are marked by depositional evidences formed by transgression and regression of the lakes. The presence of initial lake transgression is represented by the thin marl identified in the site. The transgression did not continue and it was replaced by a brief regression that brought in renewal deposition of pumice gravel containing occasional implements. During early Holocene, the level of the lake was increased and deposited the second marl with occasional shells. The sedimentary deposit of second marl about 14.45-15.55 m thick. The Marl bed was overlain by thin gravelly sand. The sedimentary deposits of this layer was over lain by another deposit which manifested by a thick bed of pumice lapilli representing a single eruption. Then, after a brief return of a lake, a more important regression is recorded by further airfall and fluvially reworked pumice beds. After this a second major regression took place and it left deposits consists mainly of interbedded pumice gravel and waterlaid ash with rich shell horizons. Thin beds of calcareous silt occurred at the top and bottom. The depositional sequence at this level dated to 6,110 ± 115 m. Finally, the upper most and the latest part of the Holocene deposit is covered by gradually colluviums bearing modern soil (Gasse and Street, 1978). New and details stratigraphic framework for the Late Quaternary deposits is presented by another researchers (eg. Benvenuti *et al*., 2002).

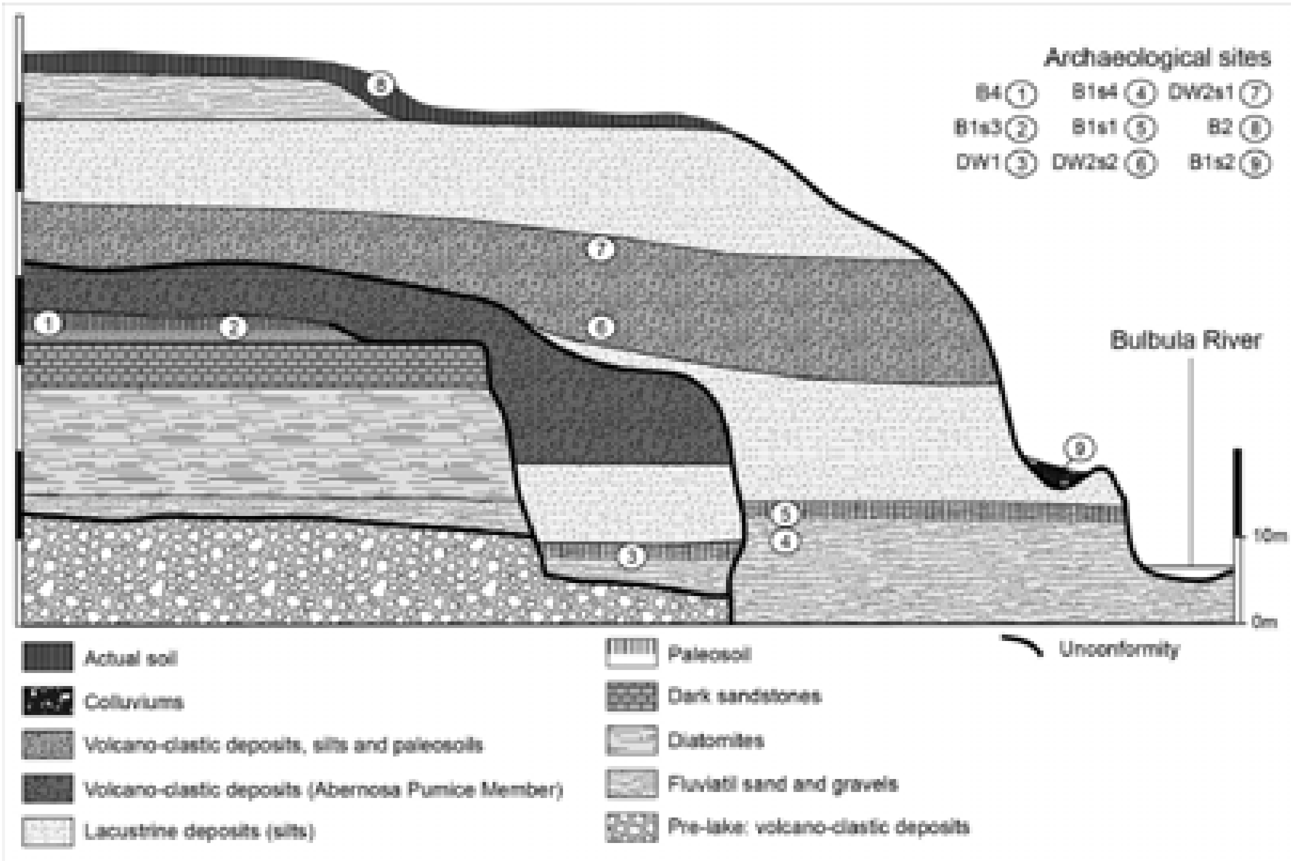


Figure 10: Geological log of the sedimentary formations identified in the Bulbula plain. Archaeological site locations are illustrated for information only (the actual context and location of B1s4 and B1s1 cannot be rendered here) (After Bon *et al*., 2013).

B1s4 was first discovered in 2008 and two test trenches (T1 and T2) were opened in 2009 on the site which is located on modern Bulbula canyon. Excavation at T2 was soon terminated, but continued on T1 in 2010 by setting up a square meter grid system (squares A, B, C and D) (figure 12). From these grids, only C and D were excavated on their whole surface. A and B B1s4 sedimentary record can be divided into 5 lithostratigraphic units that measures 1.10 meter thick sedimentary deposits of colluviums, silts and pumice (figure 12). Of these, two occupation levels (paleosols PS1and PS2) were identified, which they are separated each other by 30 cm hiatus thick intermediary silt. PS1 and PS2 contain abundant materials made of obsidian and faunal remains. In addition to the two paleosols and the intermediary silt, two sterile horizons were exposed as the older (bottom layer) and younger (top layer) stratigraphic units (Bon *et al.*, 2013).

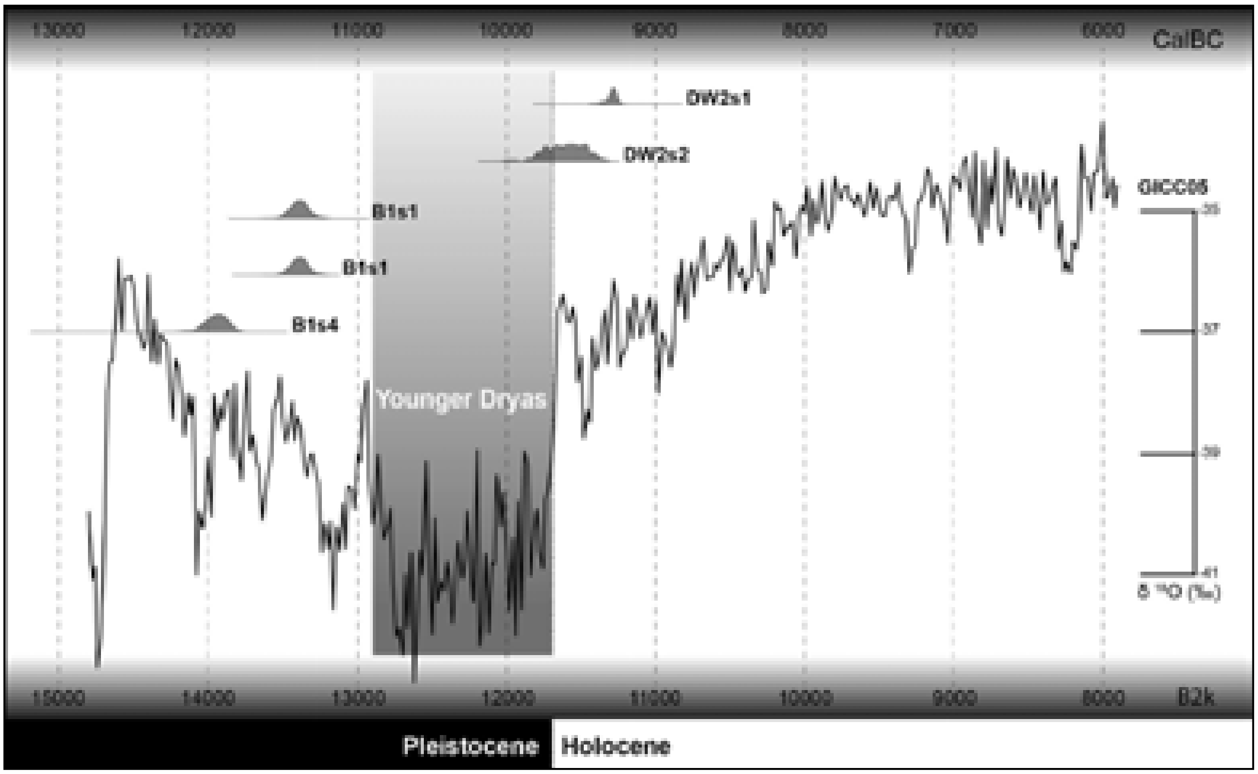


Figure 11: Radiocarbon dates of archaeological sites from the end of the Pleistocene and the beginning of the Holocene and for comparative purposes, the GICC05 curve. (after Bon *et al.*, 2013).

Table 1: radiocarbon dates of archaeological sites in Bulbula and sites outside the Ziway-Shala Basin. Dates for comparative purpose taken from other researcher publication (after Menard, 2014).

Site	Unit	Laboratory reference	Material	Method	13C/12C	Measured (BP)	Conventional (BP)	Cal BP (2 σ)	References and comments
DW2s1	PS3	Beta-320183	Charcoal	AMS	−26.8‰	9860 ± 50	9830 ± 50	11,335–11,175	This study
DW2s2	PS4	Beta-295898	Organic sediment	AMS	−18.7‰	9940 ± 50	10040 ± 50	11,800–11,311	This study
B1s1	Unit XIV (Unit XII)	Beta-292524	Charcoal	AMS	−25.8‰	11,490 ± 50	11,480 ± 50	13,443–13,214	This study
B1s1	Unit VIII	Ly-6059 (SacA-15621)	Charcoal	AMS	–	–	11,480 ± 60	13,455–13,193	This study
B1s4	Lower PS	Beta-332588	Charcoal	AMS	−24.7‰	12,040 ± 50	12,040 ± 50	14,045–13,755	This study
DW1	PS5	Beta-292527	Charcoal	AMS	−23.1‰	29,090 ± 160	29,120 ± 160	33,726–32,907	This study
Deka Wede (B20)	Member 1	SUA-588	Lacustrine shell	Conventional	–	–	27,050 ± 1540	35,160–28,335	Street, 1979; coeval to PS5
Deka Wede (B20)	Member 2	Gif-3988	Lacustrine marl	Conventional	–	–	24,000 ± 750	30,052–26,841	Street, 1979; between PS5 and APM
Deka Wede (B20)	Member 2	Gif-3987	Lacustrine silt	Conventional	–	–	22,050 ± 650	27,670–25,162	Street, 1979; between PS5 and APM
Deka Wede (B20)	Member 3	SUA-494	Charcoal	Conventional	–	–	11,870 ± 300	14,809–13,106	Street, 1979; coeval to DW2s2 paleosols
Deka Wede (B20)	Member 3	Gif-3986	Organic sediment	Conventional	–	–	10,450 ± 180	12,720–11,715	Street, 1979; coeval to DW2s2 paleosols
Macho Hill	Red soil	SMU-86	Charcoal	Conventional	–	–	10,330 ± 90	12,525–11,814	Haynes and Haas, 1974; Humphreys, 1978
Waso Hill	Red soil	SMU-72	Charcoal	Conventional	–	–	11,510 ± 110	13,556–13,133	Haynes and Haas, 1974; Humphreys, 1978
Lake Besaka - FeJx4	Lower horizon	UW-495	Ostrich eggshell	Conventional	–	21,730 ± 305	22,080 ± 305	27,111–25,821	Brandt, 1982
Lake Besaka - FeJx4	Lower horizon	UW-491	Ostrich eggshell	Conventional	–	18,915 ± 215	19,280 ± 215	23,780–22,675	Brandt, 1982
Lake Besaka - FeJx4	Lower horizon	UW-493	Ostrich eggshell	Conventional	–	19,100 ± 205	19,460 ± 205	23,956–22,934	Brandt, 1982
Lake Besaka - FeJx4	Lower horizon	UW-492	Ostrich eggshell	Conventional	–	18,155 ± 225	18,500 ± 225	22,888–21,850	Brandt, 1982

The lowest and the oldest stratigraphic units were made up of brown colluviums deposit that does not preserve any cultural materials and faunal remains. This lowest level was overlain by a paleosol (PS1), containing the oldest human occupation horizon which is dated by a single radiocarbon date to 12,040±50 (14,045-13,755 Cal BP). The large proportion of lithic materials from the total assemblage was derived from PS1 which yielded the majority of lithic artifacts and some faunal remains. PS1 is overlain by sterile 30 cm thick intermediary silt which separates PS1 from PS2.

Figure 12: view of B1s4 at the end of excavation in 2010. In black stratigraphic units; in blue grid units and in what location of the 2009 trench (courtesy of F. Bon and C. Ménard)

The PS2 stratigraphic unit is interbedded by the pumice formation and intermediary silts at the top and the bottom respectively. This unit measure 15 cm thick and have yielded few number of lithic assemblages and faunal remains. This unit has not yet been dated but probably it is the upper most of the Terminal Pleistocene phase. PS2 is overlain by 50cm thick pumice deposit and thick silt formation of the early Holocene lake deposits (Ménard *et al.*, 2014).

Correlation of the cultural horizons of B1s4 with other sites in the Ziway-Shala basin and other Late Pleistocene sites containing lithic assemblages is still problematic because yet it lacks complete and detail record of sedimentary deposits Late Pleistocene sites in the country. All the identified radiocarbon dates in the Ziway-Shala basin did not closely correlate with B1s4 human occupation horizon dated to 12,040±50 (14,045-13,755 Cal BP). The human occupation horizons in the Ziway-Shala basin and the rest parts of Ethiopia are either older or immediately younger than B1s4. The nearby B1S1 site (Habte, 2013) has a calibrated date on the two occupation horizons that ranges between 13,467 and 13,196 cal BP (Bon *et al*., 2013), which is younger than B1s4 dated 14,054-13,755 cal BP. This period was part of the terminal Pleistocene, which appeared shortly before the Younger Dryas abrupt climatic condition and some places in Ethiopia, such as Lake Besaka was marked by cool and extensive arid condition. Evidence of human occupation were hardly recognized except identifying few pieces LSA assemblage which were uncovered from weakly developed paleosol at Lake Besaka (Clark and Williams, 1978; Brandt, 1982).

2.4.Cultural and Chronological Sequence of LSA Industries in Eastern Africa

The Stone Age archaeological record in Africa covers the entire Pleistocene and the latest Pliocene (dated c. 2.6 million years ago) (Semaw *et al*. 1997). This prehistoric cultural sequence in Africa, South of the Sahara, is divided in three phases: the Early Stone Age (hereafter is called ESA) (including Oldowan and Acheulian), Middle Stone Age (here after is called MSA) and Late Stone Age (LSA) (Willoughby, 2009: 303). These schemes were first used by Goodwin and Van Riet Lowe (1929) on the basis of archaeological materials discovered in South Africa. These periods can be distinguished from each other on the basis of changes in stone tools technology.

The Early Stone Age begins with the first appearance of stone artifacts such as Oldowan. The Oldowan, which is dated between 2.6-1.5 Ma, uncovered in the archaeological sites in eastern, northern and southern part of Africa. The lithic artifacts dated from these period are cores, whole and broken flakes, core angular fragments, a small number of retouched pieces and in some instance unmodified stones transported to site. But c.1.5 Ma, the Oldowan lithic industry, which lasted over 1 million years, was replaced by an advanced stone working tradition in Africa which is called Acheulian (Semaw, 1997; 2000:1198). The Acheulian, on the other hand, is different in its types from Oldowan and manifested by bifacial tools of variable size and shape manufactured on flakes. Morphologically, the Acheulian is classified into handaxes, cleavers, picks and other types.

Around 200,000 years ago, the Acheulian lithic industry disappeared and new flake tools struck from radial, discodial, or Levallois cores continue as MSA until the beginning of LSA. MSA Assemblage is characterized by the appearance flaked lithic industries including points, scrapers and other thin flakes tools (Clark, 1988: 236; Goodwin, 1928; 1929; Willoughby, 2009:303, Bar-Yosef and Kuhn, 1999) which comes to an end in Africa between 30,000 and 40,000 years ago (Clark, 1988:236). In some places in East Africa the MSA component includes the Heavy Duty core-ax or pick, the production of blades and some LSA components like borers of various kinds, burins and backed forms (Clark, 1988:236).

The temporal transition from MSA to LSA in East Africa was not well dated so far (Clark, 1988: 236), but recent research which has been conducted in Ethiopia in the Ziway-Shala basin(Ménard et al., 2014) and Goda Buticha in southeastern Ethiopia basin have produced important data to inderstand the temporal transition from LSA to MSA. This transition in East Africa especially remains equivocal because the transition appears to be at or beyond the limits of radiocarbon dating, around 40-45,000 years BP. On the other hand, other dating methods did not provide reliable and exact dating results. This transition period in Sub-Saharan Africa is equivalent to the Middle/ Upper Paleolithic (MP/UP) transition in northern Africa and western Eurasia (Clark, 1988:236; Ambrose, 1998:377; Klein, 1992) despite it is a bit outdated idea to consider MSA/LSA as equivalent to MP/UP and research on the later transition during the last decades made big progress which indicate complex processes in a short period of time compared to what we know of the MSA/LSA (Ménard , Per. Communication, 2015).

