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An Investigation of Later Stone Age Lithic Assemblages from Laga Oda Rock shelter, Southeastern Ethiopia

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This is to certify that the thesis presented by Seminew Asrat entitled: An Investigation of Later Stone Age Lithic Assemblages from Laga Oda Rock shelter, Southeastern Ethiopia submitted in partial fulfilments for the Degree of Master of Arts in Archaeology compiles with the regulations of the university and meets the accepted standard with respect to originality and quality.

Approved by the examining committee

Supervisor---------------------------------Signature--------------------Date--------------

Co-supervisor-----------------------------Signature-------------------Date--------------

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

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

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Abstract

The Laga Oda rock shelter stands among the key sites in Ethiopia yielding evidence of LSA lithic assemblages. Despite an initial preliminary report in the 1970s, a more detailed and state-of-the art techno-typological and attribute analysis of the recovered LSA lithic assemblages remains limited. This study examined the LSA lithic assemblage (n=563) of the Laga Oda rock shelter using techno-typological and attribute features and provided insight into the behavioral, technological, subsistence, and occupation nature of prehistoric populations of southeastern Ethiopia. Various distinct typologies of LSA artifacts with retouch and none-retouch elements including flakes, cores, flake fragments, backed pieces, scrapers, denticulate, and burins have been documented. The lithic technology and morphologies of the assemblages suggest production techniques might have involved multiple type of percussions including bi-polar, hard hammer, soft hammer as well indirect percussion. Particularly, the study reveals backed pieces (n=203) are the most significant portion of the whole assemblages retaining unique technological features. The comparisons of Laga Oda backed pieces with other contemporaneous sites of Goda Buticha and Mochena Borago revealed both similarities and variations in technological and typological aspects of the LSA assemblage during the Middle and Late Holocene. The rock shelter and the eastern side of the rift escarpment may also have acted as a sporadic refugium during alternating warm and cool periods of the Marine Isotope Stage (MIS)-1.

Keywords: LSA, Laga Oda, Southeastern Ethiopia, terminal Pleistocene, Holocene

CHAPTER ONE

1. Introduction

Lithic tools are the most ubiquitous and durable archaeological records and they allow us, archaeologists, to make inferences about ancient human cultural development, subsistence, and behaviors (Andrefsky, 2009). The availability of raw materials in eastern Africa could have facilitated technological and behavioral changes expressed in the variable environments occupied by Late Pleistocene and Holocene populations in sub-Sahara Africa. Subsequently, studies on the lithic assemblages from the Late Pleistocene and Holocene have been the foci of archaeological research.

The Late Pleistocene and Holocene periods are characterized by major technological, environmental, and climatic changes in the Horn of Africa (Brandt & Carder, 1987, Brandt et al., 2012; Hildebrand, 2003). These environmental and climatic variations could have affected the technological and economic history of prehistoric societies. Because the prehistoric lifestyle, technology, and economy of the past society may have been affected during such environmental and climatic alterations, the impact and dynamic relationships could be reflected in the stone tool industries.

Thus, understanding the technological development and economic history of ancient people in light of the changing environment during the Late Pleistocene and Holocene periods is crucial. This study aims to provide an up-to-date understanding of the cultural history of Later Stone Age (LSA) hunter-gatherers, the pattern of sedentism, and environmental adaptation based on lithic assemblages recovered at Laga Oda rock shelter during the 1975 archaeological test excavations.

The lithic assemblages are currently housed at the prehistoric section of the (Authority for Research and Conservation of Cultural Heritage (ARCCH).

1.2. Problem statement

Over the last few decades, researchers working in the Ethiopian region have long been emphasizing documenting the Early and Middle Stone Age rather than the Late Stone Age cultural sequence (Yonatan, 2020). The same holds true for the Laga Oda rock-shelter, where despite an initial preliminary report (Clark and Williams, 1978) and stratigraphic and technological section description by Kurshna (1978), a more detailed and state-of-the-art techno-typological and attribute analysis of lithic assemblages remain limited.

Despite its relevance to issues of neolithization and subsequent human occupation of the region, a detailed description of the occupational sequence and the material record retrieved from occupation layers that reveal the economic lifeways of the site's occupants is far from complete. Similarly, previous authors failed to recognize intra-site and inter-site stratified occupation comparisons to understand variations and/or uniqueness of LSA technologies in time and space.

Investigating the Laga Oda LSA lithic materials is crucial to obtain a better understanding of the implications on behavioral and technological and subsistence of the prehistoric society during the terminal Pleistocene to Holocene period. Thus, to improve our understanding of the time-span and technological and economic history in southeastern Ethiopia, the investigation of the Laga Oda LSA materials housed at the ARCCH is timely and significant. Apart from characterizing the LSA assemblages from the site, attempts have been made to assess the LSA assemblages within a comparative framework of published lithic assemblages from broadly contemporaneous Middle and Late Holocene sites of Goda Buticha and Mochena Borago to better understand the nature of technological variation and similarities.

1.3. Objectives

1.3.1. General objective

The central goal of this thesis is to understand the techno-typological characteristics of LSA assemblages from the Laga Oda site so as to refine our knowledge on the behavioral and economic implications of the Holocene occupation sequences.

1.3.2. Specific objectives

The thesis has the following specific objectives.

- To carry out all the necessary curatorial procedures on the lithic assemblages and associated archaeological materials from the site that enhances their preservation.
- To examine, and characterize the technological and typological attributes of the Laga Oda LSA lithic assemblages housed at ARCCH.
- To identify the types of raw materials, use, exploitation strategies, and extant variabilities within the assemblages.
- To conduct an attribute analysis of the Laga Oda lithic assemblages and document the patterns of chronological variability.
- To reconstruct the technological and economic history of the site
- To draw comparisons and establish cultural and chronological relationships with other contemporaneous sites

4. Research questions

This thesis will research into many aspects of the LSA assemblages at Laga Oda in order to seek answers to a series of questions, including the following:

1. What were the general characteristics of human occupations in southeastern Ethiopia and the Horn of Africa during terminal Pleistocene and Holocene?
2. What are the basic characteristics and chronology of the LSA lithic assemblages from Laga Oda?
3. What are the techno-typological and morphological features of LSA assemblages at Laga Oda?
4. What does the variability/similarity in raw materials indicate?
5. Do the LSA assemblages of Laga Oda exhibit differences in attributes compared to other contemporaneous sites?

1.5. Materials and methods

According to Kurashina (1978), more than 10,000 lithic artifacts were recovered from the 1975 excavation at Laga Oda. Most of the lithic artifacts were taken abroad for preliminary analysis and were sent back to Ethiopia (Kurashina, 1978) but could not be localized yet. At the moment, about 563 pieces are available for examination at ARCCH. In this research, those LSA specimens recovered during the 1975 test excavation were analyzed.

Identification and description of techno-typological attributes of lithics artifacts were conducted at the ARCCH Lab. To do so, dimensions of LSA artifacts were measured using an electronic digital caliper. Attribute analyses and graphic representations were employed to help demonstrate variability in raw materials within the Laga-Oda lithic assemblage. Photographsand profile of representative lithic specimens and within the LSA assemblages from Laga Oda was drawn and enhanced digitally using adobe-photoshop to show details on the edge, dorsal and ventral sides of the specimens. We have also employed 3D light photo scan using Shining 3D Scanner to understand the type of retouches and morphology of the lithics. All figures, unless where they are specified, are attributed to the author of the thesis.

In terms of measurement, maximum dimensions including maximum length, maximum width, maximum thickness, and thickness at a maximum width of flakes, scrapers, bladelets, and other artifacts were carried out. For backed pieces, more attribute analysis of qualitative and quantitative variables has been employed. These include measurement of weight, proximal back thickness, medial back thickness, distal back thickness, mean back thickness, and others. Qualitative variables such as types of butt, bulb, curvature, twisting, retouch type, transverse symmetry, back location opposed edge transform, and opposed edge angle was employed for detailed analysis and comparison. These approaches of backed pieces analysis were adopted from Leplongeon and her colleagues (Leplongeon et al., 2020).

A comparison of lithic assemblages from Laga Oda was made with other LSA sites of Goda Buticha and Mochena Borago sites which are dated to the Middle and Late Holocene period from previously published sources. The comparison is aimed to understand the nature and characteristics of artifacts at the inter-site level, and to get insights on trends of change and continuity across time and space.

A combination of qualitative (observation) and quantitative (measurement) methods was used to analyze Laga Oda assemblages. Statistical analysis (SPSS and Excel) on the techno- typology of the assemblages were employed to aid data presentation and intra-site and inter-site comparison of the assemblage. The significance of statistical differences in the distribution of several variables between assemblages of the three sites was assessed using Pearson Correlation for independent study design. Moreover, an analysis of the morphological features and types of raw materials of the LSA assemblages at the site was carried out using multivariate SPSS statistical analysis to assess extant variability.

1.5.1. Inventory and documentation

One of the objectives of this project is to carry out an inventory of the LSA assemblages from the Laga Oda rock shelter available in the ARCCH. This is to know the materials and prepare a database for effective laboratory curation and conservation purpose. Documentation of artifact contexts and certation of a digital archive that can be easily used by local authorities were made. Accordingly, previous locational descriptions, stratigraphic units, current provenance, localization, depth inventory numbers, sorting, labeling, and artifact numbers are maintained. In the process, we have encountered the missing of many lithic artifacts particularly chunks that are not still localized. Even some labels on the artifacts were hard to read so that we labeled them with new artifact numbers.

	Provenance	Localization	Depth	Inventory	Sorting	Labeling	Artifact no.
2	Basement	2 x 1m test pit	10-20 cm below datum	E75/597	shaped tools	L10-20AB	2
3	Basement	D1	0-20 cm below datum		shaped tools	erased	erased
4	Basement	Lower shelter	surface collections		shaped tools	LO E75/surface	1
5	Basement	Lower shelter	surface collections		shaped tools	LO E75/surface	2
6	Basement	D1	40-50 cm below datum	E/75/559	shaped tools	LODI 40-50	4
7	Basement	D1	40-50 cm below datum	E/75/559	shaped tools	LODI 40-50	6
8	Basement	D1	40-50 cm below datum	E/75/559	shaped tools	LODI 40-50	7
9	Basement	D1	40-50 cm below datum	E/75/559	shaped tools	LODI 40-50	8
10	Basement	D1	40-50 cm below datum	E/75/559	shaped tools	LODI 40-50	9
11	Basement	D1	40-50 cm below datum	E/75/559	shaped tools	LODI 40-50	10
12	Basement	D1	40-50 cm below datum	E/75/559	shaped tools	LODI 40-50	11
13	Basement	D1	40-50 cm below datum	E/75/559	shaped tools	LODI 40-50	13
14	Basement	D1	40-50 cm below datum	E/75/559	shaped tools	LODI 40-50	14
15	Basement	D1	40-50 cm below datum	E/75/559	shaped tools	LODI 40-50	15
16	Basement	D1	40-50 cm below datum	E/75/559	shaped tools	LODI 40-50	16
17	Basement	D1	40-50 cm below datum	E/75/559	shaped tools	LODI 40-50	17
18	Basement	D1	40-50 cm below datum	E/75/559	shaped tools	LODI 40-50	18
19	Basement	D1	40-50 cm below datum	E/75/559	shaped tools	LODI 40-50	19
20	Basement	D1	40-50 cm below datum	E/75/559	shaped tools	LODI 40-50	20
21	Basement	D1	40-50 cm below datum	E/75/559	shaped tools	LODI 40-50	21
22	Basement	D1	40-50 cm below datum	E/75/559	shaped tools	LODI 40-50	22
23	Basement	D1	40-50 cm below datum	E/75/559	shaped tools	LODI 40-50	23
24	Basement	D1	40-50 cm below datum	E/75/559	shaped tools	LODI 40-50	24
25	Basement	D1	40-50 cm below datum	E/75/559	shaped tools	LODI 40-50	26
26	Basement	D1	40-50 cm below datum	E/75/559	shaped tools	LODI 40-50	27

Table 1. Inventory activities, attribute, and technological data entry to excel at the ARCCH lab.

1.6. Significance of the study

This laboratory-based research is expected to broaden the existing knowledge and open up research avenues on future investigations and revisiting of prehistoric sites in southeastern Ethiopia particularly the terminal Pleistocene and Holocene periods. It can also enhance understanding of the technological and behavioral development and cultures of prehistoric people. In addition to empirical data, the research will also provide knowledge to many of the long-standing inquiries about the identity and diversity of LSA technology in the Horn. In general, researchers, academicians, students, and individuals interested in prehistory will benefit from the research.

1.7. Organization of the thesis

The thesis is organized into five chapters. The first chapter provides the general background of the research, the archaeological potential, and research design including objectives, materials, and methods. Chapter two presents a review of the literature on the East African and Ethiopian Stone Age, LSA microlithic characterization, environmental and climatic dynamism during the LSA. The third chapter deals with the environmental and geological setting of the study area. The archaeological background of the site is also discussed in detail in the third chapter. The fourth chapter deals with the results of the analysis (data presentation). The fifth chapter will present interpretations and a discussion of the findings of the research. This chapter is also dedicated to the conclusions and the way forward related to this study.

CHAPTER TWO

Review of related literature

2.1. Conceptual and methodological frameworks in lithics analysis

Lithic artifacts and their manufacturing debris constitute the bulk of evidence and invaluable insights for archaeologists into past human life and activities, resources utilization strategies, behaviour, technology, and economy (Andrefsky,2009; Goodale & Andrefsky, 2015;Tryon & Faith, 2013). Over the last half-century, there has been growing attention to lithics studies in the archaeological literature. So far, much of our present state of knowledge on the long sequence of Stone Age records come from Eastern Africa (Semaw et al., 1997; Yonatan, 2020; Shea, 2020).

Analysis of stone tools as an archaeological record has changed our understanding of prehistoric societies. Earlier investigations on lithic were mostly descriptive focusing on the documentation of the artifacts (Bordes, 1961, Binford and Binford, 1966). During these investigations, lithic typology was the main character for the definitions and specific functions of various stone tools. In this regard, the researchers often used type fossils to define lithic typology where they introduced several terminologies to a given lithic tradition attributed to the culture-history of the region.

Gradually, significant methodological and scientific developments in lithic analysis appeared to have paramount importance towards the functional and technological analysis of the lithic materials (Bordes, 1961, Binford and Binford, 1966, Andrefsky, 2005). Several studies on lithic residue and use-wear analysis revealed that the definition and nomenclature of lithic artifacts based on morphology do not correspond to their functions (e.g., Odell et al., 1987). However, this can be confirmed solely through experimental and functional investigation of stone artifacts.

Lithic terminologies are among the critical methodological and theoretical approaches to be considered seriously by palaeolithic archaeologists (Shea, 2013). Over the years, different local and regional groups of stone artifact types were named after the area in which they were first discovered (Shea, 2013).

To this day, there have been considerable disagreements among archaeologists in the modelling of lithics artifacts. Although different terminologies have been proposed by several Palaeolithic archaeologists, there are still disagreements regarding a comprehensive lithic classification (Shea, 2013). The main obstacle for lithics modelling appeared to be the versatile nature and character of lithics assemblages among different continents and regions. For a long time, European ways of classification have been employed for African prehistory (Goodale & Andrefsky, 2015). However, it turned out that African lithic industries required quite a different modelling.

Initially, Goodwin and van Riet Lowe (1929) divided the African Stone Age into three major age-stages such as the Early Stone Age (ESA), Middle Stone Age (MSA), and Later Stone Age (LSA). This classification was based on South African stone tools. Although this trichotomy Stone Age classification has its critics, it remains to be dominant in the naming and classification of the sub-Saharan Palaeolithic literature.

In the 1960s, Grahame Clark made an effort to classify the evolution of stone tools from simple to complex and developed a system based on five lithic modes (1-5). This categorization was based mainly on European stone tools, which were also applied to Africa and other continents. Clark's classification of stone technologies includes Mode-1(pebble cores and flake tools), Mode-2 (large bifacial cutting tools made from flakes and cores), Mode-3 (flake tools struck from prepared cores), Mode-4 (punch-struck prismatic blades retouched into various specialized forms), and Mode-5 (retouched microliths and other retouched components of composite tools) (Clark, 1969; Shea, 2013).

By pointing out Clark's (1969) limitation of stone tool classification, Shea (2013) has devised a new lithic category with nine main groups and eight sub-groups (A-I). Accordingly, Shea's Modes A–I naming and classification incorporates approaches of producing stone tools by percussion (mode A), by fracture (modes B–G), and by abrasion (modes H–I). Modes involving fracture are subdivided into non-hierarchical cores (modes C and E), retouched flakes (mode D), and hierarchical cores (modes F and G) (Shea, 2013:157). This classification, however, is rarely used in the literary discourses of the lithic studies in Sub-Saharan Africa.

Eventually, the use of broader terms appeared to be significant and lithic terminologies retained the initial definitions as Early Stone Age (ESA), Middle Stone Age (MSA), and Late Stone Age (LSA) which implies different periods of the African Stone Age (Phillipson, 2005; Shea, 2020). This theoretical and conceptual framework embraces terms such as technocomplex or industrial complex. According to Shea (2020), technocomplex can be described as the group of technologies broadly sharing similar characteristics but differing in other aspects.

To better understand the lithic technological organization, a conceptual approach was devised for examining the processes involved throughout tool production known as *chaîne opératoire* (operational chain). This concept refers to a step-by-step production, use, maintenance, and eventual disposal of lithic artifacts first proposed by a French prehistorian archaeologist André Leroi-Gourhan (Inizan et al., 1999; Tixier, 2012). The *chaîne opératoire* embarrasses the entire production cycle involved in lithic industry manufacturing processes. It provides Palaeolithic archaeologists to understand raw material exploitation and the processes and techniques required to make, used, discarded, and reused stone tools (Pelegrin, 1990; Andrefsky, 2005).

Lithic artifacts pass through a series of transformational processes from raw material exploitation to disposal. The technological and typological investigations of lithic assemblages are fundamental approaches to stone tool analysis (Inizan et al., 1995). The techno-typological analysis of lithic artifacts allows archaeologists to organize the artifacts into groups or types based on their morphological features. Nevertheless, lithic analysis is carried out using different approaches depending on the needs and the research questions to be addressed by the researcher (Andrefsky, 2005).

Technological analysis of stone tools involves the identification of multiple techniques and styles used to produce usable tools from various types of stone. Technological analyses are mainly focused on the techniques, methodological approaches, and *chaînes opératoires* of the lithic assemblages to obtain insight into the cognitive, social, and economic developments of an archaeological site (e.g., Pelegrin, 1993). Thus, the main purpose of the technical analysis is to understand the life cycle of stone tools, starting from raw material procurement to tool production, use, maintenance, recycling, and disposal. Similarly, the typological investigation is also another most common approach to analyses lithic assemblages. Typology is the way of describing and interpreting artifacts by organizing and arranging them based on their types, shapes, dates, and other attributes (Andrefsky, 2005; Goodale & Andrefsky, 2015).

2.2. Lithic technologies of Ethiopia: a chronological overview

Researches carried out over the past four decades came up with a long sequence of technological records of Eastern Africa (Shea, 2020). Ethiopia is a country situated in East Africa and has more than two million years of human technological history, a sequence unique and unparalleled with most countries in the world (Phillipson, 2005). The earliest indisputable evidence of lithic Oldowan technology came from Gona, Ethiopia dated back to 2.6 million years ago (Semaw et al., 1997; Semaw et al., 2003; Stout et al., 2010). More recently, a new archaeological investigation from the Ledi-Geraru paleoanthropological site of Ethiopia in the Afar depression came up with what appears to be slightly older than the Gona Oldowan tools, dated at 2.61-2.58 Ma (Braun et al., 2019).

The Oldowan industry is generally characterized by choppers, simple flakes, and core tools. This technology is associated with *H. habilis* and probably *A. garhi* (Yonatan, 2020). According to Kooyman, (2010) Oldowan tools were used for a wider variety of purposes including butchering animals and breaking bones for marrow, and for preparing vegetable foods.

However, there is putative evidence for lithic technologies dating back to 3.3/3.4mya. This oldest lithic industry in the world was discovered recently from Kenya in East Africa. Scientists named this technology the Lomekwian industry (Harmand et al., 2015; Dominguez-rodrigo, 2016). The Lomekwi culture nonetheless raises several debatable issues. One of the main critics of this technology was the possibility of artifacts that could drop down from the slope from a younger deposit (Yonatan, 2020). This was not, however, the only evidence attributed to the earliest use of the lithic industry in Africa.

Circumstantial evidence suggesting the earliest use of the stone tool in Ethiopia comes from carcass cut marks from the Dikika paleoanthropological site in Ethiopia (McPherron et al., 2010 *but see*Yonatan et al., 2017). The researchers believe that the Dikika bone modification and the Lomekwi stone tool evidence might shed light on the current understanding of human evolution that Pliocene hominins have produced an industry dated beyond 3 million years ago (Dominguez-rodrigo, 2016). These discoveries are, however, still questioned by many scholars(e.g. Yonatan et al., 2017).

The technological advancement that appeared in Ethiopia following the Oldowan is the Acheulean techno-complex. At about 1.8 million years ago, a more refined and multi-purpose form of heavy-duty technology appeared in Ethiopia (Berhane et al.., 1992;Yonas et al., 2013). This techno-complex is dominated by Large Cutting Tools(LCT) and hand-axes(Kooyman, 2010). These are bifacial tools characterized by standardized shape and size and symmetrical on frontal side and profile(de la Torre, 2011; de la Torre et al., 2014).

The Acheulean techno-complex is associated with *Homo erectus* (*Homo ergaster*). It has been suggested that the Acheulean industry could have been used for butchery, woodcutting, digging, and other related functions (Kooyman, 2010). There are several Acheulean bearing sites in Ethiopia particularly along the Great Ethiopian Rift Valley that include Konso-Gardula, Middle Awash, Melka Kunture, and Gona among other things (e.g., Berhane et al., 1992; Semaw et al., 1997; Chavallion et al., 2004)

The timespan following Acheulean to the beginning of permanent settlement was generally characterized by recurrent settlement, environmental variability, and population increment which in turn resulted in cultural and biological evolution (Klein, 1995). The evolution of archaic *Homo sapiens* to Anatomically Modern Humans (AMH hereafter) is believed to have occurred, although the prevailing genetic studies came from another continent mainly Europe. Likewise, except with few regional variations, technological evolutions are almost similar in most parts of Africa. However, technological changes from one mode to another had barely happened at the same time (Phillipson, 2005).

The Acheulean techno-complex was gradually replaced by Levallois technology in Africa and particularly Ethiopia; the MSA. Discoidal cores, scrapers, sub-triangular points, and edge-retouched pieces are the dominant elements of the MSA lithic industries (Yonatan, 2020; Shea, 2013, 2020). Sites in eastern Africa have provided rich human fossil evidence dated to 195,000 and 160, 000 years ago from Kibish and Omo, and the Middle Awash respectively (Yonatan, 2020).

