Late Pleistocene and Holocene Human Settlement and Adaptation in Tropical High-Altitude Environments: A Contribution from the Bale Mountains, Southeastern Ethiopian Highlands

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Abstract

This dissertation presents complex cultural adaptations to the largest Afroalpine ecosystem of the continent: the high-altitude Bale Mountains in the Southeastern Ethiopian Highlands. Human occupation of African tropical highland environments is considered a relatively recent development due to the general perception of high-altitude environments as unfavorable for human subsistence. Moreover, these environments are believed to have functioned as a migration barrier in the past, due to their physiological challenges, such as high-altitude hypoxia, higher energy demand, cold stress, or UV radiation. As a consequence, the high-altitude regions remained among the least researched areas in several disciplines. Archaeological research in Ethiopia is still today largely concentrated on the main Rift Valley and on the landscapes and ecosystems of elevations below 2500 m above sea level. Thus, the western part of the Southeastern Ethiopian Highlands, particularly the Arsi-Bale complex landmass, is one of the most neglected regions for the study of Middle and Later Stone Age cultural changes. Only recently, an interdisciplinary research unit (DFG FOR 2358, *The Mountain Exile Hypothesis*) was established to reconstruct the coupled landscape and human history of the Bale Mountains. In contrast to the general perception, it is hypothesized that especially during arid Quaternary climate phases, the well-watered and stable ecosystems of the Bale Mountains might have even acted as a glacial refuge for plants and animals, but humans as well.

As part of the contribution of this research group, the goal of this dissertation is to investigate the evidence of prehistoric hunter-gatherer settlements and cultural responses to high-altitude environments. Archaeological survey and excavations on three selected rock shelters in the upper Web Valley in the northwest of the Bale Mountains provided evidence of prehistoric hunter-gatherer's occupations dating back to 47 ka cal. BP and continuing until the end of the Holocene around 2 ka cal. BP.

At least four major Paleolithic occupational events were identified and documented, based on the stratified deposits of the selected rock shelters. The earliest phase of human occupation at the Bale Mountains is associated with a late Middle Stone Age assemblage at Fincha Habera rock shelter (3469 m asl). These Late Pleistocene occupations were connected with the extraordinary exploitation of a large rodent, the giant root-rat (*Tachyoryctes macrocephalus*). A total of 1026 lithic, around 2306 faunal remains, and 86 coprolite samples were analyzed to understand the late MSA cultural adaptations at the Bale Mountains. Excavations at Simbero and Mararo rock shelters also show that the high altitudes of the Bale Mountains were repeatedly occupied by LSA cultural groups from 15 to 2 ka cal. BP. While the Terminal Pleistocene settlements were represented by limited archaeological records, later hunter-gatherer occupations during the Middle and Late Holocene show a dramatic subsistence change in response to the high-altitude environments. The LSA cultural phase at these sites contains the lithic assemblages of around 6900 lithic artifacts and 1479 faunal remains. The latter include birds and fishes, and hint at the exploitation of a heterogeneous spectrum of wild animals. The lithic assemblages show a high frequency of microliths and additional tools classes such as borers, probably related to the subsistence to the high-altitude environments. Almost all lithic artifacts were made on locally available obsidian from the Wasama Ridge around the central Plateau of the Bale Mountains. The presence of a few exotic materials such as non-local obsidian and chalcedony in the lithic assemblages show the existence of regional contacts among hunter-gatherers in South and Southeastern Ethiopia.

This study also suggests that the Bale Mountains lithic industries represent local specificities stone tool production as a long-term technological change in adapting to the high-altitude environments. Since the Bale Mountains complex was an open system, the typology and technology of the late MSA and LSA lithic assemblages show a notable technical similarity to the sites in the southern Ethiopian Rift Valley and the

Southeastern Ethiopian Highlands. Based on the identified lithic composition and the technological changes, in association with the exploitation of abundant high-altitude resources including indigenous resources and raw material, the high-altitude regions of the Bale Mountains probably functioned as a paleoenvironmental refuge during environmental changes between OIS 3 to OIS 1. More archaeological data from the Arsi-Bale Mountain complex and other high-altitude regions are needed to support the contribution of this study.

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1. INTRODUCTION

1.1. RESEARCH CONTEXT

The low-elevation habitats of East Africa were and still are the focus of extensive archaeological (BRANDT 1986; AMBROSE 2001; SEMAW ET AL. 2003; BASELL 2008; TRYON & TYLER FAITH 2013; BLINKHORN & GROVE 2018), paleontological (JOHANSON ET AL. 1978; ASFAW ET AL. 1999; HAILE-SELASSIE ET AL. 2004; MCDOUGALL ET AL. 2005; WHITE ET AL. 2006, 2009) and paleoecological (GROVE ET AL. 2015; TRAUTH ET AL. 2015; TIERNEY ET AL. 2017; LAMB ET AL. 2018; VIEHBERG ET AL. 2018) research. In contrast, research on high-altitude habitats in this region is still marginalized, especially with regard to past cultural and biological adaptations of humans to these diverse environments (BAKER 1978; ALDENDERFER 1998, 2006, 2014; VOGELSANG ET AL. 2018; BEYIN ET AL. 2019). It is only assumed that human occupation and especially permanent settlement in these habitats was a relatively recent process, primarily because high altitudes are generally regarded as unfavorable to human subsistence due to the various physiological and ecological challenges they pose. In addition, high-altitude habitats are often conceived as having acted as migration barriers in the past (ALDENDERFER 1998, 2006, 2014; JODRY & SANTORO 2017).

One of the main questions regarding human settlement in high mountain environments – especially above 2500 meters above sea level (m asl) – is how prehistoric hunter-gatherers may have interacted with high mountain ecologies, which are mostly characterized by a complex interplay of climate, altitude, and topography (BEALL 2001; ALDENDERFER 1998, 2006, 2014). As ALDENDERFER (2014) has pointed out, long-term genetic, physiological, and cultural adaptations would have been required for humans to settle permanently in high-altitude areas. However, while a long history of mountain colonization seems to be evident in Ethiopia, only very little is known regarding the nature and duration of these hunter-gatherer occupations, or the human-environment interactions that characterized these settlement events. The archaeological record so far indicates the presence of Acheulean hominids already between 1.5 and 0.7 million years before present on K/Ar at Gadeb (~2300 m asl) in the Southeastern Highlands of Ethiopia (CLARK & WILLIAMS 1978; CLARK & KURASHINA 1979; PHILLIPSON 2005; DE LA TORRE 2011) (**Fig. 1**). Likewise, Acheulean handaxes were also recovered at Mount Dendi (3270 m asl) in the western central highlands of Ethiopia (VOGELSANG ET AL. 2018). Apart from these two early incidences, the occupation of high-altitude habitats remains unclear even for much younger prehistoric phases.

The Horn of Africa, like other parts of Africa, has experienced rapid and sometimes extreme climatic changes, leading to unstable environmental conditions, including aridification (WILLOUGHBY 2007; BASELL 2008; BLOME ET AL. 2012). The climatic fluctuations between the end of OIS 4 and OIS 2 (including the LGM) are generally referred to as the "Big Dry" due to its unstable climate environment (BARHAM & MITCHELL 2008; BLOME ET AL. 2012; WILLOUGHBY 2007). However, most of OIS 3 is characterized by moist, and intermediate moisture conditions, interrupted by several abrupt drier periods, and followed by pronounced aridity between ~35–19 ka BP (VIEHBERG ET AL. 2011; TRAUTH ET AL. 2019; TRIBOLO ET AL. 2017; BRANDT ET AL. 2012; FOERSTER ET AL. 2012; BLOME ET AL. 2012). These extreme conditions might have driven hunter-gatherers to migrate from the lowlands to high-altitude environments from the end of OIS 3 to the Late Holocene (TRIBOLO ET AL. 2017; TRAUTH ET AL. 2019; OSSENDORF ET AL. 2019).

It is well possible that during such conditions, hunter-gatherers had to adapt by moving to well-watered and environmentally more stable environments, particularly to high-altitude environments with abundant natural resources (Basell 2008; Brandt et al. 2012; Hildebrand et al. 2010; Foerster et al. 2015; Stoetzel et al. 2017; Vogelsang et al. 2018; Vogelsang & Wendt 2018; Trauth et al. 2019; Tribolo et al. 2017).

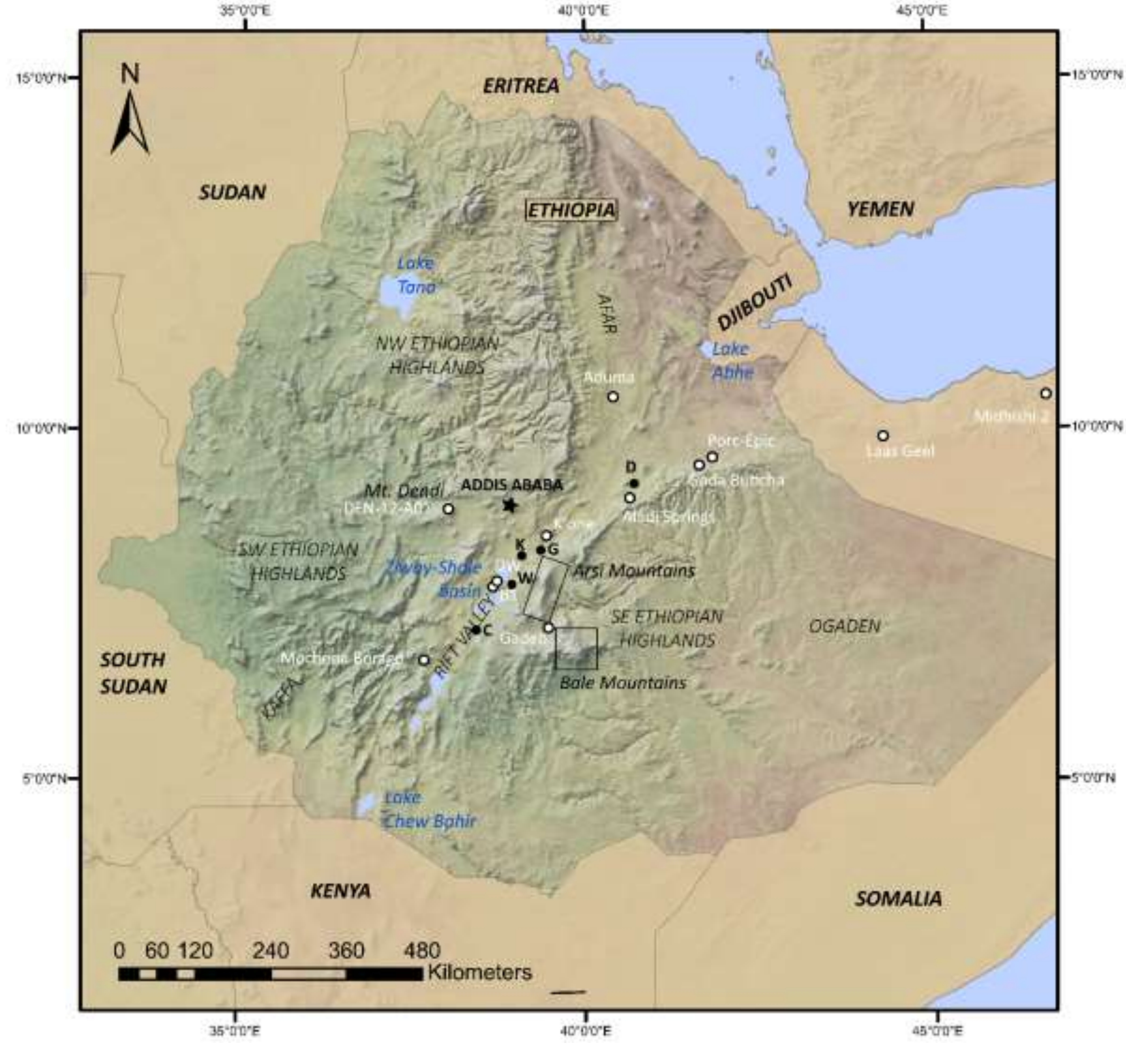

Fig. 1. *Map of the Horn of Africa with Ethiopia and bordering states, including Ethiopian regions, landscape features, archaeological sites (white circles), and selected obsidian sources (black circles; W=Weleda, D=Dalecchia, C=Chebe, K=Kersi, G=Gara Boku 1) mentioned in this thesis.*

The high-altitude environments of Ethiopia are characterized by extensive areas with plateaus and mountain massifs (MOHR 1971; BERHE ET AL. 1987; MIEHE & MIEHE 1994; ABBATE ET AL. 2015). The Bale Mountains (**Fig. 1**) of the Southeastern Ethiopian Highlands are often referred to as biodiversity hotspot given the abundance of endemic species and natural resources (YALDEN & LARGEN 1999). These environments have hardly received attention in the understanding of the peopling of the Horn of Africa/Eastern Africa between OIS 4–2. In contrast to relatively well studied regions in the Southwestern Ethiopian Highlands (**Fig. 1**; e.g. Mochena Borago rock shelter and caves around the Kaffa area) and further north in the Southeastern Ethiopian Highlands (e.g. Porc-Épic and Goda Buticha) (BRANDT ET AL. 2012; HILDEBRAND ET AL. 2010; PLEURDEAU 2006), the western part of the Southeastern Ethiopian Highlands, particularly the Arsi-Bale massif, bordering to the east of the Rift Valley, forms the archaeologically most neglected region concerning the study of MSA and LSA cultural changes (CLARK & KURASHINA 1979; BRANDT 1986; UMER ET AL. 2007; OSSENDORF ET AL. 2019).

The Bale Mountains environments as the largest alpine ecosystem of the African continent are profoundly rich in geological, topographical, biological diversity combined with high precipitation, low evaporation, and drainages to feed most major perennial rivers even to the Horn Africa (MIEHE & MIEHE 1994; UMER ET AL. 2007). The Bale Mountains and surrounding areas, like other parts of the Southeastern Ethiopian Highlands, were significantly wetter than other parts of the Horn of Africa (TRIBOLO ET AL. 2017; BLOME 2012) and might have offered high biodiversity that permitted the aggregation of different hunter-gatherers especially between the end of OIS 3 and OIS 1. The climate fluctuation at the end of OIS 3, which is characterized by moist and intermediate moisture conditions, interrupted by abrupt dry periods (TRAUTH ET AL. 2019; TRIBOLO ET AL. 2017) might have attracted hunter-gatherers to settle at the higher elevation of the Bale Mountains. Such a retreat and aggregation into ecologically favored areas with higher precipitation and high biodiversity might have first happened during the former hyper-arid conditions during OIS 4 (~72–58 ka BP), a time during which most parts of eastern Africa, including the Horn of Africa, were unsuitable for the survival of human populations (WILLOUGHBY 2007; BARHAM & MITCHELL 2008; BLOME ET AL. 2012). It is believed that the Bale Mountain system with its diverse and abundant resources might have been attractive for animals and hunter-gatherers. The abundance of rock shelters, more than 300 as REBER ET AL. (2018) have documented, for the possible prehistoric human occupations are the potential hub to provide a refugium for the Horn of African hunter-gatherers during the Late Quaternary environmental changes.

However, how hunter-gatherers of the lowland did respond to the high-altitude environments of the Bale Mountains is only a recent interest of archaeological research in the region. The emerging evidence shows that the Bale Mountains of the Southeastern Ethiopian Highlands might have functioned as a paleoenvironmental refugium for culturally diverse bands. This might have pushed the development of technological and social innovations that facilitated the dispersal of human populations within and across the Horn of Africa when conditions ameliorated between the end of OIS 3 and OIS 1. Like the southwestern and eastern parts of the Southeastern Ethiopian Highlands, archaeological research on the Bale Mountains becomes of paramount importance for furthering our understanding of human cultural and genetic adaptation even to the extreme environment.

The quest for the role of high-altitude landscapes in modifying hunter-gatherer subsistence and cultural adaption and the subsequent changes in the environment led to the onset of the *Mountain Exile Hypothesis* project. This multidisciplinary project aims to understand how and when Stone Age hunter-gatherers adapted the extreme high-altitude of the Bale Mountains into a cultural landscape with sophisticated stone tools and use of fire. It was started soon after gaining better knowledge about the distribution and status of rock shelters at the Bale Mountains by David Reber in 2016 (REBER ET AL. 2018). Accordingly, the role of rock shelters at the high-altitude of the Bale Mountains is gaining new attention for detailed archaeological research through a multidisciplinary approach.

The archaeological sites at the Bale Mountains are consisting mainly of rock shelter deposits and open-air surface sites with lithic scatters. Most of the rock shelters at the Bale Mountains are formed on volcanic rocks of aphanitic basalt and trachyte (HADUSH KAHSAY 2019). In a recent survey, a total of more than 330 rock shelters were identified and recorded at different altitudes and microclimatic regions of the Bale Mountains (REBER ET AL. 2018). Almost all of them show clear signs of human impact, especially settlement activities associated with livestock keeping (STEPHENS ET AL. 2001; VIAL ET AL. 2011; ANTENEH ET AL. 2013). The rock shelters at the northwest of the upper Web Valley in the Bale Mountains are affected to a lesser degree by recent herding, compared to those of other parts of the park. Though the Bale Mountains and their surroundings are known for abundant archives for different scientific investigations, it took a long time to consider the rock shelters of the Bale Mountains in the understanding of hunter-gatherer's behavioral changes and subsistence strategies at the high-altitude environments (OSSENDORF ET AL. 2019).

The P1 unit (Archaeology and Zooarchaeology) of the *Mountain Exile Hypothesis* project (DFG FOR 2358) is the first Paleolithic research team in exposing new insight into high-altitude human colonization at the Bale Mountains of Southeast Ethiopia during the Late Pleistocene and Holocene. This research unit has conducted intensive archaeological research and documented Paleolithic occupations not only from open-air sites but largely from rock shelters. Whereas the occupations of Late Pleistocene and Holocene hunter-gatherers are well-documented at the Bale Mountains, there is little evidence of the early and late pastoralist activities from the Bale archaeological records.