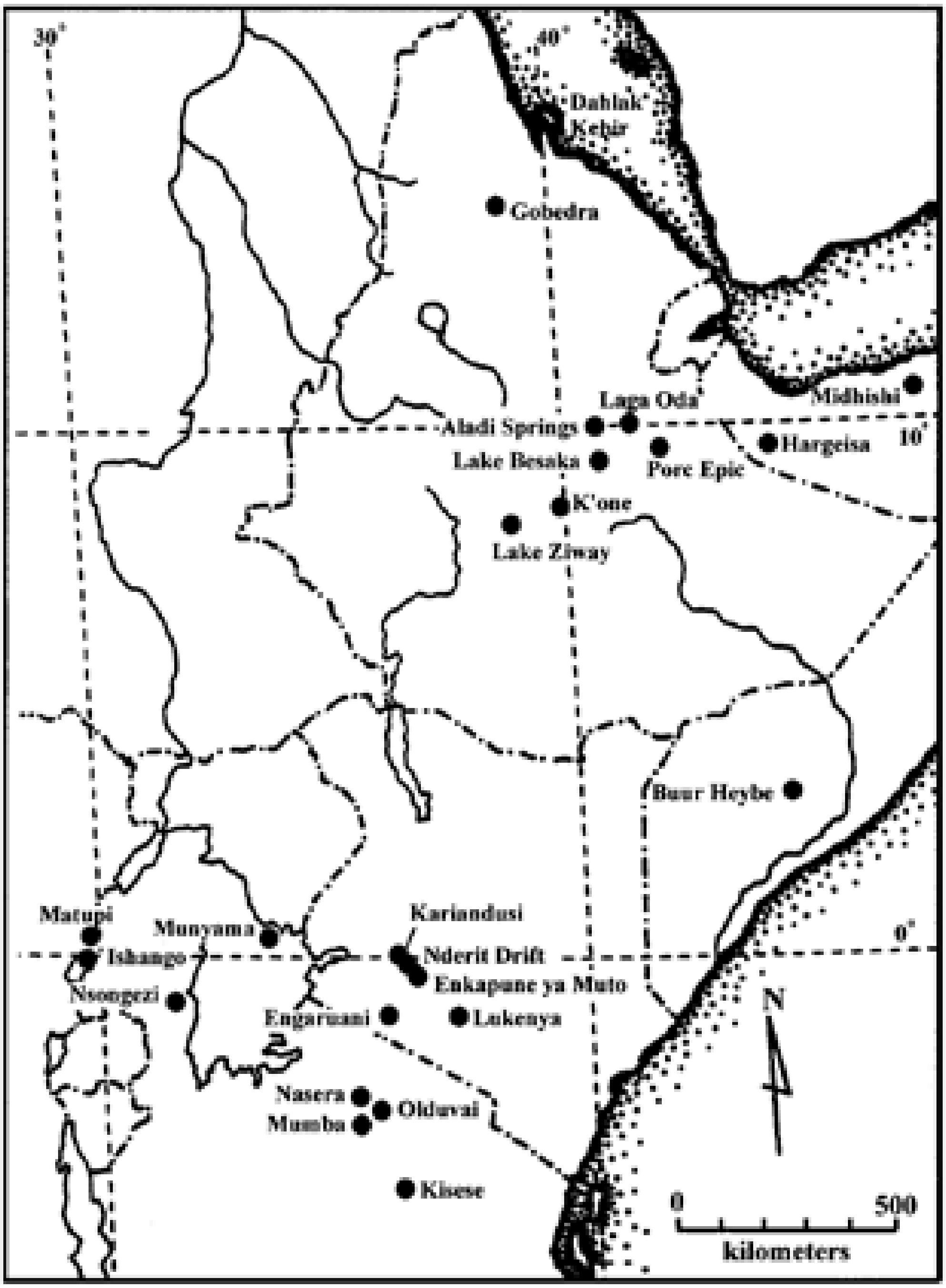


Figure 13: Location major LSA sites in Eastern Africa. Not all the sites are discussed on this thesis (after Kusimba, 2001:79).

According to Clark (1988), the transition to LSA occurred at much the same time as in other part of continent dated between 30,000 and 40, 000 years ago. However, according to

Mabulla (1996), LSA associated technological culture was dated sometime between 50 ka and 20 ka and evidence of the earliest date of transition in east Africa came from Kenya at Enkapune Yamuto rock shelter. Radio carbon and obsidian hydration dates indicate that the transition from MSA to LSA may have occurred by 50,000 BP. In Enkapune Yamuto, the younger Early LSA was found in association with ostrich eggshell head manufacture, which dated to 39,000 BP (Ambrose, 1998, 377). The other early transition evidence came from one of the late MSA site, Midhishi 2 in Northern Somalia, dated ≥ 42,000 BP (Brandt and Brook, 1984). In southern Africa, however, MSA has persisted to appear during "typical" LSA times, ending about 20 ka BP (Mabulla, 1996:21).

In the Horn of Africa, the transition between the MSA and LSA provided the Somaliland variant of the Magosian and intrusive blade and burin industries of the Hargesian. The Magosian mainly identified in southern Somalia, the Ogaden, and the Afar Rift, and the Hargeisan was found in northwestern Somalia (Clark, 1954). According to Clark (1954), this transition period is characterized by maintaining both MSA and LSA elements which comprising 'Stillbay' MSA features such as points, levallois cores and flakes as well as LSA forms including microliths, blade tools and blade cores. LSA features in Somalia include two industries which developed from the end of the Upper Pleistocene onwards, the Doian and the Somaliland Wilton (Clark 1954; Brandt, 1986:44, 59). In Ethiopia, however, the transition from MSA to LSA is not established based on the sites previously studied. Due to this, the tempo and mode of cultural change from MSA and LSA remains poorly known. But, at least there is one LSA earliest site dated radiometrically in Ethiopia at Ziway, where an exposed section near the Bulbula River revealed an occupation horizon embedded within a paleosol dated on charcoal to ca. 27,050 ± 1,540 BP (SUA-588) (Gasse and Street, 1978; Gasse *et al.*, 1980). At this site, lithic assemblages such as non-microliths, scrapers, and blades made from obsidian were discovered on the surface (Brandt, 1986: 62-63). In addition to this, the excavation at Lake Besaka had yielded artifacts of blade technology dated to 22,675 ± 500 BP. At Laga Oda, the microlithic industry, using mostly chert, was dated to 15,000 years ago

The Term LSA is originally was used to describe prehistoric flaked stone industries uncovered in the Stone Age sequence of South Africa in which these materials has shown a close resemblance to the material culture of the last stone tool using people in the Southern Africa. It was later the terminology of LSA has been used for all of the Sub Saharan Countries to define the cultural sequence of the period (Goodwin and Lower, 1929). According to Clark (1969), Chronologically LSA is marked by Later Pleistocene and Holocene industries (be "Mode 4" and/or "Mode 5"). LSA industries are commonly dominated by backed microlithic tools and blade-core technology (Brandt, 1982:8) and marked by the existence of blades- and small flake based industries, burin (gravers), bladelets and end scrapers (Ambrose, 1998; 2002; Kusimba 2005; Klein, 1992) which were technologically made from on cores which has a plain platforms (Ambrose 1998:377) and that are much easier to replace a mutual exclusive (Klein, 1992). In fact, blades and backed tools were discovered in Euroasia sites which were occupied by behaviorally archaic humans. But in Africa, blades and backing tools were often considered important features of the technology of behaviorally "modern" human during MSA period (McBreaty and Brooks, 2000) despite the shift to modern human behavior appeared during LSA in Africa (Ambrose, 1998).

LSA industry is known for its high degree of standardization and internally more morphologically variable tools forms which were used in a wider range of specialized and distinct activities. The other characteristic associated with LSA is that tools which were not used in MSA/MP including bone, antler, or ivory began to appear and become part of formal artifact types. These tools could be whittled, carved, or polished into a variety of useful artifact types which are a constant feature of LSA (Klein, 1992; Bar-Yosef, 2002:366). These shifts are interpreted as reflecting changes in style (i.e., transmitting cultural information) and rarely are related to functional needs (Bar-Yosef, 2002: 366).

LSA cultural sequence was also known yielding as personal adornments in a form of perforated ornaments including beads and pendants which were made of marine shells, teeth, ostrich eggshell (e.g. in Kenya at EYM rock shelter) and ivory (Klein, 1992, Bar-Yosef, 2002: 367; Ambrose 1998: 377). These are considered the self-awareness and identity of the individual as well as social groups (Bar-Yosef, 2002:367). The use of these objects of personal adornment also provides additional information about the exchange pattern and relationships among individuals and bands, and among the neighboring groups (Ambrose 1998:377). Klein (1992) has suggested that unlike the MP, LSA/UP art and personal adornment became one characteristics feature of UP sites. LSA/UP is marked by rapid differentiation into wide range regional and temporal variants. It is widely recognized by lithic assemblages that show temporal and spatial heterogeneity (Klein, 1992).

The LSA is known more in the shift in diet compared to earlier MSA. More diverse diets were included in the faunal assemblage of LSA hunter-gathers (Bar-Yosef, 2002; Steele and Klein, 2009). The most significant document shift is the appearance of small, quick, difficult to catch game, such as fish, birds, hares and small carnivores faunal remains in southern Africa costal sites, but absent from comparably located sites during MSA. In addition big and dangerous terrestrial games such as buffalos and wild pig were also included in the diet of LSA people in southern Africa (Bar-Yosef, 2002; Steele and Klein, 2009). This new diets may be the result of the innovation new technology that made it possible to more efficient to capture these resources (Steele and Klein, 2009). Evidence of these new tools forms in a form of microlithic tool forms began to appear LSA sites that dated after 20,000 BP. These tools were probably mounted or inserted in bone or wooden handles or staff. The ethnographic research data show that microlithic pieces associated with bone LSA assemblages were probably parts of the composite arrow, while other bone and stone artifacts were probably used for fishing.

2.5.Adaptation and subsistence Strategies of Late Stone Age Hunter-Gatherers

According to Mabulla (1996, pp. 37-38),

> "Adaptation is a useful concept that can be used to investigate variabilities in human behaviors, culture, and biological design in time and space. It is the means by which human-environment relationships develop. Therefore, adaptation can be used to account for changes in the human behavior and culture. …archaeologists and anthropologists of cultural economy and ecosystem persuasions view adaptation as a process whereby humans actively and intentionally direct change in their strategies and tactics of survival. Taking this perspective, Bennett (1984, p. 246) defines adaptation as a "set of psychological process which are probably universal or nearly so, and situations". To Bennet, adaptation is the product of the interaction between particular historical processes and human institutions. According to Hardesty (1986), cultural adaptation occurs because of changes in technology, organization, ideology, in short all aspects of culture. To Denevan (1983, p. 401), adaptation is "the process of change in response to changes in physical environment or a change in internal stimuli, such as demography, economics and social organization."

All these definitions and explanation about adaption have shown that adaptation is a broad concept, and for my thesis I have to governed by my research questions and objectives and I want to limit adaption to issues that related to direct change in their strategies and tactics of survival like economic subsistence, mobility and settlement patterns.

The subsistence pattern of hominids was not the same throughout the history of human evolution. It has a temporal and spatial variations resulted from changing environmental condition and changes in technology combined with changing social and settlement strategies

(Conard, 2007). In East Africa there is no enough data used to reconstruct the subsistence behavior of MSA and LSA population which is partially because of lack of previous research in the region. But, southern Africa is particularly rich in evidence bearing on the subsistence of Middle and Late Stone Age people (Klein, 1983). The available limited faunal assemblages, particularly in southern part of Africa, has proved that there was a dietary changes between MSA and LSA and even in later this change had brought a major change on human behavior that led to the expansion of modern humans out of Africa (Steele and Klein, 2009).

Numerous faunal remains, including large ungulate mammals of Buffalo and elands, were recorded in the caves which once had been inhabited by MSA and LSA people in Sothern Africa at Klasies River Mouth Cave 1 and Nelson Bay cave respectively (Klein, 1983). LSA people were also known by intensive use of the existing and new diets in their subsistence which were not often used or part of MSA population. In southern Africa LSA diet was known by increased exploitation dangerous games, such as buffalo and wild pigs; increased exploitation of marine mollusks, tortoises, and airborne birds; as well as the addition of fish occupied under comparable climate and environmental condition during the present interglacial (Steele and Klein, 2009; Klein, 1983). According to Klein (1983: 43), the evidence of the exploitation of new species including fish and fowl by LSA people has been supported by the discovery of fishing and fowling gear on LSA sites. These artifacts include grooved stones that were probably used as line or net sinkers, as well as bone "gorges" that were probably baited to catch either fish or flying sea birds (Klein, 1983).

In the Horn of Africa, there is no substantial data that provides evidences for the subsistence strategies of late upper Pleistocene hunter-gatherers. Our knowledge of subsistence and dietary practice of LSA hunter-gathers for this period has been relayed on very small faunal remains from the Lake Besaka site of FeJx4, dated to ca. 22,000 years. At Besaka, later Pleistocene and terminal Pleistocene stratigraphic sequence had provided hundreds of highly fragmentary animal bone and dental remains, 885.5 gm of ostrich eggshell fragments and small sample of fish bones which probably all these animal species were the subsistence and dietary preference of LSA hunter-gatherers. Bovids and hippopotamus cheek tooth fragments dominated the whole faunal assemblage in most unites. Bush pig dental fragment and/or warthog as well as rodent incisors and jaw fragments were also identified. Other faunal remains included post-cranial remains of a few reptile, rodent incisors and jaw fragments. Fish remains dated as old as 22,000 BP were also uncovered in a form of cranial and post-cranial element (Brandt, 1982).

2.6.LSA Raw Material Exploitation and Socio-Territorial Organization Pattern

The distribution and availability of lithic raw materials play an important role to understand how humans manufactured, used and reconfigured stone tools. It provides information for us about prehistoric people exploitation of their environment. The sources of raw material have the capacity to provide robust information about circulation of stone across the landscape. Therefore, locating the sources of raw material and investigation the procurement strategies are important tools for prehistorians who want to seek information on human land use and mobility pattern, and relating these to lithic technology. The availability of lithic raw materials is also a determinant factor in tool and core technological reduction strategies (Andrefsky, 2008).

This local raw material would be important to provide information about procurement strategy and raw material transport in to the site. As it was known, raw materials into the site were transported into different strategies. It could be transported into the site as a natural nodule, roughed out cores, tool blanks or finished tools. It is argued that raw material raw material procurement has direct or indirect influence on technological choice of the makers of stone tools of the prehistoric hunter-gathers (Andrefsky, 2009: 76).

In addition, exploitation of lithic raw materials, which needs an accurate knowledge to know the location of lithic sources actually exploited, provide information about the circulation of lithic artifacts across the landscape. Higher levels of behavioral inferences, such as home range, mobility pattern, and the evolution of regional interaction networks, reciprocal intergroup materials, information exchange and cooperation for risk reduction, are drawn from data on lithic site-to-source distance (Ambrose, 2006).

According to Bar-Yosef (2002:367), UP/LSA hunter-gathers had wider range of contact that covers hundreds kilometers through long distance exchange networks in lithic, raw materials, and marine shells. Their network and exchange system are different from MSA/MP people who were restricted to shorter ranges of raw material procurement. But this short raw material procurement pattern did not work for Howiesons Poort MSA hunter-gathers in South Africa because raw material was transported to the site from a long distance (Bar-Yosef, 2002). In East Africa, the dry grassland LSA hunter-gathers were highly mobile which crossed the landscape following herds of migratory ungulates. Because of this mobility, LSA hunter-gatherers in East Africa controlled large home ranges and had an access to with herds through either predictable moments or visual sighting from looking outs on high terrain. Their sites are characterized by ephemeral and seasonal occupation. However, the ethnographic study that conducted on modern desert hunter-gatherers provided different subsistence and mobility strategy. The ethnographic model proved that plant food has constituted the majority part in the dry and tropical environment in the Kalahari and Hadzabe of northern Tanzania hunter-gatherers.

Furthermore, it is not the location of the animals, but the location of water sources, that determines much of individual and group movements (Kusimba, 1999).

2.7.Characteristic Feature of Blades and Bladelets and their Production Techniques

B1s4 lithic assemblages from Bulbula are characterized predominately by blades and bladelet typology. So, it is worth noting to provide some notes about widely accepted criteria proposed by previous research works to distinguish blades from bladelets. According to Kauffman (1986), a number of attempts have been made by various researchers (e.g. Tixier 1963, Heinzelin, 1962 and Marks, 1968) to define blades and bladelets on the basis of metric attributes including length, width, length/width ratios or combination of these. On the basis of these attributes, the most widely accepted criteria is that bladelets are defined flakes as having length equal to or greater than twice their width (length/width ratio= 2:1) and also defined by maximum width of 12 mm, and maximum length of 50 mm. It includes also flakes longer than 50 mm, but its width yet not exceeds 12 mm. Additional definition for blades and bladelets is given by other authors and their metric attributes are different from Tixier (1963) (See details in Tixier, 1963 *cited* in Heinzelin 1962; Marks, 1968; Kauffman, 1986). On the other hand, blades are conventionally defined as flakes with length greater than twice their width and compare to bladelets, it is significantly greater despite differentiating blades from bladelets is inherently ambiguous and subjective (Kauffman, 1986; Ambrose, 2002).According to Inizan (1999), the production of these debitage pieces was a technical choice for the objective of either large debitage product (blades) or small ones (bladelets and micro-bladelets). So the availability of raw material does not have an influence for the choice of the debitage product (Inizan, 1999: 73). The failure to make clear classification between the two results from the overlapping nature of the blade and bladelet length as well as the quantifying definition of blades versus bladelets given by researchers (Kauffman, 1986; Ambrose, 2002). Therefore, all these definitions prove that still there is gap to establish a universal set of principles and boundary between blades and bladelets. A substantial difference has been seen in different regions depending on raw material size, mechanical properties, types of hafts, style, and other factors. Relatively, depending on quantitative description of length and width ratio is better despite problems arise relates to subjectivity (Ambrose, 2002: 9-10)

In Sub-Saharan Africa, microlithic industries are found in association with blades, but defining and identifying microlithic industries relaying on blades is misleading. Because in Sub-Saharan Africa several early microlithic industries were not blade/bladelet based and in others blades do not always form a distinct mode among the flakes (Ambrose, 2002: 9-10). In Africa this microlithic industries were fully developed by 20,000 years ago despite the microlithic industries went back to 80,000-90,000 years ago and found in a form of small blade industries (Clark, 1985:95). According to Clark (1985: 95), microliths are based on the manufacture of bladelets and flakelets in which the dimension of their length does not exceeds 50 mm and the great majorities are less than 30 mm long. Typologically, microliths industries were composed of variety of backed tools and small convex scrapers, together with a range of other artifact forms, some of which may be macrolithic in size. Such kind of tools are the characteristic feature of LSA industries in Africa south of the Sahara, despite not all LSA industries are yielded microlithic proportions (Clark, 1985:95)

LSA industries in Africa is also known by blade and blade segments which were often blunted (backed) by different techniques including steep retouch parallel to or truncating one or more ends of straight sharp edge were used during backing. Morphologically, backed microliths can be found either geometric or non-geometric forms. Crescents, triangles, trapezes, deep crescents, *petites tranchéts* (deep trapezes) and rectangles are geometric forms identified in African LSA industries. Non-geometric forms include curved backed, straight backed, orthogonal, oblique, and longitudinal truncations. In relation to size, backed tools are widely varied. For example in the earlier phase of Eburran industry, backed microliths were identified with mean length approaching 50 mm (but the maximum lengths of approximately 100 mm). To the opposite backed microliths pieces of extremely small with mean length less than 17 mm were found in some Holocene LSA and Neolithic industries (Ambrose, 2002:10).