2.3. The MSA-LSA transition

During the last 250,000 to 10,000 years, the African continent had experienced swift technological developments and regional diversification (Klein, 1995)). The Middle Stone Age (MSA) to Late Stone Age (LSA) techno-complex transition in Africa has been a subject of scholarly debate (e.g., McBrearty and Brooks, 2000). The term 'transition' by itself is found to be vague for many as it was indicated by archaeologists (Leplongeon et al., 2018; Yonatan, 2020). Many scholars have argued that there is a lack of any universally accepted time frame that can separate the MSA from LSA (Clark and Williams, 1978; Phillipson, 1982; Brandt, 1986; Brandt and Fattovitch, 1990; Finneran, 2007). Nonetheless, it is commonly understood that the transition represents the time period when both MSA and LSA technologies coexisted, and more reduced, backed flakes appeared and LSA replaced MSA tool kits (e.g., Tryon, 2019).

The MSA/LSA transition in Africa has often been associated with the anatomical and behavioral emergence and development of AMH as they were considered to be the main producers of the technology (Klein, 1995; McBrearty and Brooks, 2000)). Eventually, changes in the typology of lithic artifact production accelerated markedly after about 30,000 years ago in many parts of sub-Sahara Africa although the timing and tempo of these changes vary across the regions (Tryon, 2019).

It has been proven from previous studies that East African sites have great relevance in yielding evidence of both MSA and LSA technologies. The MSA/LSA transition in eastern African sites predates other regions of the continent (Ambrose, 2002). Evidence exhibiting features of both MSA and LSA lithic artifacts began to appear probably around 50ka at the Enkapune Ya Muto rock shelter in Kenya (Ambrose, 1998; Ambrose, 2002; Gismondi et al., 2020). The Levallois lithic types of MSA tradition appeared in Africa spanning the time between 300,000 until 20,000 BP (Bon &Fauvelle-Aymar, 2014).

In Ethiopia, some sites which were investigated intensively have provided significant information about the transition period. Despite this, there are many more sites that remained poorly understood yet (Bon and Fauvelle-Aymar, 2014). It is only after 30 ka that consistent LSA lithic components are believed to have appeared in Ethiopia (Leplongeon et al., 2020). Porc Epic, Goda Buticha, sites in Ziway-Shala basin (B1s3, DW4, Agadima Shelter 2 sites), Mochena Borago and, K'aaba (western Ethiopia) are some of the sites yielding Levallois cores, points, microliths, scrapers, and blade cores exhibiting both MSA and LSA lithic components (e.g., Fernandez et al., 2007; Brandt et al., 2012; Menard et al., 2014; Behailu, 2020). These sites provide information on the MSA/LSA transitional period for they preserve assemblages diagnostic to both the MSA and the LSA technological features (Leplongeon et al., 2018).

2.4. The LSA techno-complex

Understanding the origin and character of LSA technology can provide insight into the evolution and development of the biological and technological behavior of Modern humans and its dispersal in and out of Africa (Ambrose, 1990, 1998; Elston et al., 2002). Arguably, a universal trend when it comes to lithic industries is the tendency toward microlithization during the end of the Late Pleistocene (Elston et al., 2002). In sub-Saharan Africa, backed pieces with flakes and blades and/or bladelets are often considered as the hallmark of the LSA (Ambrose, 1998).

John Goodwin (the first professional South African archaeologist) and Clarence Van Riet Low (a South African civil engineer and archaeologist) coined the term *'Later Stone Age'* for the first time to assign the lithic industries of the last phases of South African Paleolithic technology (Goodwin & Van Riet Lowe, 1929). For Goodwin and Van Riet, LSA was characterized by "the flat striking platforms, fine longitudinal parallel flaking, and even, steep secondary trimming" (Goodwin & van Riet Lowe 1929: 150).

Microlithic technologies that appeared in Africa followed by MSA were named the Wilton industry in the early days (Clark, 1954). Eventually, scholars like Deacon (1984) came up with a broader character and elements of LSA including rock arts, microlithic tools, organic materials, use of mastic, ostrich eggshells, shellfish beads, fishing equipment, bone tools, and others. Bon and Fauvelle-Aymar (2014) stated that the technology and typology of the LSA stone industry are highly diverse and considered as a 'catch-all' concept. LSA tool kits are extremely specialized and highly complex both spatially and temporally.

Despite extant variations, the LSA techno-complex is generally characterized by microlithic tools such as geometrics (lunates, trapezes, and triangles), blades, or blank miniaturization with a variety of both retouched and unretouched flakes (Phillipson, 1982; Ambrose, 2002; Pargeter and Shea, 2019). Important variations have also been observed in these microlithic technologies consisting of edge-retouched tools, backed flakes, and bladelets during the 50,000-2000 BP interval (Phillipson, 2005). These technologies might have been made for mounting onto hafts as a hunting weapon (Yonatan, 2020).

Crescents/lunates (moon-shaped tools), blades (blanks with the length at least twice its width), scrapers (with one or more longitudinal sharp edges), burins (a blade with a transformation perpendicular to an edge, increasing its angle), and denticulate (irregular notched edges) are among the typical diagnostic features of LSA tool kits (Ambrose, 1998).

2.5. LSA sites in Ethiopia

Despite the tremendous efforts that have been made over the past decades by several researchers investigating LSA sites in the Horn of Africa (Clark, 1954; Clark and Williams, 1978; Phillipson, 1982; Brandt, 1986; Bon et al., 2006; Finneran, 2007; Hildebrand and Brandt, 2010), the lithic assemblage recovered from well-stratified sites remains still scanty. An exception would be Menard and his colleagues (2014) who recently documented and described several LSA sites and lithic assemblages in Ziway-Shala Basins (Central Main Ethiopian Rift).

Compared to early prehistory and/ or the historic periods, archaeological researchers have paid little attention to Late Stone Age(Bon et al., 2006). Since the 1970s, prehistoric investigations have focused on the study of early prehistory and rock-art, rather than the late prehistory. Only recently, some efforts have been made (Bon et al., 2014; Coudert et al., 2020; Gutherz et al., 2014; Schepers et al., 2020; Ashkenazy and Yonatan, 2021) to research into the LSA period. Particularly some LSA sites in Ethiopia have been intensively studied and provided significant insights into the potential and diversity of this technology (Ménard et al., 2014; Gossa et al., 2012; Brandt, 1986, 1982; Clark and Williams, 1978; Kurashina, 1978). Yet to better understand the technological, behavioral, and economic implications of the LSA of Ethiopia, stratigraphically sequenced, a radiometrically well-dated and large number of lithic materials are required (Menard et al, 2014).

Most of the LSA sites are distributed along with the Great East African Rift system, eastern, southern, northern, and western part of Ethiopia. It is not uncommon to expect LSA artifact-bearing sites in the Ethiopian rift system owing to its rich potential of providing a long archaeological sequence of the ESA and MSA records. Despite the marginalized nature of the archaeological research, it has also been suggested that there are ubiquitous LSA materials in all corners of the country (Bon et al., 2014; Finneran, 2007).

The majority of LSA sites are concentrated in and around the Ziway-Shala basin situated in the MER following the Bulbula River valley (Bon et al., 2006). These research areas are composed of four different lakes (Ziway, Abijata, Langano, and Shala) and have recently attracted better research attention. The archaeological potential of the area was known since the 1970s. The basin has been investigated in detail since 2007 by a project called 'LSA Sequence in Ethiopia'. This research project has come up with the discovery of several archaeological sites attributed to the MSA and LSA cultural sequence (Bon et al., 2013). The sites are dated to two occupational phases. The oldest archaeological records from these sites are dated to the end of MIS 3, and Later occupational horizons are dated between the terminal Pleistocene and Early Holocene (Bon et al.,2006; Menard et al, 2014). The two occupational phases are separated by a long chronology without any archaeological remains during the LGM (Bon et al., 2014).

Goda Buticha is one of the LSA sites situated in southeastern Ethiopia. Evidence of MSA and LSA lithic assemblages, beads, faunal, and human remains have been recovered from this site suggesting two occupational sequences dated to the upper Pleistocene (43-31.5 ka cal BP), and Middle Holocene(7.8-4.7 ka cal BP) (Pleurdeau et al., 2014). This site has both MSA and LSA technological sequences and the assemblages were analyzed in detail (Leplongeon et al., 2017; Pleurdeau et al., 2014). At Goda Buticha, evidence of depositional hiatus and the chronological gap from ca. 24 ka to 8 ka has been recorded (Leplongeon et al., 2018; Pleurdeau et al., 2014). Backed microliths and bladelets were the main components of the Middle -Holocene horizon at Goda Buticha. This site is promising to test the dynamic and tempo cultural transition between the MSA and LSA (Pleurdeau et al., 2014).

Another important Paleolithic site rich with MSA and LSA lithic assemblages from eastern Ethiopia is Porc Epic. Although the site was known since 1933, proper archaeological excavation from this site was conducted by Desmond Clark in the 1970s uncovering a long sequence of Late Pleistocene human occupation. Archaeological excavations during (1933, 1974, 1975–76) recovered thousands of bone and lithic artifacts and bones (Pleurdeau, 2006). Evidence of burnt bone, faunal, and human remains were recovered from this site (Clark et al., 1984; Clark & Williams, 1978; Finneran, 2007). Geochemical characterization and provenance identification of obsidians on the MSA lithic raw materials of Porc Epic have been investigated (Agazi& Shackley, 2006). It has been suggested that the cave was probably used as a seasonal hunting camp during the time of game migration from Afar depression to the escarpment (Clark et al., 1984).

The upper occupational horizons of Aladi Spring, a site in southeastern Ethiopia, have also yielded LSA cultural sequence. The LSA materials recovered from this site are microlithic tools, bladelets, and backed pieces (Brandt, 1986; Gossa et al., 2012).

Archaeological excavation in Lake Beseka since the 1970s produced a long cultural sequence dated between the terminal Pleistocene (ca 22,000 BP) and ca 3500 BP (Brandt 1982, 1986). Both Late Pleistocene and Holocene LSA phases of the cultural sequence of lithic artifacts found from this site (Finneran, 2007; Brandt, 1982:1986). The cultural tradition named by Steve Brandt known as '*Ethiopian Blade Tool Tradition'* has been identified from this site (Brandt, 1986: 63; Finneran, 2007: 51). Lithic evidence of backed and geometric, microliths and scrapers, and a high percentage of truncations tools representing the terminal Pleistocene, transitional, and the Holocene time span respectively (Finneran, 2007; Brandt, 1982:1986)

Melka Kunture is a site situated along the bank of the upper Awash in the Main Ethiopian Rift. The site has a long sequence of deposition with a maximum of 100 m thickness of sediments and material culture started from Oldowan to the LSA recovered from its various localities (Piperno, 2001). Some localities have yielded evidence of LSA materials characterized by end scrapers, side scrapers, burins, backed pieces, denticulate, and bladelets (Piperno, 2001).

Situated in the southwestern Ethiopian highlands in the Wolayta Sodo zone, the Mochena Borago rock shelter provides LSA and MSA lithic assemblage. This site has been investigated in detail and appeared to have great relevance in supporting the refugium hypothesis (Brandt et al., 2017; Finneran, 2007). A range of research conducted in southwest Ethiopia has so far focused on cave and rock shelter sites. Archaeological excavations of these sites in the heart of southwest Ethiopia gave a chronology of human occupations starting from the MSA to the Holocene period (Brandt et al., 2012; Hilderbrand et al., 2003; Hilderbrand et al., 2010). Subsequent archaeological researches conducted in the area by Brandt and Hildebrand (2010) documented 27 caves and rock shelters with high concentrations and formations processes.

Yabello, in Oromiya Regional State, is another prehistoric site situated in southern Ethiopia. The usual effort of documenting archaeological sites in the early days by Desmond Clark in the 1940s came up with the discovery of the Yabello site (Finneran, 2007). Recently, archaeological endeavors are being carried out by Italian archaeologists on archaeological records of LSA to Holocene transition.

In Western Ethiopia, archaeological research in BenshangulGumuz Region resulted in the discovery of MSA and LSA sequences from the rock shelters of K'aaba and Bel K'urk'umu (Fernández et al., 2007). Continues cultural sequence of both MSA at K’aaba (side-scrapers, Levallois-discoid cores, and unifacial points) and LSA lithic elements at K’urk’umu (bladelets and end-scrapers) have been identified. The raw materials from these two localities were dominated by the quartz lithic industry. The researchers (Fernández et al., 2007) argued that the highland and forest of the surrounding area might have served as refugia for MSA cultural groups.

In the northern part of the country near the town of Gorgora, the Lake Tana cave has provided evidence of MSA and LSA sequences which indicates a long-time human occupation sequence (Clark et al., 1984;Finneran, 2007). Detailed studies on this site, are, however, very limited. Similarly, there are a couple of Holocene sites with features of LSA lithic materials found associated with other materials around Aksum in northern Ethiopia, Tigray region (Finneran, 2007).

AnqqerBaahti and BaahtiNebait (Finneran, 2001, 2005, 2007) are sites in the Tigray region with LSA lithic artifacts dated to 7545 ± 50 BC and 8025 ± 55 BC (Finneran,2007). The LSA materials from these sites are characterized by bladelets, blades, and other flakes made from sandstone and mudstone (Finneran, 2007). There are also LSA lithic materials recovered from the Gobedra rock-shelter some 5 km west of Aksum. Archaeological excavation at the site provided some of the earliest phases of the LSA industry (Phillipson, 1977).

There are few terminal Pleistocene and early Holocene sites in Ethiopia. Most of the evidence that has so far been recovered from this period suffers from either a lack of research focuses or a dearth of the archaeological record. Up until recently, LSA materials have not been common from the Afar depression. Still, a recent archaeological investigation in the Lower Awash valley shed light on the Holocene human occupational sequence of the Afar rift along the Lake Abhe furnishing evidence of LSA lithic technologies, ceramic-sherds, and faunal remains (Coudert et al., 2020). According to Khalidi and her group (2020), the study has been coupled with paleoenvironmental evidence attributed to the transgression and regression of the lake level that has contributed to the sporadic human occupation during the time of Holocene.

Putting all the above information together, it is plausible to argue that all most all corners of the country can reveal evidence of LSA stone tool technology. The technological, morphological, and typological variabilities of this industry have been discussed by previous scholars. It is also understandable that there are research limitations and the information on the LSA of Ethiopia obtained so far is scanty. The recent growing attention towards the Late Pleistocene and the

Holocene archaeology by some archaeologists are encouraging. Consequently, our understanding of modern behavioral development, the processes of neolithization, pastoralism, and sedentism will be refined better.

2.6. Paleoenvironmental records during MIS 3and MIS 1

For decades, archaeologists have been trying to answer the question of human settlement patterns in time and space through the investigation of open-air sites and rock shelters. Those studies have often ignored paleoenvironmental records associated with archaeological evidence. Nevertheless, studies (Bousman, 2005; Khalidi et al., 2020; Lesur et al., 2014; Renfrew & Bahn, 2020) indicated that paleoenvironmental changes play a pivotal role in human cultural and behavioral development. Owing to the role the environment plays in human behavior and cultural development in the past, the archaeological records of the Late Pleistocene and Holocene time-period should be evaluated in light of the changing environmental conditions.

The Marine Isotope Stages (MIS) 3-1 are international environmental and climatic records corresponding to the Late Pleistocene and the Holocene periods in Africa. The time between 75 and 12 ka is known by climatic variability and environmental changes which are often associated with MIS 3–1. These variations may have created adaptive challenges on the prevailing human populations of the Horn of Africa (Leplongeon, Goder-goldberger, et al., 2020).

Leplongeon and her group (2020) have reviewed the archaeological records of the Late Pleistocene and Early Holocene against the changing climatic conditions. Accordingly, climatic records taken from the Chew Bahir basin from southern Ethiopia suggested that there was climate instability and environmental changes in the Horn during 75-29ka. During this time, there were limited but variable archaeological records in this part of Africa. Archaeological records that are attributed to

MSA show increasing production of blades and microlithic tools without any abrupt technological change.

Following this, a dry and cold MIS 2 climate emerged that corresponding to a period also known as ‘the Big Dry’ (29-15ka) and/or the Last Glacial Maximum (LGM) ~23.5-19 ka. During this time, there has been a dearth of archaeological evidence in the Horn of Africa (Ménard et al., 2014; Leplongeon et al., 2020). This could, perhaps, be due to either research bias or lack of archaeological remains.

After the big dry, increasing variability and evidence of LSA materials have been recorded in the Horn of Africa. During this time, while the Northern parts of the world were under extreme glacial coverage, the largest portion of the Horn of Africa and the Nile valley area seemed to enjoy favorable climatic conditions. Evidence of increasing precipitation and the diversified nature of economic strategies have been recorded from the relative richness of sites in the region (Leplongeon, Goder-goldberger, et al., 2020). From 15,000 to 11, 000 years, there was extreme glaciation around the Nile River. Archaeological evidence like grindstones, microliths, and cemeteries suggested that some resources were exploited in some areas (Phillipson, 2005).

The paleoenvironment of the Horn of Africa during the Early, Middle, and Late Holocene has not been assessed very well. In Ethiopia, archaeological sites dated between the Early to Late Holocene are little and dispersed chronologically and spatially. The archaeological and paleoenvironmental data are insufficient to obtain a complete understanding and chronological sequence of Holocene (Khalidi et al., 2020). Researches on the upper Pleistocene and early Holocene paleoenvironment of the Horn of Africa have been reviewed by Brandit (1986). After 12,000 years, however, there were rapid climatic changes and normal precipitations. By the time, limited occupations were inferred from material remains such as grindstones and wild cereals (Phillipson, 2005). Though sparse, the archaeological record suggests a trend towards the sedentary way of life during the early Holocene (Brandt, 1986).

On the other end of the spectrum, the Middle Holocene is generally characterized by the warm and humid climate in the Horn of Africa (Carmela & Andrea, 2019). Arguably, this increasing aridity of the Middle Holocene which was severe in the Sahara could have caused population migration from the Sahara and Sahel towards north, south, and east. Some archaeologists (Brandt, 1986; Brandt & Carder, 1987) argue that cave and rock shelter sites of southeastern and southwestern Ethiopia could have served as a refugium for the Middle -Holocene harsh environmental and climatic conditions.

Major environmental and demographic fluctuations have been recorded during the last five and four thousand years as it was documented from the paleoenvironmental and archaeological data (Brandt & Carder, 1987, Brandt et al., 2012). However, there is generally a paucity of researches during the Middle and Late Holocene which could be a potential factor in hindering our understanding of the paleoenvironmental and paleoclimatic conditions of the time-span. Future and rigorous researchers are expected to shed light on this matter in detail.

2.7. History of archaeological research in Southeastern Ethiopia

Archaeological investigations in southeastern Ethiopia have started since the pioneering surveys of de Montfried and Teilhard de Chardin in 1929 (Breuil, 1934). In the 1930s, explorations of the cave and rock shelter sites were carried out at Porc Epic Cave and Laga Oda rock shelter. The first archaeological excavation at Porc Epic yielded evidence of MSA materials for the first time in the region. Subsequent research in the 1940s and 1950s focused on the documentation and description of rock art in this part of Ethiopia (Cervicek, 1971; Clark & Williams, 1978). The rock art potential of southeastern Ethiopia was explored in the early days by archaeologists such as Cerviceck (1971), Cerviceck & Braukamper (1975), Clark (1954), Clark & Williams, 1976, 1978,1984). Most of these investigations were, however, simply documentation of individual sites like the Laga Oda paintings.

Archaeological research carried out in the 1970s in the eastern parts of the country revealed a variety of Stone Age technologies (Bon et al., 2014; Clark & Williams, 1978; Kurashina, 1978). Despite the research gap compared to ESA and MSA technologies, archaeologists have discovered overwhelming LSA sites in different parts of Ethiopia (for example, Brandt, 1986; Clark, 1954; Clark & Williams, 1978; Finneran, 2007; Tegenu et al, 2012; Hildebrand & Brandt, 2010; Menard et al, 2014; Phillipson, 1982). This region has proven to yield rich archaeological sequences spanning a long period of time starting from the paleolithic to the medieval time.

Most of our knowledge of prehistoric periods in Ethiopia has so far been obtained from open-air sites. However, the role cave and rock shelter sites played for prehistoric occupation are barely explored. While studying technological variations and specializations, it is unwise to neglect the most crucial and ubiquitous portions of prehistory known as rock art evidence (paintings and engravings) (Pleurdeau et al., 2012; Smith, 2013). The caves and rock shelters of eastern Ethiopia have provided insights into the technology, behavior, and to some extent the paleoeconomy and paleoenvironment of prehistoric societies of the region (Pleurdeau et al., 2012). There are also apparent variations of paintings and engravings in style, motif, chronology, and space (Cervicek, 1971). The rock arts of eastern Africa represent a range of animal species and personal equipment interpreted differently by researchers.

In 2007 and 2008, there have been surveys and explorations of caves and rock shelters in southeastern Ethiopia. These archaeological explorations documented about twenty-one cave sites and rock shelters with archaeological remains culturally associated with MSA and LSA technologies, faunal remains, and rock art (Assefa et al., 2013). These remains associated with all both previously known and unknown sites were documented and discussed in detail.

Currently, there are only very few active archaeological projects that are undergoing in southeastern Ethiopia. Since 2014, an archaeological investigation has been focused on Islamic archaeology in Harar and its surroundings, in Harla and Dire Dawa. Subsequent excavation and investigation shed light on the discovery of a new medieval Islamic city, Harlaa date back as far as the 10^{th} century AD (Insoll, 2017). According to the author, Harlaa is a multi-component site with settlement areas of residential and production usage, mosques, cemeteries, and defensive wall.

2.8. Previous studies at Laga Oda

The Laga Oda rock shelter was discovered in 1933 by Azias (Cervicek, 1971). The site was visited by Bruel in the 1930s and Fag in the 1940s and did photographic documentation of Laga Oda pictographs. Detailed exploration of the area was, however, carried out after the 1950s (Clark, 1954; Clark & Prince, 1978; Cervicek, 1971; Clark & Williams, 1978; Kurashina, 1978). Investigations at the Laga Oda site mainly focused on rock art (Cervicek, 1971). Despite a positive test excavation in 1975, no subsequent research was conducted on LSA lithic industries at the site.

Only a first technological characterization of the Laga Oda LSA materials (Kurashina, 1978) and a use-wear analysis (Clark & Prince, 1978) were conducted soon after the excavation. The lack of further analysis has limited our understanding of the diversity of economic and technological developments at the site.

Kurashina (1978) conducted investigations on the Stone Age of Ethiopia particularly eastern Ethiopia. His study serves as the foundation for lithic studies in central and eastern Ethiopia. The author emphasized the general technological and typological lithic examination of ESA, MSA, and LSA sites in the region. His study is perhaps, the most important groundwork that emphasis the lithics cultural sequence of southeastern Ethiopia. In his broad and general techno-typological characterization, Kurashina has dedicated a chapter on the technological analysis of Laga Oda lithic assemblage. While his work has served as a foundation for the present study, a state-of-the-art methodological technique and perceptual insights of those assemblages appear to be essential.

Clark (1978) has also conducted a study emphasis on the function of the Laga Oda lithic assemblages. The focus of this paper was examinations of lithic use-wear to draw inferences about the function of microliths. This article has also provided information on the dating of the site with calibrated radiocarbon dates. In this microscopic investigation, Clark (1978) has identified and discussed three types of use-wear from the Laga Oda assemblage such as edge damage alone, edge polish, and edge gloss.