A total of 55 sites representing different phases of human occupation and exploitation of resources were documented in the north and southwest parts of the Bale Mountains. Many of them are rock shelters (42) as opposed to open-air sites (13). Test excavation on 16 rock shelter sites was conducted to identify the potential archaeological sites at the high-altitude of the Bale Mountains. The subsequent detailed excavations of three rock shelters at the upper Web Valley, which this dissertation is based on, show the presence of late MSA and LSA material culture. The lithic artifacts of these three sites were highly dominated by obsidian, a locally available raw material from the nearby Wasama Ridge at 4247 m asl (**Fig. 2**).

Given the research context outlined above, the current thesis considers only three rock shelter sites in the upper Web Valley of the Bale Mountains, mainly to understand how hunter-gatherers successfully colonized the high-altitude environments of the Bale Mountains above 2500 m asl. In this regard, this dissertation addresses the following basic questions:

1. *When did prehistoric humans enter the high-altitude Bale Mountains and how can the settlement history of the region be characterized?*
2. *Which distinct human settlement and subsistence patterns on and around the Bale Mountains can be identified? What were the main factors for hunter and gatherer mobility on a higher elevation?*

3. *Which cultural and behavioral adaptations are responses to paleoenvironmental changes in the Bale Mountains?*
4. *Were the Bale Mountains of Southeastern Ethiopian Highlands a paleoenvironmental refugium? Were the Bale Mountains settled by culturally diverse groups and did this stimulate technological innovations or not?*
5. *Which socio-cultural or economic networks linked the prehistoric settlers of the Bale Mountains with the surrounding lowlands, such as the Main Ethiopian Rift Valley, the northern part of the Southeastern Ethiopian Highlands, the southwest Ethiopian Highlands, or even further regions of the Horn of Africa?*

This dissertation aims to elucidate successive hunter-gatherer occupations and utilization at the Bale Mountains of the Southeastern Ethiopian Highlands. It focuses on what role of Late Pleistocene environmental changes at the Horn of Africa may have had led to hunter-gatherer's migration to the high-altitude environments of the Bale Mountains and of the possible behavioral changes or adaptations to the challenges they encountered. The existing hypotheses suggest that behavioral and biological changes were direct or indirect responses by hunter-gatherers to either the short or long cold and arid conditions but also rapid and abrupt environmental changes (AMBROSE 2001; BEALL 2001; ALDENDERFER 2006, 2014; WILLOUGHBY 2007; BARHAM & MITCHELL 2008; BASELL 2008; TRIBOLO ET AL. 2017; TRAUTH ET AL. 2019). However, these hypotheses may be too simplistic in generalizing the involved highly variable behavioral or biological responses.

Moreover, this dissertation is to provide a review of findings of archaeological sites at the Bale Mountains to increase additional knowledge at the local scale of how hunter-gatherer settlements, subsistence, and social strategies developed in response to environmental fluctuations between the end of OIS 3 and OIS 1. At the same time, the new archaeological data from the upper Web Valley would enhance the debate over the scope of hunter-gatherer's migration to the high-altitude environments that might have been exerted in response to the environmental changes at the local level during the key periods between OIS 3 and OIS 1.

1.2. THESIS STRUCTURE

This dissertation attempts to offer information on high-altitude settlement and subsistence from the analyses of data recovered at three excavated rock shelter sites in the Ethiopian Bale Mountains. The introduction in **Chapter One** mainly focuses on the general background of the current study. It outlines the objectives, research contexts, and structure of the dissertation. **Chapter Two** provides an overview of the high-altitude archaeology research, as a prerequisite in order to familiarize with the high-altitude environments of the current study area, the Bale Mountains. Available literature was evaluated not only to highlight previous research undertaken but also to define the necessary framework to present the archaeological records from the targeted sites. A discussion of the physical environment is provided in **Chapter Three**. This chapter outlines the location of the study area including those geological events which contributed to modifying the landscapes of the Bale Mountains. This is followed by a review of the local climate and a brief evaluation of the physiography of the study area, the upper Web Valley at the Bale Mountains. The end of this chapter also outlines the human settlement history around the Bale Mountains after a review of the prior scientific work, including the historical and oral sources. **Chapter Four** introduces archaeological, sedimentological, and zooarchaeological methods used to produce and analyze the data in this dissertation. The archaeological assemblages in combination with the lithostratigraphic sequences were essential in establishing a meaningful correlation among different archaeological units and sites in the Bale Mountain context. **Chapter Five** separately comprises the presentation of excavated archaeological sites at the upper Web Valley of the Bale Mountains. It presents the archaeological units and records recovered, and the archaeological material is investigated in detail. This refers to lithic artifacts in the first place, but also includes the faunal assemblages. A discussion of the results is performed in **Chapter Six**. A synthesis of the reconstructed culture-historical sequence of the Bale Mountains is followed by inter-site comparisons of the archaeological record recovered from the upper Web Valley as well as intra-site comparisons of the Bale Mountains archaeological record with the broader regional context in the Horn of Africa. In the next step, human settlement history in the Bale Mountains will be contextualized with the available regional paleoecological reconstructions to discuss the roles of the high altitudes in prehistoric settlement strategies. Moreover, a summary of the behavioral changes and cultural adaptations of prehistoric hunter-gatherers to the unique environments will be is presented in this chapter. Finally, the conclusions summarize the most relevant issues of this thesis, including a brief attempt to highlight additional questions that might be addressed by future research in the region.

2. ARCHAEOLOGICAL CONTEXT

2.1. HIGH ALTITUDES IN ARCHAEOLOGY

The debate over the role of high-altitude environments as a place for human occupation and cultural adaptation forms a relatively recent – and often neglected – contribution to the reconstruction of regional prehistories (BENDER & WRIGHT 1988; RADEMAKER ET AL. 2014; WALSH ET AL. 2006; LU 2016; ALDENDERFER 1998, 2014; OSSENDORF ET AL. 2019). High-altitude mountains have regularly been perceived as marginal landscapes (BENDER & WRIGHT 1988; WALSH ET AL. 2006; STIRN 2014). The assumption that mountains were economically unattractive to earlier societies has influenced archaeologists' expectations of the fact that most prehistoric sites are located in the plains, valleys, and lowland landscapes (BENDER & WRIGHT 1988; WALSH ET AL. 2006; ALDENDERFER 2003, 2006, 2014; AMBROSE 2001; BASELL 2008). However, new and challenging studies have globally emerged from high-altitude mountains, indicating that the mountainous ecosystems at times have functioned as an integral part of subsistence and settlement strategies of prehistoric societies (BENDER & WRIGHT 1988; AMBROSE 2001; ALDENDERFER 2006, 2014; STIRN 2014; JODRY & SANTORO 2017; ASSEFA ET AL. 2014).

Moreover, archaeological research in the mountains is of paramount importance for our understanding of human cultural and biological adaptation to extreme environments in general (ALDENDERFER 1998, 2006, 2014; BEALL 2001, 2006). There is still an open debate whether environmental amelioration or deterioration in potential regions of origin formed push-factors for hunter-gatherer migrations to high-altitude environments, which eventually led to permanent human settlement there (RADEMAKER ET AL. 2014; MOORE 2017; ALDENDERFER 1998, 2014; BEALL 2001; STEWART

& MITCHELL 2018). Scholars of the field hypothesize that human colonization to the high-altitude landscapes might have been delayed since humans were required to develop specific behavioral, technological, and biological adaptations to overcome the inevitable high-altitude hypoxia, the reduced availability of oxygen to the body tissues, alongside other stressors such as cold, high UV radiation, aridity, etc. (ALDENDERFER 1998, 2014; CAPRILES 2016; MOORE 2017; BEALL 2001). On the other hand, researchers have also argued that the seasonal exploitation of a wide variety of areas by prehistoric hunters-gatherers might have occurred relatively early in high-altitude mountains (BENDER & WRIGHT 1988; WALSH ET AL. 2006; JODRY & SANTORO 2017).

Previous work on the high-altitude mountains of South America (Andes) and the Himalayas (Tibet) has identified several archaeological sites indicative of permanent settlement to be of Terminal Pleistocene/early Holocene age only (RADEMAKER ET AL. 2014; LU 2016; JODRY & SANTORO 2017). Accordingly, mountains are now attracting researchers' attention not as marginal but as an integral part of both local and regional adaptive strategies (BENDER & WRIGHT 1988; STIRN 2014; JODRY & SANTORO 2017; ALDENDERFER 1998, 2006, 2014; BEALL 2001).

However, high-altitude regions of the world are remote and inaccessible and remained the least researched areas in several disciplines including archaeology (RADEMAKER ET AL. 2014; ALDENDERFER 1998, 2006, 2014). In this context, it is often overlooked that high-altitude environments of tropical East Africa are largely characterized by a high degree of topographic and habitat diversity, which in turn already gives a hint to potentially complex human adaptations in the past (AMBROSE 1984, 2001). The largest cluster of MSA and LSA sites across east Africa are unevenly distributed along the lower and middle high-mountains below the threshold of environmental and physical challenges for explorations of hunter-gatherers (BRANDT

1986; AMBROSE 1984, 2001; BASELL 2008; TRYON & TYLER FAITH 2013; BLINKHORN & GROVE 2018).

In contrast to the Rift Valley, the topography of the high-altitude environments of East Africa is relatively uniform and supporting high precipitation rates for potential diverse economic activities. There is sufficient evidence showing that mountainous and moderately elevated environments of East Africa (below 2500 m asl) were part of complex hunter-gatherer's resources exploration (AMBROSE 1984, 2001; ASSEFA ET AL. 2014). In the southern African region, STEWART ET AL. (2012) have used the highland of the Maloti-Drakensberg Mountains in Lesotho, situated at around 1800 m asl, for the understanding of adaptations to marginal environments in the Middle Stone Age and Late Pleistocene cultural sequences. Archaeological research at these highlands shows that hunter-gatherers were recurrently settling and abandoning highland environments as a maximum resources' exploitation strategy (STEWART ET AL. 2012; STEWART & MITCHELL 2018).

The highlands of Ethiopia, which range from 1500 m to above 4600 m asl, are divided into two massifs by the Ethiopian part of the Rift Valley (**Fig. 1**): the first embraces the North- and Southwestern Ethiopian Highlands and the second is formed by the Southeastern Ethiopian Highland (MOHR 1971; BERHE ET AL. 1987; MIEHE & MIEHE 1994; ABBATE ET AL. 2015; WILLIAMS 2016). Like other high-altitude regions of the world, the plateau of Ethiopia has gained little interest in both archaeological and paleontological research since the early research mainly focused on the Rift Valley region (ALDENDERFER 2006; BRANDT 1986; CLARK & WILLIAMS 1978; CLARK & KURASHINA 1979; ASSEFA ET AL. 2014). The northern and western highlands of Ethiopia were the subject of research on middle and Late Holocene hunting-gatherers subsistence (FERNÁNDEZ ET AL. 2007; HILDEBRAND ET AL. 2010) while the eastern part of the Southeastern Ethiopian Highlands is one among the privileged areas for the earliest research on MSA and LSA behavioral changes within the Horn of Africa context (BRANDT 1986; PLEURDEAU 2006; PLEURDEAU ET AL. 2014; ASSEFA ET AL. 2014; LEPLONGEON ET AL. 2017). Especially, the research at Mochena Borago rock shelter of Mount Damota was the first attempt in the Horn of Africa to test the hypothesis of whether the high mountains of the Southwestern Ethiopian Highlands functioned as a refugium during and after the hyperarid condition of OIS 4 (~72–58 ka BP) (BRANDT ET AL. 2012; FISHER 2010).

The presence of intensive exploitations of mountain resources and possible cultural adaptations in the Southwest Ethiopian Highlands promoted the search for more archaeological sites in the high-altitude mountain environments. The high-elevation mountains around the Crater Lake of Mount Dendi in northwest Ethiopia further demonstrated that not only anatomically modern humans but also earlier hominins engaged with mountain systems around 3000 m asl (VOGELSANG ET AL. 2018). The Arsi-Bale Mountain massif of the Southwest Ethiopian Highlands (**Fig. 1**) was among the early archaeologically and geomorphologically explored areas under the 1974–1975 expeditions directed by J. Desmond Clark which mainly focused on reconstructing early and late cultural succession in Central Rift Valley and Southeastern Ethiopian Highlands (CLARK & WILLIAMS 1978; CLARK & KURASHINA 1979; BRANDT 1986; DE LA TORRE 2011). The archaeological sites at Gadeb (**Fig. 1**) lie at 2300–2400 m asl within the Arsi-Bale Mountains massif and yielded stratified Plio-Pleistocene deposits with Early Stone Age tools characterized by Developed Oldowan and Acheulian handaxes (CLARK & WILLIAMS 1978; CLARK & KURASHINA 1979; DE LA TORRE 2011; ALDENDERFER 2006, 2014). The Gadeb sites are important in understanding that the Hominid occupations were far ranging from the Rift Valley to the high-altitude of the Arsi-Bale Mountain System (CLARK & KURASHINA 1979; ALDENDERFER 2014). Similar research had never reached the high-altitude of Ethiopia including the Bale Mountains above the elevation of 2500 m asl (REBER ET AL. 2018; ALDENDERFER 2006, 2014; OSSENDORF ET AL. 2019).

Despite the archaeological gap, there have been considerable botanical explorations and geomorphological and palynological studies, and limited paleoenvironmental research which focused on the reconstruction of Holocene vegetation changes during and after the African Humid Period in the highlands above 2500 m asl of the Bale Mountains (MOHAMMED & BONNEFILLE 1998; UMER ET AL. 2007; TIERCELIN ET AL. 2008; KUZMICHEVA ET AL. 2013, 2014, 2017). This research also suggested that the late quaternary glaciations during the Last Glacial Maximum (LGM), had affected the landscapes of the central plateau and valleys of the Bale Mountains in response to global climate changes (HILLMAN 1988; OSMASTON ET AL. 2005; UMER ET AL. 2007; TIERCELIN ET AL. 2008; WILLIAMS 2016). However, the role of the Late Pleistocene hunter-gatherers in modifying the high-altitude of the Bale Mountains has been ignored, there has been no effort made in understanding how the Bale Mountains functioned as a refugium for hunter-gatherer's subsistence during the critical environment changes.

2.2. THEORETICAL PERSPECTIVES

Archaeological research on high-altitude mountains is subject to two general approaches. Since the low-elevation environments are believed to be the place where humans have evolved during the Pleistocene (WILLOUGHBY 2007; BARHAM & MITCHELL 2008; ALDENDERFER 2014), hunter-gatherers are mostly attested to have been seasonal settlers of the nearby mountains, particularly during times when the lowland environment was getting dry (AMBROSE 1984, 2001; BASELL 2008; BRANDT ET AL. 2012; STEWART & JONES 2016; MOORE 2017; STEWART & MITCHELL 2018). Others are considering the mountainous ecosystems rather as integral than seasonal areas for hunter-gatherers` subsistence and settlement strategies (PAWSON & JEST 1987; BAKER 1987; ALDENDERFER 1998, 2014). As a result, the high-altitude environments were frequently settled by either seasonal colonizers or highly organized groups who have exploited both lowland and high elevation environments altogether.

Regardless of the exact reasons how hunter-gatherers colonize the high-altitude environments, numerous scholars hypothesized that humans might have required physiological, cultural, and biological adaptations in response to the extreme environment at the high-elevation (BAKER 1978; PAWSON & JEST 1978; BEALL 2001; JODRY & SANTORO 2017; ALDENDERFER 1998, 2003, 2006, 2014). However, it is still little known what exactly enabled the hunter-gatherers initially to gain footholds in the high-elevation environments and which natural phenomena are usually subsumed as unfavorable for human occupations. There is a consensus that human colonization to the high-altitude landscapes might have been delayed since humans are required specific behavioral, technological, and biological adaptations mainly in overcoming the high-altitude stressors including hypoxia (ALDENDERFER 1998, 2014; BEALL 2001; CAPRILES 2016; MOORE 2017).

High-altitude environments above 2500 m asl are the outcome of complex interactions among extreme climate, altitude, and fragmented topography that might have impacted human migration from the lowland to high-altitude environments (BAKER 1978; ALDENDERFER 1998, 2003, 2006, 2014). High-altitude stress such as hypoxia characterized by low oxygen; increased UV radiation and higher metabolic rates (BEALL 2001; ALDENDERFER 1998, 2014) are unavoidable challenges that might have hindered migrations of early hunter-gatherers towards the high-altitude mountain areas. Like the effect of hypoxia, the patchiness of high-elevation landscapes had also a considerable impact on human activities and any form of human habitations.

However, the effects of hypoxia and the patchiness of high-elevation landscapes on humans are not sufficiently understood or even demonstrated, but expressed as either short or long-term consequences on the life and subsistence of hunter-gatherers (PAWSON & JEST 1978; ALDENDERFER 1998, 2014).

The discussion on human occupations in the high-altitude environments is complicated as most of the established assumptions are based on regional genetic (mtDNA) evidence (BEALL 2001; MOORE 2017; SCHEINFELDT ET AL. 2012). There are also additional efforts to include cultural and fossil evidence in the understanding of when and how hunter-gatherers migrated to the high-altitude environments but they also comprise the concept of genetic adaptations (ALDENDERFER 1998; RADEMAKER ET AL. 2014; LU 2016; JODRY & SANTORO 2017). The most accepted theory, proposed by Aldenderfer, is that human migration and subsequent exploitation of the high plateaus of the world occurred at the later periods of human prehistory when the high-altitude inhabitants acquired the required biological or cultural adaptations or both (ALDENDERFER 1998, 2014).

The Aldenderfer model proposes that humans could cope up with the pressure of hypoxia, either through acclimatization for the short term, or through genetic adaptation, for the long-term expositions at the high-altitude environments. The issue of cultural adaptation as a strategy in overcoming the diverse stressors including hypoxia is also considered in this model, and the possibility of the combination of biological and cultural adaptations is not ruled out (ALDENDERFER 2014). The most developed research on high-elevation environments of the world, such as the Andean Altiplano and the Tibetan Plateau, is using the altitude of 2500 m asl., as a threshold for the effects of hypoxia on either temporary or permanent occupations and resource exploitation. To date, there is no evidence that cultural adaptation could alter the impact of hypoxia in high-altitude environments (ALDENDERFER 1998, 2006, 2014).