Varieties of techniques are used for the manufacture of blades and blade-like flakes (Bar-Yosef and Kuhn, 1999). Both blades and bladelets are removed using direct percussion (using a hammer stone, wood, or antler), indirect percussion and pressure flaking. But it is not easy to get the desired blade products using a raw material in its natural condition and due to this the desired shape of the blade is achieved by shaping out of the core, and to the preparation of striking or pressure platforms and most particularly to the preparation of one or more "ridges", called crests. (Inizan, 1999). In classic prismatic flake production, one or more long ridges are prepared on the face of the core by bifacial flaking, creating the characteristic crested blade (*lame à crête*). In such a way a blade core produces a series of blades throughout its perimeter. Flat and unmodified or platforms prepared by flaking or abrasion would be used for the production of blades on the prismatic core (Bar-Yosef and Kuhn, 1999). But this does not mean that blades do not produced in blade cores without crested ridges. Some blade cores which have sufficient convex area of cortex surface are convenient for blade debitage production (Inizan, 1999)

Chapter Three

Literature Review

3.1. Previous Research on Late Pleistocene LSA

3.1.1. Late Pleistocene LSA sites in East Africa

In Eastern part of Africa, archaeology is a young discipline in which a scientific research on the field has started in the 1920s. Prior than the 1920s, archaeological exploration and research were conducted by travelers, colonial administrators, explorers, and foreign enthusiasts (Mabulla, 1996). In East Africa, the first systematic prehistoric research was begun by E.J. Wayland, who was the Director of Geological Survey in Uganda in 1920 (Clark 1988). Wayland divided the later sedimentary deposits of the country and he developed threefold glacio-plluvial hypothesis. In 1926, L.S.B. Leaky's East African Archaeology Expedition conducted its research in the basins of Lakes Naivasha and Nakuru in Eastern Kenya. On these sites, stratified, fine-grained sediments in Malewa Gorge yielded lithic assemblages which were described as later as "Kenyan Mousterian" and "Kenyan Stillbay" (Leaky, 1931; Clark, 1988: 241-242).

3.1.2. Previous Research on Late Pleistocene LSA sites in Ethiopia

According to Brandt (1982), in the Horn of Africa which includes the modern countries of Ethiopia, Djibouti and Somalia, the earliest attempt to record MSA/LSA had been taken place by Revoil between 1882 and 1888 along the coast of Somalia. In Ethiopia, the first systematic prehistoric research was commenced with discovery and excavation of the MSA site of Porc Epic cave near Dire Dawa town by Teillhard de Chardin and Henry de Monfreid between November 1928 and January 1929 (Clark, 1954).

In the 1940s, Desmond Clark has commenced his Stone Age research and he documented sites with surface findings as well as he excavated a series of stratified MSA/LSA rock shelters and open air sites in Ethiopia (Brandt, 1986: 42). The 1940s and earlier research work of Clark, which were conducted in Ethiopia and Somalia, were compiled together later and Clark (1954) published *The Prehistoric Culture of the Horn of Africa*. In the 1940s, Lieutenant-Colonel F.Moysey had also conducted his investigation in the northern and northwestern part of Ethiopia and had excavated Quiha rock shelter in the 1940s while he was serving with British armed forces in British Somaliland. The Quiha rock shelter is located in Tigray province in northern Ethiopian highlands, close to the town of Quiha and Mekele. The LSA/Neolithic lithic materials discovered at Quiha include high frequencies of obsidian microliths, small scrapers, blades and blade cores. They have never been fully published (Barnett, 199) but, these materials were dated to the Late Prehistory (Moysey, 1943; Leakey, 1943). Mosey had also partially excavated Gorgora rock-shelter in 1943, which is located to the North of Lake Tana in northwestern part of Ethiopia Gorgora had yielded a stratified 'Middle Stone Age' sequence with 'Late Stone Age'. The excavated materials were analyzed by L.S.B. Leaky and the analytical results show both MSA and LSA cultural materials. The MSA debitage belongs to the culture of Stillbay uncovered from 12-foot level upwards to the top of the 4-foot layer. Layer 4 was identified as a transitional unit that contains lithic belongs to Magosian culture. Finally, the upper most 2 feet of the black soil contain a very crude microlithic industry which may be regarded as a local derivative of the Magosian, comparison to the Wilton B of Kenya and Northern Tanganyika (Williamson, 1984; Moysey, 1943; Leakey, 1943).

In the northern part of Ethiopian plateau, the other site that provides knowledge of LSA hunter-gatherers is Gobedra hill. According to Phillipson (1977b), the presence of Stone Age material at Gobedra in the vicinity of Aksum has been reported first by Puglisi (see Puglisi, 1941). Then, in 1974, 4m^2 test-trench was excavated and he uncovered more than 26, 000 LSA assemblages. Radiocarbon dating samples were taken on the occupation layers and calculated on the basis of the 5568-year half-life. Based on this, the stratum IV (65-70cm) from square C was dated 8168 B.C ± 140 years. Different types of cores, retouched implements, backed geometrics, backed flakes, backed points, blades and various types of scrapers were discovered (Phillipson, 1977b). In Northern Part of Ethiopia, Finneran also recorded various sites with their LSA occurrences (See Finneran, 2000; 2001; 2003).

In the 1970s (1974 and 1975), University of California Expedition under the direction of Professor J. Desmond Clark and M.A.J Williams had begun a survey and excavation in the southern part of the Afar rift and southeastern plateau in Ethiopia and discovered important sites containing LSA and/or MSA cultural sequence. This was a multidisciplinary research expedition consisting of archaeologists from Berkeley and geomorphologists from Macquarie University who carried out an excavation and survey from 1974 to 1976 at K'one/Garibaldi (Middle and Late Stone Age), Lake Besaka (LSA), Aladi Spring (Middle and Late Stone Age), Lega Oda (prehistoric rock art and LSA), and Porc Epic (Middle and a few extent Late Stone Age) (Clark and Williams, 1978; Kurashina,1978, Clark and Williamson, 1984).

One of the sites which had been excavated by the research team of University of California Expedition was Porc Epic, near to the town of Dire Dawa. After the 1933 excavation, Porc Epic was revisited and re-excavated in 1974 by this research team. When they started re-excavation, the top surface was found refilled by fine sand and loam which contains a number of LSA artifacts from the 1933 excavation backfill. The excavation was continued in 1975 by J.D. Clark and Williamson and later by Williamson in 1975. The cave was occupied by LSA hunter-gathers temporarily who were used lithic assemblages dominated by microliths, small scrapers and outils ecailles (Clark and William, 1984). LSA dating results of Porc Epic sediment deposits was based on a sample taken from dripstone sealing the main artifact-brecca and was dated by ^{14}C and TH/U methods to ca. 4590 ± BP (pta-2600) and 6270 ± 1020 years (U-111) respectively.

In the district of Dire Dawa, there is also Goda Buticha cave site which is located close to hamlet of Kunama in the administrative district of Serkama village. Excavation at this cave yielded MSA and LSA cultural materials which were uncovered 2.3 m-deep sedimentary sequence. This sedimentary deposit has provided two occupational phases which were dated to the Upper Pleistocene (~43-31.5 ka cal BP) and in the Mid-Holocene (~ 7.8- 4.7 Ka cal BP) (Pleurdeau, 2014).

The other LSA site who attracted the attention of archaeologists for long was Laga Oda rockshelter, which is situated on the foot hills of Chercher Mountains. Originally, Laga Oda was known by its prehistoric rock art which was discovered in 1933 by Pere Azais and Oncieu de Chappardon (H. Breuil, 1934 *cited* in Kurashina, 1978; Brandt 1986). Researchers had continued to revisit Laga Oda and from 1950-1952, Frobenius Institute's Ethnological Expedition to Laga Oda had traced and photographed the paintings as well as did small excavation and surface collection lithic assemblages. The upper part of the floor of the shelter did not have deposit, but there was at least 140 cm deposit in the lower part of the shelter which spans 20 meters with a deposit of 1-3 meters. This test excavation by Elizabeth Pauli on this lower level had yielded flakes, blades, retouched or utilized pieces, cores burins, backed microliths and scrapers made from obsidian and chert (Kurashina, 1978). Despite it did not have a radio carbon date (Kurashina, 1978), as Clark (1954) suggested, the discovery of these lithic assemblage at the lower level had proved that the shelter had been inhabited by LSA people who were probably a part of the Somaliland Wilton Industrial Complex. At Laga Oda, in 1975, University of

California Expedition under the direction of Professor J.D. Clark had excavated a trial trench measuring 4x1m^2 and uncovered lithic artifacts and faunal remains. Like the 1950s materials, they discovered crescents (asymmetric and symmetric), geometric microliths, backed flakes, scrapers and other LSA materials made from chert, quartz, obsidian, basalt, lime stone and granite (Kurashina, 1978; Clark and William, 1978). According to Brandt (1986), Laga Oda is the only one among LSA sites in the Horn of Africa that provided securely dated evidence of human occupation during the arid terminal phase (SUA-475) 15,590 ± 460 BP.

Kone is the other important MSA/LSA site which is located in the southern Afar Rift approximately 150 km east of Addis Ababa. It is composed of eight volcanic calderas of the volcanic age. Professor J.D. Clark and his archaeological and geological research team members surveyed the area and discovered Middle and Late Stone Age obsidian workshop floor (Clark and Williams, 1978; Brandt 1986). They carried out an excavation in 1974 and 1975 and uncovered considerable number of MSA and LSA prehistoric sites sealed in primary context. LSA artifacts were derived from the upper vertisol (black organic layer) measuring 1.0 m thick at locality C, East Grid. Underlying the upper vertisol layer, 1.5 m thick upper loam dominated by calcareous was identified and this stratigraphic layer kept MSA/LSA transitional artifacts, dated to 14,670 ± 200 BP. These LSA lithic assemblages were analyzed by Hiroyasu Kurashina (1978) for his Ph.D dissertation and he classified these materials in to shaped tools, utilized pieces and debitages (including flakes and flake fragments, microburins, krukowsky microburins, core and chunk).Numerous shaped tools were identified including a single La Mouilla, point, backed flakes, scrapers and burins. All these tools are made up of good quality black obsidian and have remained in fresh condition with no cortical retained (Kurashina, 1978)

Aladi Spring was also another site which excavated by University of California research team in the 1974. The stratigraphy of the excavated trench was formed a sequence of alternating clays and loams that contained LSA and MSA lithic assemblages. These deposits were overlied by a shell-bearing tufa deposit radiocarbon dated on shell 11,070 ± 160 BP((I-7970) (Clark and Williams, 1978) and this LSA horizon, which was analyzed by Tegenu Gossa for his M.A. thesis, was characterized by microblade industry including scrapers, bladelets, burins, drills/borers, backed pieces and cores which are made of obsidian and chert (Gossa, *et.al.*, 2012; Williams *et al*., 1977; Clark and Williams, 1978).

According to Fernandez *et al*. (2007), LSA and MSA published maps in Ethiopia and the Horn are not only show few sites but also reveal empty space stretching throw the whole western part of Ethiopia. To fill this enormous gap, in 2001 and 2002 V.M. Fernandez had conducted survey and excavation at K'aaba and Bel K'uru'umu rock shelters in Benishangul-Gumuz in western part of Ethiopia which hasn't been given an attention in so far (Fernandez *et al.*, 2007). The excavation at K'aaba had revealed 1.10m sedimentary deposit and radiometric dates were identified. For the upper sample (middle level D), estimating radiation does from a fraction of sediment collected that brought a date of 2600 BP. For Bel K'uru'umu rock shelters, the oldest radiometric date is 4964 ± 340 BP based on samples took from level E or Unit 10 (Ua-19922). Despite these late dates, the K'aaba and Bel K'uru'umu lithic assemblage technological features are fairly comparable with the Midhish model (except the microliths), which was dated to 18,790 ± 340 BP (Fernandez *et al*. 2007).

Relatively detailed and complete LSA research in Ethiopia had been taken place at Lake Besaka. Four localities (FeJx1-FeJx4) were excavated in 1974 and 1975 by Clark and Willams and by Brandt in 1977 and yielded later Pleistocene/ Early Holocene microlithic assemabalge as well as other artifacts belongs to more recent times. The excavated sites are situated in three distinct physio-graphic areas. Lithic assemblages collected from the four localities were analyzed by Steven A. Brandt as part of his PhD dissertation and detailed lithic typological and technological analysis is provided by Brandt (1982). Chronologically, human occupation horizons dated from 22,000 BP to the late Holocene period. However, the prehistoric human occupation at Besaka is not continuous and by using the various occupation horizons and their associated lithic assemblages Brandt (1982) has developed cultural and environmental sequence of the region by dividing into different periods/phases of varying length and occupational intensity. Five temporal phases has been recognized which form a single technological tradition known as Ethiopian Blade tool Tradition (Brandt, 1982).

The later Pleistocene Phase: evidence of habituation of hunter-gathers in the Later Pleistocene phase was recorded at Lake Besaka and this phase was securely dated to 22,000-19,000 BP. This date provides the earliest well documented evidence in the Horn of Africa for microlithic base Late Stone Age industry (Brandt 1982). Brandt (1982) also mentioned that other researchers (eg. Philllipson 1976, 1977a, 1980 and 1982; Bower 1982) had identified similar kind of microlithic Late Stone Age industry which had been developed and used in East Africa roughly 20,000-35,000 BP. This new technology in East Africa, which was based on bow and arrow was, a response to adaptation to the changing to environmental condition from more open plains to dense vegetation cover.

Terminal Pleistocene: According to Brandt (1982), Terminal Pleistocene is the last part of the late Pleistocene period that covers c.18,000-12,000 BP and at Lake Besaka this period has known by paucity of archaeological remains. Lack of evidence of human occupation horizons of the Terminal Pleistocene compared to other known phases in Besaka may be either sampling problem or may be a reflection of the cool hyper-arid conditions that was prevalent in Ethiopia and the Afar rifts (Brandt, 1982).

Earliest Holocene: this phase began to shortly before 11,400 BP and soon followed by Middle and Late Holocene Phase. This is probably the period when the hunter-gathers of the terminal Pleistocene were forced to modify the then existing culture in response to changing resources and hunting/gathering strategies (Brandt, 1982). Brandt (1982) divides the Earliest Holocene phase into Metahara phase and Abadir phase, in which both of them were represented by the material culture of Besaka Industry. The material cultural of this Earliest Holocene phase is divided into four industrial groups, but not relevant to this study except first phase may be useful for the comparison to the Terminal Pleistocene Phase.

To sum up, the time and the mode of cultural transition from MSA to LSA technology has not been yet well demarcated in the Horn of Africa. In the region, the most likely earlier LSA cultural sequence was identified from the Lake Ziway area of Ethiopia where an exposed section near the Bulbula river had revealed an occupation horizon embedded within a paleosol dated on charcoal to ca 27,050 ± 540 BP (ca. 35-28,000 cal BP)(USA-588) (Gasse and Street, 1978; Street, Gasse *et al*., 1980,), DW1 locality at unit PSS 33,726-32,907 cal BP (Ménard et al., 2014) and in southeastern Ethiopia at Goda Buticha cave site dated in its early human occupation to early LSA phase (~43-31.5 ka cal BP) (Pleurdeau, 2014).

These lithic materials from Bulbula have characterized by an obsidian blade industry dominated by the presence of non-microliths, scrapers and blades (Brandt, 1986). The project of Late Stone Age Sequence in Ethiopia has also been revisited the known LSA sites in Bulbula since 2007 and uncovered LSA cultural sequence at Bulbula 1 locality (Bon *et al*., 2013). This research had yielded lithic assemblages dated from the upper Pleistocene (34-33, 000 Cal BP from DW1)) to early Holocene. The Pleistocene/ Holocene transition sites at Bulbula were dated between 14,000 and 11,000 cal BP (B1S1, DW2S2 and DW2S1) (Ménard *et al*., 2014).

In addition to Bulbula, several other LSA sites were excavated in 1973 by an expedition in 1973 by an expedition from the Anthropology Department of Southern Methodist University under the direction of Dr. Fred Wendorf. This project identified the Macho and Waso hills LSA sites, which are situated to command a view of ancient lake. Two trenches were excavated and they yielded an assemblage based on blade technology made of obsidian which are characterized by non-geometric microliths, scrapers, burins, blade core and other artifacts showing general similarity to the Late Pleistocene phase at Lake Besaka (Humphreys, 1978; Brandt 1986).

3.2. Brief Review Late Pleistocene Paleoenvironment in East and the Horn of Africa

3.2.1. Paleoenvironment of East African Late Upper Pleistocene

The paleoenvironment records of East Africa during the late Quaternary and early Holocene were based on a range of evidence including diatoms, microscopic charcoal, ancient dunefields and aeolian sediments, lake-level fluctuation records, fluvial deposits, glacial features of East African mountains and tropical palynology (Street and Grove, 1978; Kiage and Liu, 2006). Particularly, pollen records and the sacred lakes in East Africa providing continuous records in the region covering the period from 115,000 yr BP to the present (Kiage and Liu, 2006).

The LSA cultural sequence began in Africa at least as early as 42,000 BP (Ambrose, 1998) and this earliest phase of LSA in East Africa faced cold and dry conditions which was prevalent between 42,000 ^{14}C yr BP and 30,000 ^{14}C yr BP. Due to the cold and dry condition, high vegetation altitude could not survive and they descended to lower elevation. Evidence of these cold and dry paleoenvironment were found in the Rukiaga highlands, in Mount Kenya, Lake Abiyata (Ethiopia) and Kashiru swamp (Burundi) (Kiage and Liu, 2006). In Kashiru swamo, for example, there was a decline in forest taxa and an increase in Gramineae (Bonnefille and Riollet, 1988), which is a marker of cold and dry condition (Kiage and Liu, 2006).

Between 30,000 to 21,000 ^{14}C yr BP, records of the paleoenvironment have revealed cool and moist conditions in East Africa and this is the period leading upto LGM period of the Northern Hemisphere. During this period, there was a slight increase in temperature and precipitation that led several East African lakes experienced high stands. Places covered with ericaceous scrub in the Muchoya catchment was replaced by upper montane forest (Taylor 1990 *cited* in Kiage and Liu, 2006; Perrott and Street-Perrott, 1982). However, the increase in precipitation is not recorded at all sites of East Africa. For instance, an area like Lake Albert was dominated by an open wooded grassland assemblage, suggesting a dry climate (Kiage and Liu, 2006). The period from 21,000 to 12,500 14C yr BP in East African environment and the rest of Africa were characterized by cool conditions, punctuated by episodes of prolonged desiccation (Kiage and Liu, 2006; Street and Grove, 1976), which reached its climax 18,000 ± 300 yrs BP when East African glacier reached their greatest extent (Street and Grove, 1976). Sea level fluctuation from Lake Victoria and Lake Albert provides evidence of two separate episodes extreme ardification of this period. This desiccation in some part of East Africa was so severe that led to a low stand of at least 46m below present levels at the core site in Lake Albert (Kiage and Liu, 2006). Like Lake Albert, Lake Abhe in Ethiopia at Afar reached its minimum by 17,000 yr BP and other rift valley lakes were dried up (Street and Grove, 1976). Still there is lack of data about this period. The available pollen data are low may be because of the poor preservation of pollen in low lake levels and subsequent oxidation in these environments (Kiage and Liu, 2006).This aridity period was continued and particularly from 15,000 to 13,000 yr BP, it became even more intense and wide spread (Street and Grove, 1976; 1979). The Terminal phase of the last glaciations in East Africa was dated between periods after 12,500 BP and the beginning of the Holocene (10,000 BP).This terminal phase is considered as a transition period which is marked by an increase in temperature and moisture (Kiage *et al*., 2006). According to Street and Grove (1976), this period was considered as the African counter part of the late glacial. However, just before 10,000 BP, an abrupt return of the arid condition was recorded at several sites in East Africa (Street and Grove, 1976; 1979; Kiage and Liu, 2006).