Cervicek (1971) and Kurashina (1978) pointed out that animal figures several depicted showing pastoral scenes with long-horned and humpless cattle and human figures. The paintings are depicted in red, yellow, black, and white colors and dated to the mid-second millennium B.C. The pictographs in the Laga Oda rock shelter exhibit two different Ethio-Arabian styles such as Surre-Hanakiya, and Dahthami (Cervicek, 1971; Clark & Williams 1978). Clark (1998) study provided detailed descriptions of all the upper and lower paintings with pictures and dimensions. It has been suggested that the paintings at the lower panel of the rock shelter predate those in the upper panel (Clark & Prince, 1978). The paintings were also described by Tekle Hagos (1999) in his book entitled “rock arts of Ethiopia: the fragile resources”. The author stated the presence of plant paintings which makes it the only site in Ethiopia with a depiction of the plant.

The main purpose of this thesis is therefore to investigate the lithic assemblages from Laga Oda to understand the technology and typology and diachronic change at the site. It is also aimed to give a comparison with other contemporaneous local LSA cultural sequences.

CHAPTER THREE

The research area and itsenvironment

3.1. Location

The Laga Oda rock-shelter (figure 1) is situated geographically at 09.50 08 24° N and 41.67 74 04° E with an elevation of 1658m asl. It is located at the edge of the southeastern Ethiopia plateau about 25km southwest of Dire Dawa and 10 km north of Kulubi. Laga Oda is also known by the locals as 'Goda- Kataba' which literary means a cave with written records. The shelter is located facing west above the Oda stream.

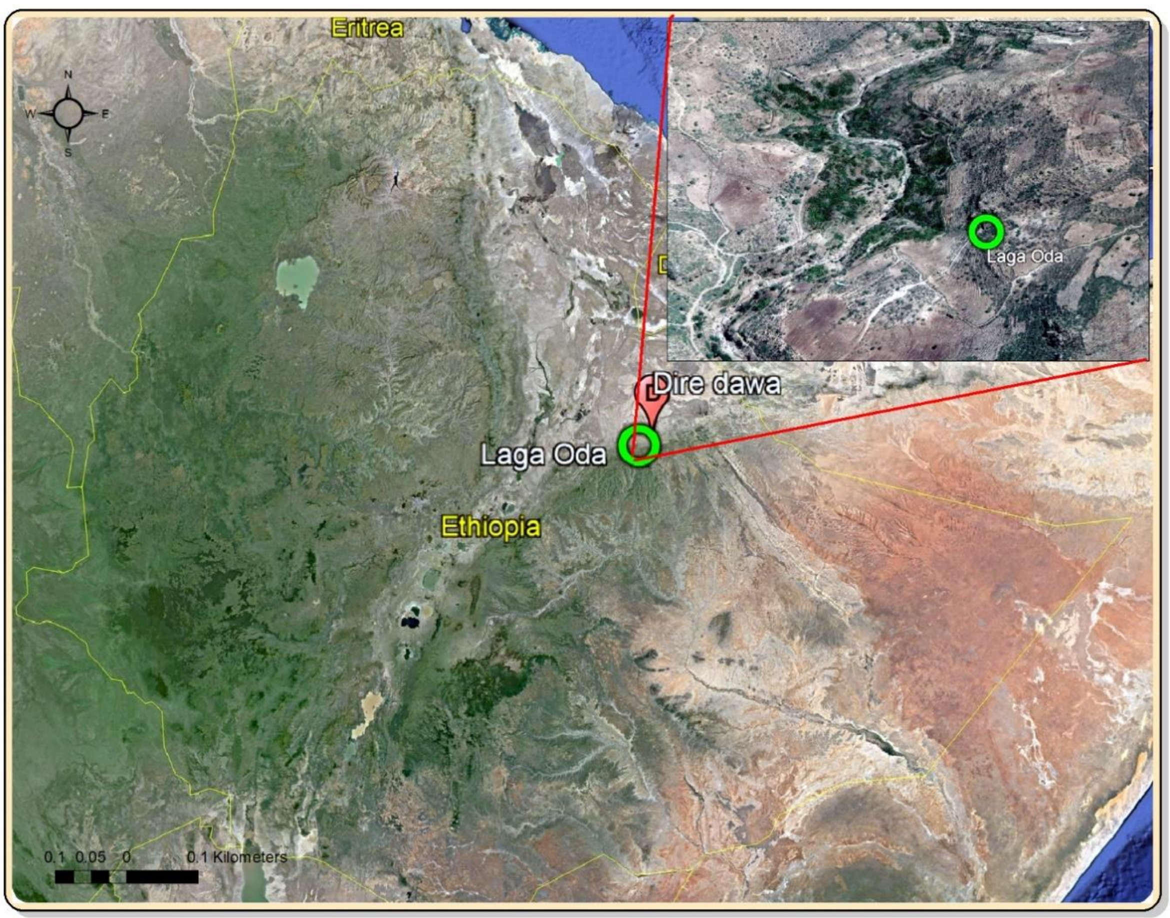


Figure 1. A relief map showing the location of the Laga Oda rock shelter (byHabir Mohammed, 2021)

This archaeological site has provided information about ancient human occupation dated between the Late Pleistocene to Late Holocene. Other rock shelters and cave sites of Porc Epic, Genda Nemo, Goda-Okotae, and Goda-Buttu rock art sites are located closer to Laga Oda. Laga Oda has two rock shelters, one above the other, in a limestone cliff facing the south. The Laga-Oda site is one of the few relevant excavated sites that supplement the repertoire of our knowledge on the origins of food production although the rest of the evidence from rock art sites is inherently circumstantial.

Assefa et al. (2014) explored the cave and rock art sites of this region and documented about 20 cave and rock shelter sites. Most of them have rock arts and show pastoralist scenes, stylistic resemblance to each other, and also unique motifs. According to Tekle Hagos (2011) fat-tailed sheep, long and short honed humpless cattle, humans, and camels are the most dominant portrayals of the rock arts in the area. Stylistically, the rock art of southeastern Ethiopia belongs to the Ethiopian-Arabian style of Sourre–Hanakiya and Dahtami (Cerviceck, 1971; Cerviceck& Braukamper,1975).

3.2.Archaeological background

The Laga Oda site was discovered in 1933 by F.B. Azaïs and Oncieu De Chappardon. In the 1950s, the rock shelter was also studied in detail by the Frobenius Institute Expedition to Ethiopia (Clark, 1954). A more detailed exploration of Laga Oda was carried out in the 1970s (Clark & Prince, 1978). As part of the archaeological exploration of the area conducted under the leadership of the J.D. Clark (University of California, Berkeley), a test excavation conducted in 1975 provided the first evidence for the preservation of LSA deposits at the site, with several stratigraphically defined and radiometrically dated occupational horizons (Clark &Willimason, 1978; Kurashina, 1978).

Figure 2. The panoramic and distance view of the Laga Oda Rock shelter (photoby: Kibrewosen Negash)

Figure 3. The closer view of the Laga Oda Rock shelter (photo by: Bertrand Poissonier, 1999)

Laga Oda is known for its spectacular rock paintings and LSA lithic assemblages. According to Cervicek (1971), the rock shelter is a two-story limestone formation, and it encompasses about 600 paintings. The paintings exhibit most dominantly animals and human representations such as horned cattle, fat-tailed sheep, and humans. This is also the only rock art site with paintings of the plant found (Clark & Prince, 1978). Udder of cow is depicted in the paintings indicating the importance of milking habit (Clark & Williams, 1978). The animal figures in the painting appeared to have significant implications about the presence of pastoral society (Kurashina, 2978).

Clark and Prince (1978) found remains of possible domestic cattle from the upper stratum (dated ca.1300 AD). This is rather fascinating as we are told by Clark (1976) that the 1stmillennium AD could well be the period for the introduction into Ethiopia and the Horn. Interestingly, Clark & Prince (1978) also noted about stone tools recovered from the Laga-Oda rockineshow "sickle sheen" which they consider as evidence for exploitation of phytolithsilicate bodiesin grasses and other types of plants.

The paintings in the upper shelter are larger in dimensions with an average of 60 x 80 cm whereas smaller depictions dominated the lower shelter. The dimensions of paintings in the lower shelter ranges from 2cm to 15 x 30 cm. The Frobenius Expedition report described the paintings of the lower shelter as 'minuscule' (Cervicek, 1971). In the original document, depiction of wild animals such as elephants, rhinoceros, giraffe, antelope, buffalo, lion, leopard, and hyena have been reported (Kurashina, 1978).

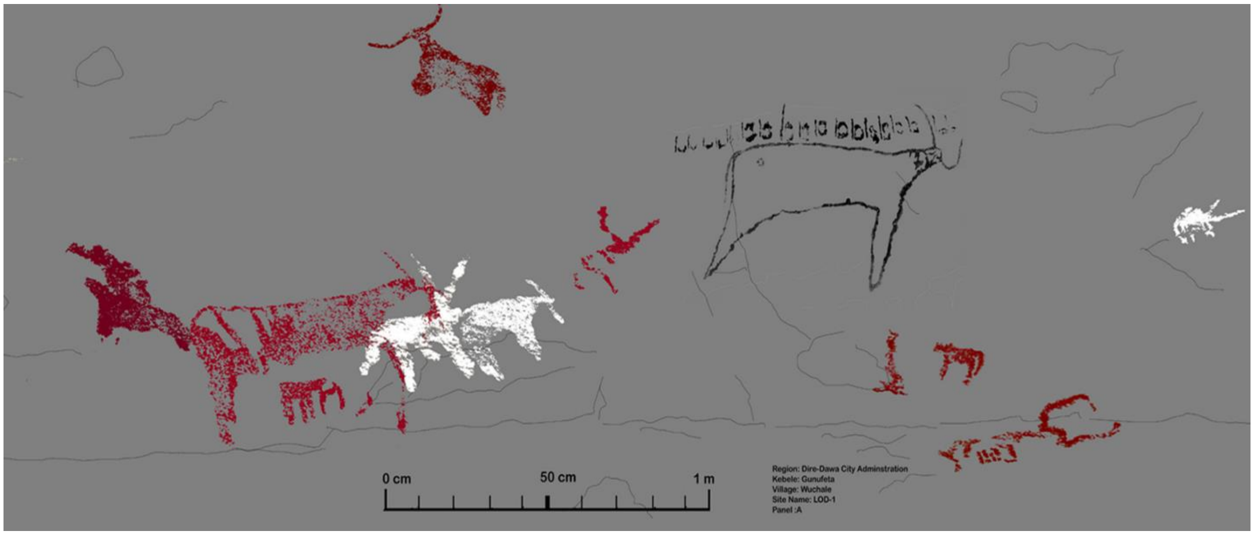


Figure 4. Some of the rock paintings from the Laga Oda Rock shelter (after Tadele, 2020)

3.2.1. Stratigraphy and chronology

There were two test excavations carried out in 1975 (Clark, 1978; Kurashina, 1978). The stratigraphy of Laga Oda is securely dated radiometrically. There is no sedimentary deposit in the upper shelter. The uppermost layer contains pottery sherds whereas the remaining layers were dominated by lithic assemblages with some faunas and ochre fragments (Kurashina, 1978).

A total of four stratigraphic units were identified during the 1975 excavation. During these two important test excavations, LSA lithics assemblages, ceramics, beads, faunas were recovered without artifact plotting. The excavation was carried out following arbitrary spits of 10 cm units (Clark & Prince, 1978). Dating the charcoal recovered from the 1975 excavation in this site has provided five dates (see the table below) ranging from 15,000 to 300 years BP (Clark & Williams, 1978).

Table 2 the stratigraphic sequence of the lower shelter deposit of Laga Oda rock shelter with 140 cm deep and three natural layers (after Kurashina, 1978)

Stratigraphic layers	Thickness	Description
Top	0-18 cm	Dark brown earth
Middle	4-70 cm	Light, brown earth
Bottom	5-100 cm	Yellow earth

The rock shelter is one of the largest known prehistoric occupation sites dated between the terminal Pleistocene (15,000 BP) and the Late Holocene (325 BP). There are fallen remains of limestone boulders in the lower shelter. In 2011, a team of conservators from the Authority for Research and Conservation of Cultural Heritage (ARCCH) conducted conservation work of the shelter and made shade for the weathered and vulnerable part of the shelter. Details about the radiometrically dated stratigraphic sequences and the occupation horizons are described by Cervicek (1971) and Kurashina (1978).

Table 3 The table shows the calibrated date of the five stratigraphic units of the Laga Oda rock shelter (Clark & Prince, 1978)

Depth	Age	Sample Number
29 cm	325 ± 70 BP	SUA 471
30-40 cm	595 ±70 BP	SUA 472
50-80 cm	3,510 ±105 BP	SUA 473
80-110 cm	10,270 ±170 BP	SUA 474
110-140 cm	15,590 ± 460 BP	SUA 475

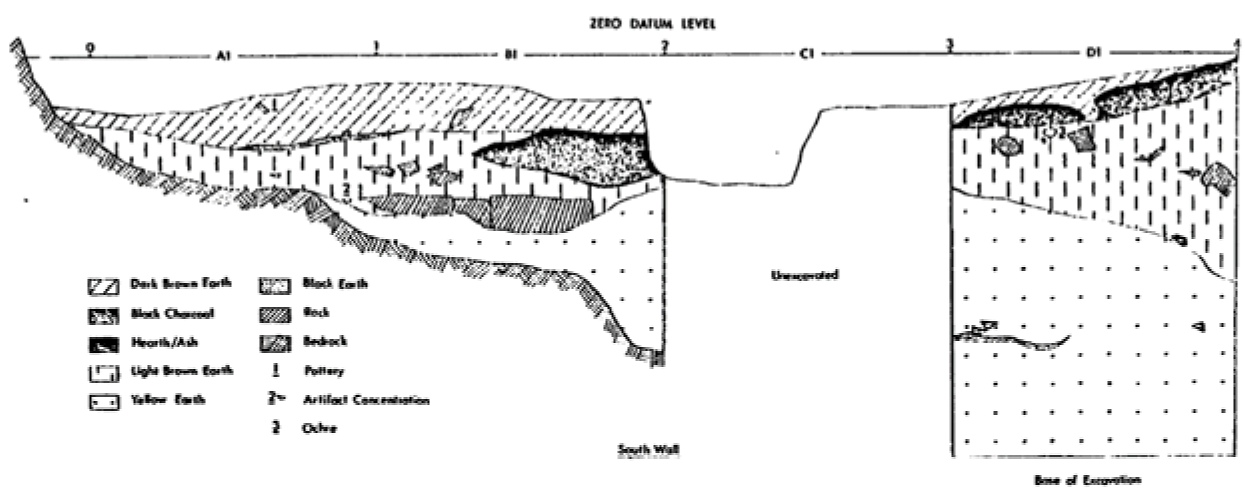


Figure 5. The stratigraphic units of the Laga Oda site established during the 1975 excavation (after Kurashina, 1978)

3.3. Geological context

The rock shelter is situated along the eastern escarpment of the rift valley which exposes pre-Cambrian granites and Mesozoic sandstones and limestones sequence (Clark & Prince, 1978). The cliffs were formed by the Mesozoic limestones that belong to the Antalo Formation of southeastern Ethiopia (Bosellini et al., 2001).

The outcrop on the southern side of Ethiopia encompasses several karstic caves and rock shelters (Assefa et al., 2014). The Laga Oda rock shelter is also the result of karstic cave formations. These caves and rock shelters of southeastern Ethiopia might have served as a refugium for the prehistoric people's occupation. They could also have provided a conducive environmental condition for the preservation of archaeological materials (Clark & Williams, 1978; Mitchell, 1997). Since the rock shelter is situated on a large cliff, the area is generally characterized by rugged terrain and valley. The surrounding area is exposed to soil erosion and land degradation. Steep-sided valleys and flat-topped masses characterized the landscape.

3.4. Environmental setting

The changing paleoenvironmental and paleoclimatic conditions of the past could have exerted profound effects on the economies, and cultures of the past. The presence of speleothems on some of the karstic cave formations in the Southeastern Ethiopian Plateau provided evidence for palaeoclimatological and paleoenvironmental reconstruction (Asrat et al., 2007).

Scholars (e.g., Brandt & Cader, 1987) have argued that environmental change during Holocene played a causal role in the origins of food production in the Horn. It was during this time that the pastoral economic systems developed as a result of the migration and/or diffusion of people from the Sahara and Sahel area to the Horn. The rift escarpments and adjacent plateaus in Ethiopia would have ameliorated the harsh Holocene environment and could have served as a human occupation. Archaeological records from the cave and rock shelter sites of southeastern Ethiopia are proven examples of this.

Figure 6.Map of Laga Oda in relation to the Ethiopian rift system and the town of Dire Dawa (Google earth)

The Laga Oda rock shelter is situated in the southeastern plateau right next to the eastern escarpment of the Ethiopian rift (see fig 6). The Ethiopian southeastern plateau is surrounded by escarpments from all sides and the Ethiopian Rift and the Somali lowlands. The elevation of this ranges from 1,500 to 2,400m above sea level. This area offers temperate climatic conditions (Brandt & Cader, 1987).

Ecologically, this area belongs to the Afro-montane and the Afro-alpine belts. Deciduous bushland and thicket dominated as we go towards the more elevated part of the plateau (Brandt & Cader, 1987). The forests of this area have been highly reduced through time due to human activities including fire, overgrazing, cultivation, and wood removal. The vegetation of the Laga Oda area is variable due to the arid and semi-arid lands such as cactus scrub, thorn scrub, and many blocks of wood and sparse grasses (Mountains & Uhlig, 2016).

The climate of the area is characterized by an arid and semi-arid climate with low and erratic rainfall. It has a bimodal type of rainfall with two rainy seasons separated by two dry seasons with an average precipitation of 878mm around Harar(Mountains & Uhlig, 2016).

CHAPTER FOUR

Results and data presentation

This chapter provides information about the assemblages from Laga Oda and the analyzed data. Characterization of the lithic assemblages and their analysis are presented. Technological, typological, and attribute characterization of the materials are analyzed and presented in this section. Tables and figures are used to present the data. The chapter also presents metric dimensions and descriptive information of each assemblage are analyzed.

4.1. Characterization of the Laga Oda lithicassemblages

In this analysis, samples of complete flakes, incomplete flakes, flake fragments, split flakes, and cores were first sorted raw material, typological and technological attributes.In the assemblages, pottery, beds, and teeth remains were also sorted out.

Artifacts were found throughout the 140 cm deposits (Clark, 1978; Kurashina, 1978). The assemblages are mostly dominated by LSA microlithic materials, most of which were recovered from the archaeological horizon situated between 20 and 60 cm below the surface. The densest concentration of artifacts occurs between 40-50 cm unit and some lithic samples were also recovered from the surface.

Table 4. The typological distribution of lithic artifacts in different stratigraphic unit

Typology

Distribution of artifacts in the different stratigraphic units(levels in cm)

	surface	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	90-100	100-110	110-120	120-130	130-140	Total
flake	22	1	1	51	42	57	10	8	3	4	3	1	3	1	223
bladelet	-	-	-	4	-	8	5	3	-	-	-	-	-	-	22
core	3	-	-	1	6	7	1	1	-	-	-	-	-	-	19
Core on flake	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1
crested bladelet	-	-	-	2	-	2	-	-	-	-	-	-	-	-	4
tablet	-	-	-	2	1	3	-	-	-	-	-	-	-	-	6
indeterminate	-	-	-	4	7	15	1	1	-	-	-	-	-	-	28
						Retouched pieces									
retouches	-	-	-	10	2	3	3	2	-	-	1	-	-	-	21
burin	-	-	-	-	-	-	1	1	-	-	-	-	-	-	2
scraper	6	-	-	1	-	-	-	1	-	-	1	-	-	-	9
backed	2	1	3	47	36	70	16	2	-	-	-	1	-	1	203

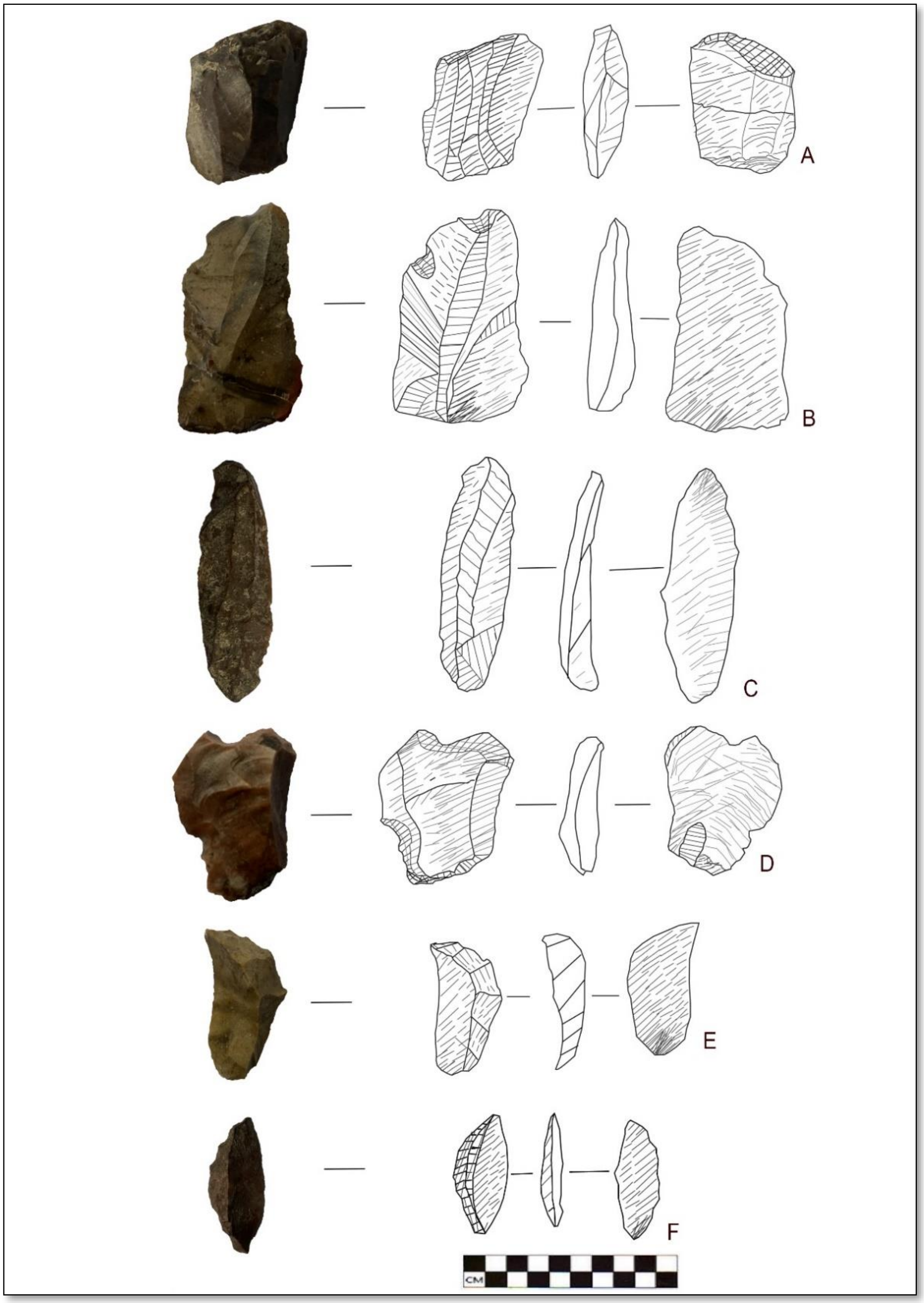


Figure 7. Typological and technological characterization of the assemblage including core (A) flake, (B), bladelet (C), burin (D), tablet (E), and backed piece (F).