On the other hand, research on the Afroalpine ecosystem, characterized by extreme remoteness and its endemic species richness of plants and animals, has prompted to establish a new hypothesis known as the *Mountain Exile Hypothesis* focusing on how humans benefited from and reshaped the African high-altitude ecosystem during Quaternary climatic changes (MIEHE ET AL. 2016). According to this hypothesis, the high-altitude ecosystem of the Bale Mountains as part of the East African Afroalpine environments was regarded as an 'ice age'-refugium for plants and animals including anatomically modern humans. It is one of the climatic and ecologically driven models that propose the apparent human biological and cultural changes in response to the challenges at higher-altitude mountains (MIEHE ET AL. 2016; OSSENDORF ET AL. 2019).

Unlike other general hypotheses, the *Mountain Exile Hypothesis* exclusively proposes that anatomically modern humans might have reached the high altitudes of the Bale Mountains and modified them as a cultural landscape through fire and stone tools. The high-altitude Bale Mountains are treated as a potential refugium for hunter-gatherer populations, especially during arid periods in the adjoining lowlands. These mountains are also believed to be the main center of attraction for human adaptation and technological innovation to overcome the challenges of high-altitude landscapes within the eastern Africa Afroalpine ecosystem.

Like the Southwest Ethiopian Highlands, the Southeastern Ethiopian Highlands were significantly wetter than other parts of North-East Africa and the Horn of Africa and offered high biodiversity that permitted the aggregation of different hunter-gatherers especially during OIS 3 and OIS 1. Such a retreat and aggregation into ecologically favored areas with higher precipitation and high biodiversity was forced by the hyperarid condition including OIS 4 (~72–58 ka BP), a time during which most parts of northeastern Africa, including the Horn of Africa, were unsuitable for the survival of human populations.

The archaeological survey and excavations on the selected rock shelter sites in the Bale Mountains are used to test the hypothesis of hunter-gatherer's cultural and biological adaptation as they successfully moved from the lowland to the high-altitude environment. It is postulated that such areas as the Southeastern Ethiopian Highlands namely the Bale Mountains may be acted as a paleoenvironmental refugium for culturally diverse bands fostering the development of new technological and social innovations that might facilitate the dispersal of human populations out of Africa when conditions ameliorated during the early stage of OIS 3 (~58–50 ka BP).

2.3. KEY PROBLEMS AND DEFINITIONS WITH RESPECT TO THE ETHIOPIAN ARCHAEOLOGICAL RECORD

As prehistoric archaeological research in the mountains is a recent development and only gaining limited attention in the specific regions of the world, there is little consensus on the terms which refer to human interactions to the complex ecosystem of the high-altitude mountains (ALDENDERFER 1998, 2014; MOORE 2017; STIRN 2014). The high-altitude mountains of the world were more frequently visited by travelers or explorers, later by biologists and ecologists than archaeologists. The effects of hypoxia as major stress to human adaptation to the high-altitude mountains of the world were first noticed and defined by biologists in the early 1960s (BAKER 1978; PAWSON & JEST 1978). So, the role of high-altitude environments on human biological and cultural changes demanded to employ the data generated through other disciplines including archaeology, anthropology, and ethnohistory (JORDY & SANTORO 2017).

There is a consensus among researchers that the altitude of 2500 m asl is an important border from which the movement of early hunter-gatherers from the lowland to high-altitude environments is affected and hindered (PAWSON & JEST 1978; ALDENDERFER 1998, 2014; JORDY & SANTORO 2017). Accordingly, M. Aldenderfer proposed a working definition of high elevation environments as extreme environments above 2500 m asl with the recognition of stressors effects including hypoxia (ALDENDERFER 1998, 2014). This working definition is important mainly to clarify the ambiguity and overlaps of definitions made by scholars of other disciplines related to other classifications of mountain environments, such as montane, alpine, and Afroalpine. The terms high-altitude, high-mountain, and high-elevation can be used interchangeably and are referring to the landscapes characterized by the extreme impacts attributed to the complex interaction of harsh climate, high altitude, and environmental heterogeneity (ALDENDERFER 1998).

In this dissertation, the archaeology of high-altitude environments refers to the research on archaeological sites located above 2500 m asl with substantial effects of hypoxia and other related extremes such as low predictability and primary productivity on human existence and subsistence (ALDENDERFER 1998, 2014). This definition also helps to exclude the inconsistent use of Afroalpine and -montane which refers to the vegetation, physiography, climate, and ecology of high mountain landscapes (MIEHE & MIEHE 1994; ASSEFA ET AL. 2007). The focus of this study is on the challenges that humans had interacted with extreme altitude environments.

The archaeological findings recovered from the Bale archaeological sites can be classified based on the tripartite division of the prehistory of sub-Saharan Africa, mainly to the Middle Stone Age (MSA) and the Later Stone Age (LSA). Although this division was based on South African lithic records by GOODWIN & VAN RIET LOWE (1929), it is still widely in use for other parts of Africa mainly for its application in describing broad stages of lithic production from a conceptual and technical perspective (BARHAM & MITCHELL 2008; WILLOUGHBY 2007; DOUZE 2011). The classification and interpretation of African Stone tools also suffer from limited regional approaches and poor dating resolution (BARHAM & MITCHELL 2008; TRYON & TYLER FAITH 2013; AMBROSE 1998), especially in Ethiopia (PLEURDEAU ET AL. 2014; BRANDT ET AL. 2017; SAHLE 2020). Nevertheless, the presence and absence of certain tools and flake production technologies in a given assemblage are used to classify sites into ESA (Early Stone Age), MSA, and LSA occupations. It is not uncommon to see MSA or LSA lithic assemblages with only few or even without the so-called markers. For example, MSA sites such as Mochena Borago (Mount Damota) and DW1 (Ziway-Shale basin) yielded only few Levallois cores, but regularly included LSA microliths, while LSA sites as DW2s2 lacked any microlithic crescents/segments (BRANDT ET AL. 2012; MÉNARD ET AL. 2014).

It is a current debate, to what extent the classification of archaeological records of East Africa (modern-day Tanzania, Uganda, Kenya, Ethiopia, Somalia, Djibouti, and Eritrea) into successive phases through ESA, MSA, and LSA, or CLARK's (1969) alternative 'mode' terminology are suitable in representing the complex regional behavioral variability during Middle and Late Pleistocene (~300–30 ka) assemblages (BARHAM & MITCHELL 2007; SHEA 2012; SAHLE 2020). Alternatively, archaeologists who are relying on the paleoclimatic and paleoenvironmental data around the study areas employed Oxygen Isotope Stage (OIS) and sub-stages to place them into a coherent chronological and environmental framework (WILLOUGHBY 2007; FISHER 2010).

Among the known OIS 3 to OIS 1 archaeological sites in the vicinity of the Bale Mountains, the Mochena Borago rock shelter, situated at 2208 m asl at Mt. Damota in Southwest Ethiopia (**Fig. 1**), has yielded the first and only well-dated late MSA or OIS 3 sequence in a mountainous environment (BRANDT ET AL. 2017). The deeply stratified sediment deposits at Mochena Borago rock shelter are showing a very complex history of natural, cultural, and sedimentological events in the Horn of Africa context. They are characterized by different depositional events at different parts of the shelter. At least four lithostratigraphic sequences were identified with recognizable flakes and tools production techniques. The earliest archaeological layers starting around 53 ka are characterized by the production of flakes and blades from minimally prepared cores but only a small number of cores typical for discoidal or Levallois technique. Typical tools are facially retouched points (BRANDT ET AL. 2012, 2017; FISHER 2010; VOGELSANG & WENDT 2018). There is no archaeological evidence at Mochena Borago rock shelter about the transition from MSA to LSA because the shelter has no deposits from the Late Pleistocene around 33 ka to early Holocene around 8 ka (BRANDT ET AL. 2012; FISHER 2010).

Other OIS 3 Middle Stone Age assemblages are from the sites Porc-Épic (1450 m asl) and Goda Buticha (1382 m asl) in the Southeastern Ethiopian Highlands (**Fig. 1**). These two sites bordering the high-altitude of the Bale Mountains in the southwest have very long stratigraphic sequences for the Late Pleistocene and Holocene. The Porc-Épic MSA assemblages have several problematic dates while the stratigraphy of Goda Buticha cave is securely dated. The lithic assemblages from both sites are characterized by high production of flakes and retouched tools with the common feature of production technologies such as Levallois, discoid and laminar blade and flake productions (PLEURDEAU 2006; PLEURDEAU ET AL. 2014; ASSEFA 2006; LEPLONGEON 2014; LEPLONGEON ET AL. 2017). Assemblages with typical MSA/LSA transition were identified from 'stratigraphically mixed' deposits at Goda Buticha (PLEURDEAU ET AL. 2014; LEPLONGEON ET AL. 2017). However, the presence of MSA, MSA/LSA transitional, and LSA lithic material with ochre, ostrich eggshell, and exploitation of a wide variety of wildlife and long-distance raw material procurement up to 140 km attested to the major behavioral changes documented in the Southeastern Ethiopian Highlands in between 60–5 ka. The typo-technology of Goda-Buticha and Porc-Épic MSA material shows notable cultural variability of the Late Pleistocene lithic assemblages in the northern parts of the southeastern Highlands (PLEURDEAU 2006; PLEURDEAU ET AL. 2014; LEPLONGEON ET AL. 2017; NEGASH ET AL. 2011).

Since 1970, archaeologists have documented late MSA and LSA assemblages from the Rift Valley near the Ziway-Shale basin, and K'one and Aladi Springs (**Fig. 1**) (BRANDT 1986; KURASHINA 1987; MÉNARD ET AL. 2014; GOSSA ET AL. 2012). These sites are relatively close to the wide-open plains bordering the Arsi and Bale Mountains to the west and north. The lithic assemblages of these sites are characterized by the production of laminar blades and recurrent Levallois method. A special feature of the K'one assemblage is the occurrence of the Nubian Type I-cores, -tools, and -flakes (BRANDT 1986; KURASHINA 1987). The late MSA lithic assemblages of Aladi Springs and Deka Wede (DW1) of Bulbula River, Porc-Épic, and Goda Buticha resemble each other in producing tools preferentially from elongated blanks, especially blades and bladelets (PLEURDEAU ET AL. 2014; MÉNARD ET AL. 2014; BRANDT ET AL. 2017; LEPLONGEON 2014; LEPLONGEON ET AL. 2017). Although the dates and stratigraphies of these sites are still discussed by researchers (PLEURDEAU ET AL. 2014; LEPLONGEON ET AL. 2017), the distinct typo-technological changes in producing tools from elongated blanks might be attributed to the behavioral changes that might have happened during the OIS 3 environmental changes.

The LSA lithic material from Bulbula and Goda Buticha are more systematically analyzed and interpreted than other similar sites in the Rift Valley. Like most of the late MSA archaeological records, the early LSA assemblages in the Rift Valley were not directly dated but frequently attributed to the MSA/LSA transition on the base of the tool-spectrum in the Horn of Africa context. The production of small tools is generally referred to as microlithization and indicates technological and economic shifts (MÉNARD ET AL. 2014; LEPLONGEON 2014; LEPLONGEON ET AL. 2017).

In attempting to understand both biological adaptation and behavioral changes that led to hunter-gatherer's successful exploitation at and around the high-altitude of the Bale Mountains, special attention is required to clarify the chronological subdivision and terminology used in the previous works about archaeology and paleoenvironment. In this dissertation, I use the chronological division of Oxygen Isotope Stages (OIS) for the temporal classification of occupational phases. These are relatively well-defined chronological phases that are important in the reconstruction of environmental changes in Africa during the critical period of human evolution between OIS 6–2 (STEWART & JONES 2016; WILLOUGHBY 2007). OIS 3 to OIS 1 broadly encompass the late Middle Stone Age and Later Stone Age archaeological records that are characterized by large spatial and temporal gaps (BRANDT ET AL. 2012; FISHER 2010).

Concerning geographic designations, the term "Horn of Africa" (**Fig. 1**) is preferred in this thesis, covering the easternmost extension of the African continent and usually including the modern-day countries of Djibouti, Eritrea, Somalia, and Ethiopia. In contrast, the term "East Africa" refers to the modern-day countries of Tanzania, Kenya, Uganda, Ethiopia, Somalia, Djibouti, and Eritrea. The region is dissected by the eastern arm of the Rift Valley and borders in the east to the Indian Ocean and the Red Sea. The term "Northeast Africa" can also be found in the literature, usually referring to those countries situated in and around the Red Sea, which are intermediate countries between North Africa and East Africa/the Horn of Africa, and comprise the countries of Sudan, South Sudan, and Egypt.

Concerning the cultural context, the term Middle Stone Age (MSA) of East Africa**,** dating broadly between 300 to 30 ka, has only little cultural and chronological value. MSA lithic industries are sometimes also called Mode 3 technology and are defined by the commonplace technique in producing flake and blade and retouched points tools through Levallois and centripetal core reduction technique with the prepared striking platform (AMBROSE 1998; DOUZE 2011; TRYON & TYLER FAITH 2013; LEPLONGEON 2014; BLINKHORN & GROVE 2018; SAHLE 2020). The debate over the appearance and non-appearance of marker tools and tool production techniques for complexity is not over in defining the highly variable MSA assemblage. Furthermore, the material attributed to MSA can be expanded to ESA or/and LSA assemblages. In contrast, the **Late** MSA archaeological record (~100–30 ka) of East Africa is characterized by increasing regional diversity but with highly standardized stone tools production and complex manufacturing sequences (WURZ 2013; THOMPSON ET AL. 2018; SAHLE 2020). In particular, the archaeological records of this period are associated with the complex history of our species demographic shifts and population movements within and out of Africa (AMBROSE 1988; LAHR & FOLEY 1998; BRANDT ET AL. 2012; WILLOUGHBY 2007). On the other hand, the later stage of the MSA or end of OIS 3 is dominated by the manufacture of elongated tools (flakes or blades) derived from the prismatic nucleus but with or without the Levallois technique (LEPLONGEON ET AL. 2017).

LSA lithic industries are generally characterized by the use of volumetric blade technologies and more importantly features bipolar and laminar technologies (LEPLONGEON ET AL. 2014; MÉNARD ET AL. 2014; TRYON 2013). As the origin and production period of LSA in East Africa is poorly understood sometimes referred back to 50 and 40 ka or so (AMBROSE 1998; BARHAM & MITCHELL 2008), the term microlith is also applied as a catchword for all small tools produced through the laminar production technique between OIS 3 and Late Holocene (AMBROSE 2002; LEPLONGEON ET AL. 2014; MÉNARD ET AL. 2014; PARGETER 2016). The attribution to the LSA industries is essentially based on the lamino-lamellar and flake production techniques mainly to produce blades, bladelets, and small triangular flakes.

The production of LSA microliths is also associated with the additional use of the bipolar flake production technique. The bipolar flake production technique can also be used to produce blades and bladelets after a platform has been established. Flakes are detached after the prepared core is placed on an anvil and struck with a hammer. Both bipolar flakes and cores can display crushed distal ends and tiny negatives either on the dorsal or ventral face opposite to the proximal end. Like the LSA of the Ethiopian Rift Valley and Southeast Ethiopian Highlands, both cores and flakes of the Bale Mountains LSA assemblages show the use of bipolar lithic production technique. This production technique is mainly oriented towards the production of triangular small flakes from prepared conical cores.

Although the term microliths belongs to relatively different cultural and chronological categories, there is a considerable consensus in understanding the techno-typology of microlithic tools especially in the Horn of the African context. The presence of significant amounts of small backed tools (geometric and non-geometric) with the characteristics features of bipolar and laminar technologies stood behind in categorizing the assemblage into the known LSA microlithic tools. Currently, researchers in the Rift Valley and southeast Ethiopia proposed that small retouched and utilized tools mainly produced through the notion of lithic maturation as one among the regional variability of microlithic tools.

The dimension of microliths remains the subject of differences among researchers. Although, there is little distinction in quantifying the difference between bladelet and blade, the dimension of flake relied upon the availability of raw material coupled with the knappers' preferences with the regional pattern and other factors. Conventionally, the blade has a length greater than twice its width than bladelet which is often believed as small size flakes with parallel edges. Based on different criteria, the maximum dimension of microliths in East Africa varies from 25-50 mm in length (LEPLONGEON 2014).

Microliths can be geometric and non-geometric backed pieces made from none elongated blanks (AMBROSE 2002; LEPLONGEON ET AL. 2014; MÉNARD ET AL. 2014; PARGETER 2016). It also includes retouched and unretouched flaked tools produced by bipolar and laminar production techniques. Among the geometric backed microliths, segments are morphologically regular curved-backed microliths without proximal parts. The curved side is often backed (blunted) with abrupt retouches either unidirectional or bidirectional. The backing angle is relatively steep and often covered the whole curved side of the piece. Crescents are curved-backed microliths with parts of proximal ends. The curved microliths become crescents when the piece retains parts of the proximal ends such as butts, bulbs, and platforms (LEPLONGEON ET AL. 2014). Like segments, the same production techniques were employed to produce crescents. All backed microliths (crescents, segments, partially- and straight-backed) are believed to function as parts of the composite tools in the Horn of Africa. Another feature characteristic of backed microliths (in the Southeastern Ethiopian context) is that the straight and curved edges show a systematic use of the bipolar on anvil method for the backing of the edge of the tool.

3. THE STUDY AREA: BALE MOUNTAINS

3.1. PHYSICAL ENVIRONMENT

3.1.1. Location

The Bale Mountains are part of the Bale Mountains National Park (**Fig. 2**), which is located around 400 km to the south of the Ethiopian capital, Addis Ababa (**Fig. 1**), in the Oromia Regional State of south-central Ethiopia. The Bale Mountains (N 6°10′–7°10′ and E 39°00′–40°00) lie at the western margins of the Southeastern Ethiopian Highlands, between the lowland Rift Valley or Main Ethiopian Rift to the west and north and the Ogaden lowlands (**Fig. 1**) to the east (WILLIAMS 2016; UHLIG 1988; MIEHE & MIEHE 1994; HILLMAN 1988; REBER ET AL. 2018; ASRAT 2016). The Bale Mountains belong to the Arsi-Bale Mountain massif within the Southeastern Ethiopian Highlands. Several areas of this mountain massif are protected National Parks due to their extensive high-altitude plateaus that cover various Afromontane and Afroalpine vegetation zones, with a unique diversity in landscapes, plant, and animal species (HILLMAN 1988; FETENE ET AL. 2006; REBER ET AL. 2018). This has also led to the inclusion into the tentative list of World Heritage sites by UNESCO. The Bale Mountains massif also includes the highest peaks of the Southeastern Ethiopian Highlands, among them Mt. Tullu Dimtu (4377 m asl; **Fig. 2**), which is the second highest peak in Ethiopia (ASRAT 2016; WILLIAMS 2016; MIEHE & MIEHE 1994).