3.2.2. Paleoenvironment of Ethiopian Late Upper Pleistocene

Like other parts of East Africa, evidences of the late quaternary environmental changes were recorded in different parts of Ethiopia. The earliest study of late quaternary paleoenvironment was conducted by E.Nilson (1940) on past glacial environment of the simien highlands of Ethiopian plateau and the lake basins including the lake basin of Tana and Yaya on the Ethiopian plateau and the lakes in the Ziway-Shala basin that could provide paleoenvironment relating to ancient beaches and terraces (Brandt, 1982). Most of the data for this paleoenvironment reconstruction derived from lacustrine and fluviatile sediments, as well as evidence from sea-level fluctuation along the Somalia coast and Ethiopia. By using these data, Clark (1954) devised the sequence of the Late Quaternary climate change in the Horn. According to Clark (1954), the upper Pleistocene three wet phases of the "Gamblian" Pluvial and an arid phase of the terminal Pleistocene. Following the terminal Pleistocene, two wet phases were recorded in the Holocene which were separated by period of aridity (Clark, 1982).

In Ethiopia most of the recent data used for the late Pleistocene paleoenvironment reconstruction has been gathered almost exclusively from five regions: 1) the lower Omo Basin at the southern end of the Ethiopian Rift, 2) the Ethiopian plateau, 3) the Middle Awash Basin in the southern Afar Rift, 4) the Lower Awash Basin and the lakes of the central and northern Afar of Ethiopia, and 5) the Ziway-Shala Basin situated in the south-central portion of Ethiopian rift (Clark, 1982). But for this study I limit myself on selected temporal phases and spatial distributions which would be useful for correlations for my study area including the Ziway-Shala basin, the Lowe Omo basin, lakes of the central and northern Afar and Lake Beseka.

3.2.2.1. Lower Omo Basin

At the Lower Omo basin, two major transgressions from the Lake Turkana formed littoral, deltaic and fluvial beds of member III of Kibish formation. These transgression of Lake Turkana, however, interrupted by desiccation (Butzer, 1970:429 *cited* in Brandt 1982). Late quaternary last transgression of Lake Turkana was recorded shortly before 35,000 Bp years ago, when Lake Turkana was 60 to 70 above its present level. Then when the desiccation started, the level of Lake Turkana dropped left behind carbonate horizons and "desert varnish" on lag pebble indicate long period low lake level and aridity which ending before 9500 BP.

3.2.2.2. Central and northern Afar

The longest continuous stratigraphic and climatological sequence of late quaternary was recorded from the central (including Lake Abhe, Dobi-Hanle and Asal) and northern Afar (Lake Afrera) Lakes. Three major lacustral phases named (Abhe I, II and III), which are separated by more arid episodes, were identified (Gasse, 1975;1977; Gasse and Street, 1978). The first lacustrine and arid phases were dated around 70,000 PB, which is not the main concern of this research. But the second lacustral phase (Abhe II) was well begun before 40,000 BP and ended around 30,000 BP, which was uncovered in the central Afar basins. During this time Lake Abhe was marked by increasing sea level and deposition very pure diatomite. After 30,000 BP, regression was followed and this regression is recorded by a thin bed of gypsum which overlies calcareous sediments dated about 30,000 BP (Gasse and Street, 1978).

The third lacustral phase of Lake Abhe (Abhe III) covers the time span from 30,000 - 17,000 BP, when the level of Lake Abhe reached its maximum during the late quaternary. This phase began to deteriorate from 20,000 BP onwards and disappeared around the onset terminal Pleistocene arid phase (17,000 BP) when it seems that all the lakes in the Afar were dried. The dry phase continued until the end of the terminal Pleistocene from 12,000-10,000 BP when most Afar lakes got dried (Gasse and Street, 1978).

3.2.2.3. Besaka:

The late quaternary sedimentary deposits in Lake Besaka are yielded plaeoenvironmental data dated to late upper Pleistocene transgression period, terminal Pleistocene regression period and early Holocene transgression period (Brandt, 1982). In the late Pleistocene transgression phase, the earliest absolute date result is between 11,200-14,400 BP from radiocarbon samples taken in pits E1 and E2. No dating had been taken from the earliest transgression deposits, which underling the deposit dated 11,200-11,400 BP, in pits E1 and E2 which certainly older than its upper sedimentary deposit. But by creating a correlation with the extensive late Pleistocene highstand in Afar and Ethiopian rift lakes c.27,000-18,000 BP, an age of 18,000 BP was suggested for the highstand of Besaka late Pleistocene transgression (Gasse, 1975; Clark and Williams, 1978). During this Late upper Pleistocene phase (22,000-18,000 BP), Besaka was probably a deep fresh water lake capable of supporting a diverse tropical fauna and flora (Brandt, 1982).

The Late Pleistocene was followed by the terminal Pleistocene regression phase which was marked by the rapid falling of the lake level of Besaka. Absolute chromomeric dating for this phase was absent, but the dates of 11,200 and 11,400 BP are the minimal ages for the loamy sands of pit E2. Despite there was no an absolute date for E2 before 11,200 and 11, 400 BP, Besaka would not be exceptional and should share the traits of the hyper-arid period, which prevalent throughout much of Ethiopia and northeastern Africa between 18,000 and 10,000 BP (Clark and Williams, 1978; Brandt, 1982). This terminal Pleistocene (c.18,000-12,000 BP) in Besaka was marked by cool and extensive arid condition. The amount of rain fall was small, not much more than half of what is today. The closed vegetation which had been prevalent during humid phase was replaced by more open and desertic conditions. The volume of Lake Besaka was minimized tremendously and may have totally dried up. Evidence of human occupation was recognized and few pieces of LSA assemblage were uncovered from weakly developed paleosol (Clark and Williams, 1978; Brandt, 1982).

At the end of Terminal Pleistocene (shortly before 11,400 BP) and the onset of the Holocene (C. 12,000-9,400 BP), the level of lake Besaka increased again and marked by a deposit remains of a thick layer of fossiliferous diatomites up to the western fault-scrap (Brandt, 1982). During this period, Besaka was covered by closed vegetation and the lake itself could provide an access for a diverse array of aquatic fauna and flora. LSA cultural remains were uncovered and these hunter-gathers occupied Besaka occupied Besaka at Early Holocene had exploited a wide range of animal and plant resources from presumably many habitats (Brandt, 1982).

3.2.2.4. K'one Crater Complex/Garibaldi Caldera Complex

K'one crater complex, also known as Garibaldi, is located in the southern Afar rift 30 kms west of Lake Besaka. Surveying and excavation at K'one had been conducted by Clark and Williams in 1975 and they had recorded clay deposit containing MSA and LSA assemblages. The LSA bearing horizons was revealed in the upper vertisol, which was deposited after 14,700

± 200 BP, and was probably synchronous with the end-Pleistocene/early Holocene wet phase evidenced at Aladi Spring and at Lake Besaka, and with the rise in Lake Shala in the Main Ethiopian rift at or after 14,400 BP (Grove *et al*., 1975)

3.2.2.5. Aladi Spring

The paleoenvironmental records of the Aladi Spring, located in the base of escarpment of South-East Plateau nearly 120 away from Dire Dawa, included two wet and three relatively dry phases during the late Quaternary. LSA cultural sequence based on microblade industry made from obsidian and chert was uncovered in the stratigraphic sequence of the second wet phase. This phase has been marked by the formation of mound spring capped by tufa containing shells dated at 11,070 ± 60 BP. The first wet phase was also identified and known by wide spread deposition of calcareous green clay loam, possibly under lacustrine condition. Between the sedimentary deposits of these two wet phases, brown gritty clay was uncovered and this unit was probably formed during the terminal arid phase of 17,000-12,000/14,000 BP (Clark and Williams, 1978).

3.2.2.6. Paleoenvironment of the Ziway-Shala Basin during the Terminal Pleistocene

The terminal Pleistocene, which was part of the cold and extremely arid Terminal Pleistocene (c.18,000-12,000 BP), was marked by cool and extremely arid conditions in which the amount of rainfall was much lower than today, probably not more than half of today. Climatically, it was marked by more arid *Bereha* (a sub-zone of arid lowlands elevating not higher than 600-700m) type. During the Terminal Pleistocene the closed vegetation existed before was changed in to open and more deserted conditions (Brandt, 1986).

The Ziway-Shala basin has yielded very valuable data for regional and global paleoenvironment reconstructions (Benvenuti, 2002). Due to this, it attracts the attention of many paleoenvironment researchers including Gasse and Street (1978), Adamson *et al*. (1980), Gasse *et al*. (1980), Street (1980) and Grove *et al.* (1975). After the study, these researchers have produced in one of the two most detail and continuous records of Late Quaternary and early-mid Holocene paleo-hydrology that provides important information about climate and environment as yet known in East Africa (Gasse and Street, 1978; Benvenuti, 1980).

Morphological and stratigraphic evidences in the Ziway-Shala Basin have provided records of two major periods of Late Pleistocene lake transgression to the extent of forming a single mega or macro lakes. The earliest evidence of transgression record came from Bulbula I and dated to earlier than 28,000 BP. Despite the extent of the lakes during Bulbula I phase was unknown, there are data that show the water level reached at least 1,605 m, which implies that during this phase Abiyata, Langano, and Shala formed a single lake. But the phases of this high lake level was interrupted and followed by a minor regression and subsequent deposition of paleosols containing artifacts of LSA assemblage.

The second major Late Pleistocene transgression record in Bulbula II phase (dated to after 27,000) was identified and during this phase the four lakes of the Ziway-Shala basin (Ziway, Abiyata, Langano and Shala) was formed a single lake in the region (Gasse and Street, 1978; Benvenuti, 1980). This situation has persisted until 21,000 BP with minor fluctuations (Brandt, 1982). In East Africa, this period is characterized by cold and moist condition which is considered as a period leading to the Last Glacial Maximum (LGM) (Kiage *et al*., 2006) in which during the hyper-arid phase the lake-level in the Ziway-Shala basin dropped below 1,600 m leaving behind fluvial gravel deposits on the Alutu piedmont (Gasse and Street, 1978).

Based on evidence collected from Ziway-Shala ancient shorelines, two wet phases were occurred after the LGM, at 14.5 and 11.5 cal. kyr BP. These wet phases were coincided with the two de-glaciations warming phases which were interrupted by the Younger Dryas cold event observed in high northern attitudes.12.6 m long sediment core record samples was taken from Lake Abiyata and provides data for the past 13,500 years. The diatoms from this sediments proves that lake level fluctuation and change of the chemistry of Lake Abiyata which confirms that conditions generally much wetter than today prevailed from ca.11 to 5.7 cal.kyr (Umer *et al*., 2004: 165-167). The Terminal phase of the last glaciations in East Africa is dated between periods after 12,500 BP and the beginning of the Holocene (10,000 BP).This terminal phase is considered as a transition period which was marked by an increase in temperature and moisture (Kiage *et al*., 2006). After Terminal Pleistocene, the level of the lakes in the Ziway-Shala basin began to increase in the minimal scale around 12,000 BP. This was followed by two major lake transgressions during the Holocene.

The first major Holocene transgression evidence record dated at 9,400-8,000 BP in which during this phase the four lakes of the Ziway-Shala basin reunited and formed a single lake. This phase is characterized the deposition of lacustrine marl towards 9,400 BP. This was followed by a regression phase which began around 8,000 BP and marked by the formation of two buried soils and deposit of airfall pumice. After this abrupt regression, the second major Holocene transgression is recorded about 6,500-4,800 BP and this phase is identified by the presence of shelly lacustrine beach gravels dated c. 6,500 BP (Gasse and Street, 1978; Brandt, 1982). This was followed by regression of the lakes which brought the separation of Lake Ziway from the southern lakes by 5,000 BP, and the formation of the Abijata strandlines (Gove *et al.*, 1975). In East Africa based on the data extracted from pollen, the early Holocene was characterized by warm and moist paleoclimate. This period was dominated by forest pollen types accompanied by a reduction in Graminae and an increase in pteridophytes (Kiage *et al*., 2006).

In the Ziway-Shala basin, faunal and floral remains dated to the Late Pleistocene hyper-arid period was not discovered. Sedimentological terrestrial investigations show that the environment was extremely cold and dry which is unfavorable for pedogensis process (Gasse and Street, 1978; Gove *et al.*, 1975). The East African environment between c. 21,000 to 12,500 BP was also characterized by cool condition that brought in an episode of prolonged desiccation. This period was marked by lack of pollen data which was the result of poor pollen preservation, probably due to low lake levels and subsequent oxidation in the region (Kiage *et al*., 2006). In the succeeding Holocene period, remains of different fauna including molluscan, fish and diatom assemblages were identified in the lake bed deposits situated above Lake Shala (Gasse and Street, 1978; Gove *et al.*, 1975). These faunal remains were uncovered in both warm and cold tropical environments. The research results of the analysis of diatom, mollusk and fish fauna, and the algal limestone above Lake Shala proves that the united Holocene lake was relatively fresh that supports aquatic vegetation and fish population (Gasse and Street, 1978; Gove *et al.*, 1975).

B1s4 study site in Bulbula is dated to 12,040 ± 50 BP (14,045-13,755 Cal BP) in which this date falls in the Terminal Pleistocene phase of the last glaciations. According to Kiage *et al* (2006), this terminal phase in East Africa is considered as a transition period which is marked by an increase in temperature and moisture. But it was also interrupted by an abrupt return to arid condition. Data that provides information for the abrupt arid condition identified several sites in east Africa dated before 10,000 ^{14}C BP, probably reflecting the Younger Dryas climate reversal. Evidence for the younger Younger Dryas effect was uncovered from Burundi highlands and Aberdare Mountains. For example in Burundi highlands the abrupt aridity was manifested by a shift to a grassland pollen types. In other sites, Lake Albert, the forest taxa has reduced nearly to zero and contemporarily replaced by grass pollen with an increment of 40%.

Selected sites of Late Pleistocene paleoenvironment of Ethiopia was briefly summarized by Gasse and Street (1978) and Grove *et al.* (1975) and like the Ziway-Shala basin lakes, the results of these previous studies have shown transgression and regression of the lake levels in the region. So, the late quaternary environment in the Horn in general has been characterized by environmental fluctuations that linked with periods of increased humidity and higher lake levels preceded by periods of increased aridity and concomitant environment and hydrological change (Brandt, 1982).

Chapter Four
Lithic Analysis

4.1. General Presentation

B1s4 had yielded numerous chipped artifacts and few fragmented faunal remains. A 1.10 m deep sedimentary deposit had yielded 4061chipped artifacts which all of them are made up of obsidian. All the lithic artifacts collected from excavation came from PS1 and PS2 stratigraphic unit and there was a dramatic increase in the number of lithic artifacts recovered as one proceeded from PS2 to PS1. The whole lithic assemblage from B1s4 is dominated by debitage which accounts for 96.8% of the total assemblage. The remaining 3.2% are tools which include retouched and utilized pieces. This chapter, therefore, have presented analytical results of these lithic assemblages and brief analytical results of faunal remains which were sorted out by Josephine Lesur*.

4.2.Faunal Remains

The faunal remains from B1s4 were identified by Josephine Lesur. A total of 105 fragments of faunal remains were collected from both PS1 and PS2 stratigraphic units (*Table 3*).

Faunal Spectrum	B1s4
Alcelaphinae	3
Damaliscus hypsodon	1
Middle-sized bovid	5
Bovidae indet.	2
Rodent	2
Total Identified	**13**
Unidentified	*92*
TOTAL	**105**

Table 2: total number of identified and unidentified faunal remains of B1s4 (Lesur, in litteris)

From the total faunal remains, about 87.6% are not identified. The identified faunal spectrum includes mainly bovid remains (*table 2*). From these bovid remains, only one extinct species, which is called *Damliscus hypsodon*, could be identified. The other identifiable faunal remain from B1s4 is rodent. But, Lesur suggested that it could be correspond to a recent intrusion and rodents were not eaten by the inhabitants of Bulbula site. Compare to B1S1, there is a paucity of faunal remains in B1s4 which needs still further investigation to understand why few faunal remains were uncovered at this section of Bulbula.

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4.3. Presentation of Lithic Assemblage

All the chipped lithic artifacts from B1s4 site from Bulbula are made up homogenous dark-colored obsidian. Obsidian outcrops are found in the immediate vicinity of the site as evidence of some obsidian lava flows and outcrops are found mostly on the slopes of individual volcanoes found in the Ziway-Shala Basin. According to Di Paola (1972), from the north to south the known obsidian flow sources include Boseti, Ittisa (inside the caldera of Gadamota), Bericcio, Boro and Alutu, and finally the the Urji and Chabbi volcanoes (grew inside the Corbetti caldera).

4.3.1. Raw Material Acquisition

To identify the obsidian source in the surrounding landscape and to reconstruct movement and resource exploitation, the project of Late Stone Sequence in East Africa had conducted a survey in the neighboring regions of Bulbula. During this time, the nearest known obsidian flow sources such as Alutu caldera and Gademotta Ridge as well as other small sources were surveyed (Figure 2). A total 175 geological obsidian samples were collected between 2010 and 2012 in the surveyed sites and analyzed geochemically by using Laser Ablation High-Resolution Inductive Coupled Plasma Mass-Spectrometry (LA-HR-ICP-MS) to know the chemical composition of the selected obsidian samples. In the same manner, 108 artifacts samples were selected from different excavated materials and were analyzed using the same method (Ménard *et al*., 2014: 56). The final result of this analysis has been being prepared for publication (Khalidi *et al*., in preparation *cited* in Ménard *etal*., 2014). Despite it is necessary to wait for the final results, the preliminary investigation result has shown that the prehistoric inhabitants of Bulbula were exploited the local raw materials which are available nearby across the landscape. This preliminary analytical result has also brought that no distant obsidian sources appear in the archaeological assemblage (Ménard *et al*., 2014: 56).

4.3.2. Raw material Condition

From the total 4061 pieces, whole or partial surfaces of 2070 pieces were covered by thin to thick white carbonate coating, which is called patina, due to post-depositional surface modification. Artifacts in which their surface is covered with patina account for 51% of the total lithic assemblage from B1s4. The degree of this patination was considerably varies which exhibited three different conditions (light, moderate and heavy). Most pieces were found in moderately patinated condition that amounted 1988 pieces, or 96% of the artifacts coated with carbonate. This was followed by heavily and light patinated pieces that form 2.5% and 1.5% respectively. The heavy patina on the lithic surfaces prevented from the identification of the direction of scar pattern, retouch and utilized modification and prevented use wear study in some of the pieces. This patination condition suggests that these artifacts were affected by post depositional activity.

Figure 14: the raw material condition that exhibits thin to thick carbonate coating (patina)

The remaining 1991 or 49% are not coated by carbonate and these artifacts are well preserved except little weathering physical condition varies from fresh (98.6%, or 1991 pieces) to slightly abrasion condition (28 pieces, or 1.4 %).

4.3.3. **Dorsal Scar Pattern and Number of Flake Scars**

Dorsal flake scars indicate removals from a core made prior to the removal of the flake itself. The orientation of these flake scars to the axis of the striking platform indicates in what direction flakes were removed prior to the movement of a flakes detachment. The orientation of flake scars are also brings an idea the orientation and the number of platforms on a core. It also provides clues about the method of reduction at the time the flake was removed. The direction of flake scars is also provide clues about whether a core was being reduced from one platform or multiple platforms as well as it brings an idea their relationships to each other (Baumler, 1987). Based on this scar pattern, different types of cores have been exploited that ranges from single platform to multiple platform in lithic assemblage of B1s4 (table 2)

The analysis of selected flaked artifacts (whole flakes including blades and bladelets and flakes which preserved their distal ends) has revealed various scar patters on their dorsal surface. As it has presented in table 2, six main types of dorsal scar orientations were recognized in which their dorsal flake scar number ranges from 1 to 7.