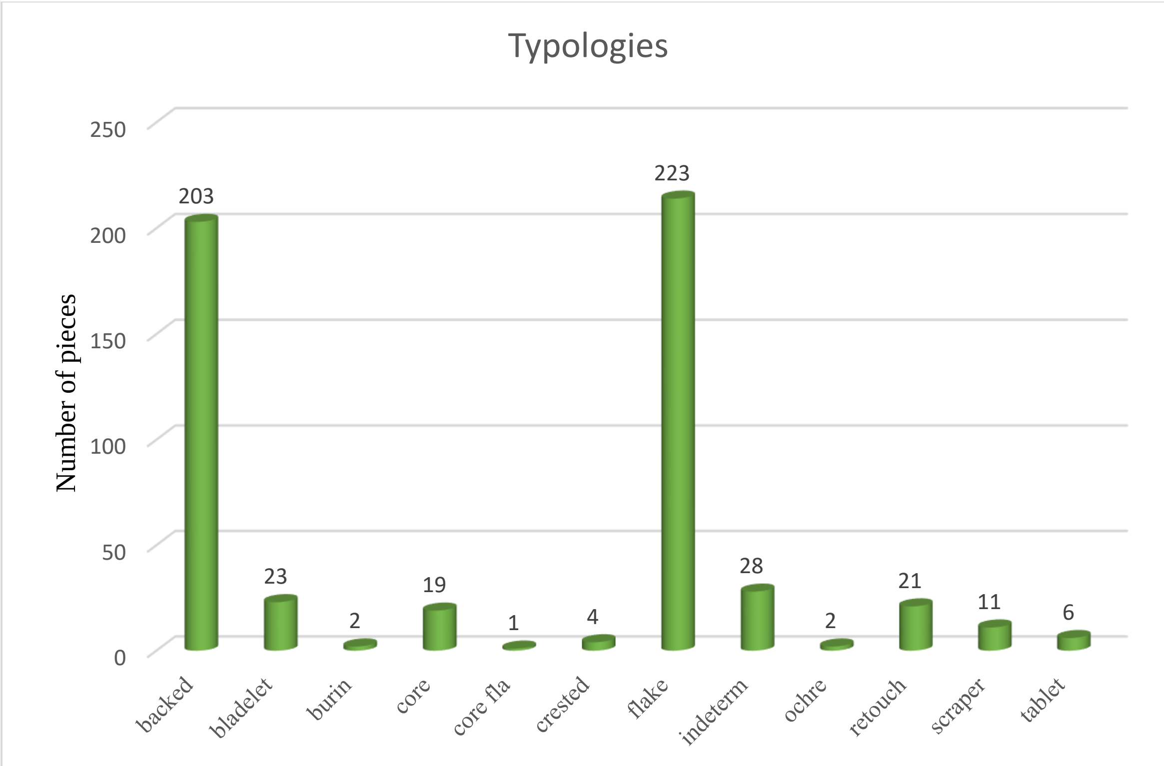


Figure 8.A graph showing the count of Laga Oda lithicsamples in terms of typology

There are about four units excavated with artificial excavation units of 10 cm level each. Most of the assemblages are concentrated between the stratigraphic unit of 20 cm and 70 cm. However, the highest percentage of lithic artifacts were recovered from 40-50 cm (n=159), and 20-30 cm (123) units whereas the most upper, and lower deposits provided a relatively small number of artifacts (see figure 9). There are about 33 artifacts recovered from the surface which are not indicative of any particular horizon because they could have been exposed by disturbances. The most artifact-bearing stratigraphic horizons are dated from the end of the Middle Holocene to the beginning of the Late Holocene period (Clark, 1998).

Figure 9.Some examples and variations of the assemblage including backed pieces (A-H, L), bladelets(I-J), burin (K), scrapers (M-P) of the Laga Oda assemblages.

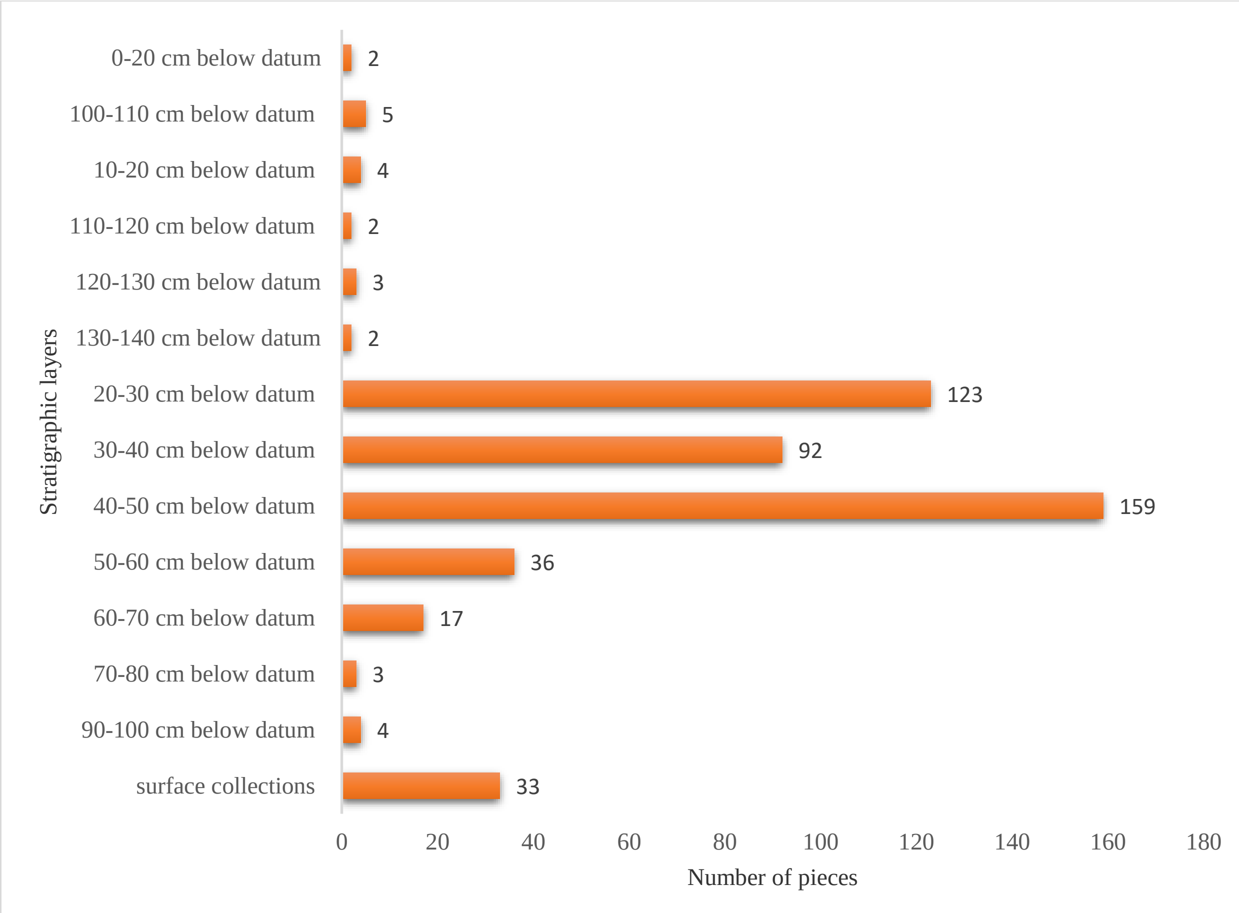


Figure 10.The distribution of Laga Oda LSA lithic assemblage across excavated units.

We have also examined the physical condition of the Lag-Oda lithic assemblage. In this regard, they mostly seem a good state of preservation showing little or no weathering. However, the majority of them had been subjected to thermal treatment. We do not know for sure why they were treated by heat. Nevertheless, the previous experimental analysis indicated that it is much easier to knap artifacts that are treated with heat. There are also remains of thermal spalls categorized within the indeterminant lithic class.

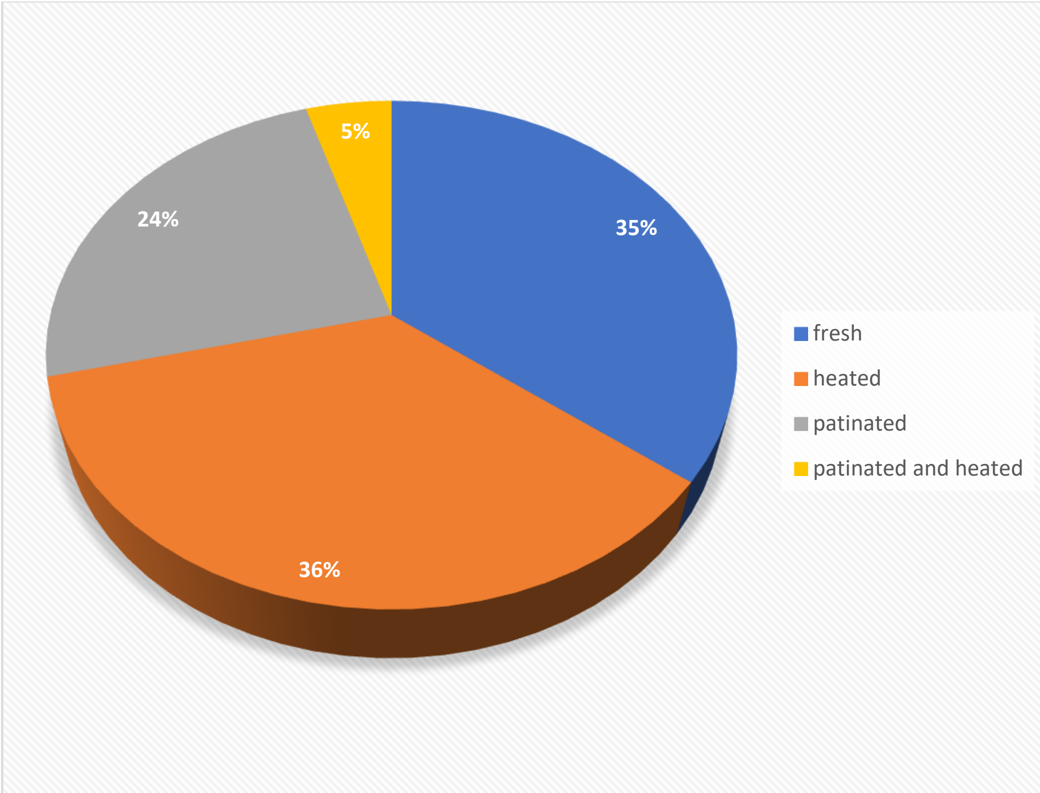


Figure 11.Variability in alteration and physical condition of the Laga Oda assemblages.

As it is seen from the pie chart above (figure 11), the majority (36%) of the artifacts have heat impacts. 24% are patinated by natural factors whereas 35% of the assemblages are fresh. It can be said that except for heat impact, most of the artifacts had not been exposed to physical weathering. This assumption can be confirmed by the sharpness observed on the edges of each artifact. The lithic artifacts have not been transported either by slop, water, or other natural forces. Observation with the necked eye indicates that the edges of the tools are fresh and sharp.

4.1. Raw materials

The dominant raw materials used in the production of artifacts within the Laga Oda assemblage are cherts which account for about 95%. The remaining 5% of the raw materials are comprised of obsidian, quartz, jasper, basalt, and limestone. The site is located closer to many major chert sources in the southeastern Ethiopian plateau which are dominated by sedimentary deposits. Cobbles and large nodules of chert are situated ubiquitously along the valley just below the rock shelter. It is due to this that the majority of flaked lithic artifacts were manufactured from this raw material. The source(s) of the other raw materials are yet to be known. However, these exotic raw materials could have been obtained from distant areas or were either imported through trade or exchange.

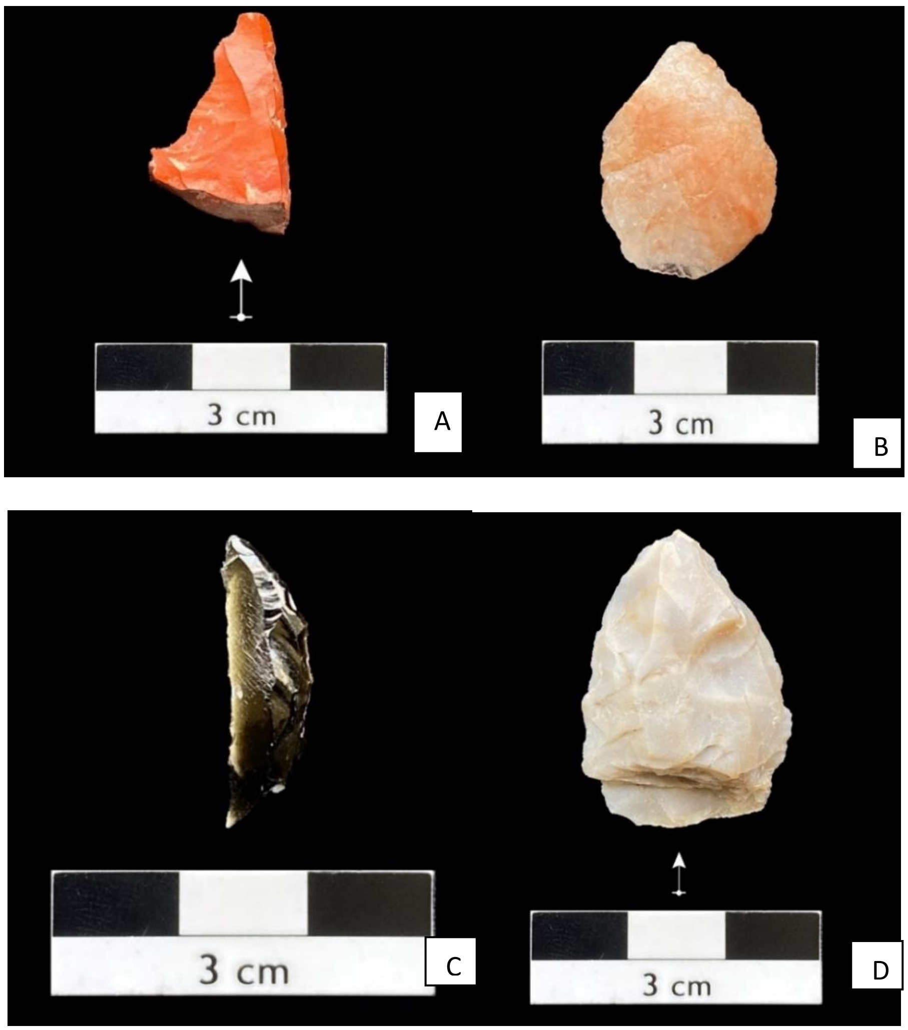


Figure 12. These lithic artifacts were produced from different raw materials such as jasper (A), quartz(B), obsidian (C), and chert (D).

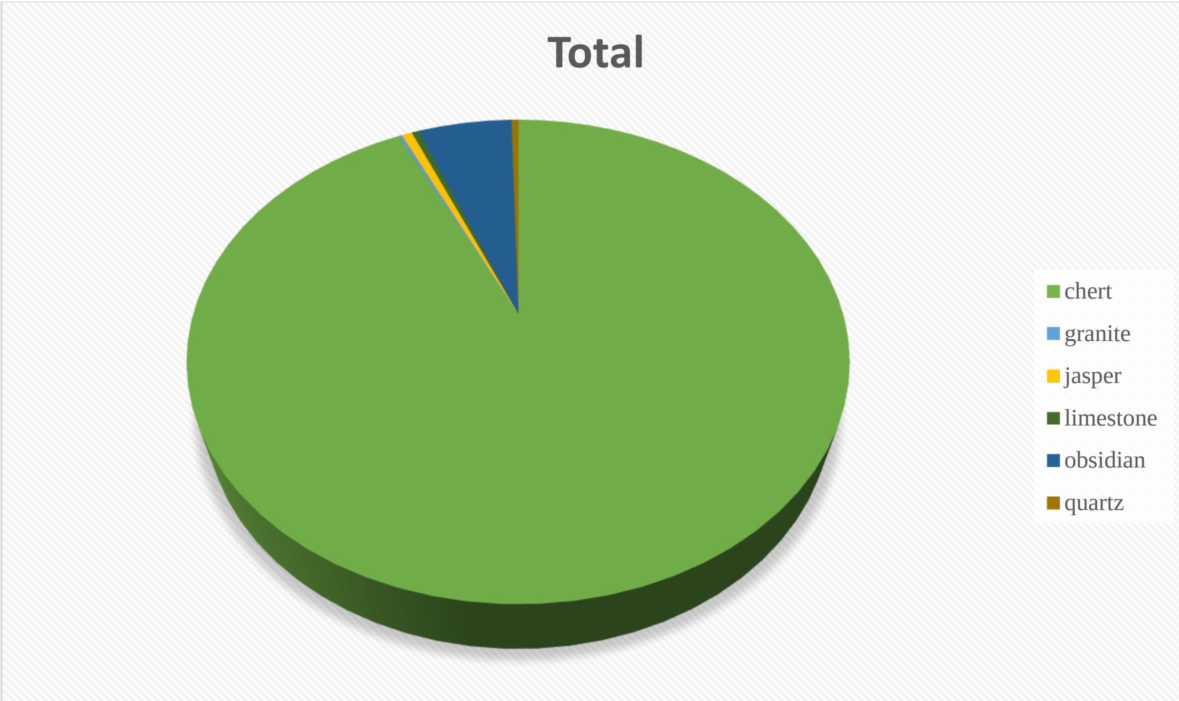


Figure 13.Percentage composition of raw materials of the whole Laga Oda lithic assemblages.

4.2. Cores

Cores are identified by the negative scares of the flakes which are removed from them (Inizan et al., 1999). Understanding the types of cores provides insights into the technology and the reduction strategy and sequence of lithics assemblages (Inizan et al., 1991). In Laga Oda, the density of cores is very small, represented by 19 cores which accounts for only 3.5% of the entire assemblages. 65.5% (n=13) of the cores were recovered from 30-50cm stratigraphic unites. Yet only a single micro-bladelet core was recorded in the samples we studied assemblages. Since the number of cores is small, and there are small sample sizes, we decided to carry out only a descriptive analysis.

Based on the core typological classification system, different shapes types of cores have been observed including discoidal, pyramidal, prismatic, blanks, bipolar cores, cores on flake, and irregular types. Likewise, based on the direction of the removals visible on the cores, different core types such as single platform core, multiple platform core, conical and radial core. There are also opposed double platform cores. Most of the cores exhibit strips of elongated ridges and negative scares which were core areas that such bladelets were struck from.

Most of the cores lack cortical surface indicating the effective utilization of raw materials. 100% of all cores are made on chert and they are exhausted. The cores of this site have several flake scars. Heavy exploitation of cores has been inferred since their sizes are small. Although the cores seem physically fresh and unpatinated, thermal alterations have been observed documenting heat treatment of most of the lithic assemblage of the site.

Figure 14. Different bladelet cores of various morphologies.

The Laga Oda assemblage also consists of one micro-bladelet core. The core is very small in size and has a conical shape. It measures less than 2cm in length and about 1cm in width. Like the majority of other artifacts, this core is produced from chert. The techno-morphology features and the bladelet scares of this tool are understandably bladelet core. It could also have been used as hafted tools. This inference rests upon the analogous use of similar artifacts for similar purposes. Inference can be made from the micro-bladelet core that the production microlithic tools were taking place at Laga Oda probably using soft hammer percussion technique.

Figure 15. Bladelet core made from chert.

4.3. Flakes

Flakes are blanks or portions of rock pieces produced by percussion or pressure flaking techniques that have diagnostic attributes including striking platform, butt, bulb, flake scars, arise, point of percussion, and others (Inizan et al,1999). We document 223 (40%) flakes which make up the largest quantities out of the entire LSA assemblage from the Laga Oda site.

Investigating flakes provide information on knapping techniques, skills, technology, and typology of a particular lithic tradition (Andrefsky, 2005). Most of these flakes lack retouches and these blanks are unretouched pieces. Unretouched flakes could be modified into some retouched flakes, scrapers, and backed pieces. Flakes of Laga Oda could be employed for cutting, scraping, and other similar functions.

In this study, different attributes of flakes have been analyzed. The principal of these attributes embraces types of raw material, fragments length, width, maximum thickness, thickness at maximum width, dorsal type, alterations, and platform type. These attributes were selected to obtain information about the lithic reduction sequence, technological characterization, and morphological features.

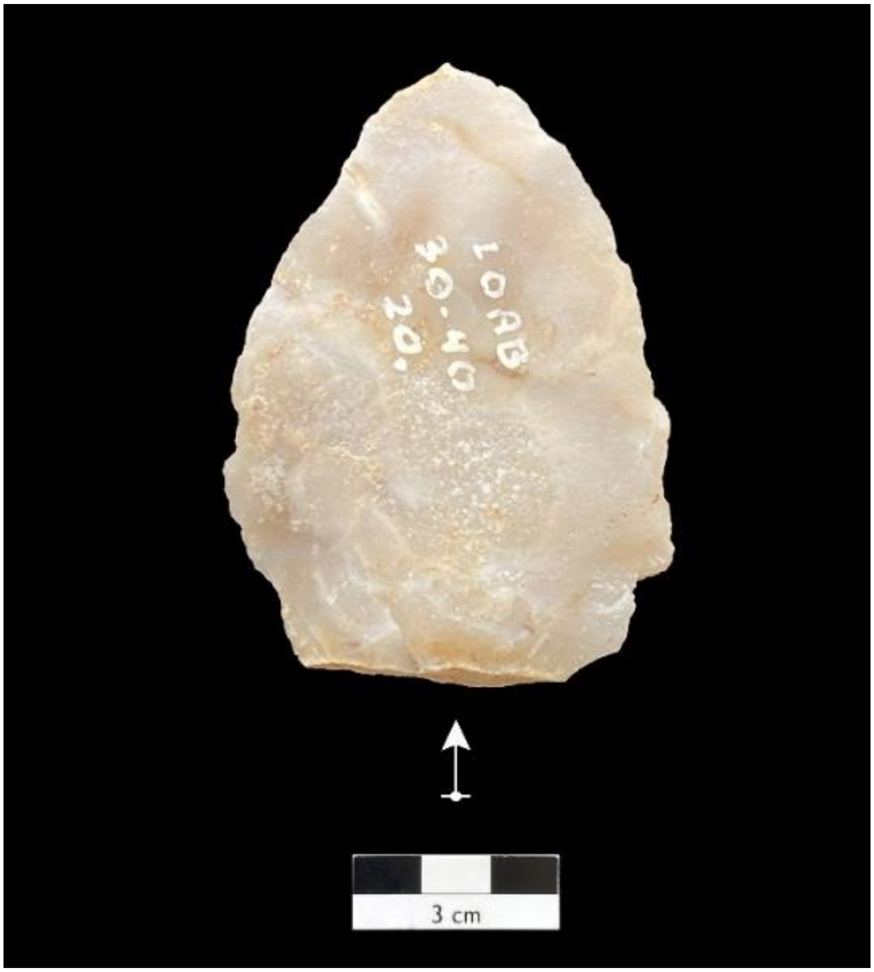


Figure 16. The ventral view of a flake produced from chert.