3.1.2. Geology

The Bale Mountains of the Southeastern Ethiopian Highlands are part of the Arsi-Bale mountain massif, comprising extensive high-altitude plateaus and mountain ranges (HILLMAN 1988; MOHAMMED & BONNEFILLE 1998; OSMASTON ET AL. 2005; FETENE ET AL. 2006; ASRAT 2016). The Bale Mountains consist of the volcanic outpourings of Tertiary

Trappean lavas, predominantly trachytes, rhyolites, and basalts, including agglomerates and tuffs. They covered Mesozoic marine sediments and the underlying Precambrian rocks after the Eocene uplifting of the Ethiopian Highlands (MOHR 1971; HILLMAN 1988; MIEHE & MIEHE 1994; WILLIAMS 2016; UMER ET AL. 2007, TIERCELIN ET AL. 2008; ASRAT 2016). Thus, the Bale Mountains were formed before the creation of the Rift Valley, and its morphology is dictated by the normal fault within the general NE–SW orientation along with the main Rift system (BERHE ET AL. 1987; ASRAT 2015; MIEHE & MIEHE 1994).

The lava outpourings on the Bale Mountains' central Sanetti Plateau (**Fig. 2**) have been modified and even flattened by several glaciations and millions of years of erosion by water, wind, and ice (UMER ET AL. 2007; WILLIAMS 2016; MIEHE & MIEHE 1994). It is one of the few glaciated mountain landscapes in the Horn of Africa with traces of former glaciers such as moraines, glacial cirques, ice serrations, swamps, and lakes within the current Ericaceous and Afroalpine belts (HILLMAN 1988; OSMASTON ET AL. 2005; WILLIAMS 2016; ASRAT 2016; OSSENDORF ET AL. 2019). According to a new study, around 350 km^2 of the Bale and Arsi Mountain landscapes were glaciated during the local Last Glacial Maximum (LGM), which occurred here already at around 40 ± 10 ka BP – in contrast to the global LGM (GROOS ET AL. 2021). Since the upper strata of the Bale Mountains are predominantly volcanic, the soils are mainly characterized by fertile loam of reddish-brown to black color and are entirely derived from the basaltic and trachytic parent rock (LÖFFLER 1978; MIEHE & MIEHE 1994; TIERCELIN ET AL. 2008; HADUSH KAHSAY 2019).

3.1.3. Climate

Like in other regions of the Horn of Africa, the climate of the Bale Mountains is determined by the seasonal movements of the Intertropical Convergence Zone (ITCZ) and of the monsoonal moisture (Mohammed & BONNEFILLE 1998; FRIIS ET AL. 2010; TIERCELIN ET AL. 2008). The main raining season is in summer between June and September, when the ITCZ moves to the northern parts of Ethiopia. At the same time, northwestern and central Ethiopia are highly influenced by southwesterly and southerly monsoon flows. Between October and March, the climate around the Bale Mountains is getting cold and dry as the ITCZ moves to the south of Ethiopia with a northerly flow of dry and cold air from the Arabian continent (MOHAMMED & BONNEFILLE 1998; TIERCELIN ET AL. 2008). In winters (especially during December to February), the climate is dry until the influx of humid air from the Indian Ocean leads to a first rainy season starting in March (MOHAMMED & BONNEFILLE 1998).

The Bale Mountains are characterized by distinct altitudinal vegetation zones, which can be roughly summarized as consisting of three major vegetation belts: the Afromontane forest belt, the ericaceous belt, and the Afroalpine belt (UHLIG 1988; MIEHE & MIEHE 1994; MOHAMMED & BONNEFILLE 1998; FRIIS ET AL. 2010; KUZMICHEVA ET AL. 2017), all of which are internally variable due to meso-climatic regions. The pattern and distribution of rainfall and temperature on the Bale Mountains and surrounding areas also vary according to altitude and terrain (**Fig. 2**): the steep southern escarpment is at present more humid than the gentler and dissected northern slopes (TIERCELIN ET AL. 2008; FETENE ET AL. 2006; HILLMAN 1986). In the northern and central parts of the Bale Mountains, the average annual rainfall is about 600–1000 mm whereas the southern slopes receive between 1000–1400 mm. Unlike the northern and central areas of the Bale Mountains, the lower altitude areas including the Harenna Forest are characterized by two rainy and two dry seasons.

The temperature record at the Bale Mountains also depends on the altitudinal variation of the northern and southern slopes. At the higher altitudes, average low temperatures are recorded up to -5° at night during the dry season. The highest temperatures are also recorded during the dry season, however, rarely exceeding 20° C (HILLMAN 1986; FETENE ET AL. 2006). During the local LGM (ca. 42–28 ka), the temperature depression at the Sanetti Plateau and the surrounding areas most probably amounted up to around 5.2 ± 0.5 °C (GROOS ET AL. 2021). In general, frost is common at higher altitudes above 4000 m (MOHAMMED & BONNEFILLE 1998; TIERCELIN ET AL. 2008), but it rarely freezes during the rainy season, which is characterized by relatively modest temperatures as well as high temperature fluctuations.

3.1.4. Vegetation and wildlife resources

The Bale Mountains comprise the world's most extensive areas of Afroalpine vegetation and Africa's most extensive ericaceous vegetation. The presence of a large amount of endemic flora and fauna resulted from the combination of different aspects; mainly the isolation of the Bale Mountains from other Ethiopian Highlands and the Rift Valley, coupled with the spatial extent of the mountains and the unique climatic conditions (HILLMAN 1988; MIEHE & MIEHE 1994). The Bale Mountains represent one of the world's key biodiversity areas (YALDEN & LARGEN 1992).

Apart from the above mentioned three altitudinal vegetation zones, two additional vegetation zones define the habitats of plant species and consequently determine the distribution of the animal species. The northern part of the mountains is designated as the northern grasslands and woodlands (Gaysay Valley; **Fig. 2**), while the west and southwestern parts of the Bale Mountains National Park contain the most extensive ericaceous forests. The Afroalpine moor- and grassland is confined to the center and east (Sanetti Plateau), while the Harenna Forest consists of different dry and moist Afromontane vegetation habitats – depending on altitude – which is located at the steep southern slopes of the Bale Mountains (HILLMAN 1988; MIEHE & MIEHE 1994).

The distribution of vegetation broadly reflects the topography of the Bale Mountains. The northern slopes between 3000 and 3800 m asl are referred to as ericaceous belt (*E. trimera* and *E. arborea*), additionally characterized by a mix of *Juniperus, Hagenia* (African redwood), and *Hypericum,* whereas montane grassland and heath dominate the vegetation above the tree line. The central Sanetti Plateau with its peaks comprises the Afroalpine belt with sparse vegetation such as dwarf shrubs (*Helichrysum splendidum* and *Alchemilla haumanii)*, the Giant Lobelia (*Lobelia rhynchopetalum*), grasses (*Festuca richardii*), and other herbaceous species. The steep southern escarpment – situated between 1400 and 3800 m asl – constitutes the Harenna Forest which is dominated by *Juniperus procera* and *Hagenia abyssinica, Erica arborea, Hypericum, Aningeria, Podocarpus falcatus, Schefflera abyssinica*, *Maesa lanceolata*, and *Rapanea simensis*. Afromontane forests, however, do also occur to a much lesser degree on the other margins of the central plateau up to 3500 m asl (MIEHE & MIEHE 1994).

The Bale Mountains are known to host among the highest incidences of both animal and plant endemicity within the terrestrial habitats in the world (FRIIS ET AL. 2010). A total of 110 endemic species, representing 18.8 % of the national counts of flowering plants, were identified at different topographic situations of the Bale Mountains. The density of endemic plants at the Bale Mountains reached up to 2.5 taxa per 100 km^2 (ASEFA 2011; ASEFA ET AL. 2020; KIDANE ET AL. 2019). Additionally, the tropical highlands of the Bale Mountains also host large numbers of endemic animals, mainly mammals and birds. Mammals predominate the animal population and 20% of the identified mammals are endemic to the mountains. The Bale Mountains contain 6.1% of the count of national endemic birds. The entire global population of giant root-rat (*Tachyoryctes macrocephalus*) is concentrated in the Bale Mountains. Most of the endemic species are under threat especially from human settlement, even in highly sensitive areas.

3.1.5. Physiography

The regional focus of this study will be on the upper Web Valley (sometimes called Weyib Valley) that is located northwest of the Sanetti Plateau (**Fig. 2**) and extends up to the Gaysay Valley in the north of the Bale Mountains (STEPHENS ET AL. 2001; DECHESA ET AL. 2019; KUZMICHEVA ET AL. 2013, 2014, 2017). Apart from grasslands, it also comprises stripes of Afromontane forests as well as the ericaceous belt, and extends to the boundary between the ericaceous and Afroalpine belts that varies between 3500 m to 4100 m asl, depending on the location. The upper Web Valley is characterized by varying landscapes and is partly closed off by a ridge of peaks and lava cliffs in the west and south (STEPHENS ET AL. 2001; KUZMICHEVA ET AL. 2017; MIEHE & MIEHE 1994), but relatively accessible through two major plains of the region; the Genale and Kotera plains to the west and northwest, respectively (**Fig. 2**). These plains are the main entrance to the Bale Mountains from the direction of the Rift Valley and the Southeastern Ethiopian Highlands. The rock shelters which were documented at the upper Web Valley are directly related to the mountains, formed through horizontally and sub-horizontally bedded basalt and rhyolite rocks, plains, gorges, and ridges.

The vegetation around the Web Valley is dominated by trees and grasses of the characteristic ericaceous belt, and also supports limited Afroalpine types such as *Alchemilla* pasture and *Helichrysum* spp. mainly at the transition to the afroalpine belt (MIEHE & MIEHE 1994; STEPHENS ET AL. 2001; UMER ET AL. 2007; KUZMICHEVA ET AL. 2017). The upper Web Valley also has extensive plain grounds, highly modified by fossorial impacts of large giant root-rat populations (*Tachyoryctes macrocephalus*), covered with abundant mounds of this “landscape engineering” species. These grounds, alongside with the central Sanetti Plateau, harbor considerably larger biomass of rodents than any other parts of the Bale Mountains. The abundance of resources in the upper Web Valley might have also attracted a large number of carnivores in the past. Today the region is known as the optimal habitat of the endemic and similarly threatened Ethiopian Wolf (*Canis simensis*) (STEPHENS ET AL. 2001; KUZMICHEVA ET AL. 2017).

The Web Valley also acts as the main water catchment of the region (MIEHE & MIEHE 1994). The Web River is the main tributary of the Genale and Dawa rivers before leading to the border between Ethiopia and Somalia (DECHESA ET AL. 2019; STEPHENS ET AL. 2001). Moreover, the presences of swamps and marshes along the Web Valley and its tributaries are additional sources of water for plants and animals. Like other parts of the Bale Mountains, the landscapes of the Web Valley including the rock shelters, are witnessing considerable changes resulting from human settlement activities (REBER ET AL. 2018).

3.2. PRIOR RESEARCH

The high altitudes of the Bale Mountains were subject to early botanical and geographic explorations (HILLMAN 1988; MIEHE & MIEHE 1994; FETENE ET AL. 2006). The Bale Mountains and the surroundings were first visited by early travelers and explorers such as Donaldson Smith in 1897, von Erlanger in 1899, and Du Bourg de Bozas in 1910. The early exploration works by von Erlanger and Du Bourg de Bozas focused on the vegetation and massif of the Bale Mountains. These early explorations might have encouraged later geographers to document the elevation and vegetation cover of the previously unknown peaks, including Mt. Batu and Mt. Tullu Dimtu (**Fig. 2**). They also reported the presence of glaciation traces as well as human impacts such as the current use of fire and grazing in the forests. European exploration at the Bale Mountains focused on botanical research, first by Mooney (1958–1959) and then by Hedberg during the 1970s (MIEHE & MIEHE 1994; HILLMAN 1988).

There are only limited sources of information from the early exploration regarding the archaeological potential of the Bale Mountains. The surface collections of lithic artifacts by Dr. Brumpet on open-air sites around Goba were later reported by BREUIL & KELLEY (1936). The first systematic archaeological survey and excavation of cave deposits at the Bale Mountains started in 1962, when chemists, zoologists, metallurgists, and pedologists of the British Imperial College of Science and Technology and the College of Addis Ababa visited the areas around Goba (**Fig. 2**) and the Sanetti Ridge (HERBERT 1965). According to this published report, caves around Togona Valley, Goba, and Ghinner (the old trade center of the Bale Region) were surveyed. A single cave was also tested by Herbert and his partners. As the shelters around the Togona valley were described as being of only little interest to the group, a cave called *Robie,* around the lower elevation of the Ghinner district was excavated and yielded only limited archaeological findings such as bones, charcoal, and pottery. It was reported as a recent nomadic settlement site (HERBERT 1965).

The archaeological investigations under Desmond Clark in southeast Ethiopia (1974–1975) also included research at lower altitudes adjacent to the Bale Mountains. The archaeological sites at Gadeb (ca. 2400 m asl) around the upper Webi Shebele River revealed the presence of Early Stone Age stone tools which could be dated between 1.5 and 0.7 Myr on K/Ar (CLARK & WILLIAMS 1978; CLARK & KURASHINA 1979; CLARK 1988). It is argued that this expedition team was the first to unravel successful hominin exploitation of high-altitude areas (ALDENDERFER 2014). However, this research group did not expand archaeological investigations to above 2500 m asl in the Bale Mountains.

Since 1980, researchers were mainly interested in the vegetation and ecology of the Bale Mountains, and frequently undertook fieldwork. The establishment of the Bale Mountains National Park in 1970, which was followed by the all-weather road construction in the early 1980s, had encouraged different research activities in general and led to a formative phase of research of the high altitudes of the Bale and Arsi Mountains (MIEHE & MIEHE 1994; HILLMAN 1988). Paleoenvironmental studies were started by M. Umer and his partners at the end of the 1990s and subsequently pushed the depth of research at the Bale Mountains back into prehistoric times. The paleoecological evidence shows that Late Holocene hunter-gatherers already modified the ecosystems of the Bale Mountains and the surroundings (MOHAMMED & BONNEFILLE 1998; UMER ET AL. 2007; MIEHE & MIEHE 1994; KUZMICHEVA ET AL. 2017). The recent publications by a Russian-Ethiopian team on the ecological history of the Bale Mountains suggest that the impact of humans in the region went even back to 15 ka, however, solely based on the presence of charcoal and without any direct archaeological evidence (KUZMICHEVA ET AL. 2013, 2014, 2017).

3.3. EARLY HISTORY

The early history concerning the land and the people of Bale is still obscure and even remains the subject of contention among local historians (HASSEN 1999; PANKHURST 1997; HENZE 2000; GEDA 2013). The earliest oral traditions of the Bale region mainly consist of the legends of *Shaykh Hussayn*, who brought Islam to the land of Bale during the 13th century AD, and to the later migration of the Oromo people in the 16th century AD (ØSTEBØ 2012; TESHOME 2008). The name Bale was first mentioned in different accounts as being one of the seven Islamic states which flourished between northern Somali and the central Ethiopian Rift Valley during the early 13th century AD (TRIMINGHAM 1952; BRAUKÄMPER 2002; HENZE 2000; TESHOME 2008). However, the territory and center of the Bale Sultanate are not mentioned. Only a general description of the state is available as a mountainous country with fertile land and rich vegetation compared to other contemporaneous Islamic states of the country. The economy of the Bale inhabitants during Sultanate times is little known, but they were definitely highly connected to other Islamic states with long-distance trade extending up to Ziela in Somalia (PANKHURST 1997; BRAUKÄMPER 2002; HENZE 2000; TESHOME 2008).

Like other parts of the country, the Bale region has experienced significant changes soon after the defeat of Imam *Ahmad ibn Ibrahim al Ghazi*, locally known as *Ahmad Gragn*, who in the early 16th century AD overtook the power from the previously dominant kings of the Christian Kingdoms in northern Ethiopia (PANKHURST 1997; HENZE 2000; TESHOME 2008). The new geopolitics of the country allowed population expansions of the Oromo people to the low, as well as partially to the high altitudes of the Bale region, especially between 1530 and 1538 (HERBERT 1965; HENZE 2000; BRAUKÄMPER 2002; TESHOME 2008). Local accounts, however, rather claimed that the highlands of Bale (namely Walabu) were the original home of the Oromo people already in the 12th century AD (HASSEN 1999).

The new settlers of the Oromo population were practicing a transhumant economy at the lowland with mixed farming at the higher elevations. The Oromo population who settled around the Bale Region were following a patrilineal descent system and a patrilocal settlement pattern, which are the center of the Oromo socio-political institution, the *Gada* (TESHOME 2008; HASSEN 1999). Although the Oromo populations who settled around Arsi and Bale had successfully adopted the practice of agriculture (HENZE 2000; TESHOME 2008), a large portion of the inhabitants between the Arsi lowlands and the Bale Mountains maintained a long-established pastoral economy or traditional transhumance system called *Godantu* (FLINTAN ET AL. 2008; VIAL ET AL. 2011). The early Oromo communities were practicing a nomadic way of life, through seasonal migration with their cattle and families from the surrounding lowlands (mainly from the Adaba region) to the mountainous areas of the Bale Mountains. As agriculture became the mainstay of the populations, the practice of *Godantu* deserted, but Oromo are still today practicing a semi-pastoralist lifestyle (STEPHENS ET AL. 2001; FLINTAN ET AL. 2008; VIAL ET AL. 2011; REBER ET AL. 2018).