Types of Dorsal Scar Patterns	Total Numbers	% from the total sample
One direction irregular	85	22.5
One direction parallel	51	13.5
One direction convergent	33	8.7
Two direction irregular	11	3.0
One direction opposed	45	11.9
Multiple direction irregular	28	7.4
Indeterminate	125	33.0
Total	378	

Table 3: the identified dorsal scar patterns from the flake assemblages of B1s4

One direction parallel dorsal scars are originated on one side only and they have parallel ridges. These flaked artifacts which have one direction parallel dorsal scar pattern form 13.5% of the samples. There were also flaked artifacts which have revealed one direction irregular dorsal scar patterns. These artifacts have scars originated one side only, but their ridges are neither parallel nor convergent. One direction irregular dorsal scar pattern accounts for 22.5% of the collection which revealed dorsal scar patterns. There are also artifacts which show one direction dorsal scar pattern. Artifacts which exhibited such kind of dorsal scar pattern are characterized by scars originated on one side only and ridges converge towards the opposite edge. 33 pieces or 8.7% have one direction dorsal scars which converges towards its distal end. These negative scars in general oriented in broadly the same direction may indicate that the previous flakes had been removed from the same platform.

Other types of dorsal scar pattern such as two direction irregular, one direction opposed and multiple direction irregular account for 3.0%, 11.9% and 7.4 respectively, while the remaining 33% or 125 pieces have indeterminate dorsal scar patterns. Flaked pieces which possessed one direction opposed dorsal scars have scars originated on two opposite edges which their ridges were either parallel or converge at their center. The data collected from the dorsal scar pattern of flaked artifacts suggests that the majority of flakes were produced using a single platform core and flakes which revealed dorsal scar pattern taken form one directions accounts for 44.7%.

The absence or the presence of the exterior flake scars provides important sources of information about the reduction stage of the removed flakes. Flakes removed from exhausted core reveals more flake scars than flakes removed from an early stage. At late stage, cores become smaller and smaller and the flakes which are knapped during this stage show more complex scar patterns and higher scar counts than those from early stages (Munday, 1976: 120 cited in Gang, 1997: 101). The dorsal scar number from B1s4 ranges from 1 to 7 which indicate various stage of reduction stage, probably from early stage to late stage, had been taken place.

Like flake scars, core scars also reflect the detached pieces which were direction taken from the core.

4.3.4. Striking Platforms

Butt of detached pieces is the remnants of the original striking platform of the core from which the flake was taken. Different type of platforms recorded on the detached pieces provided information about the stage manufacture at which the flake was removed (Gang, 1997:94). The analyses of striking platforms show that various flakes including blades and bladelets were produced on various striking platform types. Four major butt types were identified and these are plain, faceted, punctiform and point.

Butt Type	**Total Number**	**%**
Plain	60	15
Faceted	29	7.3
Punctiform	240	60.3
Point	65	16.3
Indeterminate	4	1.0
Total	398	

Table 4: inventory butt types from B1s4

Plain platform is characterzed by a single facet and show smooth and previously flaked surface. On the other hand, other knapped stones which have faceted striking platorms are characterized by the intersection of three or more facets along the surface. From a total 398 flaked artifacts that preserves striking platforms, punctiforms, which exhibits very narrow or small striking platform, account for 60.3%. This is followed by point (16.3%), Plain (15.0%), faceted (7.3%) and indeterminate (1.0%). Flakes with cortical platforms were not identified from

B1s4 assemblages. From the total 398 flaked pieces which have a platform, 81 pieces or 20.4% have shown series of small flake scars below their platform extending a few millimeters down on the dorsal surface and close to the edge of the platform. Such kind of detached pieces have been removed from the perimeter of the prepared core which has been prepared prior to the removal of the flake.

Striking platform morphology and variability is one indicator of overall flaking technique and technology. They have been used to determine the type of hammer used during the flaking, stage of tool production and the size of detached pieces (Andrefsky, 2005: 89). From the total flakes which preserved their butts, punctiform and point platforms types are dominated the assemblages in which such kind of platforms is the results of soft hammer percussion technique. According to Debenath and Dibble (1991:23), there is a general consensus that punctiform platforms are the results of indirect percussion technique with a soft hammer. But, flakes with punctiform platforms are not a definitive indicator that the prehistoric knappers used soft hammer. Instead, according to Dibble and Whittaker (1981) *cited* in Debenath and Dibble (1991:22), the striking platforms and flake morphology are more relayed on aspects of platform and surface preparation than on the hammer itself.

4.3.5. Debitage Assemblage Analysis

Debitage includes all non-tool chipped stone artifacts. According to Anderfsky (2005: 82), discarded and unused detached pieces of artifacts are considered as debitage. It is represented by flakes which are waste product from the core preparation, in the preliminary stage of tool manufacture, and from the occupational modification of tools during their life time (Fish, 1979:3). It also incorporates artifacts which have flake and non-flake characteristics in which particularly are not recognized as retouched pieces/tools. Specifically, it incorporates flakes (and fragments), blades and bladelets (and fragments), burin spalls, cores, *outil ecallé*, angular waste, shatters and chips which falls in different size and classes (table 4).

Type		**N**	**% from the total assemblage**
Debitage		3930	96.8
	Whole Flakes	54	1.4
	Bipolar Flakes	5	0.1
	Flake Fragments	969	24.6
	Burin Spalls	17	0.4
	Blades	31	0.8
	Proximal Blades	38	0.9
	Medial Blades	24	0.6
	Distal Blades	11	0.3
	Debordant Blades	3	0.07
	Bladelets	27	0.7
	Proximal Bladelets	34	0.9
	Medial Bladelets	51	1.3
	Distal Baldelets	25	0.6
	Angular wastes	1253	31.8
	Chips	440	11.1
	Shatters	924	23.5
	outil ecallé	1	0.02
	Cores	23	0.6

Table 5: descriptive analysis of different debitage classes in terms of their number and percentage

From the total assemblage of B1s4, debitages accounts for 96.8%. This debitage is dominated by angular wastes which form 30.9% of the total assemblages of B1s4 and 31.8% of the debitage assemblages. This is followed by flake fragments 24.6% (969 artifacts), shatters 23.5% (924 pieces), chips 11.1% (440 pieces), broken bladelets 2.8% (110 pieces) and broken blades 1.8% (73 pieces).

Debitage products are important indicators of stage of reduction sequence. Except primary or initial stage of decortication stage reduction, the other stages of reduction sequences seemed to be taken place at the site which are reflected by the presence of preparation flakes, blanks, fragments (may have occurred either during manufacture or use or by trampling), chips, shatters and discarded angular wastes.

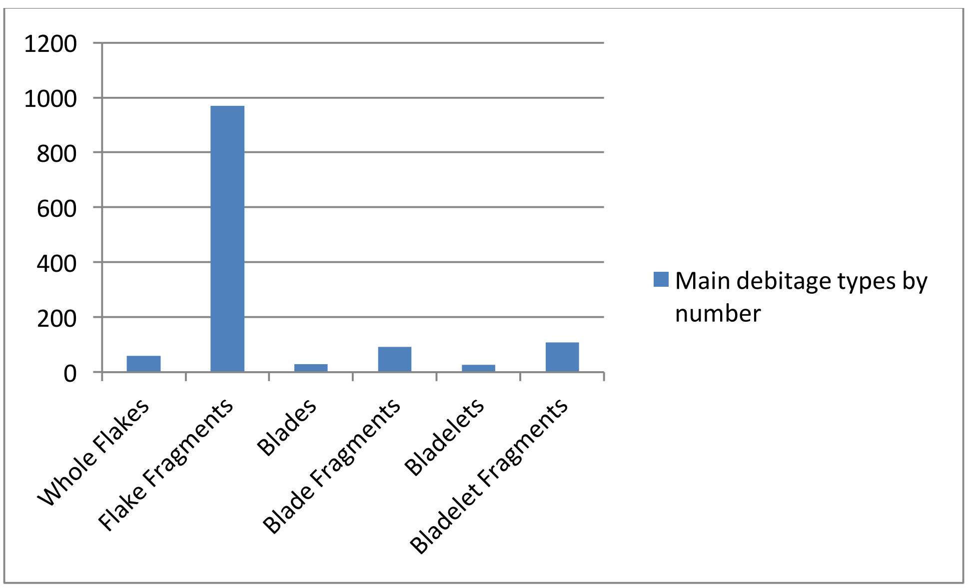


Figure 15: graph shows classes of main debitage from B1s4

4.3.5.1. Cores

A total of 23 cores were recognized from B1s4 and this number accounts 0.56% from the total lithic assemblages. PS1 stratigraphic unit yielded 17 cores and the remaining 2 from the surface and other 3 cores are PS2 stratigraphic unit. These cores have the mean weight of 12.1g, length of 37.6 mm and mean width of 24.6 mm. The length of the cores ranges from 17.1 to 60.4 (mm) and the dimension of the width ranges from 11.4 to 56.2 (mm). Based on the type and the manner of flake removal on the surface of the core, the cores from B1s4 are considered as flake, blade or bladelet cores. From the total 23 cores, 20 or 95.3% are bladelet cores. These cores are also varies based on the type and number of platforms or the type of striking platforms (Table 5).

Type of Platform			**Blank Type**		
	N	%		N	%
Single Platform core	14	61	Nodule	9	39.0
Double Platform core	2	8.7	Flake	7	30.5
Bipolar core	3	13	Indeterminate		
Opposed double Platform	3	13	Indeterminate	7	30.5
Multiple Platform	1	4.3			
Sub total	**23**			**23**	

Table 6: inventory of platform types and core blank types

These different cores are found in different stage of exploitation which provides analytical information about the reduction sequence. On their surface, cores show a number of negative flake scars which are left by the flakes that have been removed. The scar numbers ranges from 1to 6 with the mean value of 3. Five cores had only 1 scar on the surface. Two cores had 2 scars, seven cores had 3 scars, six cores had 4 scars, one core had 5 scars and two cores 6 scar numbers. This shows that from the total 23 cores, 14 cores have 3 or less scar umbers on their on their surface. Despite small number of flakes scars, the majority of the cores are small which seemed to be found in their late stage of exploitation. The remaining 9 cores have revealed 4 or more flake scar numbers on their surface.

The ripples left by the shock wave provide information to determine in which direction the flakes was removed. Based on this, four major groups of cores were identified, and each of these groups is representing a slightly different set of reduction sequence during the removal of flakes. More than half (14 cores) had single platforms in which flakes were removed from a single platform. These are single platform non-prismatic cores in which flakes were exploited on partial face of the cores. This single platform non-prismatic cores accounts for 61 % of the total core group, followed by opposed double platform and bipolar core each of them form 13% (3 cores each), double platform 8.7%(2 cores), and multiple platform 4.3% (1core) as it has presented in table 6.

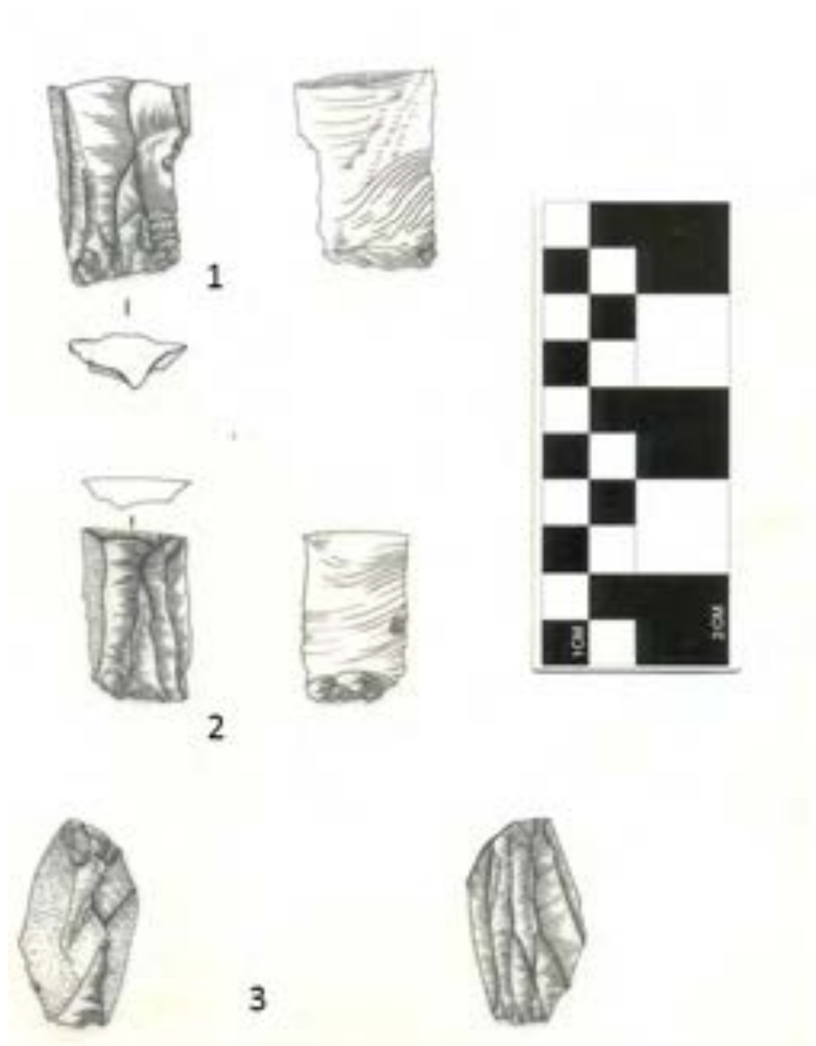


Figure 16: the various core types: 1) Multiple platform core; 2) Single platform Core; 3) Bipolar Core.

As it has presented in table 5, uni-lateral single platform core dominated B1s4 core assemblage. The analysis of these cores has shown that they are made in two ways. In one way, a flake was taken unidirectional from a block fragment/indeterminate piece which has plain (flat) surface or prepared faceted platform served as the striking surface. 78.5% of single platforms are bladelet cores and the negatives of their flaking surface shows parallel or sub-parallel scars and flat (plain) or prepared faceted striking platforms. In the other method, relatively big flake fragment was chosen and faceted striking platforms were prepared systematically which served as a striking platform. These cores-on-flakes had yielded small flakes which morphologically fall on bladelet category. These unilateral-single platforms were identified in different stage of exploitation which exhibited from 1 to 6 negative flake scar numbers on their flaking surface.

In case of opposed double platform core, flakes are taken on opposed striking platforms. This is bidirectional exploitation of the flaking surface more or less from parallel striking platforms at opposite ends served as striking platforms. 3 cores or 13% have opposed double platform from the total core assemblage. Alike unilateral-single platform cores, the flaking surface of these cores revealed parallel or sub-parallel small scars. On the other hand, double Platform Cores from B1s4 do not have opposed platforms. There three double platform cores and flakes were taken on two different striking platforms which are not found in opposed end. Two cores have more than two striking platforms and they can be grouped as multiple platform core.

4.3.5.2. Flake and Flake Fragments

Flakes and flake fragments include whole flakes (includes also bipolar flakes) and broken flakes fragment category respectively which all together account for 25.3% of the whole lithic assemblage. Flake fragments are essentially refers to broken pieces of flakes only and does not include broken blade and bladelets. It includes proximal flake fragments where still preserve the platform. It also incorporates medial and distal fragments. From a total 969 flake fragments, 445 are proximal flake fragments. The cause of their breakage is not investigated on this study, but it may have occurred during production or use. It may occur also because of post depositional activities.

The majority of these flakes and flake fragments (864 pieces) were discovered from PS1 stratigraphic unit which yielded 84.0% of the collected flakes and flake fragments. PS1 stratigraphic unit produced 116 pieces or 11.2% of flake and flake fragment assemblages. 5 pieces were discovered on the surface and the remaining 43 pieces were collected from the surface and PS1 stratigraphic unit together as these pieces are found kept in the same bag.

Types		**N**	**% from the total flake assemblage**
Flakes		54	5.6
Bipolar Flakes		5	0.5
Flake Fragments	Proximal Flake	519	53.5
	Medial Flake	281	29
	Distal Flake	169	17.4
Total		969	

Table 7: inventory of Flakes as whole flakes and fragments

The ratio of whole flakes from the total debitage assemblage is low and it accounts only 1.5%. From the total 59 whole flakes, 5 of them are bipolar flakes which all of them were discovered from PS1 stratigraphic unit. The majority of these whole flakes and proximal flake fragments have punctiform platform which accounts 73.4%. This was followed by indeterminate (10.6%), plain platform (7.3%), faceted platform (4.5%) and point platform (4.1%). The length-breadth- thickness measurement of these whole flakes range from 11 X 5.1 X 1.4 (mm) to 59.9 X 37 X 14.6 (mm), with mean value of 19.6 X 13 X 3.8 (mm) respectively.

4.3.5.3. Blades and Blade fragments

As it has been presented in section 2.7, blades and bladelets vary each other on the basis of metric attributes such as length, width, length/width ratios or combination of all these. Based on measuring attributes, a total of 34 whole blades and 73 broken blades were recognized from B1s4. These number account for 0.9% and 1.8% of all the debitage assemblage and 0.8 and 1.8% of the total lithic assemblage respectively. The length-breadth-thickness measurement value of whole blades ranges from 26.6 x 10.5 x 2.0 (mm) to 68.8 x 25.2 x 14 (mm) with a mean value and standard deviation of 40.0 x 14.1 x 5.2 (mm) and 11.9 x 14.1 5.2 respectively. The length-breadth ratio of blades measures 2.8 mm.

Figure 17: selected blades blanks

About 90.7% and 2.8% of blades and blade fragments together were discovered from PS1 stratigraphic unit and the surface respectively. The remaining 6.5% of blades and blade fragments were discovered from the surface and PS1 stratigraphic unit as these artifacts was found bagged together in a single bag. Four types of platforms were identified from blades and proximal blade fragments that preserved their striking platforms. From a total of 72 or 6.9% pieces that preserved their striking platforms, only 5 (7%) pieces have prepared faceted platforms. Plain and point platforms form 16.6% and 20.8% respectively. More than half (40 pieces) of the remaining blades and proximal blade fragments have punctiform platform which accounts for 55.6%. From a total of 72 pieces, 23 blades and proximal blade fragments together have revealed trimming marks on the dorsal face below the butt which provides information about the preparation of the striking platforms. This was the remnants of platform preparation of the core prior to the removal of the flake.

4.3.5.4. Bladelets and bladelet fragments

As it has been presented in chapter 2, bladelets are widely defined as flakes having length equal to or greater than twice their width (length/width ratio= 2:1) and also defined by maximum width of 12 mm, and maximum length of 50 mm. It includes also flakes longer than 50 mm, but its width yet not exceeds 12 mm. Based on this definition, 34 whole bladelets and 110 bladelet fragments were recorded and the number together accounts for 3.7% of the debitage assemblage and 3.5% of the total lithic assemblage.