4.3.1. Alteration

Analysis was made on 22 fresh, 33 heat-treated, 40 patinated, and 9 both patinated and heated flakes. The majority of the flakes are thermally treated. One of the most significant features understood from the analysis of the lithic assemblage from the Laga Oda assemblages is thermal treatment. It can be argued that apart from thermal treatment, the artifacts are predominantly fresh. The edges are fresh and not rolled or moved by either slope, erosion, or any other natural factors.

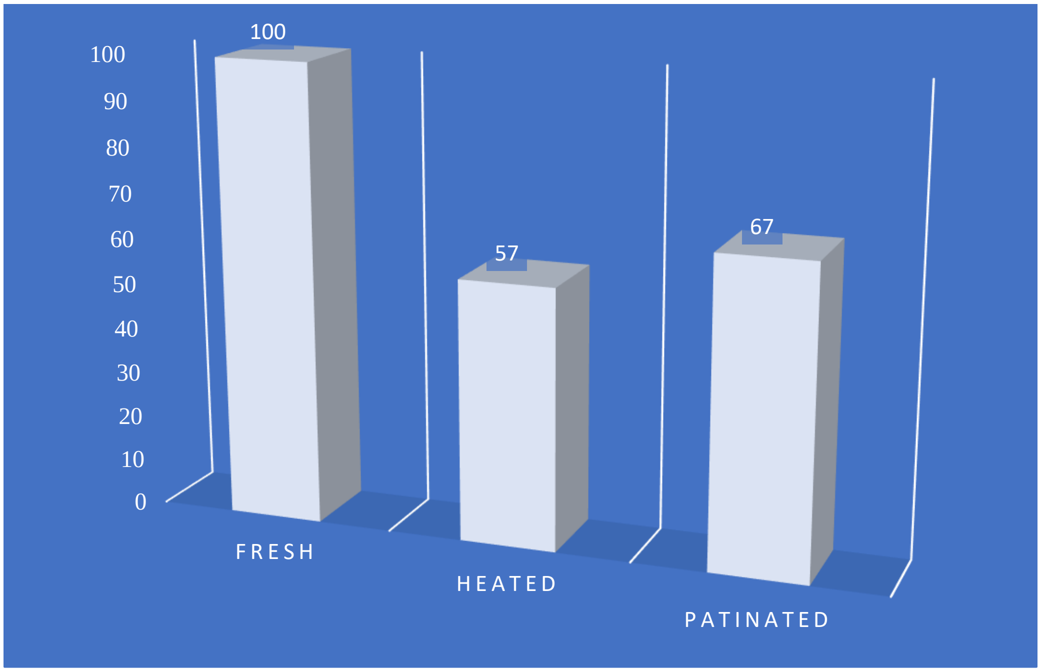


Figure 17. Types of flake alterations.

4.3.2. Striking platform

The type of flake striking platforms has been analyzed. This is because striking platform morphology and variability are crucial to determine the type of hammers used and the flaking techniques during production (Andrefsky, 2005). Accordingly, we documented and described the following striking platform features: cortical (n=5), dihedral (n=20), faceted (n=10), plane (n=79) and punctiform (n=42). Here, pointed platforms have been considered as punctiform since the two features are more or less similar morphologically. The majority of the flakes have a predominantly plane platform (35%), whereas the small samples have a cortical platform (2%). This type of platform is a single facet with a previously flaked surface.

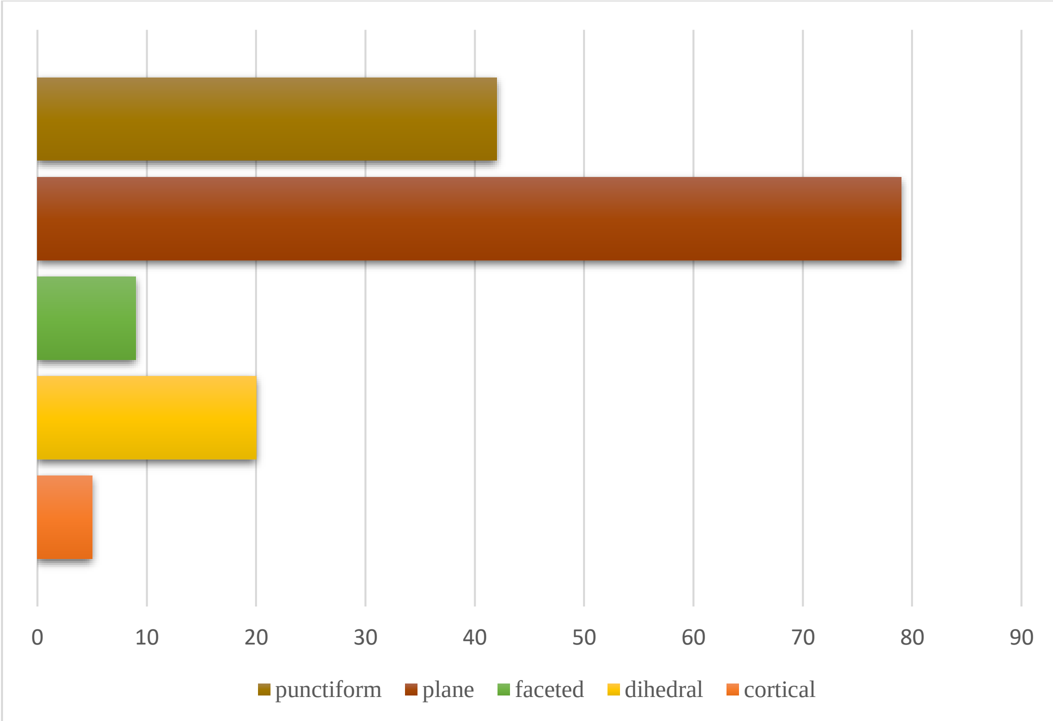


Figure 18. types of flakesstriking platform.

4.3.3. Dorsal features

There are only (5) cortical flakes and 2 flakes with greater than 50% cortical surface of flakes have cortical surfaces in the entire assemblage. These data show the lack of primary flakes. The majority of the flakes (n=109) have 0% cortical surface. The remaining 21 flakes have less than 50% cortical surface. Secondary and tertiary flakes appear to have occurred abundantly which indicates the continued reduction sequence of lithic production.

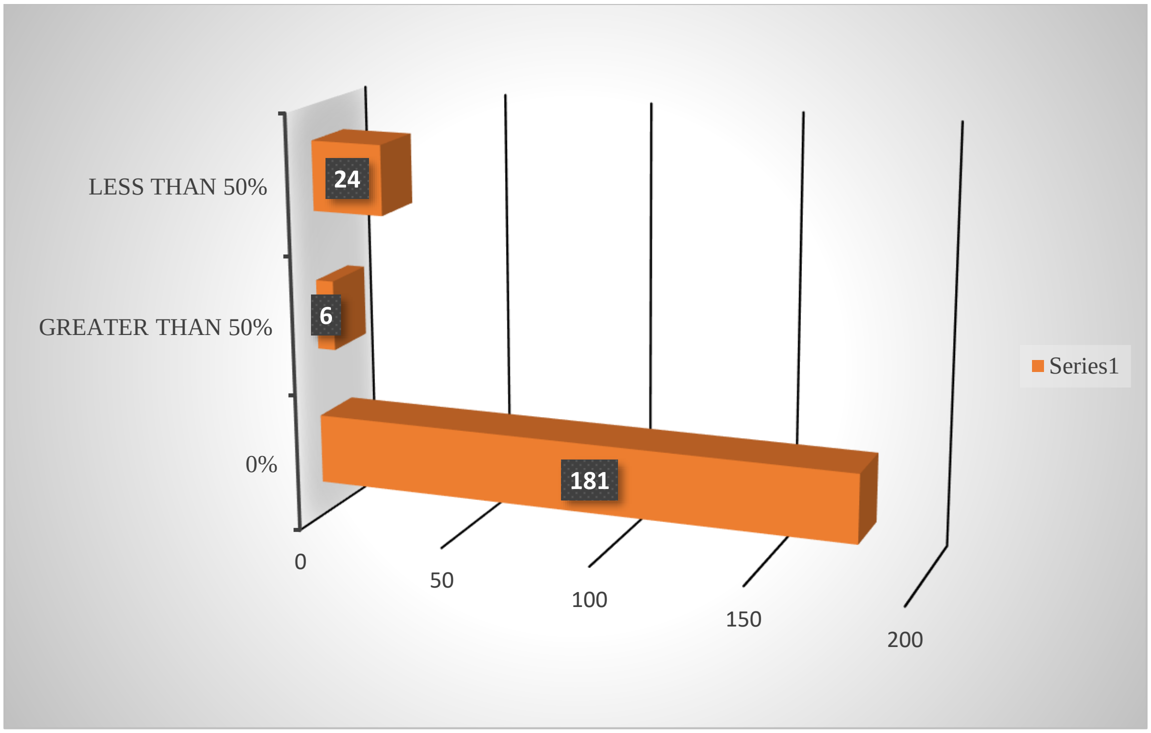


Figure 19. cortex percentage of dorsal surfaces of flakes.

4.3.4. Flake dimensions' analysis

Metric attributes of flakes and the dimensions of each artifact were measured and analyzed in detail. Thus, the length of the longest flake measures 54.37mm, whereas the shortest flake measures 7.39mm long with an average of 26.19mm. Flakes have width values ranging between 2.81mm to 37.4mm with an average of 13.21mm and a maximum thickness ranging from 1.43mm to 25.42mm with a mean thickness of 5.21mm. Thickness at maximum width was also measured and it ranges from 0.59mm to 25.42 with a mean value of 5.14mm). The table below summarizes the minimum, maximum, mean, and standard deviation of the complete flake dimensions of the Laga Oda assemblages.

Table 5. Metric dimensions flake analysis

Dimensions	Minimum value	Maximum value	Mean value	Standard Deviation
Length	7.39mm	54.67 mm	26.19	8.21
Width	2.81mm	37.4 mm	13.21	7.41
Thickness	1.43 mm	25.42 mm	5.21	3.12
TMW	0.59 mm	25.42 mm	5.14	8.7 5

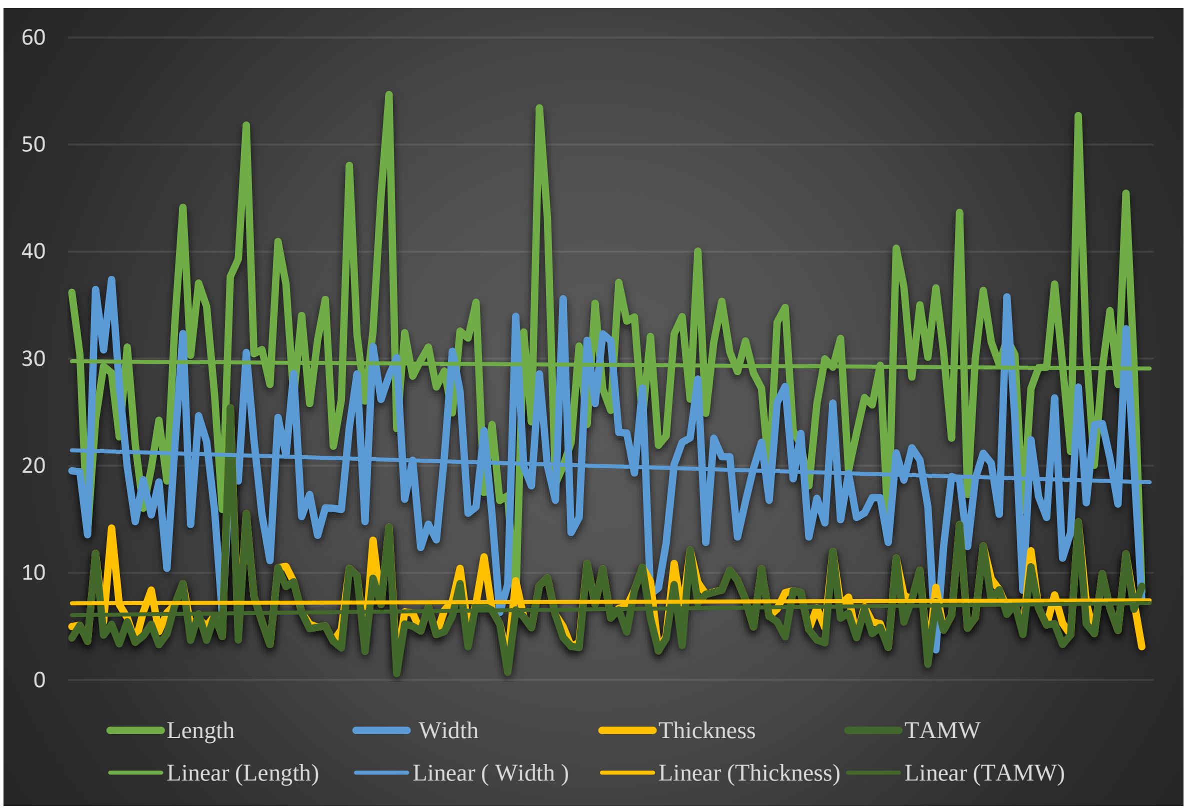


Figure 20. Flake length, width, thickness, and thickness at maximum width correlations graph across upper to the lower stratigraphic unit.

As it can be seen from the above graph (figure20), there are no dimensional (length and width of the flakes) differences across the different stratigraphic units. Length, width, thickness, and thickness at maximum width are consistent throughout the several stratigraphic units as is shown from the trendline. Maximum thickness and thickness at maximum width have overlapping lines indicating the consistency of production techniques.

4.3.5. Flake fragments

Flake fragments are flakes but without all of the characteristics mentioned for a flake (Andrefsky, 2005). They are with broken proximal or medial or distal parts. The breakage could have occurred either intentionally or unintentionally. According to Andrefsky (2005) analyzing the condition of a flake and its fragment would provide insights into the nature of flake removal and the character of flake attributes.

There are 29 (7%) proximal fragments, 10 (2%) medial fragments, and 50 (12%) distal fragments within the Laga Oda assemblages (see the chart below). The majority of the fragments were recovered from the 20-70 cm horizon. Almost 79 % of the entire flake assemblages are complete and the remaining 21% are flake fragments. The flake fragments of Laga Oda could possibly be due to taphonomic processes.

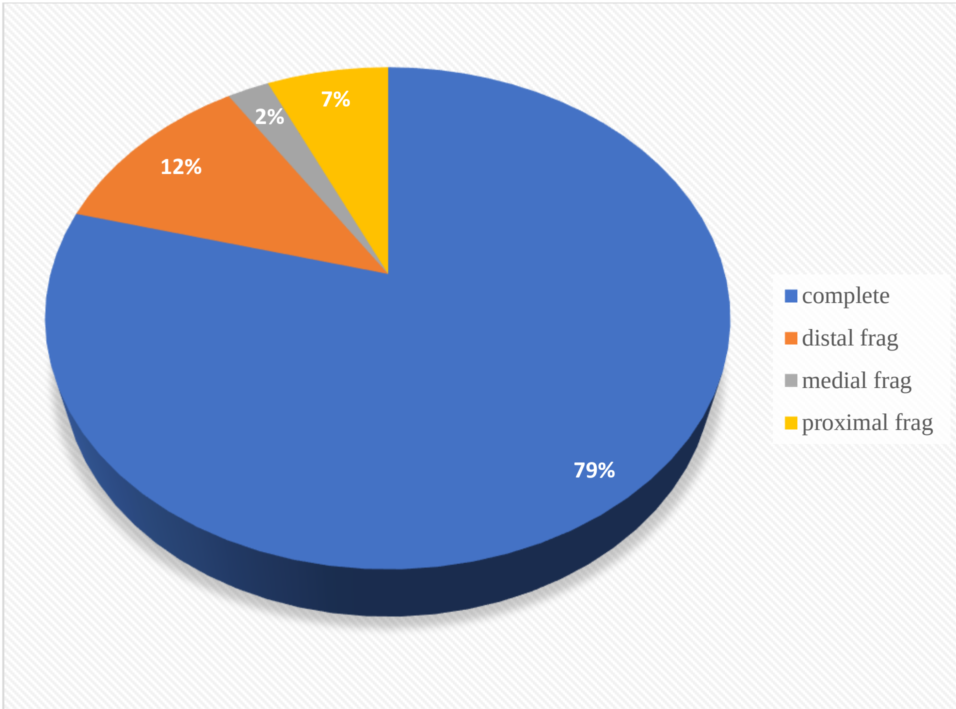


Figure 21. Percentage distribution of complete and sub-complete flakes of Laga Oda assemblages.

4.5. Bladelets

There have been conceptual controversies about the difference between blades and bladelets (Ambrose, 2002). Most archaeologists define blades and/or bladelets as flakes that are twice as long as they are wide and having parallel and sub-parallel edges (Andrefsky, 2005; Inzian et al., 1999). For this research, we have preferred to use the term 'bladelets'.

Bladelets are also more associated with terminal Pleistocene LSA assemblages. Some consider bladelets as small blades with small parallel-sided flakes between30mm and 50mm long, and with a maximum width of 12mm wide, or they usually have a thickness less than 5mm. The analysis of the bladelets from Laga Oda shows that the majority of the bladelet sizes fall in this category.

There are about 23 bladelets from the Laga Oda LSA assemblage recovered between 20and 70cm stratigraphic units. They account for only 4.3% of the entire lithic assemblages. The Laga Oda bladelets are exclusively made from chert.

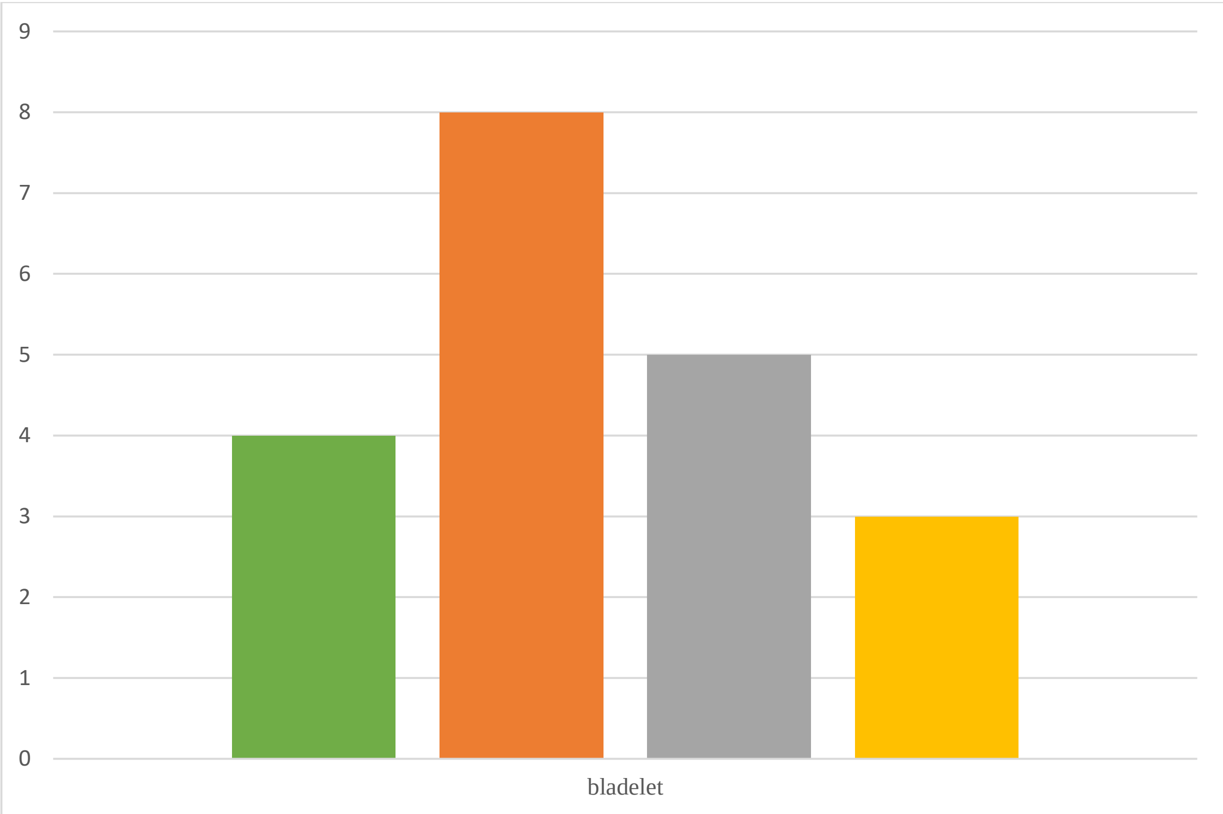


Figure 22. Distribution of bladelets along with the multiple stratigraphic units.

Although bladelets were generally recovered from 20-70 cm stratigraphic units, the majority of them appear to have been concentrated between 40-70 cm unit levels. Though the sample size is small, it has been observed that the concentration came from between the Middle to Late Holocene strata. The majority of them exhibit a punctiform platform type and they have also been thermally treated. Regarding the dorsal type, none of the bladelets have preserved cortex.

Figure 23. Bladelets of the Laga Oda assemblages.

Bladlets have a minimum and a maximum length of 25.52 mm and 47.55mm respectively with a mean of 37.01mm. The minimum and maximum width of bladelets are 7.38mm and 18.33mm with an average of 12.05mm. The assemblages minimum and maximum thicknesses are 2.19mm and 9.69mm with an average of 5.59mm. Thickness at maximum width ranges from 2.39mm to 9.69 mm with a mean of 5.24mm.

4.7. Retouched tools

Retouched tools are modified flakes or flake fragments that have been steeply retouched ("backed" or "truncated") along with at least one of the edges and some parts of their edge remain unretouched (Shea, 2013). 23 retouch artifacts from the Laga Oda LSA assemblages have been meticulously analyzed. The retouches were made on flake tools. All of the retouched pieces from Laga Oda lithic assemblages are made from cherts. Their length ranges from 24.73mm to 43.63mm with a mean of 32.16 mm. Similarly, the width of retouch tools is between 23.03mm and 25.01mm. The thickness of these artifacts is also between 1.45mm to 10.74mm. More than 98% of retouch tools have no cortical surface.

There are also few (n=3) truncated pieces from the whole assemblages. Evidence of backing lithic tools from the distal and proximal end remained very limited in our assemblage. The retouches analyzed in this category here are not referring to scrapers, burins, denticulate or backed pieces.

4.9. Scrapers

Scrapers are other components of the lithic assemblages from the Laga Oda rock shelter. They are rudimentary tools which account for nearly 2% (n=12) of the entire assemblages, and all of them were made from chert. Scrapers have retouches including double-side, single side and, double-side-and-end. Most of them are side scrapers.

The number of the scrapers appears to be small compared to other assemblages which shows the limited production of this tool class at Laga Oda. Scrapers have come from the deposit between 20cm and 70cm units predominantly. The retouch pattern on the scrapers generally went from the ventral surface to the dorsal surface which mostly forms the convex shape.

Table 6 . The measurement of minimum, maximum, mean, and standard deviation values of lithic scrapers

Dimensions	Minimum value	Maximum value	Mean value	Standard Deviation
Length	22.06mm	52.94mm	32.1mm	8.21
Width	16.81mm	31.48mm	22.82mm	7.41
Thickness	7.52mm	15.26mm	11.13mm	3.12
TMW	7.5 mm	15.26 mm	10.45mm	8.7 5

Abbreviations – thickness at maximum width

As it is summarized in the above table, the minimum and maximum lengths of scrapers are 22.06mm and 52.94mm with an average length of 32.10mm respectively. Concerning width, the value ranges from 16.81mm to 31.48mm (with a mean value of 22.82mm). In this assemblage, scrapers have a minimum thickness of 7.52mm and a maximum thickness of 15.26mm with an average thickness of 11.13mm. Thickness at maximum width has also been measured. Thus, the minimum and maximum values are 7.52mm and 15.26 (mean of 10.45mm). The similarity of measurements between maximum thickness and thickness at maximum width shows the correlation of the two attributes and the consistency of lithic production techniques at Laga Oda.