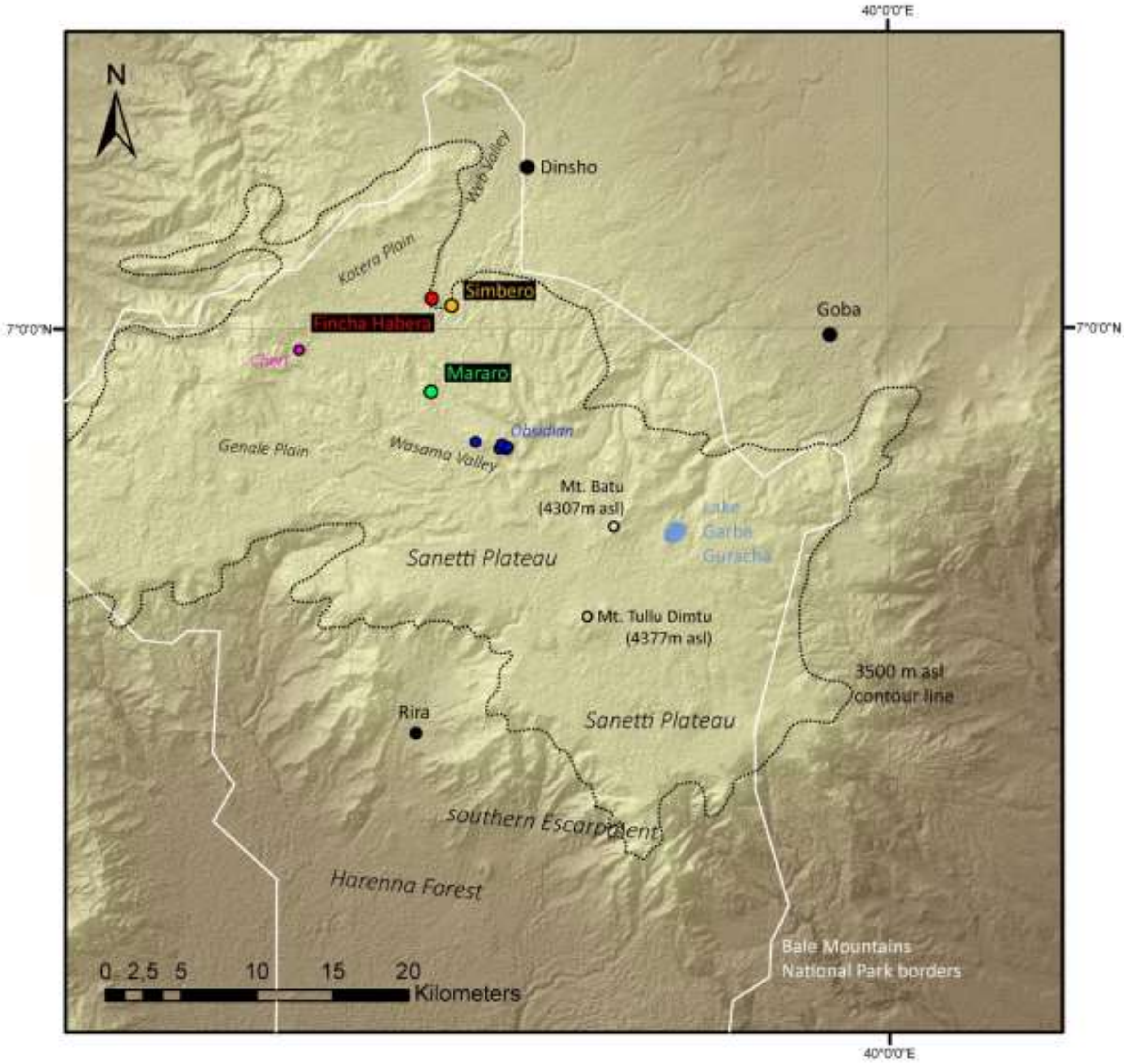

Fig. 2. *Map of the Bale Mountains with location of the studied archaeological sites, location of lithic raw material outcrops, prominent landscape features, boundary of the present National Park and the 3500 m asl contour line.*

4. METHODOLOGY

4.1. INTRODUCTION

Archaeological sites of the upper Web Valley were targeted first to understand if, when, and how hunter-gathers successfully exploited the extreme high-altitude environments of the Bale Mountains. Moreover, the identification of possible regional correlations on cultural adaptations with better known MSA and LSA sites around the Rift Valley and the eastern parts of the Southeastern Ethiopian Highlands formed another major aim of this study. Surveys and excavations of selected sites took place during spring 2017 and 2018. Systematic surveys were conducted in the plains around 3500 m asl, the valleys of the escarpment, and the central Sanetti Plateau, focusing on the absence and presence of diagnostic stone tools and other archaeological surface findings. The recovered samples include lithic artifacts, faunal remains, coprolites, botanical remains, and charcoal. These samples were further processed for different analyses at the laboratory of the National Museum of Ethiopia, Addis Ababa Köln University, and Martin Luther University Halle-Wittenberg, Germany.

The rock shelter and open-air sites discovered by the P1 unit of the DFG FOR 2358 project were documented and examined through the established archaeological data recording and analysis methods that have been used by the CRC 806 projects of Köln University. The survey of archaeological sites at the high-altitude of the Bale Mountains followed the published map of rock shelters and settlements on the Bale Mountains by the Faculty of Geography of the Marburg University (REBER ET AL. 2018). Out of these sites, and amended by additional rock shelters identified by the P1 team, three rock shelters of the upper Web Valley were chosen for archaeological investigations and are presented in this dissertation. These rock shelters contain stratified deposits with Late Pleistocene and Holocene archaeological records. It is of utmost importance, therefore, that a systematic analysis of archaeological samples from the surface and rock shelters of the selected three sites is established.

4.2. SURVEY, EXCAVATION, AND SAMPLING PROCEDURE

In 2017, two archaeological field-seasons were conducted in the northwestern and central parts of the Bale Mountains. During these expeditions, the sites Fincha Habera and Mararo were documented and tested through archaeological investigations. A second archaeological square at Mararo (G8) was opened during the third field expedition in 2018. The archaeological site Simbero was excavated during the same field campaign. These archaeological sites were identified after a systematic and extensive survey conducted at the north, center, and southwest parts of the park.

The excavation sites were selected based on the recovered diagnostic MSA and LSA tools at the surface of the shelter. Each square was opened with the orientation of true north after the datum was established through GPS (UTM 37N zone). A 1 x 1 square meter was excavated in quarter-squares, vertically separated by natural levels or artificial spits of 0.5 cm. The second archaeological square from each site was excavated to expand the data depth both spatially and temporally. Samples were extracted for radiocarbon dating, pollen analysis, and sedimentological analysis. All sediments with archaeological records were sieved using a standard sieve size between 1.5, 3, and 5 mm screen and bagged separately according to levels and stratigraphic units. Documentation and stratigraphic affiliation followed the CRC 806/SWEAP of Köln University standards.

During the 2017 and 2018 excavation seasons, the recovered archaeological material was individually bagged, labeled, and numbered according to the square, date, quadrant, and artifact category, as well as entered on the site record at the Lab. All archaeological records from the sieves were bagged only through artifact category and levels with necessary labels such as the square, quadrant, and date. Besides artifacts, structures, features, and disturbances in the unit were carefully documented through photographs and drawings. The lithic artifacts recovered from each site were separately documented on Excel files (see **Appendices I**, **II**, and **III**).

4.3. SEDIMENT ANALYSIS

The stratigraphic context of the deposits was reviewed through geomorphological and anthrosol analyses at the Institute of Geography, University of Cologne, Germany and Martin Luther University Halle-Wittenberg, Germany. The samples were further processed for sedimentological and geochemical analysis (**Appendix IV**). Only the Late Pleistocene deposits of Fincha Habera were analyzed in detail with the above-mentioned methods while the Holocene deposits of Simbero and Mararo rock shelters were pending the same analysis. The sediment samples were carefully collected as bulk from the selected profiles. Moreover, sediment samples were collected from other profiles with an interval of 1-2 cm depending on sediment variation. These samples have less contact with modern samples mainly to avoid contamination in the field and were properly labeled and bagged with protective plastic bags.

Using their archaeological squares and context as a guideline, the undisturbed deposits (of Fincha Habera) were analyzed and corroborated with the field notes mainly to determine the textural difference (grain size), contacts between sediment layers, and more importantly to identify natural (geological) and anthropogenic components of impacts during sediment deposition. Moreover, X-ray diffractometer (XRD) and X-ray fluorescence (XRF) analysis were used to determine the mineralogical and elemental composition of the sediments. Anthrosol analyses included additional element analysis (nitrogen, potassium, phosphorus, calcium), black carbon content, and fecal biomarker analysis (**Appendix IV**). The deposits of Simbero and Mararo were determined based on detailed field notes and careful examination of the deposition pattern of the shelters. The identification of deposits, in turn, allowed us to determine the litho-stratigraphy of each shelter presented in this dissertation. The depositional history of these three shelters could be corroborated with detail paleoenvironmental and paleoclimatic data of the region, the high-altitude of the Bale Mountains.

The description of stratigraphic sequences of the three shelters at the upper Web Valley was determined from the main sources of information: lithology and archaeology. The lithostratigraphy of the site has a special correlation to the cultural sequences that can be identified at the same deposits. The lithostratigraphy of each shelter is presented in descending order, from the younger to the oldest deposits with the initial two capitals from the name of the shelter. The Fincha Habera lithostratigraphy, as an example, is presented from FHLU-01 to FHLU-09. This kind of presentation provides maximum information about the depositional history of the shelter.

4.4. RADIOCARBON DATING

The archaeological sites documented at the high-altitude of the Bale Mountains were exclusively dated by the AMS radiocarbon dating method. A total of 47 radiocarbon dates were obtained from Fincha Habera, Simbero, and Mararo rock shelters (**Table 1; Table 9; Table 16**). Most of the dating samples came from charcoal, but the chrono-stratigraphy of the late MSA site of Fincha Habera was reconstructed by additional samples from black carbon (n=5), coprolites (n=3), and bone collagen (n=2). The Holocene occupations at Simbero and Mararo were reconstructed from eight and seven charcoal samples, respectively. Radiocarbon dating was carried out by two independent laboratories (Beta Analytic, Miami, FL, USA and CologneAMS, Cologne, Germany). Calibrated radiocarbon ages were given as 2σ probability calendar year ages, calculated with CALIB 8.2 (STUIVER ET AL. 2021), based on the probability method by BRONK RAMSEY ET AL. (2009), and using the IntCal13 calibration curve (REIMER ET AL. 2013).

4.5. LITHIC ANALYSIS

All archaeological records of the three rock shelters were recovered from shallow deposits that commonly occurred at the high-altitude of the Bale Mountains. In most cases, the lithic assemblages are located below the recent cattle dungs and thick charcoal layers. The lithic artifacts of the Late Pleistocene and Holocene are surprisingly high in number. All lithic artifacts were sorted and carefully analyzed at the National Museum of Ethiopia, Addis Ababa, and the SFB of Köln University. In order to capture multiple dimensions of lithic variability, a detailed attribute analysis of each lithic specimen was carried out and forms the backbone of the current analysis (see **Appendices I, II, III**).

Statistical analysis for the lithic artifacts made on the known attributes such as artifact type, raw material, physical condition, and others including lithic dimensions was documented using the standardized SFB806 Access 2007-2013 database form. Excel 2002 version was used to develop tables, bar graphs, and figures while the wall profile and plan views were developed with Adobe Illustrator CS2 Program.

4.6. FAUNAL ANALYSIS

The analyzed faunal assemblages come from Fincha Habera and Simbero rock shelters. The H11 archaeological square of Fincha Habera and K4 of Simbero supplied abundant and highly variable faunal remains in association with lithic artifacts and charcoals. These faunal remains recovered from Fincha Habera and Simbero rock shelters were compared with modern osteological collections stored at the National Museum of Ethiopia. In most cases, the specimens were identified to species, genus, or even sub-family levels, and those unidentified faunal remains were determined by the size of the bones.

Almost all faunal remains are well preserved and not mineralized. A significant number of faunal remains were altered by intentional fire. Especially, the Middle and Late Holocene deposits of Simbero rock shelter contain a high frequency of faunal remains with a clear impact of fire. On the other hand, the impact of hyena on bone fragmentation was also documented on the faunal remains of Fincha Habera rock shelter. It is believed that the impacts of hyena and fire coupled with taphonomic processes might have increased the extent of bone damage at both shelters. Based on the taphonomic analysis, both humans and carnivores have acted as the accumulators of bones at Fincha Habera during the end of OIS 3. In contrast, the Simbero faunal remains appear to be accumulated only by humans, especially by Middle and Late Holocene occupants. The Late Holocene deposits of Mararo yielded only unidentified fragments of bones.

5. ARCHAEOLOGICAL SITES IN THE BALE MOUNTAINS

5.1. FINCHA HABERA ROCK SHELTER

5.1.1. Introduction

The rock shelter Fincha Habera (meaning "Habera Waterfall" in the local Oromo language) is located at 7.014650° N and 39.720002° E at an altitude of 3469 m asl in the northwestern Bale Mountains (**Fig. 1; Fig. 3**). The bedrock was formed in the flat south-north basalt ridges of the eastern upper Web Valley. Here, these ridges consist of continuous, horizontally bedded basalt rocks mostly forming the western edge of the Wella current. This stream is one of several outflows of the upper Web Valley, which flows immediately adjacent to the rock shelter before it joins the Web River only about 200 m downstream at the Fincha Habera waterfall (**Fig. 4**).

The roof of the rock shelter is formed by a long flat basalt outcrop which characterizes the western ridges of the landscape surrounding the waterfall. Fincha Habera rock shelter was formed by long-time weathering and erosion of conglomeratic deposits, embedded between the basalt bedrock and the upper basalt layer (HADUSH KAHSAY 2019). The wall and roof of the shelter witness abundant cracks and fissures. The northern end of the shelter is covered with basalt blocks that collapsed from the roof. Water erosion from the Wella river and water infiltration at the back has contributed to the forming of the long-curved basalt cavity with a width of approximately 70 meters from south to north and about 17 meters from the drip line to its rear wall in the west (**Fig. 4B**).

Fig. 3. *Upper Web Valley at Genale Plain with the location of the archaeological sites and the obsidian raw material outcrops (black) on the ridge north of Wasama Valley. Source: Google Earth.*

The height of the ceiling is approximately 1.60 m from the current floor at the entrance areas and steadily declines towards the rear wall. The shelter is partitioned by a columnar basalt wall in the middle into a southern part – mostly of bare bedrock – that is covered with abundant animal droppings. These mainly originate from spotted hyena (*Crocuta crocuta*), common warthog (*Phacochoerus africanus*), and rock hyrax (*Procavia capensis*). A large colony of the latter was inhabiting the shelter during all field stays. The northern part exhibited substantial sediment deposits which were archaeologically studied. Beyond the western rear wall, a small opening gives access to a larger chamber with a diameter of up to 10 m. It is possible to stand in an upright position in the chamber but due to the missing daylight, it was probably never used for human occupation.

Fig. 4. *Views of Fincha Habera rock shelter.*

The wide entrance of the shelter (**Fig. 4A**) is protected by roof fall, basalt blocks naturally piled up to a height of between two and three meters at the steep slope towards the adjacent stream. In some areas, this natural stone wall was additionally raised with basalt blocks by humans, possibly to enclose small livestock. Fincha Habera rock shelter has no visible engravings and paintings, however, the entire roof exhibits the spatial extent of past fire use inside the shelter. The surface of the shelter is entirely covered by soft and light brown sediment with undecomposed animal dung and plants. The fact that the surface of the shelter is only slightly affected by recent human activities is in stark contrast to almost all other shelters investigated in the Bale Mountains.

Fincha Habera rock shelter was not documented in the recent rock shelter inventory of the Bale Mountains (REBER ET AL. 2018), but it was first mentioned in paleoecological studies by a joint Russian-Ethiopian team (KUZMICHEVA ET AL. 2013, 2014, 2017), investigating animal dung deposits from the deeper western chamber of the shelter.

5.1.2. Archaeological squares

The deposits were examined by two test trenches to evaluate the total depth of the sediments and the distribution of archaeological remains both temporally and spatially. The first test square, E8, was opened in the southeast of the shelter, while H11 is located in the western parts of the shelter (**Fig. 5**). The position of E8 was preferred for its proximity towards the entrance of the shelter and the presence of daylight. E8 was excavated to the depth of 70 cm until the bedrock and nine stratigraphic units with different depth and deposition histories were identified (**Fig. 6A**). Square H11 is located west of E8 and is orientated to the back of the shelter. It was opened to increase the archaeological sample size and to test spatial differences of the deposits. Given its higher altitudinal position as well as its distance to E8, it was assumed that H11 may reveal a different deposition and occupation history in the shelter (**Fig. 5**). The depth of the square is shallow, not more than 70 cm to bedrock (**Fig. 6B**) but sediments are moister compared to E8. The surface deposits of H11 also show more impact by animal trampling.