Figure 18: Long and thing bladelets blanks

80.3% of these bladelets and their fragments were collected from PS1 stratigraphic unit. PS2 stratigraphic unit has yielded 10.9% bladelets and bladelet fragments together. The remaining 8.8% bladelets and their fragments were uncovered on the surface and/or PS2 stratigraphic unit as these artifacts were bagged together in one bag. Whole bladelets and proximal bladelet fragments which preserve their proximal end have revealed various platforms. Unlike the blades, prepared faceted platforms were not recorded. Like the blades, punctiforms are the dominant platforms identified from the bladelets and punctiform platforms account for 67.2%. This was followed by point (26.2%) and plain (6.6%) platforms. Like blades, some of these bladelets and some proximal fragments have revealed series of small flake scars or trimmings below the butt or platform on their dorsal face. These distinguished flake scars or trimmings were prepared prior to the removal of these bladelets. The bladelets and proximal fragments which have trimming scars below the platform account for 21.3%. The length-breadth-thickness measurement value of whole bladelets range from 14.1 X 3.8 X 1.2 to 41.7 X 11.7 X 6.9 (mm) with a mean value and standard deviation of 21.6 X 7.7 X 2.3 (mm) and 8.1 X 2.0 X 1.2 respectively. The length-breadth ratio of these bladelets measures 2.8mm.

4.3.5.5. Chips and shattered pieces

Chips and shattered pieces are part of the debitage category and they account 10.8 % and 22.8% of the while lithic assemblage of B1s4. From the total debitage categories, chips and shatters form 11.2 % and 23.5%. Pieces which grouped as chips are small flakes and according to Butler (2005:41), chips are by-products of flaking, platform preparation or retouching. Chips exhibit all characteristic features of flakes. On the other hand, shatters are products of knapping, but they do not display one or more of the main recognition features of flaked pieces. Finally, chips and shattered pieces yield diagnostic information that knapping was taking place at the site.

4.3.6. Tools

Tools category include detached lithic artifacts that have revealed signs of deliberate modification on its edges and/or surfaces and also those flaked stone artifacts that shows signs of modification or edge damage as a result of use. Based on this criteria, B1s4 tools lithic assemblages includes both shaped/retouched pieces as a result of modification and unshaped/utilized pieces as a result of use. According Brandt *et al* (2012) unshaped (informal) tools are defined as tools which have "minimally invasive edge damage/ retouch ('utilized') or irregular, discontinuous retouch ('modified'), whereas shaped tools have more invasive having minimally invasive edge damage/retouch ('utilized') or irregular, discontinuous retouch ('modified'), whereas shaped tools have more invasive, patterned, and repetitive retouch". This modification took place on the thin and long lateral edges and/or distal edges of the flaked artifacts. These various tool compositions amount to 131 pieces or 3.2% of the total lithic assemblage. They comprise 77 various retouched and 54 utilized pieces which exhibiting continuous retouch along their edges.

Type		N	% from the total tool assemblage
Tools		131	
Shaped/ Retouched pieces		**77**	
	Backed	6	4.6
	Borer	2	1.5
	Burin	16	12.2
	Microliths	3	2.3
	Notched	5	3.8
	Retouched	31	23.6
	Scraper	14	10.6
Unshaped		**54**	
	Utilized Pieces	54	41.2

Table 8: inventory of various tool classes from B1S4.

As it is presented in table 8, shaped tools form 1.9% of the whole analyzed assemblages of B1s4 and 58.8% of the tool categories. It is composed of 6 backed, 2 borer, 16 burin, 3 microliths, 5 notches, 31 retouched and 14 scraper pieces. On the other hand, all unshaped tools are composed of only from utilized pieces which form 41.2% of the tools categories and 1.3% of the total assemblages of B1s4. The most common category of shaped tools is retouched pieces, which is made up 40.2% of the shaped tools. This is followed by burins and scrapers, which are formed 20.8% and 18.2% respectively. Other tool classes such as backed tools, borers, denticulate, microliths and notched pieces form all together the remaining 19.8% of the shaped tool assemblage.

4.3.6.1. Scrapers (N=14)

B1s4 had yielded 14 scrapers which form 18.8% of shaped tools. Flakes and blades were used as blanks for scrapers which seemed to be elongated blanks were seemed to be preferred for edge modification. From the total 14 scrapers, 11 of them were collected in PS1 stratigraphic unit, 1 from the surface and 2 of them were collected in unidentified unit. These scrapers were found in fresh (11 pieces or 78.6%) and moderately (3 pieces or 21.4%) abrasion conditions. Typologically, 4 different types of scraper were recognized. These are end scraper, side scraper, end and side scraper and double end scraper.

Scraper type	Total number	% from the total scraper tools
End scraper	10	71.5
Side scraper	1	7.1
End and side scraper	1	7.1
Double end scraper	2	14.3
Total	14	100%

Table 9: different classes of scraper in number and percentage and their blank types

As it has represented in the table 9, the most common type of scraper is single end scraper which represents 71.5% of the scrapers and 18.2% of shaped tools assemblage. This is followed by double end scrapers (14.3%), end and side scraper (7.1%) and side scraper (7.1%). The length-breadth- and thickness measurement ranges from 19.3 x 11.3 x 4.4 (mm) to 58.1 x 35 x 14.5 (mm) with a mean 40.5 x 21 x 7.5 (mm). The length/breadth, length/thickness and breadth/ thickness ratios have a mean value of 1.9 x 5.4 x 2.8 (mm) respectively.

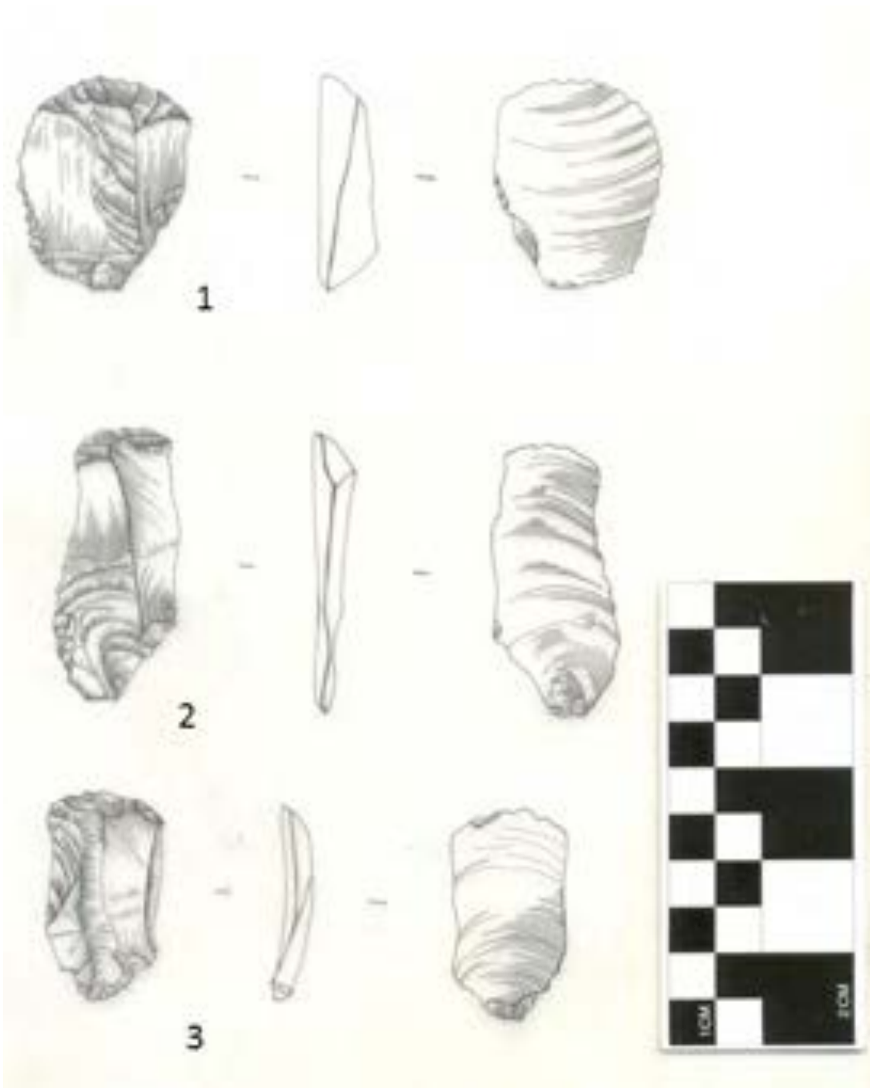


Figure 19: end scrapers drawing illustration, 1 end scraper on a broken piece and 2 and 3 are ends scrapers on blades

78.6% or 11 scrapers are convex end scrapers when it was viewed from the dorsal surface. This is followed by 2 straight retouched shape which account for 14.3% and 1 nosed scraper shape which form 7.1%. Analysis of these scrapers has yielded information that the makers seemed to prefer to use the distal end of the flakes/blades which have convex distal end. Only a single side scraper was identified and this scraper had modified edge along the longest lateral edge. There is a considerable amount of variation in the degree of the scraper angle that ranges from 43 to 85 degree. Very steep (> 80 degree), steep (60-80 degree) and flat (from 40-60 degree) degree scraper angle was recognized. From the total fourteen scrapers, only one scraper had a very steep (85^0) scraper degree angle and the steep scraper accounts for 7.2%. Most scrapers are dominated by flat scraper degree angle that account for 71.5% of the scraper assemblage. The remaining two scrapers have revealed steep scraper angle and these scrapers produced 14.3% of the scraper assemblage. The distribution of the retouch along the edges of these scrapers is continuous and the extent of the retouch on these scrapers is considered as light in which the retouch scars were not extended far from the edge. With regards to the position of retouch, all scrapers display unifacial retouch which is directly took place on the exterior surface along the distal/ lateral edges flakes/ blades.

4.3.6.2. Use Wear Study of Scrapers

In order to understand the function of some tools, use wear study was conducted on a total of 14 tools (morphologically called scrapers) (see the Appendix) by Elizabeth Peterson who is a PhD candidate from Simon Frazer University. All the scrapers were recovered from PS1 stratigraphic unit which characterized by ashy fill deposit. According to Peterson (2015) report, this ashy deposit has protected the tools from most depositional wear (i.e. trampling) and where thus well situated undergo a use wear study.

Hardness Type	Material Type
Animal Soft	Raw Meat, Fish, etc.
Vegetable Soft	Plant Matter
1 Medium	Wet/ Soften Hide
1 Medium	Soft Wood, Dry Hide, Wet Bone
1 Hard	Dry Bone, Hard Wood
2 Hard	Dry Antler
3 Hard	Stone and Ground Earth

Table 10: use wear hardness scale revised from Odell 1979 (after Peterson , 2015).

The results of this use wear study has yielded that from a total 14 studied tools, 13 of them were used as either scraping or cutting motion (Table 10). According to Peterson (2015) report, the most dominant motion was scraping and such kind of motion was indicated by scraping located on one face of the tools and this motion was identified on 10 tools. Small feather fractures and medium sized hinged fractures use wear pattern running close to one another primarily on one face were identified. The type of polish use wear pattern was also identified and this natty polish found primarily on the opposing face from the flake scars, but along the used edge. Thus these use pattern indicate the tools were used for working wet/soften hide (1M-table 9). According to Peterson (2015), previous experimental and ethnographic research results has suggested that the scrapers may have been used to process soften hide (wet hide). But, using residual analysis and use of higher power microscope study would help to identify the use wear pattern more clearly (Table 10).

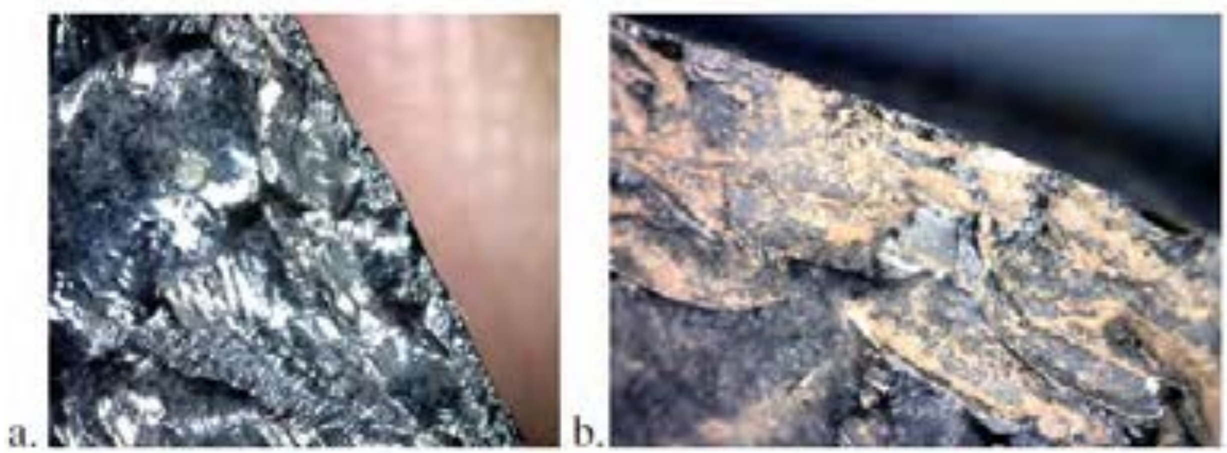


Figure 20: a. Bulbula scraper showing 1m scraping wear at 60x magnification. b. Wolayta scraper showing 1m scraping wear at 60X magnification (after Peterson, 2015).

Of the 10 scraping tools, hafting wear was identified on 3 of them. These hafting wear traces were found located on the opposite end of the tool from the scraping wear. Like, the scraping wear, the hafting wear was revealed in a form of small feather and some small-medium sized hinge fractures clumped together and appearing on both faces of the tools. Polish wear was not recognized. But to understand better, higher magnification should be needed.

Retouching of these 10 scraper tools were conducted before and possible during use. In southern part of Ethiopia ethnographic study has been conducted on hide workers and the results of the ethnographic study have provided that the hide workers in order to clean the hide scarpering, they will retouch the tools, hitting off small flakes from one surface (that of the opposite of the contact edge).

The other activity identified for the scraper class was cutting. This cutting motion was identified on 4 tools only and was created during the cutting of some type of soft vegetable or animal material (Table 9). From the total four tools, only one of these cutting tools was used as scraper. Based on the study result of Peterson (2015) on these tools, the cutting motion and the type of material of these tools were indicated by light rounding accompanied by feather flake scares running along the right lateral edge seen at 40X magnification (figure 21). Attempts have been done to identify the hafting wear, but it was not recognized on any of these tools during this primary research.

Figure 21: a. Experimental tool used in a cutting motion on 1V at 50X magnification. b. Bulbula scraper showing cutting of 1V at 50X magnification.

4.3.6.3. Burins

A total of 16 burins, which form 20.8% of the shaped tools were identified. Except one burin which was collected on the surface, the others were uncovered from PS1 stratigraphic unit. All burins are made up of either burin on truncation or burin on break. Each group represents 50% of all the burins and these two burin classes seem to be the major pattern of production in the site. In case of burin on break, the knappers used the broken distal or proximal end as burinated facets and were removed burins spalls on the lateral edge with one or more blows. The analyzed burins exhibited flat lateral edges /flat distal ends or burin spall scars on the lateral edges where burin spalls were removed over it. No burin spall scars are recorded on the dorsal surfaces of the flakes.

Burin Dimension	Minimum	Maximum	Mean	Std. Deviation
Length (mm)	16.1	61.2	30	10.5
Breadth (mm)	5.6	24.3	14	5.0
Thickness (mm)	2.6	10.4	4.7	2.1
Weight (gm)	0.3	6.0	2.3	1.5

Table 11: Descriptive statistics of burin

Morphological dimension of these burins vary considerably as it has presented in table 10. The length-breadth- and thickness measurement ranges from 16.1 x 5.6 x 2.6 (mm) to 61.2 x 24.3 x 10.4 (mm) with a mean value of 30 x 14 x 4.7 (mm) respectively. The length/breadth, length/thickness and breadth/ thickness ratios have a mean value of 2.1 x 6.4 x 3 (mm) respectively.

4.3.6.4. Other shaped tools

These tools category constitute all together 20.8% of all shaped tools from B1s4. They include 3 microliths, 2 borers, 2 denticulates, 6 backed pieces and 3 notched pieces. Borers and denticulates constitute the lowest percentage of all shaped tools in which each of them account for 2.6% of all shaped tools. This is followed by microlithic and notched pieces which each of them form 3.8% of all the shaped tools from B1s4.

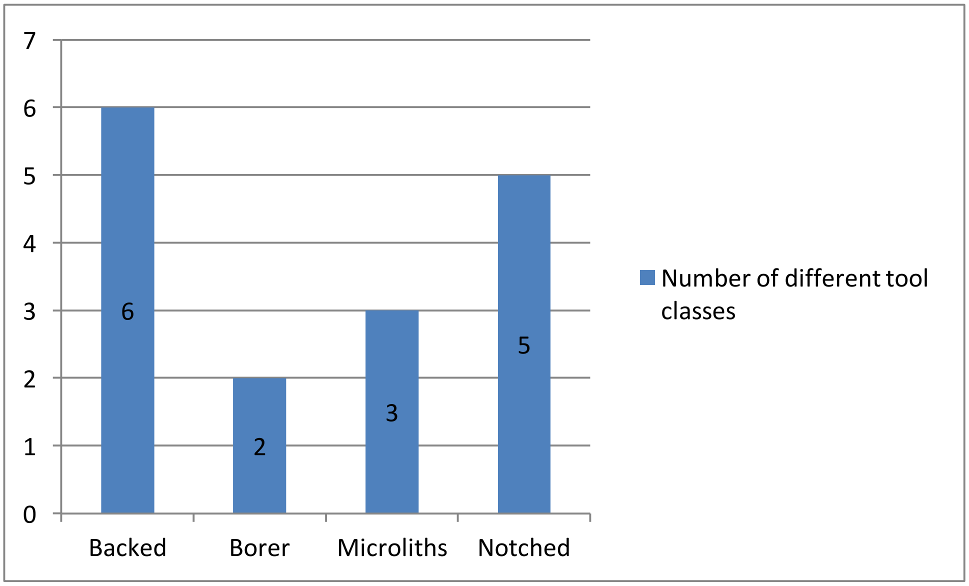


Figure 22: the graphs represent the frequency of different tool forms

All the microlithic and all notched pieces were discovered from PS1 stratigraphic unit. Despite backed microliths are often considered as diagnostic markers of LSA culture, only 3 microliths were discovered from B1s4. From these 3 pieces, one of the pieces is curved backed and the remaining two are straight backed.

Figure 23: Straight backed pieces from B1s4, bulbula.