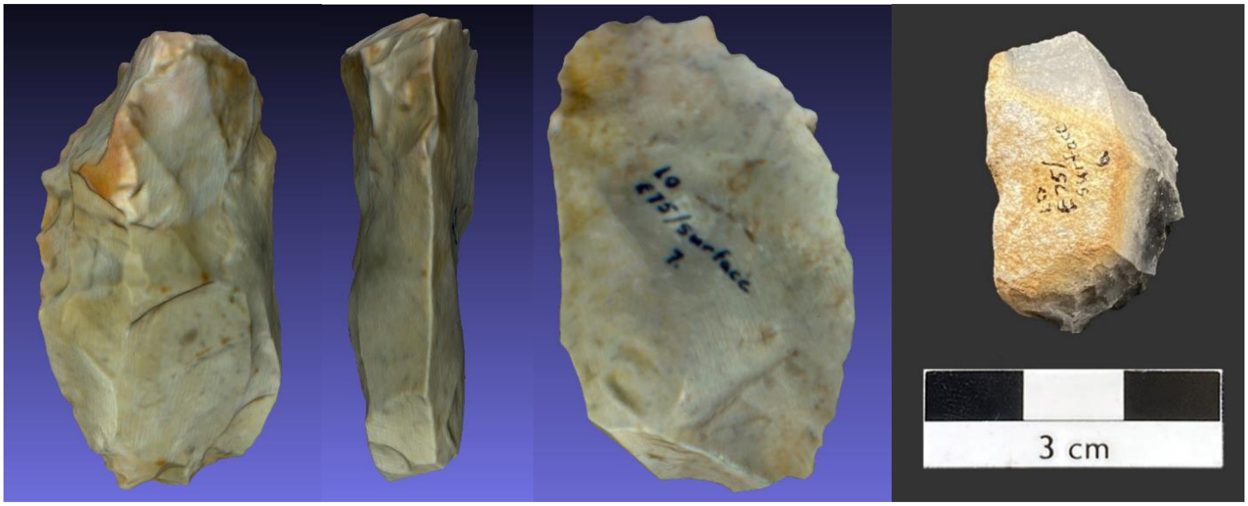


Figure 24. Double-side-end scraper (3D illustration and 3D view) and side scraper (right).

4.10. Burins

The name comes from the French word ‘Burin’ to refer to *“cold chisel”*. Burins are retouched tools associated with bladelet technology rapid retouch and preparation for hafting tools on organic materials (Method, 2005).It’s a type of handheld lithic flake with a notched edge. There 2 burins analyzed from the Laga Oda lithic assemblage. One burin was recovered from 40-50 cm and the other 50-60cm unit. Both of them were made from chert. The Burins from the assemblage are bifaces and truncated.

Figure 25. Burin spall showing micro burin production technique with notches at both sides .

4.11. Backed pieces

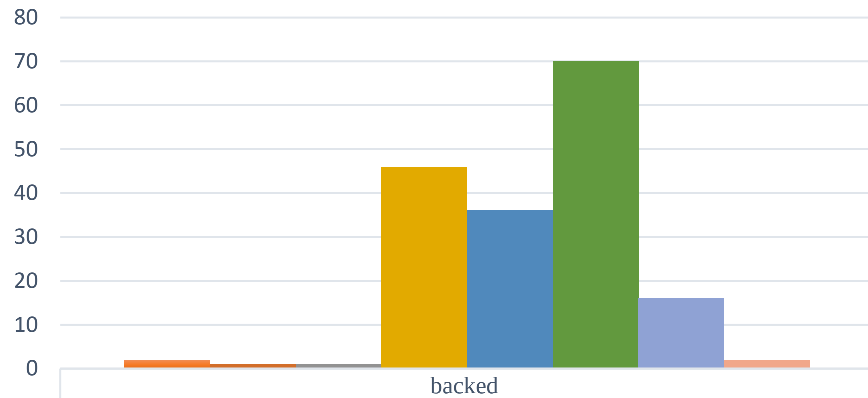
One of the unique features of Laga Oda assemblages is the presence of backed pieces which share the majority from the entire assemblages 36.1% (n=203) as confirmed after flake analysis at the laboratory of ARCCH. Backed elements persist the largest percentage of the entire assemblage following flakes (n=213) at Laga Oda. They are the most predominant tools from this site.These backed pieces have been analyzed as shaped tools in previous publications (Clark & Prince, 1978; Kurashina, 1978).

The term backed pieces, shaped tool, geometrics, backed bladelets, and microliths have often been employed interchangeably in many archaeological works of literature. Leplongeon *et al*., (2020) define a backed piece asa lithic product with at least one edge, or part of an edge, modified by abrupt to semi-abrupt continuous retouches.

These authors believe that this definition is generic that embraces various components such as totally and partially backed artifacts and geometries of various size ranges. For this research, we have also employed the term '*backed pieces*' for the assemblages with abrupt and semi-abrupt retouches.

It has been argued by Phillipson (2005) that backed pieces are the technological hallmark of LSA technology. Similarly, since the backed pieces are the desired by-products of the entire assemblages of Laga Oda rock shelter, we have employed more attributes for the typological, technological, and comparison with other contemporaneous sites of similar chronology and LSA technology, in general, to better understand the '*chain opératoires'* of the site. Since they have abrupt, semi-abrupt, and continuous retouches, geometrics (triangle, trapeze), crescents, and segments are included in this section as part of backed pieces.

Figure 26. Examples of backed pieces with abrupt and continuous retouches from the Laga Oda assemblages.



	backed
10-20 cm below datum	2
110-120 cm below datum	1
130-140 cm below datum	1
20-30 cm below datum	46
30-40 cm below datum	36
40-50 cm below datum	70
50-60 cm below datum	16
60-70 cm below datum	2

Figure 27. Concentrations of backed pieces across the different stratigraphic levels.

Among 203 backed pieces, 155 of them are complete and 48 are sub-complete. The sub-complete pieces are proximal, media, and distal fragments. The Laga Oda assemblage is characterized by abundant production of backed pieces. Based on our analysis, almost all of the backed assemblages do not differ from each other at the several stratigraphic units. Although the backed pieces are situated between 20-70 cm stratigraphic unit, while there are dense concentrations between 20-50 cm stratigraphic unit which is dated to the Middle Holocene to Late Holocene.

Dimensional analysis on the complete pieces of backed pieces considered multiple attributes mainly maximum length, maximum width, maximum thickness, thickness at maximum width (TMW), weight, length to width ratio (LW), width to thickness ratio (WT), back thickness proximal, back thickness medial, back thickness distal, and back mean.

Table 7 Summary of main dimensions of backed artifacts.

Dimensions	Minimum value	Maximum value	Mean value	Standard deviation
Length	12mm	44.59mm	23.67mm	8.2mm
Width	2.98mm	18.51mm	8.22mm	7.41mm
Max thickness	1.38mm	8.23mm	3.31mm	3.12mm
TMW	1.38mm	5.6mm	3.05mm	8.75mm
Weight	0.1mg	3.8mg	0.65mg	2.9mg
LW	1.43mm	8.97mm	3.05mm	1.23mm
WT	0.39mm	4.99mm	2.61mm	1.49mm
BK-T-Prox	0.77mm	5.32mm	2.64mm	1.49mm
BK-T-Mes	0.67mm	5.46mm	2.67mm	1.49mm
BK-T-Dis	0.8mm	5.04mm	2.42mm	0.98mm
BKT mean	0.78mm	5.18mm	2.58mm	1.13mm
BKTrel	0.31mm	1.18mm	0.79mm	0.41mm

Abbreviations: TMW- thickness at maximum width; LW-Length to width ratio; WT- Width to thickness ratio; BK_T_Prox - Back thickness proximal; BK-T-Mes- Back thickness medial; BKT_mean – Back thickness means; BKTrel- Relative back thickness (ratio of BK mean to maximum thickness).

The length of the longest-backed piece measures 44.49mm and the shortest piece is 12.88 mm with an average of 23.67mm. In terms of artifact width, the dimensions are ranged from 1.92 to 18.51 mm with an average of 8.22mm. The thickness of backed pieces ranges from 1.38mm to 8.23mm with an average of 3.31mm. The maximum thickness of most artifacts lies about 5mm. We only have one bigger piece with a thickness of 8.23 mm. As it can be seen from the above graph (trend line) and the mean and standard deviation of each attribute, there have not been differences of dimensions between the different stratigraphic units. There is a slight increment in length as we go deeper into the stratigraphy. However, it is generally observed that length, width, and thickness are consistent throughout the several stratigraphic units.

The above graph on dimensions backed pieces shows measurement attributes of backed pieces such length, width, and thickness, thickness at maximum width, length to width ratio (LW), width to thickness ratio (WT), back thickness proximal, back thickness medial, back thickness distal is consistency throughout the several stratigraphic units. Maximum thickness and thickness at maximum width have overlapping values.

All the backed pieces are small in size and so belong to microliths. There is very few geometrics present in the Laga Oda assemblages. Our examination shows that the opposed angle ages of the backed pieces are pre-dominantly sharp. Similarly, the majority of these tools are shaped not symmetrically. Irregular shapes have appeared largely.

58% of the backed pieces have removed butt or striking platform at Laga Oda. Backed pieces without bulbs are 153 (68%) whereas the remaining 32% have bulbs. Curvature analysis indicates the presence of 40% (84) curved, 31% (63) flat, and 29% (29) slightly curved, and one sinuous backed piece. Most backed elements are either curved or slightly curved which indicates the large presence of crescents and segments abundantly. 73% of the backed pieces (n=152) are not twisted, whereas 27% (n=59) have twisted shapes. Thus, there is a limited number of twisted elements in the assemblage. In terms of transverse symmetry, 73% of the backed tools have no transverse symmetry, whereas the remaining 27% have symmetric shapes.

Analysis of back location has been performed with the parameters of total backing, almost backing, and partial backing. Accordingly, 94% backed, 5% partially backed and 1% almost backed artifacts have been identified. Thus, abrupt and continuous backing of the backed pieces is predominant. Analyzing the opposed edge transform was also carried out to see if the opposed edges have retouches or not. Thus, 94% have a continuous edge, 5% discontinuous edge, and 1% partial edge transform. Similarly, the opposed edge angle of the backed assemblages indicates 94% sharp edge and 6% steep edge angle.

Retouch type analysis of backed assemblages shows that the backed pieces have retouch types of 109 (63%), direct, 22 (13%) cross, 21(13%) alternates, and 21(13%)inverses. The majority of the pieces have direct retouch and they were backing from the ventral surface to the dorsal surface.

4.11.1. Comparison of backed pieces with other contemporaneous sites

To have a better understanding of inter-site technological and typological variations and the uniqueness of the Laga Oda assemblages, two contemporaneous LSA sites are selected. For qualitative analysis, seven qualitative variables (see graphs 29 and 30) were employed both for the Middle Holocene and Late Holocene sites of Goda Buticha and Mochena Borago with Laga Oda such as dorsal type, butt, bulb, curvature, retouch type, transverse symmetry, backed location, opposed edge transformation, and opposed age angel.

All of these attributes are taken from the developed approaches by LeplongeonMénard*et al*. (2020). Goda Buticha is a site situated close to Laga Oda whereas, Mochana Borago is located in a different ecological zone in the southwestern Ethiopian highlands. Both sites chosen for comparative analysis are rock shelters. While the dominant raw material for Goda Buticha is chert (Pleurdeau *et al*., 2014) whereas the raw material of Mochena Borago is obsidian. Chert as a raw material occurs in high frequency at Laga Oda as well.

Table 8. The number of backed pieces and chronology of sites taken for comparative analysis.

Sites	Number of backed pieces	Chronology	References
Laga Oda	146	Middle-Late Holocene	
Goda Buticha	21	Middle Holocene	(Leplongeonet al.,2017)
Mochena Borago	46	Middle Holocene	(Leplongeon, Ménard, et al., 2020)
Goda Buticha	16	Late Holocene	(Leplongeonet al., 2017)
Mochena Borago	33	Late Holocene	(Leplongeon, Ménard, et al., 2020)

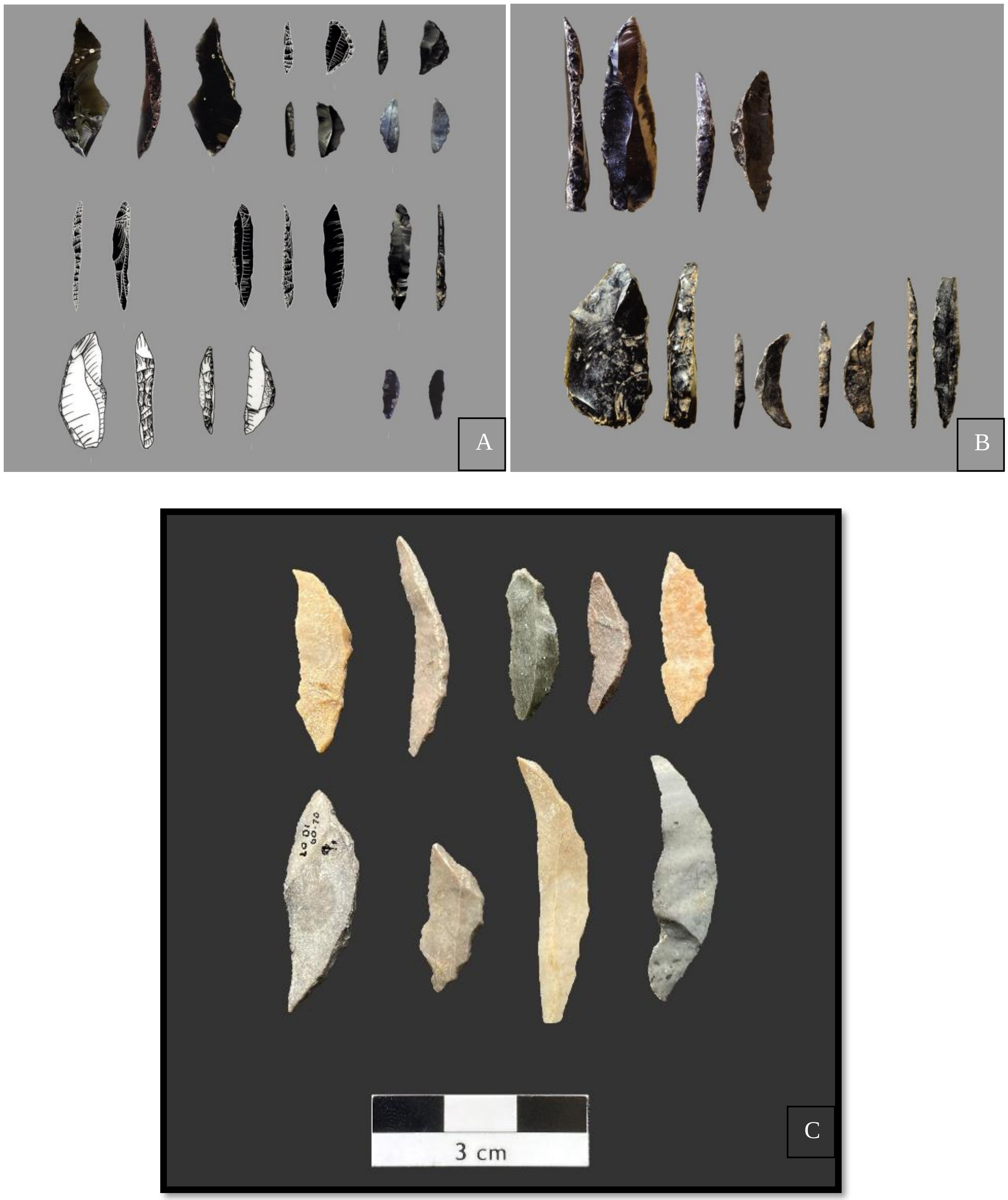


Figure 28. Backed pieces from Goda Buticha (A), Mochena Borago (B), and Laga Oda (C)

(photo A and B after Leplongeon, Ménard, et al., 2020).

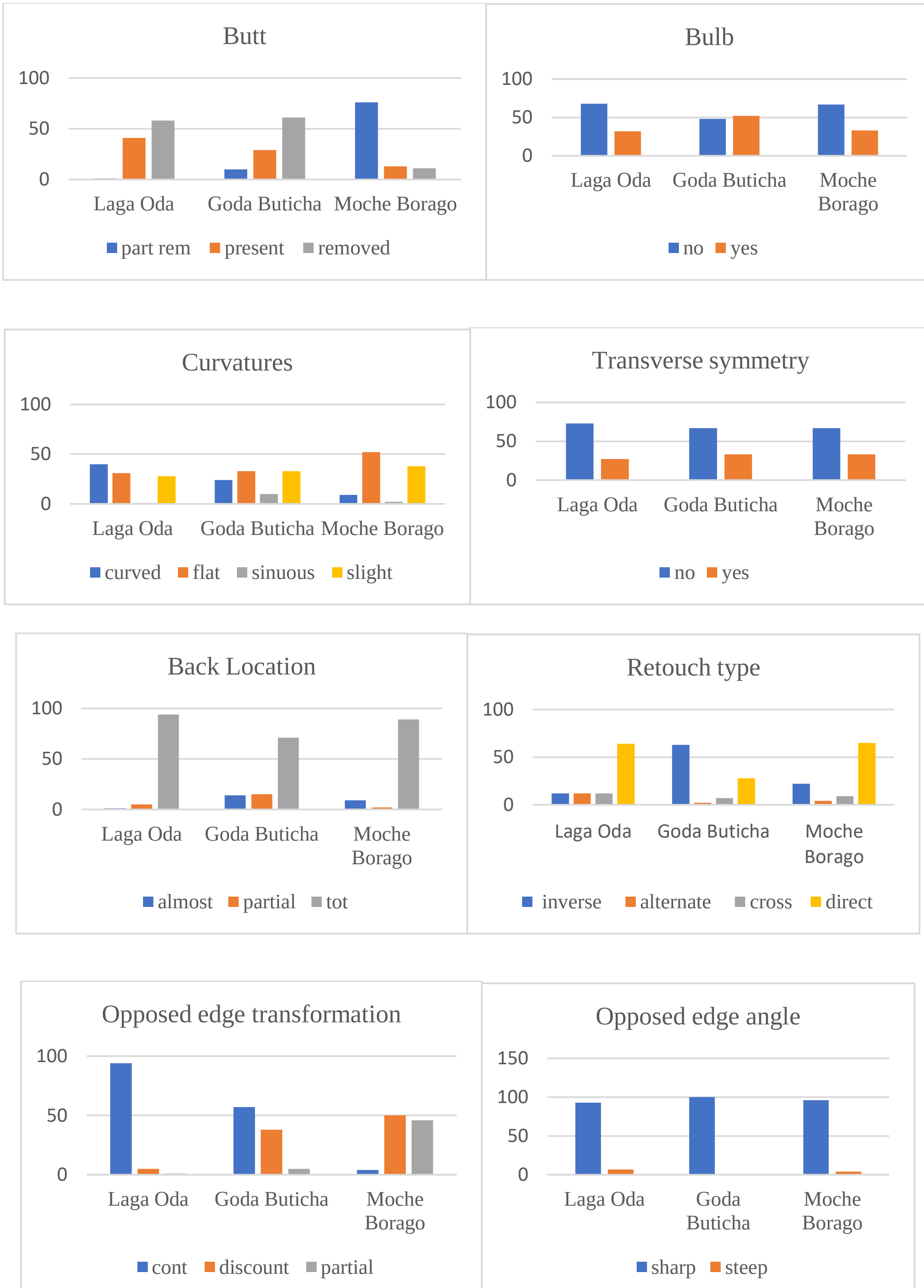


Figure 29. Comparison of Middle Holocene backed pieces of Goda Buticha and Mochena Borago with Laga Oda using various attributes pieces such as butt, bulb, curvatures, twisting, transverse symmetry, backed location, opposed edge transform, and opposed age angle,

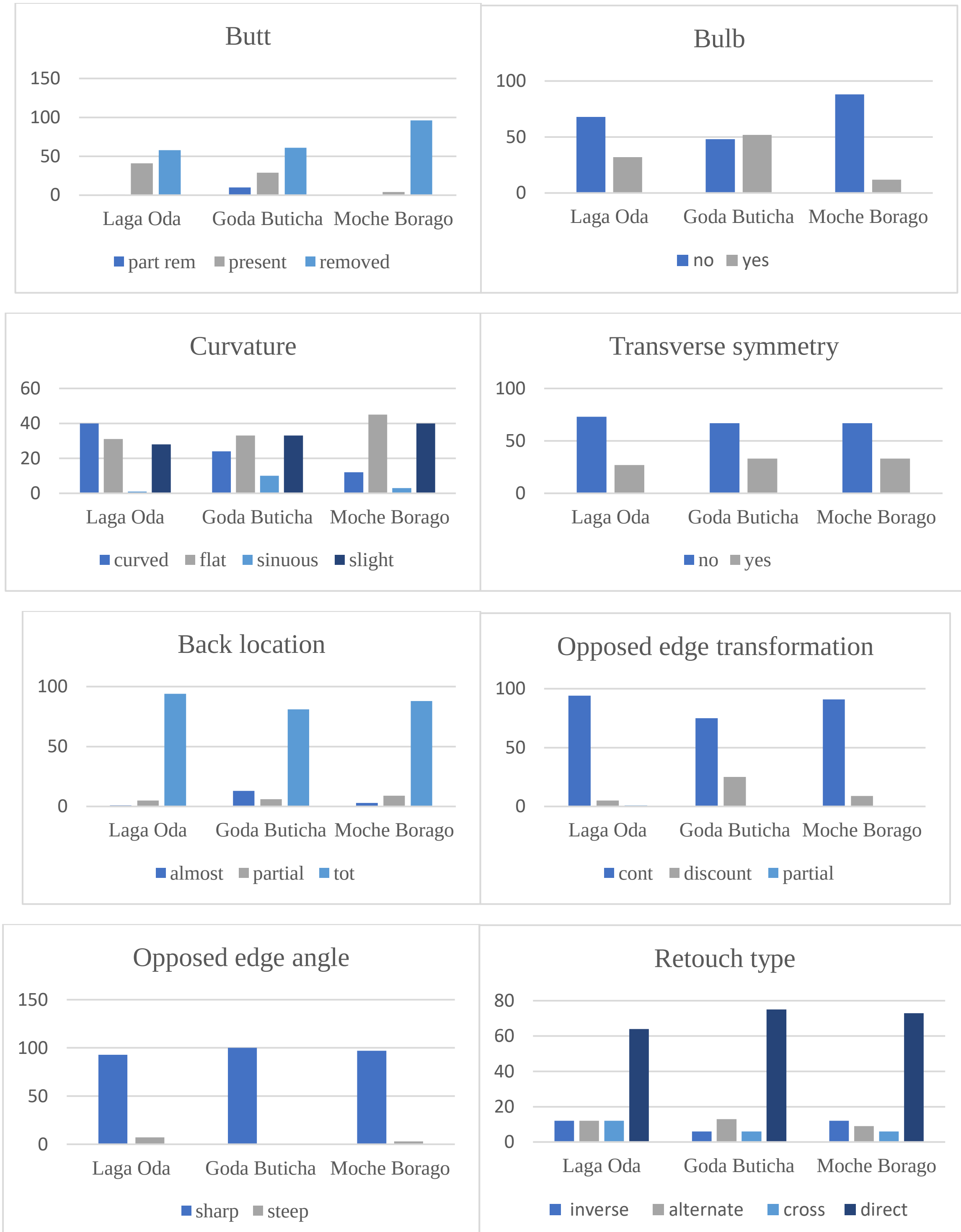


Figure 30. Comparison of Late Holocene backed pieces of Goda Buticha and Mochena Borago with Laga Oda using various attribute variables pieces such as butt, bulb, curvatures, transverse symmetry, backed location, opposed edge transform, and opposed age angle.