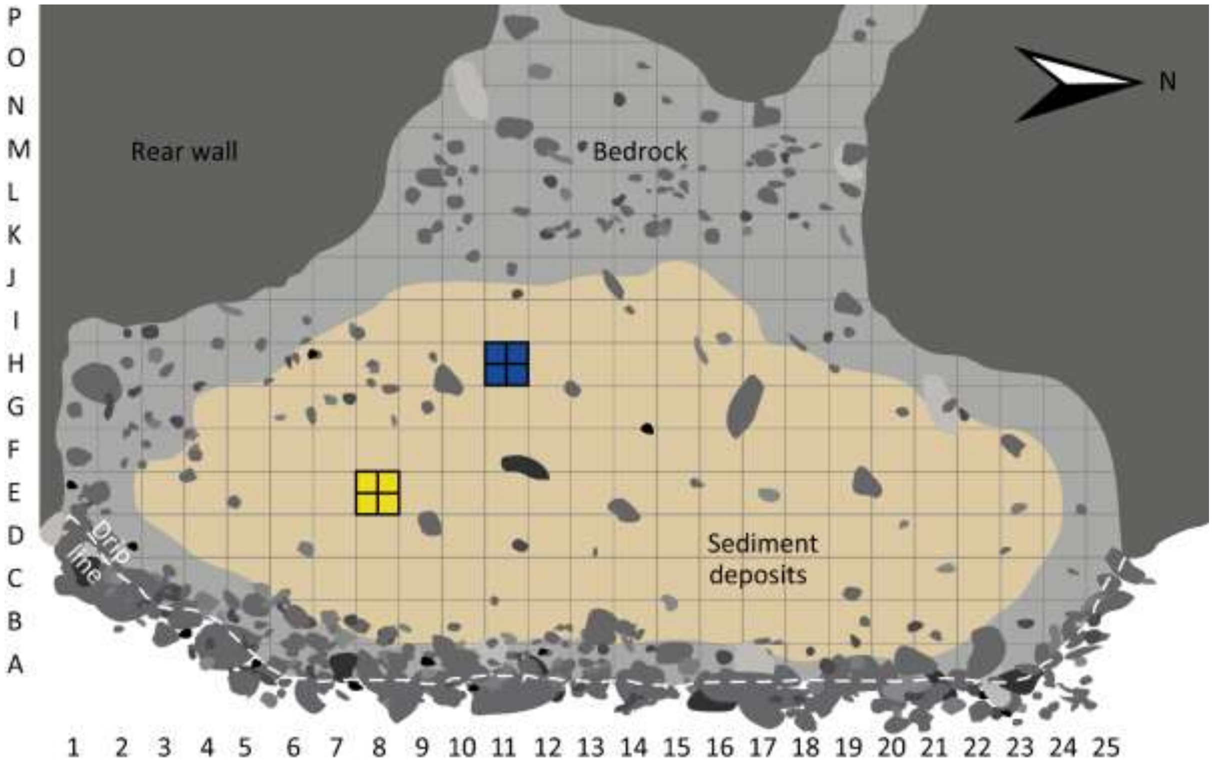

Fig. 5. *Plan view, excavation grid, and location of sediment deposits in the northern part of Fincha Habera rock shelter. Colored squares show excavation squares E8 (yellow) and H11 (blue).*

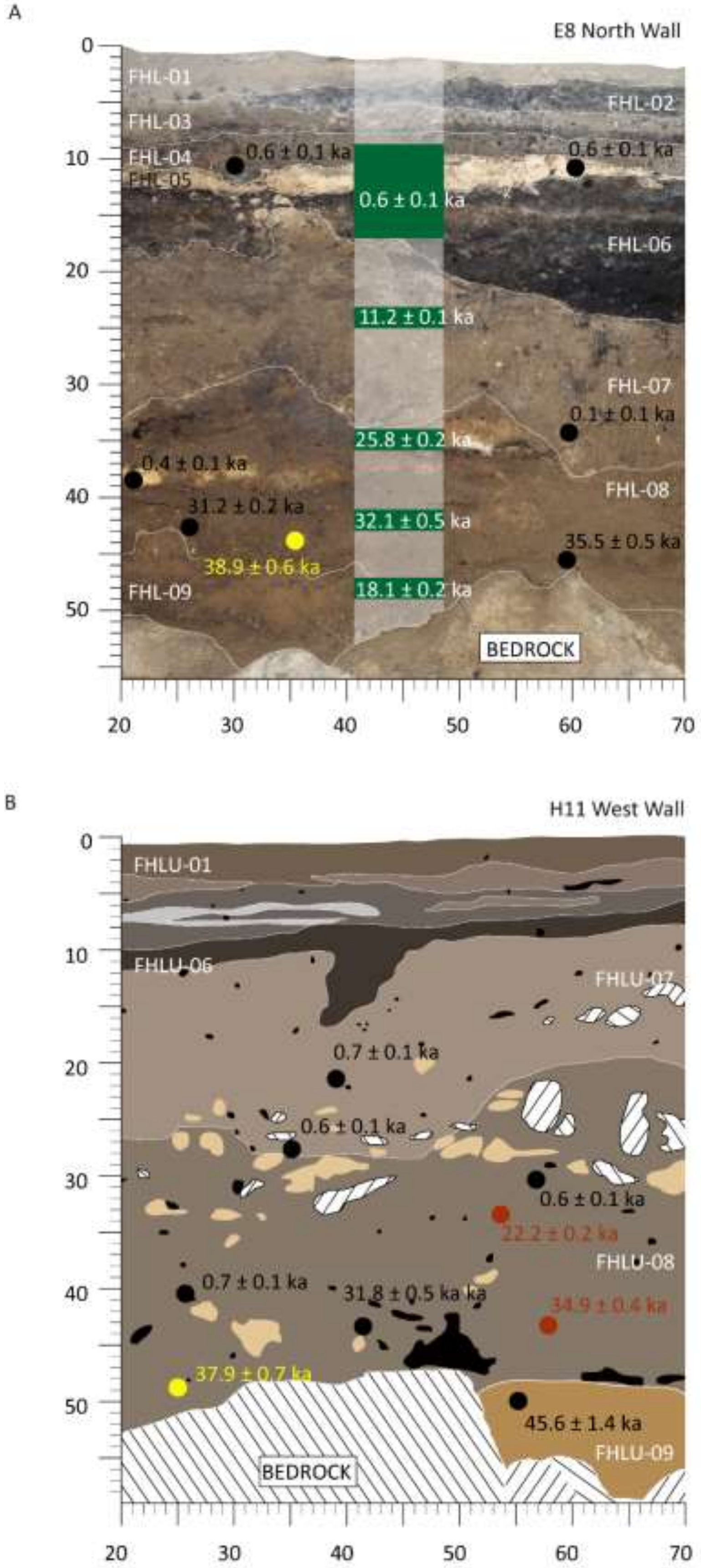

Fig. 6. *Stratigraphic sequences at Fincha Habera rock shelter with projected radiocarbon dating results. Photograph of the north wall section at square E8 (A) shows the sedimentological sampling column in the middle. Drawing of the west wall section at square H11 (B). Symbols for dating samples: charcoal (black), coprolites (red), giant root-rat mandibles (yellow), black carbon from sediment (green). See* ***Fig. 5*** *for the location of the profiles.*

5.1.3. Lithostratigraphic sequence

Based on the results of the sedimentological analyses (HADUSH KAHSAY 2019), a total of nine stratigraphic or lithological units will be presented in the following, from the most recent top to the oldest Late Pleistocene deposits. A profile photograph (E8) and a profile drawing (H11) of both archaeological excavation squares are provided together with the results of a total of twenty-six radiocarbon dates in **Fig. 6** (see also **Table 1**).

FHLU-01: FHLU-01 of E8 and H11 is loose topsoil, variably deposited with three to five cm depth throughout the shelter. It is composed of highly weathered, grayish soil that is clearly compressed by both human and animal trampling. Parts of the surface are also covered with basalt blocks fallen from the roof and rear wall, especially at the back and the northern edge of the shelter. There are little signs of active erosion which might have affected the topsoil of the shelter. During the excavations, the upper surface yielded only recent charcoal, bones, and wood, but no lithic material. This uppermost unit of the deposits corresponds to the archaeological level 0 in both excavation squares, E8 and H11.

FHLU-02: This stratigraphic unit exclusively shows one significant fire event in the shelter. It is characterized by burned, fine-grained sediment mixed with large, undecomposed chunks of charcoal of about 3 to 5 cm thickness. This unit is seemingly uniform and might have covered large areas of the shelter during one event. It is conformably deposited above the subjacent layer. There is no unequivocal evidence of whether this layer of charcoal was accumulated through human activity or by natural fire. No lithic artifacts were recovered in FHLU-2, which represents archaeological level 1.

Table 1. *AMS radiocarbon dating results from Fincha Habera rock shelter.*

Provenance	**Material**	**Lab No.**	**14C Age BP**	**cal BP (1 Sigma)**
E8/NW/L9	Charcoal	COL5197.1.1	143 ± 37	37 - 244
E8/SW/L7	Charcoal	Beta – 486378	330 ± 30	337 - 448
E8/SE/L3	Charcoal	COL5196.1.1	533 ± 38	530 - 620
E8/SW/L3	Charcoal	COL5195.1.1	547 ± 36	537 - 624
H11/SE/L8	Charcoal	COL5199.1.1	558 ± 37	543 - 628
H11/SE/L7	Charcoal	Beta – 486376	660 ± 30	576 - 661
E8/NWprofile/9-17cm	Black carbon	Beta – 507233	680 ± 30	579 - 669
H11/NW/L11	Charcoal	Beta – 486375	780 ± 30	689 - 728
H11/SE/L5	Charcoal	COL5198.1.1	770 ± 38	684 - 729
E8/NWprofile/23-25 cm	Black carbon	Beta – 507234	9.710 ± 30	11.143 - 11.195
E8/NWprofile/47-49 cm	Black carbon	Beta – 503927	14.930 ± 60	17.979 - 18.463
H11/SE/L9	Coprolite	Beta – 506526	18.320 ± 60	21.671 - 22.308
E8/NWprofile/34-36 cm	Black carbon	Beta – 507235	21.520 ± 80	25.249 - 25.996
E8/NW/L11	Charcoal	Beta – 486377	27.240 ± 120	31.757 - 32.035
H11/NE/L11	Charcoal	Beta – 506528	28.000 ± 140	32.185 - 32.772
E8/NWprofile/41-43 cm	Black carbon	Beta – 507236	28.220 ± 130	32.333 - 32.940
H11/NE/L11	Coprolite	Beta – 506527	30.940 ± 170	34.666 - 35.360
E8/SW/L10	Charcoal	Beta – 506529	31.640 ± 200	35.106 - 36.002
H11/NW/L13	Bone collagen	Beta – 522263	33.600 ± 230	37.781 - 40.438
E8/NW/L12	Bone collagen	Beta – 522264	34.380 ± 250	38.920 - 40.538
H11/SW/L12	Charcoal	COL5451.1.1	42.086 ± 711	44.579 - 46.521

FHLU-03: FHLU-3 is corresponding to archaeological level 2 and forms a relatively thin unit, characterized by laminated clay-sized, dark brown sediment. It is highly compacted with a gradual transition to the upper and lower units. Unlike the upper stratigraphic unit FHLU-02 and the lower FHLU-04, it shows a drastic decline in charcoal concentration with almost no archaeological findings, except for a single piece of obsidian (angular waste) and few pottery shards. The recovered ceramic is highly fragmented due to human or animal trampling.

FHLU-04: The stratigraphic unit of FHLU-4 is formed by a laminated charcoal layer. It is characterized by a dark gray sediment of clay- to silt-size with planar contact to the lower layer. FHLU-04 also yielded no lithic artifacts but limited ceramic fragments and is dated to around 640 years cal. BP (Beta-486376, **Tab. 1**). This unit is represented by archaeological level 3.

FHLU-05: FHLU-05 is the only sediment deposit at the upper part of the stratigraphy with a clear trace of fire use to process bones. This unit yielded a large number of small fragmented bones that were only recovered from sieving of the sedimentological samples with a 2 mm mesh size. The sediment is light brown and not compacted, but the frequent use of fire might have changed the color of the sediments. A single radiocarbon date from charcoal of this layer complies with the age of the sample from the above unit. FHLU-05, corresponding to level 4, was found conformably deposited over the dark brown deposits.

FHLU-06: This unit is unconformably deposited over the lower deposits, with varying thicknesses from 6 to 10 cm. This unit consisted of exceptionally uniform and heavily consolidated charcoal and was excavated as a single layer due to the absence of archaeological findings. Moreover, the moist deposit of the unit is unique in its recognizable dark brown color and interspersed with burned pieces of sediments. FHLU-06 also shows a high concentration of black carbon and nitrogen (**Appendix IV**). Archaeological findings were not recovered from this unit during excavation. Dating black carbon from a mixed sediment sample of the entire unit yielded a similar age as those obtained in the above units (**Table 1**).

FHLU-07: Located stratigraphically just below the wet and dark sediment with fine charcoal, the FHLU-07 stratigraphic unit has a varying thickness between 18 to 24 cm and is characterized by compact, poorly sorted, and partially wet, light brown sediments with a high concentration of gravel. This unit appears to be compacted by an animal or human trampling. Only the upper part of FHLU-07 is composed of channel deposits, in contrast to its lower part. The contact between FHLU-07 and FHLU-06 seems sharp while it was deposited unconformably over the lower FHLU-08 unit. It is the first unit at Fincha Habera rock shelter representing Late Pleistocene human occupations. FHLU-07 yielded a significant number (> 250) of late MSA lithic artifacts, charcoal, coprolites, and animal bones without any lithic artifact technologically or typologically diagnostic for the LSA. The youngest reliable chronometric age for the upper parts of FHLU-07 is ~31 ka cal. BP (Beta-486377, **Table 1**). There are, however, a considerable number of young dates (corresponding to the ages obtained from units FHLU-3 to FHLU-5). Only in square H11 abundant coprolites are associated with late MSA artifacts and faunal remains. Archaeological levels 5–8 are comprised within this lithostratigraphic unit.

FHLU-08: Below FHLU-07 was a distinct stratigraphic unit, unconformably overlying both, parts of the bedrock as well as the bottom-most sediment (FHLU-09). Stratigraphic unit FHLU-08 has a varying thickness with a maximum of 16 cm and is characterized by grayish light brown sand-size sediment with a high concentration of gravel. Like the overlying unit, the bottom of FHLU-08 also contained signs of a channel deposit event with distinct fragments of boulders. Unlike the upper unit, FHLU-08 was not affected by carnivores and contains only few coprolites, indicating that the presence of hyena was not significant at the earliest phase of sediment depositions. The dating results of materials recovered in FHLU-08 range from 31.2 (charcoal) to 38.9 (rodent bone) ka cal. BP; with much younger charcoal still present (**Table 1**). FHLU-08 contained the majority of late MSA lithic artifacts and faunal remains in the shelter. The presence of high quantities of phosphorous and calcium in this unit has been related to the abundance of animal bones (**Appendix IV**). This unit also contains a high ratio of 5ß-stanols indicating the presence of omnivore species – most probably humans – since the unit has abundant lithic artifacts and processed animal bones. FHLU-08 unit is represented by three archaeological levels (levels 9–11).

FHLU-09: Stratigraphic unit FHLU-09 is the lowermost deposit of the shelter and is unconformably overlying the bedrock of the shelter, although unevenly present in all parts of both squares. Unit FHLU-09 unit has a varying thickness of 5 to 8 cm and is characterized by poorly sorted gravely sand-size sediment deposits. At the base of the unit, the presence of a significant proportion of gravel with brownish-yellow sediment represents a single and rapid deposition event that may have inducted sediments to the shelter through thin channel deposits. So far, a single radiocarbon date from charcoal points to an age of 45.6 ka cal. BP. The lowermost unit of the shelter corresponds to archaeological levels 12 and 13 and yielded only few MSA lithic artifacts (< 100) and animal bones.

5.1.4. Stratigraphic summary

The excavated deposits at Fincha Habera rock shelter comprise only 70 cm of depth and clearly show a two-fold division between very recent upper layers (FHLU-1 to FHLU-6) and Late Pleistocene lower deposits (FHLU-7 to FHLU-9). Holocene deposits (beyond the short occupation reflected in the upper layers) could not be identified at Fincha Habera rock shelter. The same holds true for sediments belonging to OIS 2, including the global LGM. Instead, the sequence at the site is characterized by a hiatus comprising more than 30,000 years. Most deposits appeared to be fluvial and were created by overbank deposits from the nearby Wella River. However, the Late Pleistocene deposits also show at least two thin channel deposits. The impacts of erosion in accumulating soils from outside the shelter seem to be minimal.

At first glance, the upper units show the impact of pastoral activities: the use of extensive fire, burnt animal bones, and pottery. There was at least one big fire event that covered the entire excavated area of the shelter with an undecomposed layer of charcoal. The age of the pastoral occupation can be bracketed by dates pointing to the 12th/13th century AD.

The Late Pleistocene deposits were exclusively observed in the stratigraphic units FHLU-07 to FHLU-9. These lower parts of the stratigraphy date between 31.2 and 46.5 ka cal. BP and are characterized by the presence of late MSA lithic artifacts and abundant faunal remains, none of which occur in the upper layers. However, younger charcoal from the upper units has entered the lower deposits. Apart from pits (**Fig. 6**) digged by humans during the occupation of the 12th/13th century AD, hyenas are additional agents who contributed to the mixing of sediments. According to the dating results, this must have happened during the younger phases of the late MSA occupation, or even possibly during OIS 2 (**Table 1**). Mixing of the sediment is also evidenced by the dating results of black carbon, which reveal mixed ages due to the intrusion of younger charcoal into the Late Pleistocene deposits.

5.1.5. Faunal remains

The analysis of the faunal assemblages at Fincha Habera rock shelter was restricted to the archaeological square H11. The faunal remains include a total of 2305 bone remains and were overwhelmingly recovered from the Late Pleistocene phase. Within these, FHLU-08 hosts the majority of the H11 bone assemblage (**Table 2**). The faunal remains are well preserved and not mineralized. Moreover, bone fragmentation occurred mainly due to the fragility of rodent bones and to burning by humans.

The faunal sample is highly dominated by a single rodent species, the endemic giant root-rat (*Tachyoryctes macrocephalus*) (**Fig. 7**), followed by different species of the Bovidae family. Faunal remains of giant root-rats represent between 84 and 99% of the remains, depending on the lithostratigraphic units. Other faunal identifications include the remains of other mammals such as Muridae, fox (*Vulpes sp.*), baboon (*Papio anubis*), and mountain nyala (*Tragelaphus buxtoni*) (**Table 2**). Most of the giant root-rat bones were altered by humans and only minimally by hyenas. Significant numbers of faunal remains have been fire-altered which indicates that hunter-gatherers were processing wild animals' meat by roasting (**Fig. 7A, 7C, 7F**). Moreover, the presence of limb bones of large mammals with signs of lateral percussion as well as splinters that appeared to be broken at a fresh state indicate both human and carnivores might have accumulated the faunal remains at the shelter. Moreover, the surface of a considerable number of bovid bones with digestion and gnawing marks (n=199) show evidence of carnivore consumption. The faunal assemblage of Fincha Habera rock shelter also includes a single fragment of ostrich eggshell (**Fig. 8A**).