Microlithic piece Dimensions		Minimum	Maximum	Mean	Std. Deviation
	Length (mm)	8.9	12	11.3	2.1
	Breadth (mm)	3.5	6.8	4.9	1.6
	Thickness (mm)	1.2	3	1.8	1.0
Notched Piece Dimensions	Length	22	41.2	29.7	7.5
	Breadth	10.8	45	22.9	13.5
	Thickness	3.8	10.6	6.6	2.7
Backed piece Dimensions	Length (mm)	17	45.5	28.7	11.8
	Breadth (mm)	9	19.5	14.7	3.8
	Thickness (mm)	3	6.6	5.0	1.2

Table 12: Descriptive statistics of microliths, notches and backed pieces

As it has presented in the table, the length dimension of microliths varies from 8.9 to 12 (mm) with the mean value 11.3 mm. In the same way, the breadth and thickness dimensions of microliths varies each other which the morphological dimension of breadth-thickness measurement ranges from 10.8 x3.8 (mm) with mean value of 6.9 and 2.0 (mm) respectively. Like the microliths, length-breadth-thickness dimensions of backed pieces are also show measurement variations that ranges from 17 x 9 x 3 (mm) to 45.5 x 19.5 x 6.6 (mm) with mean value of 28.7 x 14.7 x 5.0 (mm) respectively.

Notched pieces from B1s4 revealed light concavity on the margin of a flake or a blade. Out of the five notched pieces, 3 flakes exhibit a single concavity on their lateral edge in which such kind of retouch is made by a single blow. On the other hand, the remaining two flakes, exhibit notches which were created by very small and continuous retouch. The length of notched pieces varies from 22 to 41.2 (mm) with a mean value of 29.7mm. Breadth-thickness dimension descriptive analysis of the notched tools are also varies from 10.8 x 3.8 (mm) to 45 x 10.6 (mm) with a mean value of 22.9 mm and 6.6 mm respectively.

4.3.6.5. Utilized tools

During the analysis of B1s4 lithic artifacts, utilized tools are considered as a class of unshaped tools that reveals evidences of utilization and or modification along their edges. They are not referring to any lithic artifact that shows evidence of pattered modification in their edge. According to Nelson (1973: 242 *cited* in Brandt 1982: 95), unshaped tools are characterized by casually trimmed ("modified") edges or casually retouched ("utilized") edges which are ubiquitous to most East African LSA industries. Based on this definition, flaked pieces that have shown trimmed ("modified") edges or casually retouched ("utilized") edges are classified as utilized pieces.

Figure: 24: photo illustration of utilized broken blade fragments.

Utilized flakes form 41.2% of all the tools and 1.3% of the total lithic assemblage from B1s4. The majority of these utilized pieces were made up of fragments of flake, blade or bladelets which all together accounts 65.5 % of the total utilized pieces. The remaining utilized pieces were made up of whole flakes (7.4%), blades (16.7%) and bladelets (7.4%). Length-breadth and thickness measurement dimensions of these utilized pieces ranges from 10 x 5 x 1.6 (mm) to 107 x 31 x 10.9 (mm) with a mean value of 29 x 12.4 33 (mm) and standard deviation 17.7 x 5.3 1.8 respectively. From the total 54 utilized pieces, 47 (87%) of them were collected from PS1 stratigraphic unit. The surface and PS2 stratigraphic unit together have yielded the remaining 7 (13%) of all utilized pieces.

Chapter Five
Discussion and Conclusion

5.1. Lithic reduction sequence analysis

5.1.1. Raw material procurement and site function

Lithic reduction sequences include various stages such as acquisition of raw materials, core preparation and initial reduction, optional primary trimming, optional secondary trimming, and finally optional maintenance and modification (Collins, 1975). The first marked stages of reduction sequence (acquisition of raw materials) are linked to the distribution and availability of raw materials. This distribution and availability of lithic raw materials play an important role to understand how humans manufactured, used and reconfigured stone tools (Anderfsky, 2008). Efforts to locate the raw material sources of B1s4 have been made by the project Late Stone Age Sequence in Ethiopia. Obsidian chemical analysis was conducted by Khalidi but results are not available yet (Khalidi *et al*., in preparation *cited* in Ménard, 2014). Preliminary results from survey conducted on the obsidian sources around the Bulbula River (figure 2) and obsidian samples collected from the excavated materials has shown that the prehistoric inhabitants of Bulbula exploited the local raw materials which are widely available. Based on Bon and Dessie field report (2010) the more likely obsidian source for Bulbula sites including B1s4 could be the Alutu Volcano which is located only a few kilometers away from the site. This primary observation is supported by the presence of various debitage products on the site such as core trimming flakes, expedient flakes, unretouched blanks and debris dominating the whole lithic assemblage which could indicate the inhabitants of B1s4 had an easy access to abundant nearby raw material sources.

Once the raw materials were obtained from the sources, testing and shaping of the blocks into rough-outs of optimal shape and transportable size allowed them being carried to the nearby workshop and/or habituation sites that might took place elsewhere and were subsequently transported into the site. Primary reduction did not taken place on the camp site. This is supported by the absence of natural blocks, as well as cortical flakes and flakes with cortical platforms which indicate initial stages of the reduction sequences did not take place there. This is further supported by the fact that other production stages which did take place on the site and are represented by large number of debitage pieces such as shatters and chips, shaped tools, different types of blanks and discarded cores all together. The presence of all these various types of pieces proves that the majority of reduction sequences were taken place at the site except initial stage of reduction.

B1s4 was not only used as lithic production campsite, but it was also an ephemeral occupation site for Bulbula foragers. This idea is supported by the presence of faunal remains as well as shaped tools that show traces of use-wear. The analysis of the faunal remains shows that B1s4 faunal assemblage was dominated by mainly bovid. Among these bovid, only one species could be identified. It is an extinct species (*Damaliscus hypsodon*) that is very abundant in the nearby site of B1s1. Despite detailed investigation has not yet been conducted on B1s4, preliminary investigation on B1s1 faunal remains, which is very close in time and space to B1s4, show intentional breakage, traces of burning and spiral-shaped fracture on more than 30% of long bones which may lead to suggest cooking activity and extraction of bone marrow was taking place on the site (Lesure, 2013 *cited in* Habte 2013).

In addition, the discovery of shaped and unshaped tools (which form together 3.2% of the total lithic assemblage) and finally discarded on the site after use has strengthened the argument that suggests B1s4 was habituation site. The discovery of tools on the habitation site is an important source of information to determine the function of the site. But, according to Anderfsky (2005:210), the association of artifact morphology with artifact function pose question and does not have fully acceptance by researchers nowadays. Because, correlations between artifacts form and function is almost universally rejected by ethnographers and ethnoarchaeologists (Anderfsky, 2005). But, macroscopic variability in the stone tool form can also provide information to determine the function of the site. In our case, the function of the site is determined by micro-wear study of the tools. From the total 14 tools (morphologically called scrapers) which were analyzed by Peterson (2015), traces of use wear were recorded on them. Of the total 14 tools, 13 were identified as having been used in either a scraping or cutting motion. Tools with scraping motion wears were used to process soften hide (wet hide). On the other hand, there are tools which show traces of cutting motion and these tools were used for cutting some type of soft vegetable or animal material. So, these tools might have been used on the site and finally discarded there. Therefore, all these evidences provide information that the prehistoric people at Bulbula (B1s4) had multiple functions such as habitation, knapping workshop and probably butchery site alike B1s1 (see Habte, 2013). But, no cut marks were identified on the bones from B1s1 and this absence brings doubt on the importance of butchery on the site (Lesur, 2013 *cited in* Habte, 2013).

Habte (2013:81) associated the multi functionality of B1s1 with the harsh environmental condition that prevailed during the terminal Pleistocene. He argued that the extreme harsh environmental condition of the terminal Pleistocene could probably limit movement of hunter-gatherers from their habitation to butchery site and finally could limit themselves to restrained environments where they undertook multiple tasks. This argument also seems to work for B1s4 where multi-oriented activities took place on the site.

5.1.2. Reduction Sequence

Freehand core reduction method was the most dominant one using single, double, and multiple platform core types. A single bipolar core and 3 bipolar flakes were identified and the presence of these cores and flakes indicate that bipolar core reduction method was used at B1s4. Various core types, from single to multiple-platforms, were recognized and each group representing slightly different set of reduction sequence. Only one core with cortical platform was identified and flakes were removed from either plain platforms created by removed flakes or facetted platforms formed by removing small flakes. The majority of the cores are small in terms of sizes which results from either over-exploitation or technical choice of the knappers for the production of small bladelets using small flaked pieces. From the total 23 cores, 20 or 95.3% are bladelet cores which provide important data to suggest that B1s4 lithic industry was oriented towards the production of bladelets rather. From these cores, flakes were knapped using from plain to facetted platforms in which the facetted butt on some of the cores are prepared by inversely retouched the broken edge knapped pieces. Cores with facetted platform were also recorded from older Bulbula sites and Ménard *et al*. (2014) indicate these cores had the appearance of an inverse truncation. It seems that the reduction sequence took place by keeping transversal and longitudinal convexities blade and bladelet core morphology as indicated by the presence of crescented blades, bladelets and flakes with pointed distal ends.

When we relate the source of B1s4 to the reduction stages and the final artifacts, it makes us to question about it. Despite yet we are waiting the final results, it is argued that B1s4 hunter-gatherers had an easy access to the abundant raw material sources which are not far from the site.

Sites identified near a raw material sources usually yield abundant cores which have been discarded in their early stage of reduction sequence. On the opposite at B1s4, the ratio of cores to flakes is too small and even the available cores are found in an exhausted stage of exploitation or made from flakes (core-on-flakes). So, the lack of cores on the site in one hand and over-exploitation of the available cores on the other could tell that easy accessibility and availability of raw material do not necessarily mean an abundance of cores discarded in their early stage of reduction sequence. Elston and Kuhn (2002) pointed out that other than distance for access to raw material source, the mobility of prehistoric society might have been affected by environmental, social and behavioral motives for procurement of raw material.

Butt morphology variability yields information about the overall flaking techniques and technology. They are useful indicators to determine the type of hammer used during the flaking, stage of tool production and the size of detached pieces (Andrefsky, 2005: 89). Butts recorded from various flaked pieces indicate that hunter-gatherers of B1s4 had practiced various flaking techniques. Despite the limited number of bipolar flakes and cores identified from the total assemblage the use of bipolar technique could be identified (figure 16/1). Soft hammer flaking technique could be also used. From the total flakes which preserved their butts, punctiform and point platforms types are dominated the assemblages in which such kind of platforms is the results of soft hammer percussion technique.

5.2. **Cultural affinities and chronological place of B1s4 within local and regional LSA framework**

5.2.1. Cultural tradition and chronological sequence

Analysis of the debitage on both unit levels (PS1 and PS2) indicate the presence of similar features that lead us to assume that B1s4 lithic industry was oriented towards the production of blades and bladelets. From a techno-typological perspective, there appears to be no significant change among the two assemblages (PS1 and PS2) except the amount of artifacts in each level. In fact, the total numbers of artifacts discovered from PS2 stratigraphic unit are too small to afford a meaningful comparison with PS2 stratigraphic unit. But, the artifacts from both levels have LSA attributes which are characterized by the presence of blades and bladelets other than flakes and other kinds of shaped tools (e.g. end scrapers, burins), in which closely correspond to "Ethiopian Stone Tool Tradition". The butts of knapped pieces also provide comparable technical data as plain and punctiform striking platform types are appeared to be the dominant features at both levels. Therefore, comparative results of these techno-typological data could confirm that the hunter-gatherers occupied B1s4 have not brought a significant technological and typological change on lithic production at both levels despite temporal gap existed between both levels.

The cultural industry B1s4 could be compared to what Brandt (1980: 1982) and Clark and Williams (1978) are referred as "Ethiopian Blade Tool Tradition". According to Brandt (1982), "Ethiopian Blade Tool Tradition" is characterized by six distinct features. The first distinct feature of this technological tradition is almost exclusive use of obsidian and more rarely chert as a raw material. This argument works well for B1s4 where all the pieces are made up of exclusively obsidian artifacts.

Other than the raw material type, according to Brandt (1982) "Ethiopian Blade Tool Tradition" is also manifested by the use of soft hammer and punch-technique for primary production of flakes and blades from a single to multiple-platform tabular and prismatic cores. Of course this argument proposed by Brandt is also supplemented by B1s4 as the butt of the majority of flakes are either punctiforms or point which provide useful information to suggest soft hammer or punch technique was practiced to remove thin and long flakes more likely with a non-prismatic cores. Despite the absence of prismatic cores needs scrutiny investigation, it may be related to a small sample size of the core assemblage uncovered in B1s4.

"Ethiopian Blade tool tradition" is also represented by the dimension of flake/blade which flake/blade ratio ranging from 2:1 to 3:1. The metric attributes recorded from blades and bladelets from B1s4 has shown that they are part of this significant dimensional definition. The other significant feature of "Ethiopian Blade Tool Tradition" is the proportional lack of shaped tools component. According to Brandt (1982), shaped tools are dominated by microliths, endscrapers, and burins, but generally lack *outils ecailles* and points. These characteristic features of "Ethiopian Blade Tool Tradition" could be also characteristic feature of B1s4 but lacks microliths (only three pieces) in B1s4 which may show cultural adaptation and subsistence strategy shift took place during the Terminal Pleistocene.

5.2.2. Environmental and cultural comparisons

As it has been presented in chapter three, there are limited number of LSA occurrences which have been reported within Ethiopia and East Africa. Some of these LSA sites in Ethiopia and East Africa closely correspond to in time and space as well culture with B1s4. Among these LSA occurrences in Ethiopia only few of them are very close in time with B1s4 and these are B1s1, DW2s2 and DW2s1 at Bulbula in the Ziway-Shala Basin (Ménard *et al*., 2014), Aladi Spring (Gossa *et al*., 2012; Clark and Williams, 1978); Lake Besaka (Brandt, 1982); K'one (Kurashina, 1978); Porc Epic; and Laga Oda, (H.Breuil, 1938 *cited* in Kurashina, 1978; Kurashina 1978; Brandt, 1986). Some of these sites share strong cultural affinities with B1s4. Particularly B1s1 in the Bulbula Valley which is characterized by blade technology (Habte, 2013) and "Ethiopian Blade Tool Tradition" at Lake Besaka and other LSA sites in Ethiopia are closely share significant LSA feature with B1s4 as it has been presented below at this chapter. Outside Ethiopia, there are LSA sites in the Horn and East Africa somehow correspond in terms of chronology and technological behavior with B1s4. GvJm19 cultural sequence from Lukenya Hill in Kenya (Kusimba, 2001) and Mumba Rock in Tanzania (Marks and Conard, 2008; Diez-Martin et al. 2009) are important LSA sites in East Africa.

Local Comparisons: The paleoenvironmental and chronological data which provide information about Upper Pleistocene in general and terminal Pleistocene in particular are very limited in East and the Horn of Africa. One of the site which yielded important paleoenvironmental and chronological data to elucidate cultural and chronological sequences of terminal Pleistocene hunter-gatherers came from different localities of Bulbula and Deka Wede (a tributary of the Bulbula) in the Ziway-Shala Basin. The archaeological sites at Bulbula were radiocarbon dated by AMS and brought two clusters of dates which are separated by a time gap corresponding to the LGM. Sites dated to the earliest phase were fallen at the end of MIS 3 or pre-LGM and these groups include B1s3 and DW1. On the other hand sites at Bulbula and Deka Wede canyon which are fallen at the later phase dated at the beginning of MIS 1 (Post-LGM) or the onset of African Humid Period. Post-LGM sites include B1s1 locality dated to the very end of the Pleistocene at Bulbula locality, and DW2s1and DW2s2 sites dated to the very beginning of Holocene at Deka Wede locality (table 1). These sites were developed at margins of the lake and were inhabited by foragers before the last main transgression which was dated to the early Holocene. These two chronological phases are separated by Younger Dryas, which occurred at the very end of the terminal Pleistocene (Ménard *et al*., 2014). Therefore, comparison of B1s4 cultural remains at Post-LGM sites at Bulbula would provide better data to understand the chronological sequence and paleoenvironment of B1s4 hunter-gatherers during the terminal Pleistocene.

B1s4 was dated to 14,045-13,755 cal BP in PS1 stratigraphic unit and this phase is very close in time and space with B1s1 which was marked by more arid condition. The faunal remains from B1s4, which can provide data to understand paleoenviroment of the region, are limited as well as highly fragmented. But, faunal remains from B1s4 have similarities with B1s1 which is dominated bovid remains. Of the bovids, one extinct species (*Damaliscus hypsodon*) was identified and this species is particularly very abundant in B1s1 assemblage (dated on two different levels to 13,443-13214 and 13455-13193 cal BP). This late Pleistocene extinct bovid species is a dry-adapted species which may help to conclude B1s4 was also more dry during the occupation of the site (Lesur, 2013 *cited in* Habte 2013). This argument is also supported by the abundant paleoenvironmental records that indicates much of the late Upper Pleistocene in East Africa was colder and drier than at present, temperature being 5.1 to 8.8 °C lower than present (Coetzee, 1967 *cited in* Kusimba, 2001: 81) and precipitation being 5.1 to 8.8 °C in the Central Rift Valley (Gasse and Street, 1978). Fish remains are also absent at B1s4 and which is an important indicator that the basin was dried when it was occupied by hunter-gathers during the terminal Pleistocene period. In Ethiopia, this terminal Pleistocene phase was characterized by cool and dry condition and according to Brandt (1982), this phase extends ca18,000-12,000 uncal BP at Besaka which is also a characteristic feature of much of Ethiopia and northeastern Africa.

Overlying PS1 main occupation horizon, there is an occupational hiatus of 30 cm thick intermediary silt. This intermediate phase may be corresponding to other sterile horizons which are identified in the archaeological sites in Bulbula area and this sterile horizon which is interbedded between PS1 and PS2 may correspond the Younger Dryas phase which was recorded in other sites of Bulbula (see Ménard *et al.*, 2014). Above the intermediary silt, there is 15 cm undated abrupt occupation horizon and probably it is the upper most of the Terminal Pleistocene phase occupied by the hunter-gathers of Bulbula before the onset of the Holocene phase.

On the other hand, comparing B1s4 to early Holocene sites at Bulbula (DW2s1 and DW2s2) indicate a strong technological and industrial variability. These two sites very close in space but relatively far in time in which DW2s2 (dated to 11,800-11,311 cal BP) is slightly older than DW2s1 (dated to 11,335-11,175 cal BP). DW2s2 lithic production tradition is strongly marked by small lozenge shaped tanged points which were flaked on bipolar blade core (a core with two opposing platforms, not by bipolar percussion technique). On the other hand, DW2s1 is characterized by a microlithic industry the majority of them made on burin spall pieces (see Ménard et al., 2014: 65) which is almost absent from B1s4. This different industrial traditions show that notable variability exists between terminal Pleistocene (B1s4 and B1s1) and Early Holocene (DW2s2 and DW2s1) lithic assemblages collected at different sites in Bulbula.

Despite it was not dated, the probable Holocene phase at B1s4 was marked by 50cm thick pumice deposit and thick silt formation of the Early Holocene lake deposits which does not preserve any human cultural remains and faunal assemblages. This phase seem to correspond to the Holocene phase of other sites in Bulbula studied by Ménard (2014: 55) and based on his study result, this phase was either not suitable for settlement because of the basin was flooded or cultural materials were not preserved.