The above graphs (figures29 and 30) show the chronological and geographical comparisons using the above-mentioned qualitative variables. Since large assemblages of lithic artifacts are concentrated during the Middle and Late Holocene stratigraphic horizons, two sites with different geographical locations were selected for comparison.

Based mainly on the Middle Holocene dataset comparison and as indicated by the above bar graphs (figures 29 and 30), both spatial variations and similarities of lithic production trends are observed. Variations are observed on the variables of butt, curvature, retouch type, and opposed age transform. While both Laga Oda and Goda Buticha have the most dominantly removed butt, Mochena Borage exhibits a high percentage of the parts removed butt.

Similarly, Laga Oda has a high frequency of curved pieces whereas the other two sites show flat curvatures most commonly. When it comes to the retouch type, Laga Oda and Mochena Borago pieces show direct retouch whereas Goda Buticha is dominated by inverse retouch. A significant number of Goda Buticha backed pieces are also retouched directly though the percentages are less compared to the direct retouch type. Direct retouch is produced from the ventral to the dorsal surface.

The other variable in which variation is seen is the opposed edge transformation. Whereas mostly continues opposed age transformation can be seen on Laga Oda and Goda Buticha assemblages, discontinues edge transformation appears to have dominated from Mochena Borago assemblage.

Consistency of trends has been observed on some variables across all sites showing similarity of lithic reduction techniques. These variables are bulb, transverse symmetry, back location, and opposed age angle. All three sites exhibited the absence of bulbs in their backed elements to a greater degree. However, this does not rule out the totality of the presence of bulbs from these sites. Likewise, significant numbers of the backed pieces from these sites show the production of symmetric shape backed pieces. The back location of the artifacts from these sites is produced with total continuous and abrupt backing.

In terms of Late Holocene datasets, significant variations are observed only on curvatures. Otherwise, there are no overall noticeable differences, and similar trends can be seen in attributes such as butt, bulb, transverse symmetry, back location, opposed edge transformation, opposed edge angle, and retouch type.

Generally, removed butt, absence of bulb, curved and/or slightly curved, lack of symmetry, continues backing of back location, no age transformation, sharp edge angle, and direct retouch have been dominated the backed assemblage from all the three Late Holocene sites. Thus, based on the examinations of these qualitative variables, we can argue that similarity of production techniques might have been taking place at all sites during the Late Holocene.

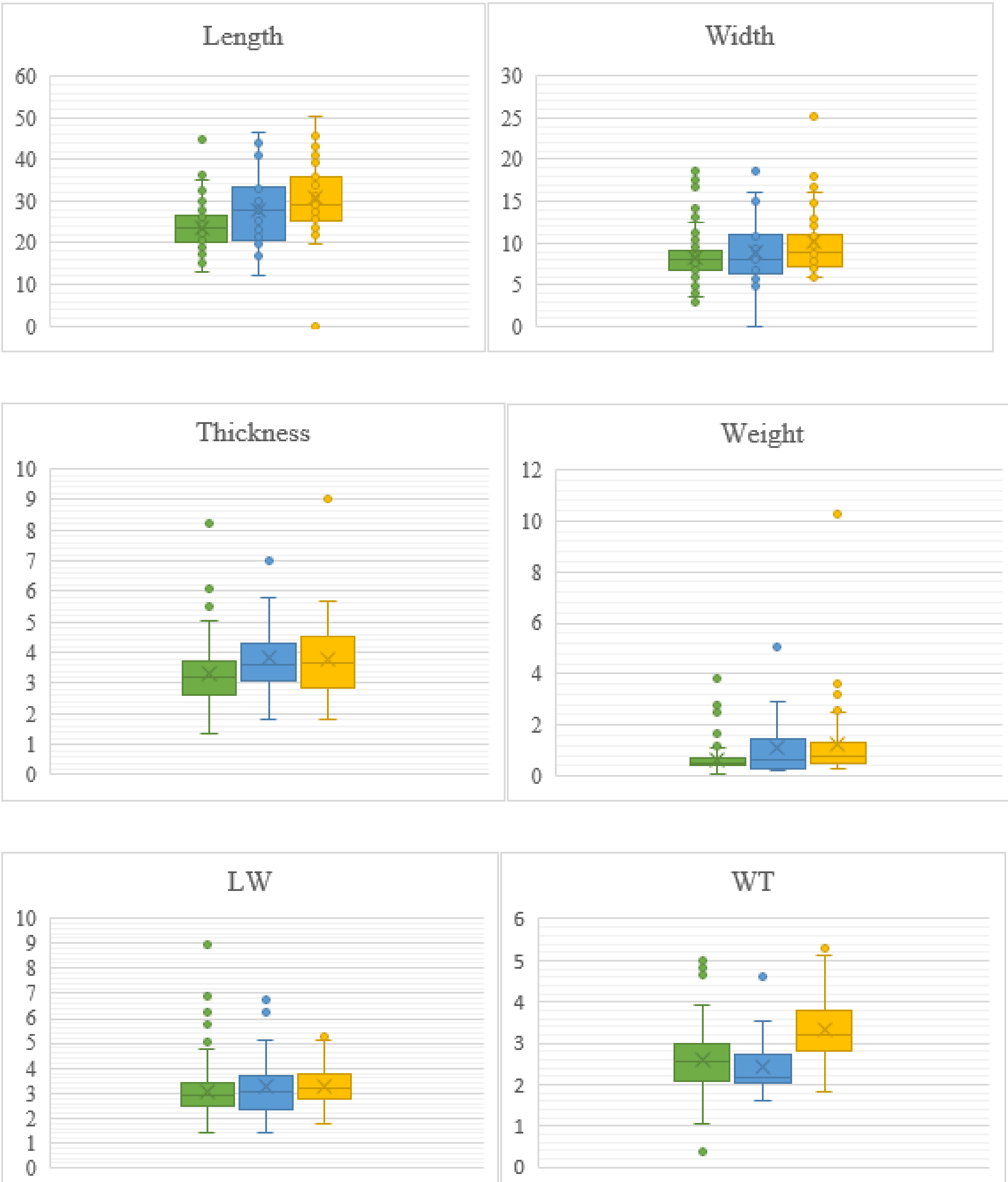


Figure 31. The graphs showing the comparison of Middle Holocene backed pieces of Laga Oda with Goda Butich and Mochena Borago using univariatestatistical analysis of quantitative variables such as maximum length, maximum width, maximum thicknessweight, length to width ratio (LW), width to thickness ratio (WT), back thickness proximal, back thickness medial, back thickness distal, and back mean (boxplot). (Left to right Laga Oda, Goda, Buticha, and Mochena Borago).

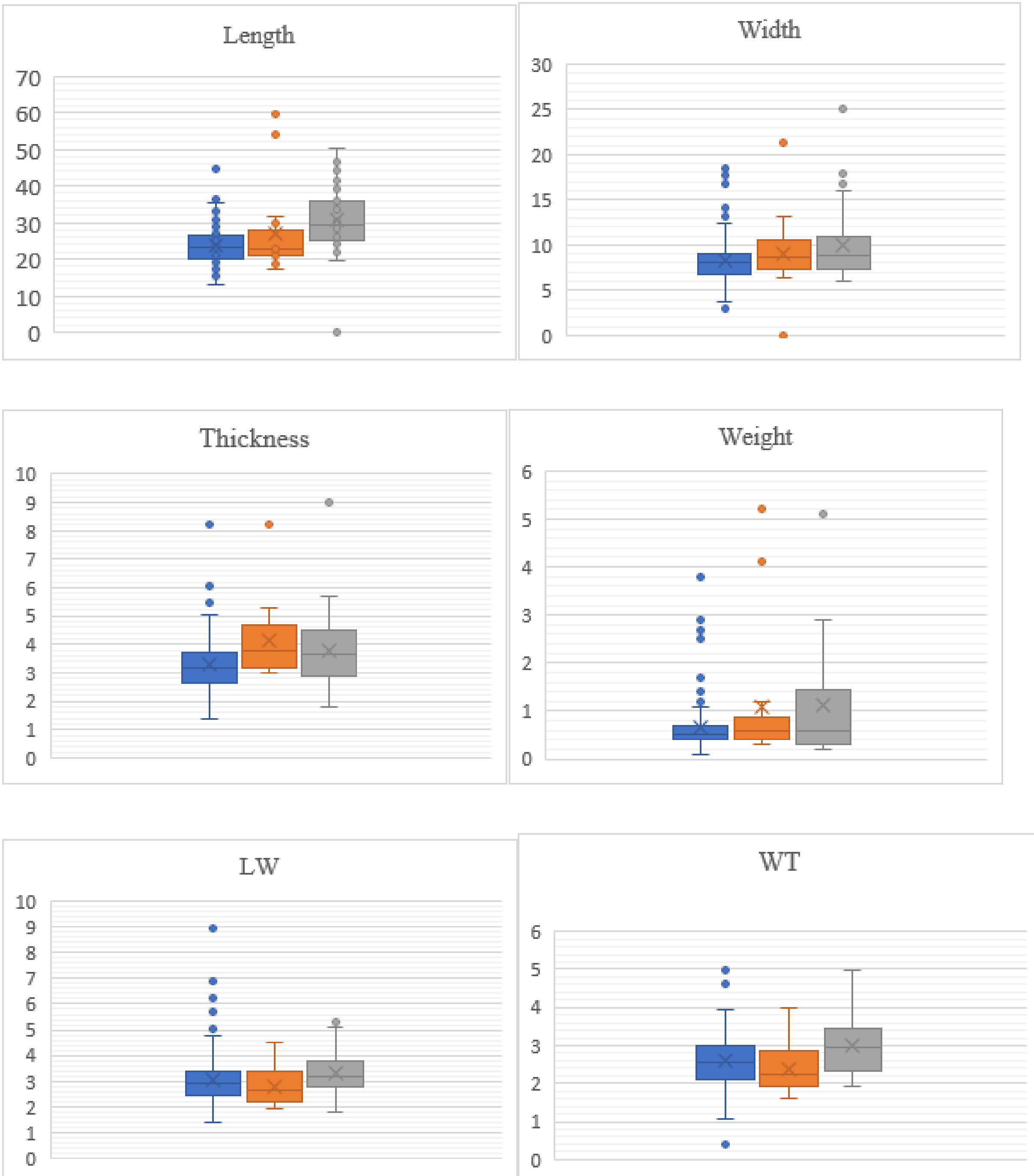


Figure 32. The graphs showing the comparison of Late Holocene backed pieces of Laga Oda with Goda Butich and Mochena Borago using univariate statistical analysis of quantitative variables such as maximum length, maximum width, maximum thickness, weight, length to width ratio (LW), width to thickness ratio (WT), back thickness proximal, back thickness medial, back thickness distal, and back mean (boxplot). (Left to right Laga Oda, Goda, Buticha, and Mochena Borago).

Based on the whisker and box-plot analysis of backed pieces, the difference in length, width, thickness, and weight have been observed between the Laga Oda backed assemblage with both Goda Buticha and Mochena Borago during the Middle -Holocene. A general trend of decrements is common in all of the mentioned attributes. On contrary, the size of Goda Buticha and Mochona Borago is also not correlated in both chronological times. Pearson Correlation on the metric dimension variables using SPSS software has been carried out to see the variation and similarities between the three sites.

Table 9. The Pearson Correlation of the metric variables of the assemblages dated to the Middle Holocene between Laga Oda, Goda Buticha, and Mochena Borago

Metric variables	**P-value LO vs GB**	**P-value LO vs MB**	**R-value LO vs GB**	**R-value LO vs MB**
Length	0.14	0.35	0.34	-0.141
Width	0.003	0.426	0.61	-0.12
Thickness	0.499	0.512	0.156	-0.099
Weight	0.000	0.572	0.732	-0.085
LW	0.029	0.017	0.477	0.351
WT	0.154	0.962	0.373	0.009

Abbreviations:LO- Laga Oda, GB- Goda Butichha, and MB- Mochena Borago.

There are significant relationships between Laga Oda with Goda Buticha in terms of width and weight. As it can be seen from the above table, the p-value and r-value reflect significant relationships. However, but no significant correlation with the Mochena Borago site. There are internal variations with a higher degree in the Goda Buticha and Mochena Borago assemblage. No statistical significances are observed regarding the length, thickness, LW, and WT (see table 9) of all the three sites during the Middle -Holocene.

Internal variations have been seen in all metric attributes of length, width, thickness, and weight at both sites of Goda Buticha and Mochena Borago (table 9). There are many outliers in the weight measurement of all sites.

Table 10. The Pearson Correlation of the metric variables of the assemblages dated to the Late Holocene between Laga Oda, Goda Buticha, and Mochena Borago

Metric variables	**P-value LO vs GB**	**P-value LO vs MB**	**R-value LO vs GB**	**R-value LO vs MB**
Length	0.176	0.544	0.356	-0.11
Width	0.003	0.868	0.61	0.030
Thickness	0.410	0.148	0.221	-0.258
Weight	0.010	0.430	0.625	-0.142
LW	0.584	0.207	0.148	0.226
WT	0.154	0.962	0.373	0.009

Abbreviations:LO- Laga Oda, GB- Goda Butichha, and MB- Mochena Borago

Like that of the comparisons for Middle Holocene data of Goda Buticha and Mochena Borago, a similar comparison has been carried out for the Late Holocene metric datasets of the three sites. Thus, it is identified that similar statistical results happened with the Middle Holocene. This means there are significant relationships that can be seen between Laga Oda with Goda Buticha in terms of width and thickness (see the p and r values of table 10). Likewise, there are no significant relationships between Laga Oda with Mochena Borago. There are internal variations within the Goda Buticha and Mochena Borago assemblage. No statistical significances are observed regarding the length, thickness, LW, and WT of all the three sites during the Late-Holocene.

The variations of values within the site continued to be seen during the Late Holocene assemblages of Goda Buticha and Mochena Borago. Notable differences in the quantitative variables are not observed chronologically between the Middle andLate Holocene. A slight decrement of the overall size could be seen in both Goda Buticha and Mochena Borago pieces.

4.12. Technical pieces

Core trimmings or core rejuvenation pieces have crucial importance in providing insights into the type of technological production and particularly core reduction sequence (Andrefsky, 2005). The technical pieces identified from the Laga Oda assemblages are tablets, crested blades, core rejuvenation flakes, and core sides. Tablets (n=6), crested bladelets/ (n=4), and few core rejuvenation flakes are the major technical pieces from the Laga Oda assemblage. The tablets show the preparation of the core for the removal of flakes from the ventral to the dorsal side. As is seen from the picture below, there are crest retouches.

Figure 33. Core tablets (left), crested bladelet (right), and 3D of core tablete of the Laga Oda assemblages made from chert.

4.13. Indeterminants

About 28 artifacts of the whole assemblages have not been identified to specific technological and/or typological categories. These lithic records have been considered as indeterminants which are none identifiable materials. It has been observed that some of these pieces are the result of heat fractures rather than any particular knapping technique. Thus, some lithic artifacts are heat spalls.

While 97% (n=26) of indeterminants were produced from cherts, the remaining 7% (n=2) artifacts were made from obsidian. Evidence of patination has been observed on some materials. The flake scars are natural and crushed fractures. They also have irregular shapes.

4.14. Hammerstones

Hammerstone is a piece of rock that has been used to remove flakes or flaked piecesfrom a core or nodule by force or percussion. Repeating battering actions during percussion leaves a significant scar on a hammerstone. There are 2 hammerstones made from chert within the Laga Oda assemblages. They are medium-sized hammerstones exhibiting shattered scars and could have been used in the production of flakes and other stone tools.

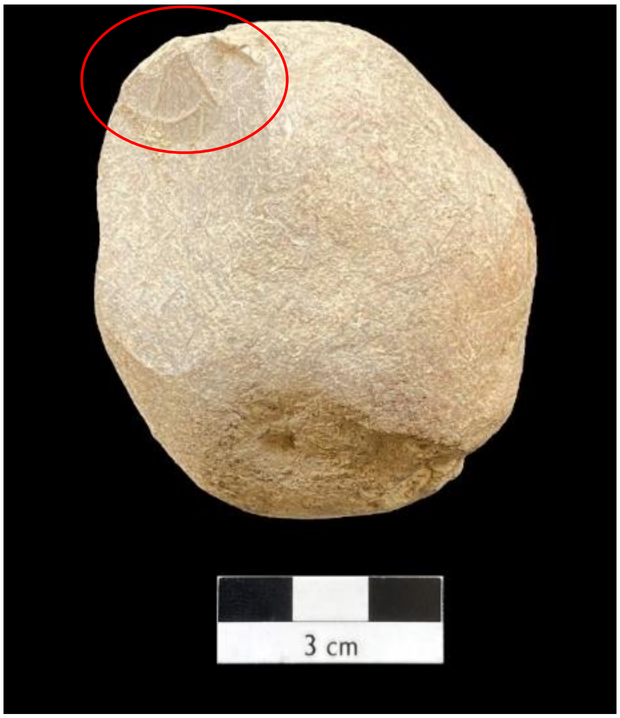


Figure 34.Hammerstone produced from cherts.

4.15. De´bitage (chips and shattered pieces)

Debitage in this context is used to refer to those unneeded stone fragments, chip stones, and/or chips and chunks. The whereabouts (s) of debitage materials (chips and chunks) have not been able to localized yet, and de´bitage classes are not analyzed in this study. However, it is stated in the previous studies (e.g., Kurashina, 1978) that there were many debitage elements recovered from the initial excavation. The presence of chunks and chips can provide information about the workshop sites. Workshops show where the lithics were produced. Unfortunately, we have limited information on this subject due to the lack of debitages in the LSA assemblages of Laga Oda stored at ARCCH.

4.16. Other archaeological remains

The LSA lithic assemblages were not the only archaeological records previously documented from the Laga Oda rock shelter. As it has been immensely reported in previous studies the rock shelter has been known for its rock paintings. In addition to these, other archaeological remains including ochre, faunal remains, ceramics, beads, and ashes of the hearth were reported. However, more emphasis has been given to rock art and some extent to lithic materials. The presence of other associated artifactual evidence provides more information on the prehistory of the area.

4.16.1.Ochre

Ochre is a pigmental material known from many African sites starting from the time of MSA. From southeastern Ethiopia, Porc Epic has been yielding rich evidence of ochre. There are also remains of ochre (n=4) recovered from the upper stratigraphic units of the Laga Oda Rock shelter.

Ocher is a type of rock rich in iron oxides. Mineralogically, it is formed mostly mixed with clays, silicates, and other elements with red to yellow-reddish color.

The presence of ochre has often been considered as an indication of symbolic behavior. The exploitation of ochre as a pigment, decoration, and pottery abrasion has been documented in many South African MSA and LSA sites as one of the evidence attributes for behavioral modernity. They were also used as an adhesive material for hafting-backed tools. Evidence of mastic and adhesive exploitation has been recorded from Laga Oda (Clark & Prince, 1978).

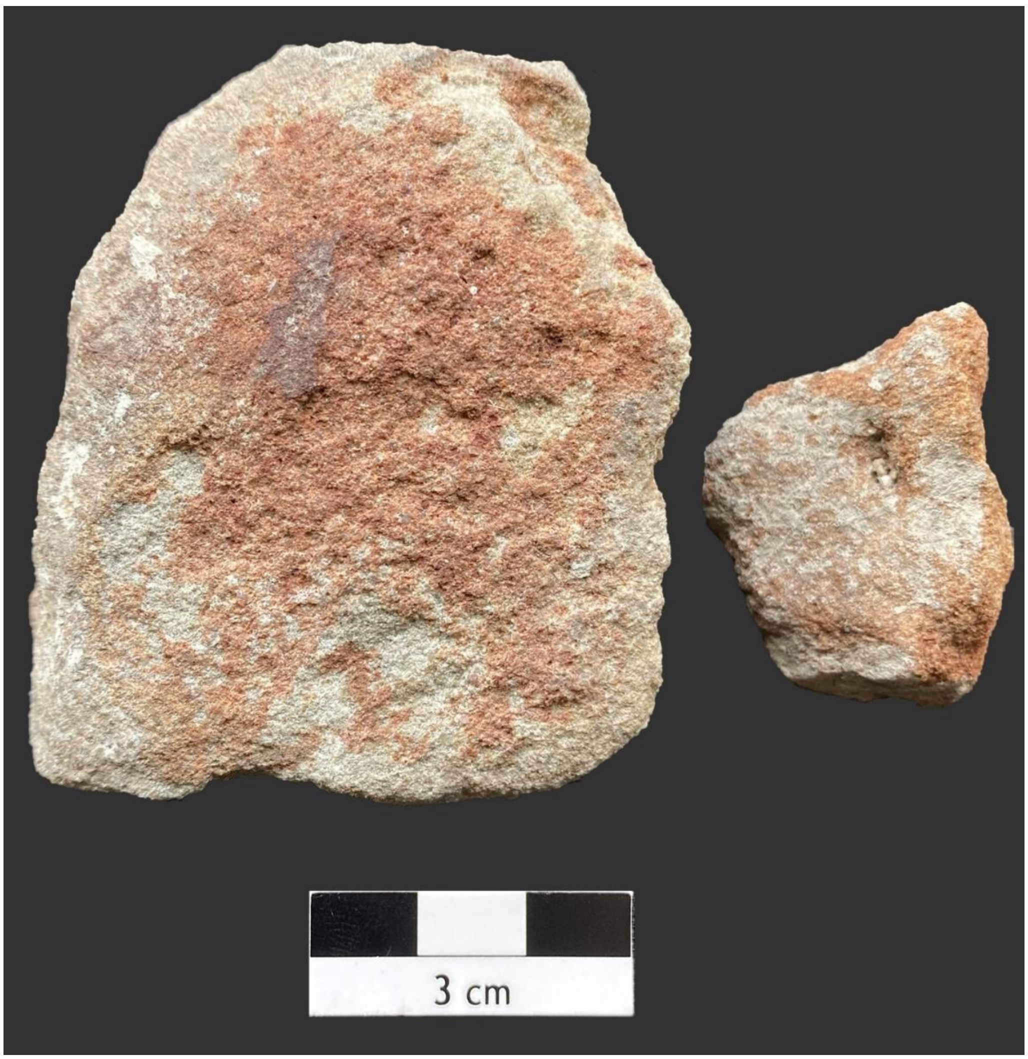


Figure 35.Ochre found in association with the Laga Oda lithic assemblages.