Table 2. *Identification of faunal remains from square H11 of Fincha Habera rock shelter (NISP). Data from* O*SSENDORF ET AL. (2019).*

Taxa	**FHLU-07**	**FHLU-08**	**FHLU-09**	**Total**
Baboon (*Papio anubis*)	-	3	-	3
African buffalo (*Syncerus caffer*)	-	-	1	1
Bovidae size 4	15	8	-	23
Mountain nyala (*Tragelaphus buxtoni*)	-	1	1	2
Bovidae size 3	23	22	-	45
Reedbuck (*Redunca* sp.)	1	3	-	4
Bovidae size 2	2	1	-	3
Bovidae	3	-	-	3
Fox (*Vulpes* sp.)	4	6	1	11
Muridae	2	3	-	5
Giant root-rat (*Tachyoryctes* cf. *macrocephalus*)	266	758	418	1442
Ostrich (*Struthio camelus*): eggshell	-	-	1	1
Identified	**316**	**805**	**422**	**1543**
Unidentified	*404*	*335*	*23*	*762*
Total	**720**	**1140**	**445**	**2305**

Fig. 7. *Giant root-rat mandibles from the MSA deposits of Fincha Habera rock shelter showing various degrees and locations of heating and burning.*

Based on the high numbers of identified specimens at the shelter, giant root-rat seems to have been an important contribution to the prehistoric diet. A large number of root-rat bones (more than 500) show burning marks, especially at the extremities, which is indicative of roasting. Hunter-gatherers at Fincha Habera appeared to have been dependent on the all-year available rodent meat as a sustainable source of food, which was probably easy to catch. The interference of the hyenas seems to have been intense but limited to distinct periods during the youngest MSA occupational phase when the shelter was alternately occupied by humans and hyenas, as the vertical distribution of bovid bones with hyena gnawing and mastication marks suggests.

5.1.6. Coprolites

The excavated MSA deposits from Fincha Habera also include a well-preserved sample of 86 coprolites, probably belonging to spotted hyenas (*Crocuta crocuta*) based on their size and morphology (**Fig. 8B**). Whereas the Late Pleistocene omnivorous fecal deposits at the site only occurred in a decomposed state, hyena coprolites are better preserved and usually contain much higher numbers of bones. Of these, 64 specimens are complete. Almost all of them were exclusively recovered from archaeological square H11. The spatial distribution of coprolites appeared to be concentrated in the rear areas of the shelter. The vertical distribution of the coprolites sample is highly clustered at the upper parts of the Late Pleistocene deposits (lower half of FHLU-7).

Several coprolites indicate that giant root-rats were not only consumed by humans but also by hyenas, as they include giant root-rat incisors (**Fig. 8C**). A significant number of broken coprolites show that hyenas also consumed other mammals (**Fig. 8B**).

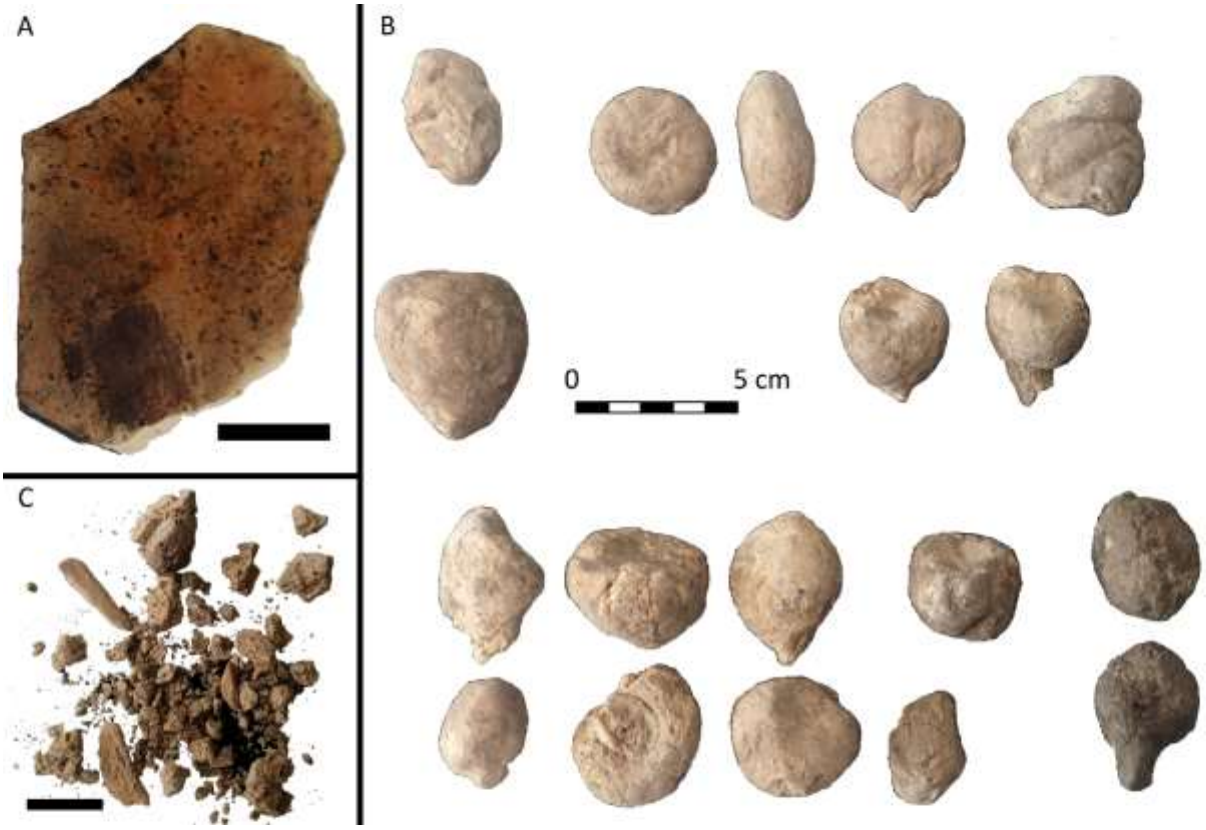

Fig. 8. *Ostrich eggshell (A) and hyena coprolites (B, C) from the MSA deposits of Fincha Habera rock shelter. The inclusion of faunal remains within coprolites is clearly visible in degraded (C) and complete specimens (B: bottom row, second from left). The scale bar (A, C) is 1 centimeter.*

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5.1.7. Lithic assemblage

5.1.7.1. Introduction

All the lithic materials attributed to the late Middle Stone Age were recovered from the Late Pleistocene deposits of excavation squares E8 and H11 (**Fig. 5**) (see **Appendix I**). The lithic assemblage may have been influenced by post-depositional processes, as indicated by the inconsistency of dating results. In particular, the Late Pleistocene occupational layers were exposed to both human and animal trampling, disturbances caused by hyenas, and re-deposition by fluvial processes. However, the degree of lithic fragmentation and the composition of the lithic assemblage indicate intensive knapping activities on-site and only minor post-depositional disturbances. The total number of lithics (n= 1,026) includes a hammerstone, retouched and utilized tools, debitage elements such as flakes, blades, fragments, as well as angular waste and chips, and finally cores, core fragments as well as tested pieces (**Table 3**).

Table 3. *Frequency and percentage of lithic artifacts according to lithostratigraphic units at Fincha Habera rock shelter.*

Flaked Stone	**FHLU-07**		**FHLU-08/09**		**Total**	
	N	%	N	%	N	%
Cores						
Single platform	1	33,3	5	55,6	6	0,6
Double platform	1	33,3	1	11,1	2	0,2
Multi-platform	-	-	2	22,2	2	0,2
Fragment	1	33,3	1	11,1	2	0,2
Total	**3**	**100,0**	**9**	**100,0**	**12**	**1.2**
Debitage						
Angular waste	94	22,0	136	26,8	230	22,4
Flakes/blades	236	55,3	275	54,2	511	49,8
Chips	83	19,4	57	11,2	140	13,6
Core trimming flakes	4	0,9	17	3,4	21	2,0
Tested nodules	10	2,3	22	4,3	32	3,1
Total	**427**	**100,0**	**507**	**100,0**	**934**	**91,0**
Utilized Tools						
Utilized	10	100,0	16	100,0	26	2,5
Total	**10**	**2,2**	**16**	**100,0**	**26**	**2,5**
Formal Tools						
Points	10	47,6	16	55,2	26	2,5
Blades	8	38,1	7	24,1	15	2,5
Scrapers	3	14,3	6	20,7	9	2,5
Total	**21**	**100,0**	**29**	**100,0**	**50**	**4.9**
Miscellaneous						
Drill	-	-	2	66,7	2	0,2
Nubian point?	-	-	1	33,3	1	0,2
Total	**-**	**-**	**3**	**100,0**	**3**	**0,3**
Hammerstone	1	100,0	-	-	1	0,1
Total	**1**	**100,0**	**-**	**-**	**1**	**0.1**
Total Lithics	**462**	**45,0**	**564**	**55,0**	**1026**	**100.0**

Table 4. *Frequency and percentage of lithic artifacts according to excavation squares at Fincha Habera rock shelter.*

Flaked Stone	**E8**		**H11**		**Total**	
	N	%	N	%	N	%
Cores						
Single platform	2	40,0	4	57,1	6	0,6
Double platform	1	20,0	1	14,3	2	0,2
Multi-platform	1	20,0	1	14,3	2	0,2
Fragment	1	20,0	1	14,3	2	0,2
Total	**5**	**100,0**	**7**	**100,0**	**12**	**1,2**
Debitage						
Angular waste	112	21,5	118	28,6	230	22,4
Flakes/blades	280	53,7	231	55,9	498	48,5
Chips	102	19,6	38	9,2	140	13,6
Core trimming flakes	7	1,3	14	3,4	12	1,2
Tested nodules	20	3,8	12	2,9	32	3,1
Total	**521**	**100,0**	**413**	**100,0**	**934**	**91,0**
Utilized Tools						
Utilized	19	100,0	7	100,0	26	2,5
Total	**19**	**3,2**	**7**	**1.5**	**26**	**2,5**
Formal Tools						
Points	17	58,6	9	42,9	26	2,5
Blades	6	20,7	9	42,9	15	1,5
Scrapers	6	20,7	3	14,3	9	0,9
Total	**29**	**100,0**	**21**	**100,0**	**50**	**4,9**
Miscellaneous						
Drills	1	50,0	1	100,0	2	0,2
Nubian point?	1	50,0	-	-	1	0,1
Total	**2**	**100,0**	**1**	**100,0**	**3**	**0,3**
Hammerstone	-	-	1	100,0	1	0,1
Total	**-**	**-**	**1**	**100,0**	**1**	**0.1**
Total Lithics	**576**	**56.1**	**450**	**43.9**	**1026**	**100.0**

5.1.7.2. Hammerstone

Hammerstones are rare at the shelter. Only one complete specimen was recovered from archaeological square H11 (**Fig. 9; Table 4**). It is made of local basalt (**Table 5**). This artifact was recovered in the upper parts of stratigraphic unit FHLU-07 (Level 7). The hammerstone shows pitted and pounded surfaces, indicating the intentional use as a hammering object, probably on hard material like stone.

Fig. 9. *Basalt hammerstone from Fincha Habera rock shelter. The scale bar is 1 centimeter.*

5.1.7.3. Raw materials

Four major raw materials were identified from the lithic assemblages (**Table 5; Fig. 10**). Obsidian is the dominant raw material accounting for 93.1% (n=956) of the total assemblage, while basalt with 2.9% (n=30), chert with 0.7% (n=7), quartz with 0.1% (n=1) and indeterminate materials with 3.1% (n=32) form only minor components of the assemblage. **Table 5** summarizes the types of raw material used according to the stone artifact categories.

Most of the raw materials were transported from locally available source areas. The source of obsidian closest to Fincha Habera is Wasama Ridge, 10 km further southeast to the center of the Bale Mountains. The chert outcrops appeared to be limited to the Genale Plain, in the southwest of the Bale Mountains (**Fig. 2**). Moreover, hunter-gatherers at Fincha Habera also used ubiquitously available basalt as a raw material to produce tools. The indeterminate materials are highly weathered local volcanic rocks, probably basalts or rhyolites. Among the non-obsidian material, only a single quartz flake (H11, Level 5), could be identified as a non-local material. The obsidian raw material exploited at Fincha Habera is largely characterized by a fine and homogeneous black variety. Electron microprobe analysis verified that this homogeneous black obsidian is identical in geochemical composition with those samples analyzed from Wasama Ridge (OSSENDORF ET AL. 2019). However, two samples (ID64 and ID85) were internally homogeneous, but significantly different in their composition compared to the Wasama obsidian (**Appendix V**). The closest match of their compositional values is Dalecchia (NEGASH ET AL. 2020), an obsidian source in the northern Rift Valley, at ~250 km direct distance to Fincha Habera. However, the obsidian outcrops of Kersa and Welela (both in the central Rift Valley at 140/160 km direct distance) also show similar values (NEGASH ET AL. 2020). Few rolled and patinated obsidian are present, recovered from throughout the entire Late Pleistocene deposits of Fincha Habera rock shelter. These pieces are comparable to obsidian artifacts collected from the surface of Wasama Ridge and especially on its southern slopes. The majority of these were only tested by hunter-gatherers at the site and in most instances discarded (**Fig. 11**).

Table 5. *Frequency and percentage of raw material types according to artifact category at Fincha Habera rock shelter (combined data of squares E8 and H11).*

Raw material	Chips	Flakes & blades	Angular waste	Tested nodules	Core trimming flakes	Cores	Retouched & utilized tools	Hammerstones	Total	
									N	%
Obsidian	139	474	210	22	21	12	78	-	956	93.3
Basalt	-	17	4	7	-	-	1	1	30	2.8
Chert	1	2	4	-	-	-	-	-	7	0.7
Quartz	-	1	-	-	-	-	-	-	1	0.1
Indet.	-	17	12	3	-	-	-	-	32	3.1
Total	**140**	**511**	**230**	**32**	**21**	**12**	**79**	**1**	**1026**	**100.0**

The late MSA lithic tools were made from obsidian (n=90) and basalt (n=2). The cores (n=12) are exclusively made from obsidian. The debitage (n=934) also includes the other types of raw materials. The high-quality obsidian of Wasama was highly suitable for the production of retouched tools and the use of other high-quality materials such as chert therefore was unnecessary (**Fig. 10**).

Table 3 shows the entire lithic assemblage composition according to lithostratigraphic units. The upper unit, FHLU-07 yielded a relatively low number of artifacts compared to the lower units (FHLU-08 and 09), which reflects the main occupational events of the shelter. There are parallel raw material exploitation patterns in archaeological squares E8 and H11, as shown in **Table 5** and **Fig. 10**.

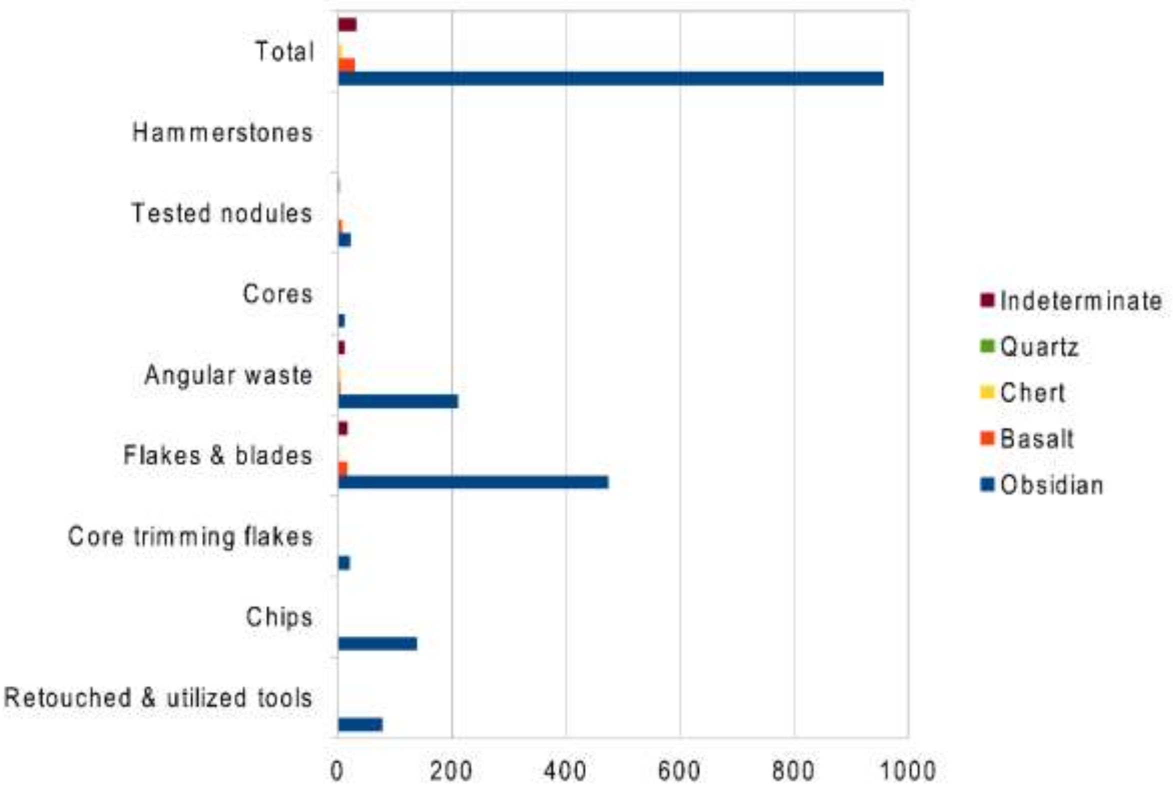

Fig. 10. *Chart of the frequency of raw material types according to artifact category at Fincha Habera rock shelter (combined data of squares E8 and H11).*

In summary, the raw material procurement at Fincha Habera was highly dependent on the locally available sources; Wasama Ridge for obsidian and the Genale plain for chert (**Fig. 2**). Obsidian was the main source for tool production (**Fig. 10**); only a single convergent point is from basalt. The quality of the chert appears to be rather poor and this might explain that it is not represented in the tool category. It is evident that obsidian was also preferentially used to produce cores and blanks in the Fincha Habera MSA assemblage.

5.1.7.4. Cores

The sample of cores is limited to twelve pieces. Single-platform cores account for six pieces and are followed by two double-platform cores and two cores with multiple platforms (**Table 3**). Two core fragments reveal only little information about the reduction methods. Most of the cores show a plain platform (n=6), produced by a single knapped flake from either side, the negative was then used as a platform. Facetted platforms (n=4) occur regularly, while a cortical platform was identified only on a single core. Nevertheless, all cores retained cortex which still covered up to 50% of the surface, indicating rather short lithic reduction sequences. Only initial exploitation of the cores on-site but also the relatively small size of the collected raw material nodules.