Alike these two upper most deposits levels, the lower and the oldest deposit level of B1s4 did not yield any cultural or faunal remains. This level was filled with brown colluviums deposit which probably corresponding to LGM period prevalent also in other sites in Bulbula (see

Ménard et al., 2014) and sites in other parts of Ethiopia (see Brandt, 1982). Ménard (2014: 55) suggested that the Ziway-Shala Basin during LGM period was filled with thick Pumice deposit (Amernosa Pumice Member) which did not preserve any cultural remains. The date of this pumice deposit has not yet been known, but it is ongoing analysis which will help to know the precise period.

Regional comparison: in addition to the terminal Pleistocene and Early Holocene sites which were found in Bulbula, there are other terminal Pleistocene LSA sites in Ethiopia that provide technological and chronological comparison to B1s4. One of these sites is Aladi Springs. Its LSA occupation horizon was dated to ca. 11 ka BP (Gossa *et al.*, 2012) LSA lithic assemblages from Aladi spring could be compared to B1s4 assemblages and the technological and typological investigation reveal that it is oriented towards the production of blades and bladelets alike B1s4 (See Gossa *et al.*, 2012).

The cultural sequence of B1s4 could also compare to sites which are found in Besaka what Brandt (1980) and Clark and Williams (1978) are referred as "Ethiopian Blade Tool Tradition" which we discussed above in this chapter. These characteristic features of "Ethiopian Blade Tool Tradition" from human occupation period of FeJx2 (dated to 11,400-19,000 BP) site at Lake Besaka can be characteristic feature of B1s4 except lack of microliths and prismatic cores in B1s4 lithic assemblage.

The radiometric date of K'one is also correspond with the dates of B1s4. The site yielded both MSA and LSA assemblages and its LSA deposit was after 14,700 ± 200 BP which synchronous with the rise in Lake Shala in the Main Ethiopian rift at or after 14,400 BP (Krushina, 1978; Grove *et al.*, 1975). Despite both B1s4 and K'one were dated to Terminal Pleistocene and represented by LSA assemblage, they show variability in their lithic composition. Technologically, B1s4 is oriented towards the production of blades and bladelets from single to multiple-platforms cores.

Outside Ethiopia, one of the site in East Africa which have a relative close chronology is Lukenya Hill in Kenya. There are six sites at Lukenya Hill and of the six at least four of them have levels dated to the terminal Pleistocene period. One of the site which is very close in chronology with B1s4 is GvJm62 and it was dated to 12,195 ± 330 (radiocarbon date BP) based on samples taken from 130-140 cm below the datum point. There are also other sites such as GvJm16, JvJm19 and JvJm22 and dated to 13,150 ± 200 (120-125 cm below the datum), 13,705 ± 430 (115-120 cm below the datum), 13,730 ± 430 (190-200 below the datum) respectively. But these dates are unlikely to be correct, because bones are exposed to modern carbon contamination from soil carbonate and humic acids, affecting their likely age (Brooks and Robertshaw, 1990 *cited in* Kusimba, 2010: 97). Alike B1s4, typologically, scrapers are the dominate group from the total tool assemblage at Lukenya Hill sites. But unlike B1s4, microliths are widely identified tool assemblages from Lukenya Hill sites followed by a small member of burins (Kusimba, 2010).

5.3. Conclusion

Cultural adaptation occurs when changes in all aspects of life such as changes in technology, organization, ideology and changes in physical environment take place. An adaptive strategy of the hunter-gathers at B1s4 is expressed by the change of some of shaped tools which had been widely used at a local and regional scale before and after the terminal Pleistocene. During the terminal Pleistocene, the environment was more arid and significant tools such as microliths which were used before were not anymore important at B1s4 as well as B1s1 (see Habte, 2013). For example at a local scale, comparing B1s4 to Early Holocene sites from

Bulbula (DW2s1 and DW2s2) which provided an important technological and industrial variability. These two sites very close in space but relatively far in time in which DW2s2 (dated to 11,800-11,311 cal BP) is slightly older than DW2s1 (dated to 11,335-11,175 Cal BP). This different industrial traditions shows that notable variability exists between terminal Pleistocene (B1s4 and B1s1) and Early Holocene (DW2s2 and DW2s1) lithic assemblages collected at different sites in Bulbula as an adaptive strategy to the environmental change occurred after the terminal Pleistocene and might have forced the hunter-gathers in sites to develop new adaptive strategies.

During the terminal Pleistocene, the environment was more arid and significant tools types such as microliths which were used before the terminal Pleistocene in other sites were not any more important at B1s4 as well as B1s1 (see Habte, 2013). For example, LSA cultural sequence at Lake Besaka was dated to both pre- and post- terminal Pleistocene yielded a considerable amount of microliths which are almost absent in the terminal Pleistocene sequence of B1s4. Instead the assemblage yielded relatively more scrapers, burins, and unshaped utilized pieces. According to Habte (2013:88), B1s1 also lacks microliths and yielded instead other shaped tools such as scrapers .The analysis of B1s4 materials indicate microliths were not necessarily widespread during the terminal Pleistocene LSA which it corresponds to change in material culture (hunting gears) or adaptation (hunting strategies).

Appendix

Usewear Report

Bubula

June 2015

Elizabeth Peterson

Usewear Analysis

A small usewear study was conducted upon a selection of shaped obsidian tools classified as different types of scrapers from the site of Bubula (n=14). The goal of this study was to identify the use of the scrapers, complementing the morphological analysis and expanding understanding of the nature of the lithic assemblage for this site.

The usewear study was conducted by PhD Candidate Elizabeth Peterson from Simon Fraser University. Peterson has spent the last three years conducting experimental usewear studies aimed at understanding lithic assemblages from sites found throughout Ethiopia. She has recently finished an ethnoarchaeological usewear study conducted upon the Wolayta hideworkers located in the south of Ethiopia.

Methods

Usewear analysis is the study of the function of tools based on the complex analysis of all traces of use, including macro-deformations, micro-linear traces and polishes. All aspects of wear can be reduced to a twofold change that include: 1) alteration in shape and 2) reduction in volume. Experimental studies have shown that through use, the contact edge of a stone tool will change in form based on the material being worked as well as the motion of use. Wear features observed and tracked include edge scaring (micro flakes), abrasion (rounding), and polish. When taken as a whole, the wear pattern and location of polish should reveal tool motion and worked material. The type of material being worked is identified through a hardness scale (fig 1).

Low-power use-wear analysis involves using a stereomicroscope with a polarizing external (and with the new digital microscopes, an internal as well) light source and has a magnification power of 10-100X. Most motion can be detected through this form of analysis as well as most worked material types including wet and dry hide, hard wood, and soft animal and vegetable materials. Specific wear features observed using low-power analysis include edge rounding and crushing, shallow edge scarring, striations, and some micro-polish.

Hardness Type	Material Type
Animal Soft	Raw Meat, Fish, etc.
Vegetable Soft	Plant Matter
1 Medium	Wet/ Soften Hide
1 Medium	Soft Wood, Dry Hide, Wet Bone
1 Hard	Dry Bone, Hard Wood
2 Hard	Dry Antler
3 Hard	Stone and Ground Earth

Figure 1: Usewear hardness scale revised from Odell 1979

A total of 14 tools where selected for the analysis based upon their morphological type (i.e. scraper) and their stratigraphic location. All tools where recovered from ashy fill deposits. Such deposits help to contain the tools, providing protection from most post depositional wear (i.e. trampling) and where thus well suited to undergo a usewear study. Past experiments and ethnographic tools where used ascomparisons to aid in the identifying of specific wear patterns and a blind test was conducted to check the skills of the analysis before the study commenced.

The method used within the analysis is the standard low-power usewear method developed by Dr. George Odell (1977). Before evaluation, each stone was washed carefully in water and then lightly bathed in 50% acetone to clear away any hand grease that could be confused as polish under microscopic inspection. The tools were then each evaluated under a stereomicroscope of 6 to 80X magnification, tracking the location, type, and frequency of the different wear attributes.

Results

Of the 14 tools studied, 13 were identified as having been used in either a scraping or cutting motion (Table 1). The most common motion found was that of a scraping motion (indicated by the scaring located on one face of the tool) and identified upon 10 of the tools. The wear pattern typesidentified upon these scrapers (small feather fractures with corresponding medium sized hinged fractures running close to one another primarily on one face) along with the type of polish and its location (matty polish found primarily on the opposing face from the flake scars but along the used edge) indicate the working of a material that falls under 1M (fig 1). Past experimental and ethnographic studies conducted by the analysis suggest that the scrapers may have been used to process soften hide (wet hide), though a high power study and residue analysis could identify this more clearly (fig. 2).

a.  b. 

Figure 2: a. Bubula scraper showing 1m scraping wear at 60x magnification. b. Wolayta scraper showing 1m scraping wear at 60X magnification

Possible hafting wear was also identified upon 3 of the 10 scraping tools. This wear was found located on the opposite end of the tool from the scraping wear and was found in the form of small feather and some small-medium sized hinge fractures clumped together and appearing on both faces of the tool. No polish was identified though highermagnification should be used to further explore this.

All 10 scrapers were identified as having been retouched before and possibly during use. Ethnographic studies have shown that hideworkers in southern Ethiopia, to clean the hide scarpering tools during use, will retouch the tools, hitting off small flakes from one surface (that of the opposite of the contact edge).

A total of 4 tools were identified as having been used in a cutting motion on some type of soft vegetable or animal material (Table 1). Only one of these cutting tools was also identified as having been used as a scraper. The cutting motion and type of material of these tools was indicated by the light rounding accompanied by feather flake scares running along the right lateral edge seen at 40X magnification (fig. 3). Hafting wear was not identified on any of the tools though more research is needed to further explore this.

a.  b. 

Figure 3: a. Experimental tool used in a cutting motion on 1V at 50X magnification. b. Bubula scraper showing cutting of 1V at 50X magnification

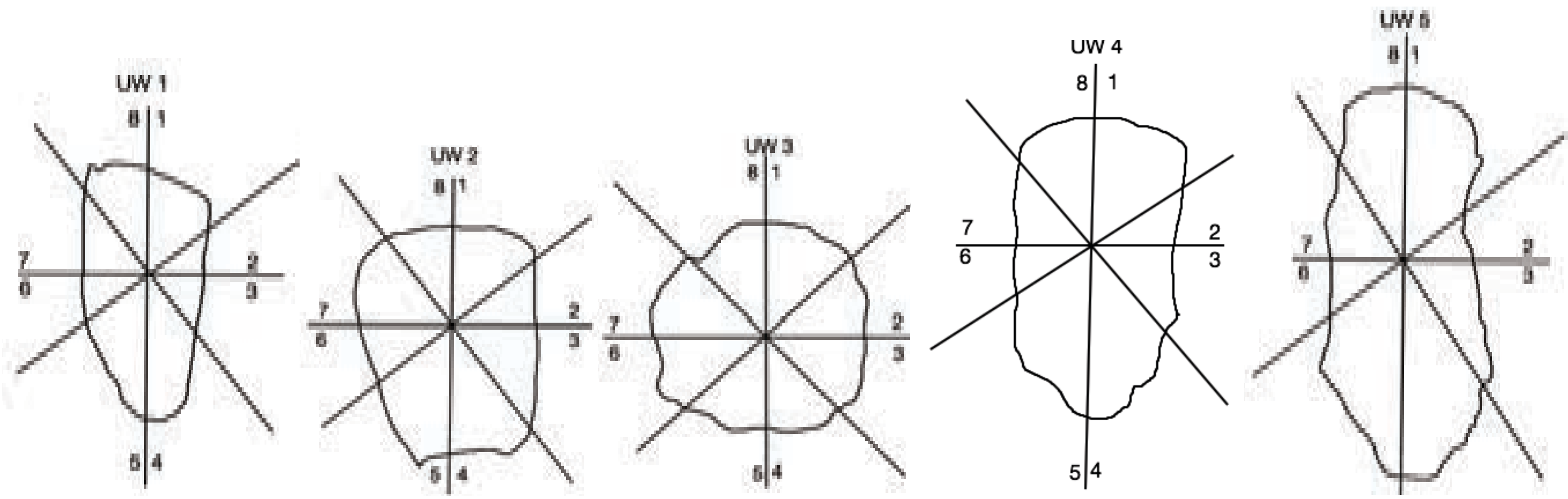
Conclusion

The usewear study conducted upon the scrapers form the site of Bubula confirms that 10 of the 14 labeled scrapers where indeed used in a scraping motion. The material primarily being worked by these scrapers was identified as being softened hide (wet hide) confirmed by experimental and experimental studies of obsidian scrapers from southern Ethiopia. The other activity identified for the scraper class was cutting. All except for one of these cutting tools showed now sighs of having been used as a scraper. The possible scraper retouch of which identifies these tools as scrapers morphologically may have come not from retouch or use, but through post-deposited wear and or during the tools manufacturing (crushing and/or platform prep).

Table 1: Usewear data for all scrapers

				Abrasion			Scarring							
EU	PC	ACT	WM	Rdg	Pol	Loc	L	D	T	S	RM	Ret	Type	Artifact n
1	8-1	6	1M	MR	N	D	D	R	FH	SM	OBSIDIAN	D	SCRAPER	1
2	6-7	1	VS	LR	N	D	D	R	FH	S	OBSIDIAN	N	SCRAPER	1
3	4-5	23	N	MR	MP	B	B	P	FS	SM	OBSIDIAN	N	SCRAPER	1
1	7-2	6	1M	MR	N	D	D	C	FH	SM	OBSIDIAN	D	SCRAPER	2
2	2-6	23	N	LR	MP	B	B	P	FB	SM	OBSIDIAN	N	SCRAPER	2
1	7-2	6	1M	MR	MP	D	D	R	FH	SM	OBSIDIAN	D	SCRAPER	3
2	3-6	23	N	LR	N	B	B	P	FH	SM	OBSIDIAN	N	SCRAPER	3
1	8-1	6	1M	LR	N	D	D	R	FH	SM	OBSIDIAN	D	SCRAPER	4
1	8-1	6	1M	LR	MP	D	D	R	FH	SM	OBSIDIAN	D	SCRAPER	5
1	3-5	6	1M	LR	N	D	D	C	FH	SM	OBSIDIAN	D	SCRAPER	6
2	7-2	2	N	LR	N	B	B	P	FB	SM	OBSIDIAN	D	SCRAPER	6
1	7-2	6	1M	MR	MP	B	D	R	FH	SM	OBSIDIAN	D	SCRAPER	7
1	4-5	6	1M	MR	MP	B	D	C	FH	SM	OBSIDIAN	D	SCRAPER	8
1	5-7	1	AS	LR	MP	B	B	P	F	S	OBSIDIAN	N	SCRAPER	9
2	1-4	1	AS	LR	MP	B	D	R	FC	SM	OBSIDIAN	N	SCRAPER	9
3	4-5	23	N	LR	N	D	D	P	F	M	OBSIDIAN	D	SCRAPER	9
4	8	0	0	0	0	0	0	0	0	0	OBSIDIAN	0	SCRAPER	9
1	6-8	1	VS	LR	N	B	D	R	F	S	OBSIDIAN	N	SCRAPER	10
2	8-1	6	?	LR	N	D	N	N	N	N	OBSIDIAN	D	SCRAPER	10
1	4-5	6	1M	MR	MP	B	D	R	FH	SM	OBSIDIAN	D	SCRAPER	11
1	2-4	1	VS	LR	N	D	D	R	F	S	OBSIDIAN	N	SCRAPER	12
N	0	0	N	0	0	0	0	0	0	0	OBSIDIAN	0	SCRAPER	13
1	8-1	6	1M	LR	N	B	V	R	FH	SM	OBSIDIAN	V	SCRAPER	14

Polar coordinates for all scrapers



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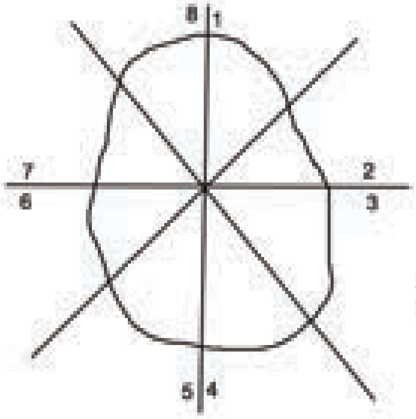

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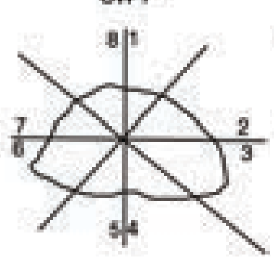

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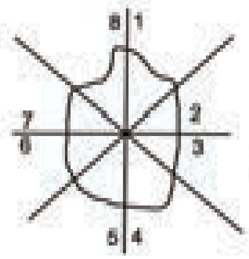

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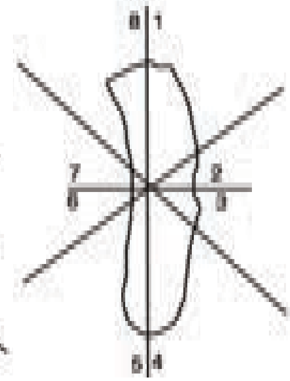

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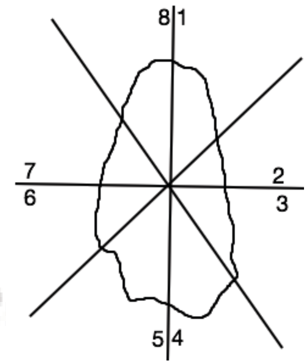

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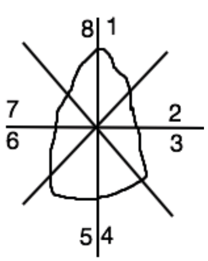

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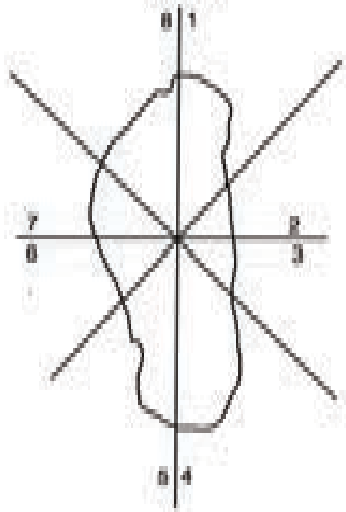

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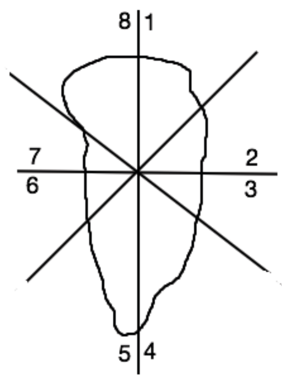

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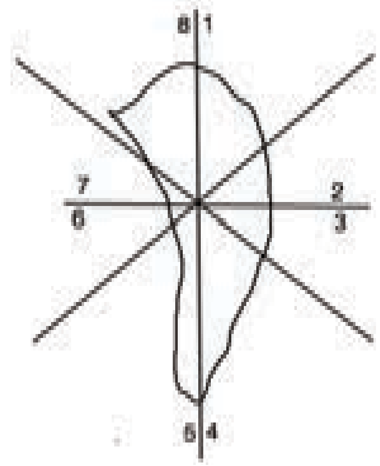

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