4.16.2. Pottery

In most rock art and LSA sites of southeastern Ethiopia, the presence of pottery was rare. There are 13 pottery sherds found together with the lithic assemblages from Laga Oda. The sherds are none diagnostic and they are dark black and dark gray in color. The majority of ceramics sherds were recovered from the top most archaeological strata, between 20 to 30 cm units, dated to very recent time. Nonetheless, there was also a small number of ceramics fragments recovered from 40-50cm (n=3).

Figure 36. Evidence of non-diagnostic pottery sherds from Laga Oda Rock shelter.

4.16.3. Teeth

Although numerous faunal remains have been mentioned in the previous studies (Kurashina, 1978), currently we only have remains of human teeth pieces. As shown in the figure below, there are three molars and one canine tooth. These remains of human teeth were not reported in any of the previous publications. Detailed and laboratory analysis of these teeth has not been made so far. More data is required to obtained more inferences from human remains. However, a record of human remains is not common in most LSA sites of Ethiopia.

Figure 37. Human teeth fragments.

4.16.4. Beads

There are ostrich eggshell beads found in association with the LSA lithic artifacts. The beads were coming from older deposits of 50-60cm stratigraphic units. This stratigraphic unit also yielded the densest artifactual evidence. Beads are indicative of human behavioral modernity such as symbolism and ornamentation. Evidence of beads have come from many MSA sites and are common in some LSA sites of Ethiopia. The LSA sites of Porc Epic and Goda Buticha have yielded ostrich eggshell beads.

Figure 38 Ostrich eggshell bead from Laga Oda.

CHAPTER FIVE

Discussion and conclusions

The Laga Oda site, with its evidence on rock arts and LSA lithic assemblages, is one of the most informative rock shelters in southeastern Ethiopia. Its rock art potential and the rock shelter general features was investigated in detail by previous scholars (Cervicek, 1971; Clark, 1998.). The current typological and technological analysis of LSA assemblages from this rock shelter has entirely been dependent on the assemblages recovered during the 1975 excavation and stored in the Laboratoryof ARCCH. Based on the research questions and objectives of the thesis, this section discusses and summarizes the implication of the data analyzed in the previous chapter.

5.1. Techno-typological features of Laga Oda lithic assemblages

The archaeological significance of Laga Oda is crucial in terms of studying the subsistence transition from foraging (hunting & gathering) to food production (pastoralism) in southeastern Ethiopia and the Horn of Africa. The technological and typological evaluation of LSA lithic assemblages has offered us information on the lithic reduction processes during the Late Upper Pleistocene and Holocene periods. Evidence of lithic artifacts was recovered up to 140 cm depth reflecting the presence of human occupation from the terminal Pleistocene to the present time. Kurashina (1978) supported this assertion that the rock shelter had been occupied for a longer period. However, the present study indicates that higher frequency of material record was found dated to the later periods.

The typological analysis was aimed at understanding the typology of the different artifacts and their place in the *chaîne opératoire.* An assessment of retouch tools such as scrapers, burins, denticulate, backed pieces, technical pieces, and other tools with retouches have been carried out. None retouch lithic artifacts including flakes, bladelets, cores, and other debitage elements were also examined. These stone artifacts suggest the production of diversified tools probably utilized for several functions.

In terms of the procurement of raw materials, cherts were utilized exclusively. Cherts in the Laga Oda rock shelter are most likely have local origins. The rock shelter is situated within chert-bearing rock outcrops. The availability of chert sources close to the site suggests the importance of local resource procurement strategies. Some other raw materials such as obsidian, quartz, limestone, and jasper have been utilized to a minimum extent. The presence of few numbers obsidians and other raw materials indicates those materials could have been imported from distant areas since they are not locally available. Geochemical prominence analysis of raw materials (Agazi& Shackley, 2006) would provide information about the sources of obsidians in the future.

The availability of raw materials and their distribution have crucial significance to know how ancient people exploited their landscape and manufactured lithic technologies (Anderfsky, 2008). Tryon and Faith (2013) discussed that site-to-source distances of lithics raw material provide insight about valuable empirical information on the size of the physical and social landscapes that are familiar to past human populations. Mobile pastoralists of Laga Oda might have traveled long to procure locally unavailable lithic raw materials. It is also plausible to suggest the presence of trade/exchange networks of manufactured lithic tools among several groups of prehistoric communities.

Based on the recovered and analyzed data, the absence of natural nodules, chips, and chunks, and cortical flakes make us argue that the site was not a workshop area. It could have been possibly used as an occupation site than a production site. However, given the availability of limited data for our assessment and the nature of the initial test excavation, it is impossible to rule out the nature of primary lithic production from the rock shelter. In fact, the presence of other associated remains such as ceramics, fauna, and beads with the existence of backed pieces, tools, and debitages reflect that the site was used as an occupation area. Clark's (1978) use-wear analysis of the Laga Oda lithic assemblage with the evidence three types of use-wear such as edge damaged, gloss, and polishhave supported this assumption.

The significant lack of cortex in cores and flakes indicates a higher reduction intensity of the cores. Similarly, the prevalence of chert as the dominant raw material indicates effective and economical utilization of local resources. Exhausted cores and lack of cortical surfaces on flakes show the effective utilization of lithic raw materials and late-stage reduction sequence.

It is generally observed that the absences of cortical elements within the assemblage. The amount of cortical surface on a blank indicates a reduction sequence (Andrefsky 2005). According to Inizan *et al*. (1999), the absence or the low frequency of blanks with the cortical dorsal surface in the lithic assemblage suggests that the early stages of the reduction sequence were performed elsewhere. Similarly, the lack of flake cortical surface also implies the presence of a small mobile group with a short period of occupation. This can go in line with the assumption that mobile pastoralists were sporadically occupied the Laga Oda rock shelter.

Typologically, the Laga Oda site is backed pieces-based assemblages through both retouch and non-retouch other tools of different typologies are evident including cores, backed pieces, bladelets, retouches, and other artifact production using most dominantly chert is represented.

Production techniques might have involved multiple type of percussions including hard and soft hammer as well indirect percussion.

Though the sample size is small, the majority of the bladelets from Laga Oda are recovered from 40-70 cm units of strata. This suggests an early stage of production during the Middle to Late Holocene compared to the backed pieces produced during the Late Holocene. However, this should be tested with large sample size and more investigations in the future. It has also been observed that there had been less production of bladelets. The analysis of the bladelets reflect that some of the bladelets were produced by the laminar production technique as is indicated from flake scares, elongated blanks that yield parallel ridges. The presence of technical pieces and crested bladelets indicate a series of prismatic bladelet production with the preparation of the face of the core. This suggests that core reduction strategies were more effective and complete (Bar-Yosef & Kuhn, 2017).

Striking platform analysis of flakes shows that the plain and punctiform platforms have been dominated the majority of the flake and bladelet assemblages. The presence of a punctiform or point platform suggests the possibility of using a soft hammer or indirect percussion. Brandt's (1982) "Ethiopian Blade Tool Tradition" support this assumption that this kind of platform can be formed by using the soft hammer and punch technique for the production of flakes and blades from a single to multiple-platform tabular and prismatic cores.

The scrapers from Laga Oda appear to show continuously retouched edges. Scrapers from this site are larger in size which suggests its utilization without hafting. The paucity of scrapers from this LSA site in contrast to some other MSA sites could be due to retouch techniques. The production of scrapers has been documented throughout every Stone Age and they are among the consistent tool classes (Tryon & Faith, 2013).

The few burin spalls show burin blow has been struck and the burin production technique might have been employed at Laga Oda. The presence of burin has often been associated with preparation for hafting purposes like engraving activities on wood for bladelet/blade tools to be mounted into organic materials.

Some technical pieces such as tablets, crested bladelets, and core rejuvenation flakes have been analyzed. These pieces represent a type of preparatory bladelet removal before the desired blades were removed from the core. Crested bladelets are also indicating the presence of bladelet workshops. Crested blades/bladelets were ubiquitous at the nearby site of Goda Buticha and have been interpreted as the culture of bladelet productions (Pleurdeau et al., 2014).

It has never been mentioned in the previous literature that the lithic assemblages of Laga Oda were heat treated. We have found out the presence of fire traces on many of our assemblages. Experimental analysis has proven that thermal fractures would enhance the quality of stone knapping techniques (Brown & Marean, 2010). This accords with the hypothesis that prehistoric toolmakers were treating stones to aid knapping. While the response of different raw materials for thermal treatment is variable, obsidian and cherts appeared to be the most thermally treated materials from the archaeological record in general (Brown & Marean, 2010).

The retouching and backing techniques of the entire artifacts reflect the similarity of lithic production techniques across the different stratigraphic horizons. In the previous studies (Clark,1998.;Clark & Prince, 1978; Kurashina, 1978), the technology of Laga Oda assemblage had a common with the definition of the Somaliland Wilton industry. According to Clark (1954), the Somaliland Wilton industry is characterized by microliths, with circle segments produced by direct and sometimes crossed retouch, backed bladelets, and micro end-scrapers (including thumb-nail ones) along with splintered pieces. These similar features have been observed from the backed pieces of Laga Oda assemblages indicating the transmission of knowledge of products in the same geographic region.

Based on the standard deviation values of the size of the backed pieces, an overall similarity in the backing, retouch as well as edge modification techniques have been inferred. The dimensions and other attribute analysis suggest the presence of a pretty consistent and standardized manufacturing strategy in the backed pieces and other technological attributes.

5.1.1. Backed pieces

Backed pieces make up a substantial and high frequency of Laga Oda lithic assemblages. Backed pieces in this assemblage include backed bladelets, crescents, segments, and geometric microliths. There are LSA sites without backed pieces and with backed pieces. They can also be found within the MSA assemblages (Ambrose *et al.*, 2002). We have found out that the majority of the assemblages from the Laga Oda rock shelter appear to have been abruptly and continuously backed. In the backed pieces tool class, there are crescents/lunates, backed bladelets, pointed bladelets, and some geometries (trapeze).

The analysis of backed pieces from this site suggests the distinct technological features of the site. Consistency in size and forms of backed elements have been confirmed at Laga Oda. They could have been hafted onto wooden handles to produce composite cutting tools or spears. Evidence of hafting and mounting has been documented by the previous researcher at Laga Oda using use-wear analysis (Clark, 1978).

The attribute analysis of backed pieces including the curvature, butt, twisting, and others indicates the process of stone tool manufacturing could have involved the use of the use of soft hammer technique. Technological production of curved pieces has been observed with a high frequency at

Laga Oda. The analysis of flake and backed pieces butts indicates that punctiform platforms types dominated the assemblages. This type of platform is the result of the soft hammer percussion technique (Andrefsky, 2005: 89).

The backed tools of Laga Oda could have been used for cutting grasses, leaves, vegetables, and other materials. Anderfsky (2005) stated that the association of lithic morphology with their function was found to be questionable and has now been rejected by archaeologists. Despite this, use-wear and lithic experimental analysis on Laga Oda lithic materials (Clark, 1978) suggests that backed pieces could have possibly been mounted and used for processing plant remains. The presence of mastic remains and evidence of polish and gloss on the backed pieces suggest the tools were mounted on hafts of armatures like sickles (Clark & Prince, 1978). This implies that the tools were functioning as a composite implement. Many scholars argue that backed tools were hafted to flexible organic materials to make edges, barbs, hooks, and teeth (e.g., Elston, et al., 2002).

5.2. Cultural and chronological relationship with other coeval sites

The uniqueness and technological and typological similarities and/or versions of the Laga Oda assemblages were one of the goals of this research. To address these questions, comparisons have been made with other contemporaneous sites of Goda Buticha (Leplongeon et al., 2017, 2018), and the Mochena Borago (Bon et al., 2014; Leplongeon, Ménard, et al., 2020). Sample datasets dated to the Middle -Holocene, and Late-Holocene have been chosen since most of the Laga assemblages (data) are concentrated in an archaeological horizon dated between the end of Middle and Late Holocene. Both sites selected for comparisons are from different geographical and environmental contexts to each other. Goda Buticha is located in the southeastern Ethiopian closer to Laga Oda whereas Mochena Borago is situated in the southwestern highlands.

It seems that a stylistically distinct production technique might have taken place at Laga Oda based on the analysis of quantitative attributes. Chronological variabilities between the Middle to Late Holocene have not been observed in both Goda Buticha and Mochena Borago. According to (Leplongeon, Ménard, et al., 2020), both units are stratigraphically closer to less than 300 years apart and it is plausible to share similar technological and cultural affinities across. However, both variabilities and similarities have been reflected. There are similarities concerning some metric variables with the Goda Buticha site. This cultural affinity makes sense since the two sites are situated closer to one another and were occupied by prehistoric pastoralist society. The Laga Oda assemblages are shorter and more standardized in size compared to the other two sites. On the other hand, no similarities of dimensional variables have been seen at Mochena Borago. Mochena Borago is a rock shelter site situated in a different ecological and environmental setting. It has been interpreted from the previous researcher that the occupants of this site were hunter-gatherers and they might have used technologies needed for their subsistent strategies (Brandt et al, 2012). Investigation on the variation of rock arts in Ethiopia (Agazi, 2018) shows the cultural affinities both in style and motives of the rock arts in the southern and eastern Ethiopia.

Qualitative data analysis on lithic materials from three sites (Laga Oda, Goda Buticha & Mochena Borago) shows the presence of a slight variation and a consistently similar lithic reduction sequence during Middle Holocene and Late Holocene respectively. Despite some variations, there are overall similarities in retouching and reshaping techniques employed during tools modification. Backed pieces in all the selected assemblages are dominantly directly curved. Other common features of backed pieces from the three sites are removed butt, absence of bulb continues backing of back location, no age transformation, and sharp edge angle.

As opposed to the previous assumptions of the lithic productions towards symmetric production of backed pieces, (Brandt, 1982; Leplongeon, 2014), our data show that the production of less symmetrical tools at all three sites during the Middle to Late Holocene. It does not, however rule out the fact that there are significant number of assemblages with transverse symmetry. The production of geometrics at all three sites is also highly limited as well.

Chronologically, the Laga Oda site is dated between the terminal Pleistocene to the Late Holocene period (Clark, 1978). Previous authors (Clark, 1978; Kurashina, 1978) discussed the site was occupied during the Early Holocene, Middle Holocene, and Late Holocene. However, our present study suggests much of the lithic artifacts came from the horizon dated to the Middle to Late Holocene. The technological and morphological analysis of lithic tools has also shown that the technological and typological features of Laga Oda lithic assemblages do not show any variation across the different stratigraphic units. The difference may also be explained due to the more intensive occupation of the rock shelter in the later periods. This cannot rule out the presence of few artifacts along with the several stratigraphic units. Although the sample size is not enough to conceive the occupational history of each period, it is plausible to argue that sporadic short-stayed occupations might have existed at the rock shelter.

Overall, we have observed both similarities and variations between Laga Oda and the other two sites. Morphological similarities have been observed generally both in the Middle and Late Holocene lithic assemblages. However, there are no similarities in terms of size with Mochena Borago in all quantitative variables. There are statistical correlations in width and weight of Goda Buticha site suggests that cultural affinities since the two sites are geographically close to one another. On the other hand, there are no correlations between Mochena Borago and Goda Buticha concerning size and shape.

5.3. Nature of human occupations in southeastern Ethiopia during the Middle to Late Holocene

Paleoenvironmental and chronological data which provide information about the early, Middle, and Late Holocene are very limited in Ethiopia. The lack of strong LSA lithic assemblage during the Terminal Pleistocene, early Holocene, and Middle Holocene suggest two possible scenarios. On one hand, the presence of some but small data shows the lack of detailed archaeological investigation and research biases. On the other hand, it could also be indicative of sporadic pastoralist occupations with limited archaeological records. Archaeological researches from southeastern Ethiopia (Clark and Prince 1978; Clark and Williams 1978) suggests that the area was occupied by pastoralists sporadically during the Early and Middle Holocene.

Charcoal samples recovered from the Laga Oda Oda rock shelter are dated to terminal Pleistocene, and early, Middle, and Late Holocene deposits. The largest concentration of the LSA assemblages were, however, came from the archaeological horizon dated to the late Holocene. This would make Laga Oda one of the few sites bearing evidence of LSA materials dated to this period.

Chronologically, the lithic assemblages from Laga Oda predate the rock arts which dated back to the second millennium BC at the site(Clark & Prince, 1978). It seems that descendants of prehistoric communities (pastoralists) who manufactured the lithic artifacts could be the ones who executed the rock art during the later times who later immediately learned and adopt the culture of rock paintings and taming of animals as it can be inferred from the rock paintings. It could have also been the arrival of a new group of the pastoral community into the area.

From the material culture distribution, the composition of the assemblage (mainly backed pieces), the rock art, and other assemblages, pastoralist subsistence strategies may have been employed bythese prehistoric communities. The rock shelter and the eastern side of the rift escarpment may also have acted as a sporadic refuge area for the environmental and climatic fluctuation that happened during the MIS-1. It has been argued that the site has provided crucial information on the transition from of hunter-gather way of life to sedentism and/or food production and the subsequent occupational history of ancient societies in the Horn of Africa (Clark, 1954).

5.4. Associated archaeological materials

Laga Oda is a rock shelter site known mainly for its paintings and LSA lithic assemblages. Remains of other archaeological materials such as pottery sherds, faunal remains (teeth), ochre, and mastic were also reported from this site. In the first few stratigraphic units, evidence of pottery and faunal materials were recovered which indicates the Late Holocene human occupations of the rock shelter. Our lithic data and the rock paintings could be linked to the Suri-Hanakiya stage pastoralist communities who could be responsible for the production of LSA technology at Laga Oda.

Although the presence of cattle bones has been documented earlier, currently we have no evidence of faunal remains stored at the ARCCH laboratory. It was suggested that the existence of faunal remains indicated an area that could have been used for pastoralist subsistence (Clark & Prince, 1978). Similarly, evidence of human teeth including three molars and one canine have been documented in this study. The presence of human teeth at this site has not been reported in the previous studies. Goda Buticha is one of the MSA and LSA sites with remains of human teeth which have been analyzed in detail (Pleurdeau et al., 2014). To understand the implication of human remains from the Laga Oda site, a large amount of data is required in the future so that one can describe the dietary adaptation and subsistence behavior of the prehistoric society in this region.

Thirteen ceramic sherds documented in this study are found to be non-diagnostic. Little information can be inferred from the pottery sherds since the sample size is small. Since pottery sherds of this site have not been studied very well so far, detailed archaeological and archaeometry analysis of more sample sizes will be essential in the future.

There was one bead examined together with other assemblages. It was indicated by previous publications (e.g., Kurashina, 1978) that a few more beads were recovered during the first excavation. The presence of beads in the archaeological record is an important indicator of symbolic behaviors and ornamentation. The earliest evidence of beads in Ethiopia was reported from the site of Porc Epic during the MSA time dated between ∼33 and 143 ka (Assefa, Lam, and Mienis, 2008). The site of Goda Buticha has also yielded remains of a large number of beads both in its MSA and LSA horizon.

5.4.1. The use of ochre

Studies on the use and exploitation of ochre during the MSA and LSA have been documented very well from Southern Africa sites. The exploitation of ochre as a mastic has been documented from many MSA and LSA sites (Ambrose, 1998). In Ethiopia, ochre-stained grindstones have been reported from the LMSA sites of Aduma (Yellen et al., 2005) and Porc Epic cave (Clark et al., 1984). Recently, the investigation of ochre from MSA and LSA archaeological sites in Africa has been a major research theme.

The presence of ochre at Laga Oda might have been associated with the rock art of Laga Oda as a possible pigment used for adornment during the LSA, and later perhaps an important raw material in the execution of pastoral rock art. This is also discussed and supported by the experimental work of Clark and Prince (1978) from the same site of Laga Oda. Certainly, these pieces suggest that there are direct associations with the rock arts of the Laga Oda rock shelter. However, a future study and geochemical analysis will offer a clear association between them.

Studies on the use and exploitation of ochre during the MSA and LSA have been documented very well from Southern Africa sites. The exploitation of ochre as a mastic has been documented from many MSA and LSA sites (Ambrose 1998). In Ethiopia ochre stained have been reported ochre from the LMSA sites of Aduma (Yellen et al. 2005) and Porc Epic (Clark et al. 1984).

The presence of ochre at Laga Oda has been associated with rock art as a possible pigment. This is also discussed and supported by the experimental work of Clark and Prince (1978) from the same site of Laga Oda. For sure, these pieces suggest that there are direct associations with the rock arts of the Laga Oda rock shelter. However, detailed study and geochemical analysis remain to be done to offer a clear association between them.

5.5. Conclusions

The primary purpose of this research was to investigate the Laga Oda LSA lithic assemblages recovered by the 1975 test excavations. Laga Oda rock shelter is a well stratified and securely-dated archaeological site. This laboratory-based research was conducted to fill the research lacuna on the lithic assemblage from the site. The site has well-stratified archaeological layers with remains of ceramics, bones, stone tools, and items of personal adornment (beads), as well as hearths and rock paintings. The investigation of the Laga Oda LSA lithic assemblages enhances our knowledge of the technology, economy, and behavior of prehistoric communities during the LSA.

This study shows Laga Oda as one of the key sites in Ethiopia for Middle to Late Holocene occupation human prehistory. The presence of artifacts at all stratigraphic levels shows a sequence of sporadic human occupations with similar technological and typological traits. The technological and typological analysis of LSA lithic materials suggests that the similarity of production techniques in different stratigraphic levels.

The production of backed pieces appears to have been the main target of lithic technology at Laga Oda particularly at the end of the Middle Holocene and beginning of the Late Holocene. The techno-morphological character of the backed assemblages suggests the use of mastic and other adhesive materials for hafting. The lithic materials could have been utilized for cutting materials and plant processing purposes including grasses. There are also possibilities that some of the technologies could have been used as a projectile weapon, skinning as well as hide working.

This study has revealed the presence of thermal traces on the majority of the lithic assemblages of Laga Oda. Thermal treatment could have done intentionally to facilitate the knapping of stone artifacts. Besides, the comparison of backed tool classes with the contemporaneous sites of Goda Buticha and Mochena Borago indicate both cultural affinities and variation of technological and morphological features. Nonetheless, more similarities have been inferred with Goda Buticha than Mochena Borago.

Overall, the technological, typological, and attribute investigation of Laga Oda shows prehistoric human technological, behavioral, and cultural development milestones. At Laga Oda, both a unique and similar level of tool production and craftsmanship have been identified.

5.6. Recommendations

Laga Oda rock shelter has rich archaeological potential and has deep sedimentary deposits waiting for future investigations. We believe that future archaeological inquiries should emphasize the development of detailed research and systematic documentation of the paintings. Since the lower shelter is wide and has deep sedimentary deposits bearing LSA lithic and other associated records including faunal, ceramic, and bead remains, proper archaeological excavation would provide significant information about the prehistory of southeastern Ethiopia and the HoA.

Furthermore, new research focused must address faunal, and botanical evidence to understand human-environmental interaction and some local and regional occupation and subsistence patterns. Piecing circumstantial evidence on the use of backed pieces in hafting and especially Clark's (1978) experimental study on the use wear analysis of these tools suggesting the exploitation of wild plant resources, it is possible to surmise the possibility that the archaeological deposits in the area can furnish archaeobotanical data. More extensive work is expected in the future to understand the complete picture of the period and to characterize the occupational patterns. In the end, we believe that the present research will serve as a stepping stone for future investigations.

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