The core sample at Fincha Habera shows that the blanks were prepared from a prismatic and tabular-like core with single, double, and multiple platforms (SDM), and probably through hard hammer percussion. The latter is indicated by pronounced flake bulbs and lips. The cores at Fincha Habera have been used in order to produce both elongated end-struck flakes (**Fig. 12**) as well as laminar blades (**Fig. 13**). The largest core at Fincha Habera rock shelter is a complete single-platform core with a maximum height of 36 mm. The low number and high degree of fragmentation of the cores can be associated with the intense use of raw material.

Since Fincha Habera rock shelter is not far from the Wasama Ridge obsidian outcrops (~10 km), large cores can well be expected to be present in the deposits of the shelter. The intense working of the raw material could be inferred from the high numbers of debitage elements, which account for more than 950 pieces. The possible reason why cores were not abundant at the shelter might be associated with the off-site intentional reduction of cores, before they were transported to the shelter. Large nodules were effectively reduced into smaller ones at the quarry and then transported to the site, where they were further processed to manufacture the intended tools (**Table 3**). A significant number of highly rolled and poor-quality obsidians were transported as a core and seem to be discarded at the shelter after being tested (**Fig. 11**).

Fig. 11. *Poor-quality obsidian with patina from Fincha Habera rock shelter. The scale bar is 1 centimeter.*

In summary, the available core sample of the Late Pleistocene deposits of Fincha Habera represents flake production from SDM-cores without the use of Levallois and discoidal concepts. The platforms of these cores also clearly display preparation such as lateral flaking, the establishment of (mostly single-) platforms, and facetting of the platforms as the most dominant techniques for core preparation at the site. The range of the analyzed cores varies from 30-36 mm (complete cores) in length. The presence of cortex up to 50% on the surface of the cores suggests that cores were not intensively reduced after being transported to the site. The cores were used to produce blanks with shapes such as elongated flakes as well as blades.

Fig. 12. *End-struck flakes from Fincha Habera rock shelter. The scale bar is 1 centimeter.*

5.1.7.5. Debitage

The debitage at Fincha Habera shelter is represented by functional and non-functional elements. The functional debitage in the assemblage is composed of core trimming flakes (CTF), while the non-functional debitage is composed of unmodified flakes, blades, flake & blade fragments (proximal, medial, distal), angular waste, and chips. The debitage of squares E8 and H11 represents 90.9% (n=934) of the total lithic category. E8 had a higher total count of debitage than H11 (**Table 4**). The lower units, FHLU-08 and FHLU-09 yielded the highest concentration of debitage compared to the upper units of the shelter (**Table 3**).

The debitage of the shelter is dominated by flakes and blades, accounting for 49.8% (n=551) of the total lithic artifacts. Flakes and blades are followed by angular waste with 22.4% (n=230), chips with 13.6% (n=140), and core trimming flakes with 2% (n=21). The debitage category also includes a considerable number of highly rolled, tested obsidian artifacts (n=32) with only few artificial negatives (**Fig. 10**). Some of these tested obsidians show poor quality for lithic production. For the debitage category, obsidian is also the most dominant raw material (**Table 5; Fig. 10**).

The production of elongated flakes and blades dominates the count of the debitage (**Fig. 12; Fig. 13**). The general pattern of lithic reduction at the shelter appears to emphasize elongated blanks from prepared cores. The high number of elongated flakes indicates that lithic reduction may have started off-site, probably at the obsidian source. The presence of unused, but tested rolled obsidian indicates the behavior of the hunter-gatherers in exploiting different qualities of obsidian at the shelter. Moreover, the presence of CTFs, which mainly consist of crested blades – apart from elongated cortical flakes – also shows that the production techniques were predetermined to produce both flakes and blades from prepared cores.

Most of the debitage elements recovered from the Late Pleistocene deposits consist of broken pieces, amounting up to 60.5% (n=621), and include mostly angular waste. In contrast, complete flakes are only represented by 19.7% (n=203). A total of 218 lithics (23.6%) of the debitage category exhibits a variable range of cortex, covering up to 75% of the surface of the respective pieces. Although the presence of cortical flakes signifies a high degree of primary lithic reduction at the site, a modest quantity of non-cortical flakes also shows that cores were transported partly decortified to the site. Furthermore, only few lithic artifacts show minimal traces of abrasion, indicating that the assemblage contains a high proportion of fresh flakes.

Fig. 13. *Utilized blade from Fincha Habera rock shelter. The scale bar is 1 centimeter.*

In summary, the number of debitage and the core samples at Fincha Habera is not proportional. The dominant production technique at the shelter corresponds to the manufacture of elongated flakes from prepared cores. Local high-quality obsidian was highly preferred, dominating the lithic assemblage at Fincha Habera. The middle and lower part of the Late Pleistocene deposits show a much higher frequency of debitage than other units. The presence of a high proportion of cortical flakes coupled with core trimming flakes and tested obsidian suggests that the production of elongated blanks was conducted at the shelter after larger nodules were reduced to preferred cores mostly outside of the shelter.

5.1.7.6. Tools

5.1.7.6.1. Utilized tools

The considerable presence of a variety of modifications of the original shape of the edge(s) shows that unretouched tools also characterize the late MSA lithic assemblage at Fincha Habera. In contrast to the retouched tools, unretouched tools are represented mainly by utilized and basally modified tools in the assemblage.

A total of 26 utilized tools were identified from the Late Pleistocene deposits of squares E8 and H11 (**Table 3**). Most of the utilized tools can be classified as convergent flakes (n=19), while blades were represented by seven pieces. These unretouched tools were mainly recovered from the lower units, FHLU-08, and FHLU-09 (**Table 6**). The concentration of utilized tools also parallels the percentage of debitage at these occupational units as well as their distribution according to archaeological squares: E8 yielded the majority of unretouched tools (n=19) (**Table 4**).

The utilized tools represent only 32.9% of all the tool classes in the assemblage (**Table 6**). All recovered utilized tools exhibited utilization by edge damage, from marginal up to < 3 mm edge alterations, probably caused by use at the shelter (**Fig. 13**). Additionally, most of the utilized tools display some form of modification at the proximal end. Basal thinning on flakes and blades appears to be common. The intentional, repeated narrowing of the base is probably associated with hafting purposes. The proximal modification also reaches the dorsal end, probably to reduce the entire thickness of the base. Moreover, this type of modification is also observed on non-utilized blanks (**Fig. 12**) and retouched tools (**Fig. 18H**).

The utilized tools, represented by elongated flakes and blades, were made from prismatic and tabular-like cores with prepared platforms. The flakes appeared to be removed as end-struck whole flakes from the prepared platform (**Fig. 12**). Like the analyzed cores, the flakes of utilized tools show no signs of Levallois or discoidal production techniques. It is not yet clear why the hunter-gatherers at Fincha Habera used utilized tools besides retouched tools, but their presence in the assemblage might be associated with their general function. The tasks for which hunter-gatherers deployed these probably required the production of informal tools.

5.1.7.6.2. Miscellaneous tools

There are three miscellaneously retouched tools present in the lithic assemblage. Two drills made from obsidian and a single point similar to a Nubian Type I-point (VAN PEER 1988) made from basalt (**Fig. 14; Table 3**), represent only 3.8% of all tools. One drill (ID 387, H11, Level 6) was produced from an elongated flake, was then shouldered at the midsection, and exhibits a pointed tip at the distal end. This drill (**Fig. 18H**) has a length of 44.4 mm and possesses distinct typo-technological features: The proximal end was exceptionally thinned on its dorsal and ventral faces to form a triangular base. The entire dorsal part is also facially and invasively retouched. Edge damage occurs on both lateral edges and at the tip as well. In contrast, the second drill is the smallest tool (length of 21.5 mm) in the present assemblage. This piece was alternatingly retouched on the transverse distal end to form the tip. Additional fine retouch appears on one lateral edge. Finally, a convergent point (ID894, E8, Level 9) (**Fig. 14**) was made on basalt and has three small convergent negatives on the dorsal face. Only the middle negative shows the knapping direction to the distal end. The remaining two negatives are highly weathered which makes it impossible to assess whether the knapping occurred in the opposite direction compared to the middle negative. The base of this Nubian-like point shows basal thinning for possible hafting. Both lateral edges and the tip displayed intensive edge damage indicating that this tool was actually used by the Fincha Habera hunter-gatherers.

Fig. 14. *"Nubian Type I"-like point from Fincha Habera rock shelter. The scale bar is 1 centimeter.*

5.1.7.6.3. Scrapers

Scrapers are represented by nine pieces, accounting for 11.4 % of all tools (**Table 3**) and were exclusively manufactured from obsidian raw material. Both flake and blade blanks were used to produce these scrapers. Some of the scrapers are triangular and tabular in shape (**Fig. 15**). Unlike other retouched tools, the scrapers were shaped with elaborated techniques such as invasive retouch and proximal thinning. A significant number of scrapers are fairly elongated regarding their height. Several scrapers were facially retouched on the dorsal, and ventral edge(s) and at the tip of end-struck flakes. The edge and dorsal face of the scrapers was thoroughly altered by invasive and semi-invasive retouch. Both soft hammer and pressure retouch appeared to be used for the shaping of the scrapers. Most of the scrapers possess cortical surfaces up to 25%.

Most of the scrapers were recovered from the middle and lower occupational phases (**Table 6**). The concentration of scrapers also parallels the general distribution of debitage elements at the shelter. Side scrapers (**Fig. 15A, 15C**), represented by six pieces, are the most dominant tool type, followed by double-side scrapers (n=2) (**Fig. 15B**) and a single end scraper (**Fig. 15D**).

Table 6. *Frequency and percentage of retouched and utilized tools according to lithostratigraphic units at Fincha Habera rock shelter (combined data of excavation squares E8 and H11).*

Retouched & utilized tools	**Points**		**Retouched blades**		**Scrapers**		**Miscellaneous**		**Utilized**		**Total**	
	N	%	N	%	N	%	N	%	N	%	N	%
FHLU-07	10	38.5	7	46.7	2	22.2	-	0.0	10	40	29	36.7
FHLU-08/09	16	61.5	8	53.3	7	77.8	4	100.0	15	60	50	63.3
Total	**26**	**32.5**	**15**	**18.7**	**9**	**11.3**	**4**	**3.8**	**25**	**32.9**	**79**	**100.0**

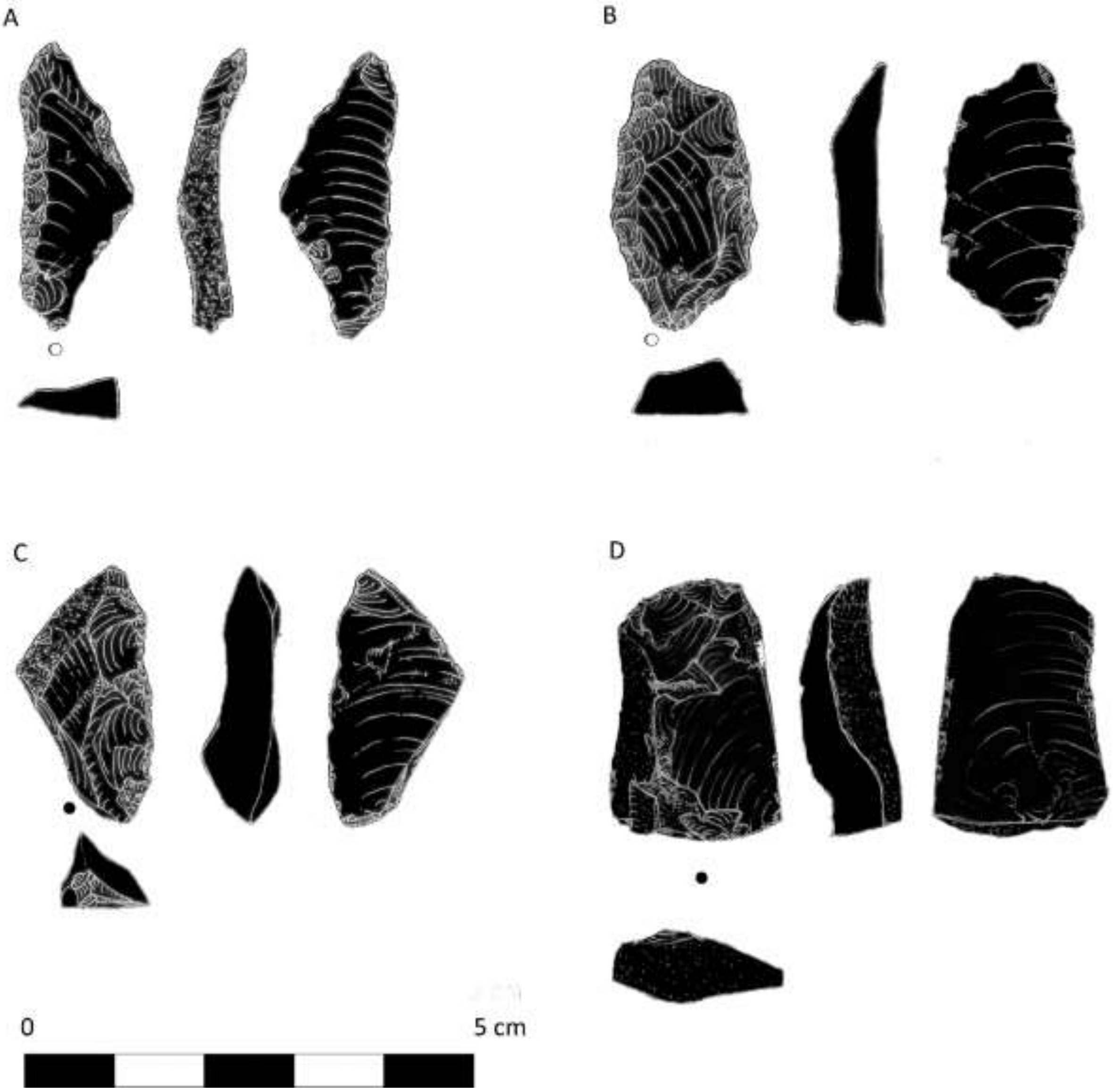

Fig. 15. *Drawings of scrapers from Fincha Habera rock shelter.*

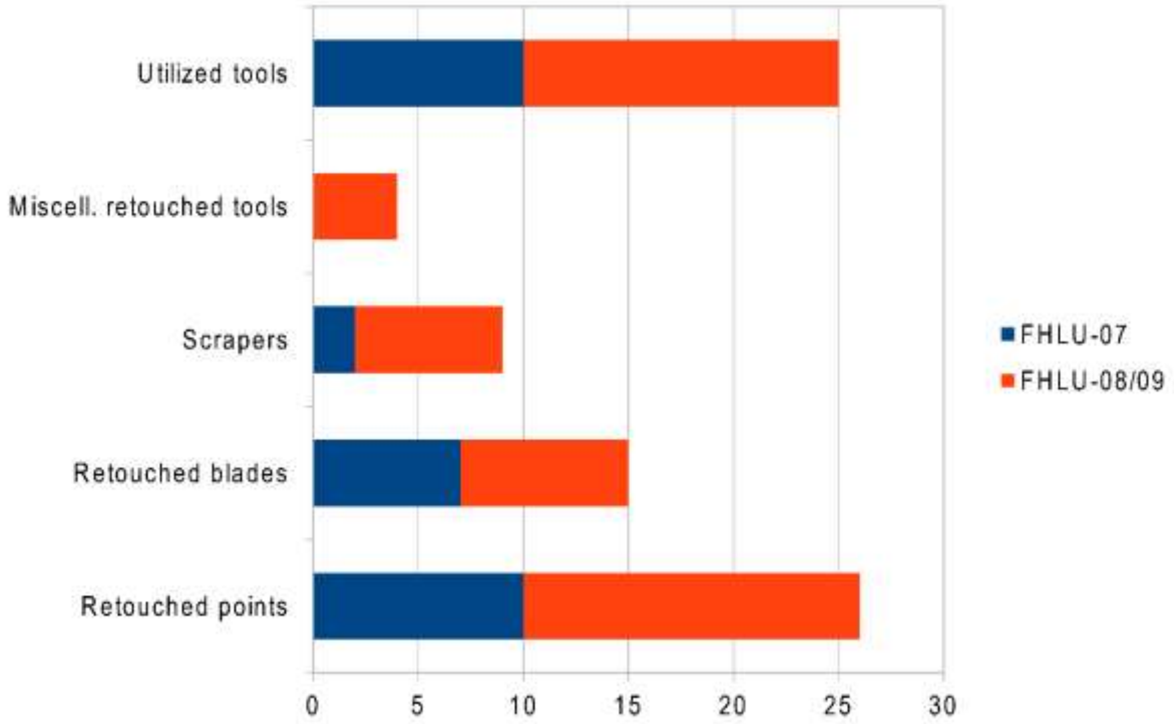

Fig. 16. *Chart of the frequency of utilized and retouched artifacts according to lithostratigraphic unit at Fincha Habera rock shelter (combined data of excavation squares E8 and H11).*

5.1.7.6.4. Points

Points are the predominant tool class and represent 32.9 % (n=26) of the total tools (**Table 3**). Most of the points were recovered from archaeological square E8 (**Table 4**). Unlike the scrapers, the distribution of points is relatively even in the upper, middle, and lower Late Pleistocene units. The lower stratigraphic unit has more counts of points compared to other retouched tools (**Table 6; Fig. 16**). Stratigraphically, these points were closely associated with a high concentration of bones. Almost all points share the common obsidian raw material; only one point was made of basalt. The preferred blank form was elongated end-struck flakes. Morphologically, points possess convergent or semi-convergent lateral edges from their proximal end up to the distal tip. Almost all points were created from a prepared core with a distinct platform. However, the points of Fincha Habera shelter were produced from non-Levallois and discoidal cores.

At least two dominant point types can be identified in the tool assemblages. The first consists of laterally retouched points (n=14), two of which only exhibit partial retouch of the lateral edges. The second type is represented by facially retouched points (n=12), which can be further subdivided into unifacial (n=9) and partifacial (n=3) specimens (**Table 7**). Most laterally retouched points show dorsal (obverse) fine retouch on the edge (n=12), whereas two points show alternate retouch on both edges (**Fig. 18C**). The facially retouched points exhibit an exclusively invasive retouch on the dorsal face (**Fig. 17; Fig. 18A–B, 18D, 18G)**.

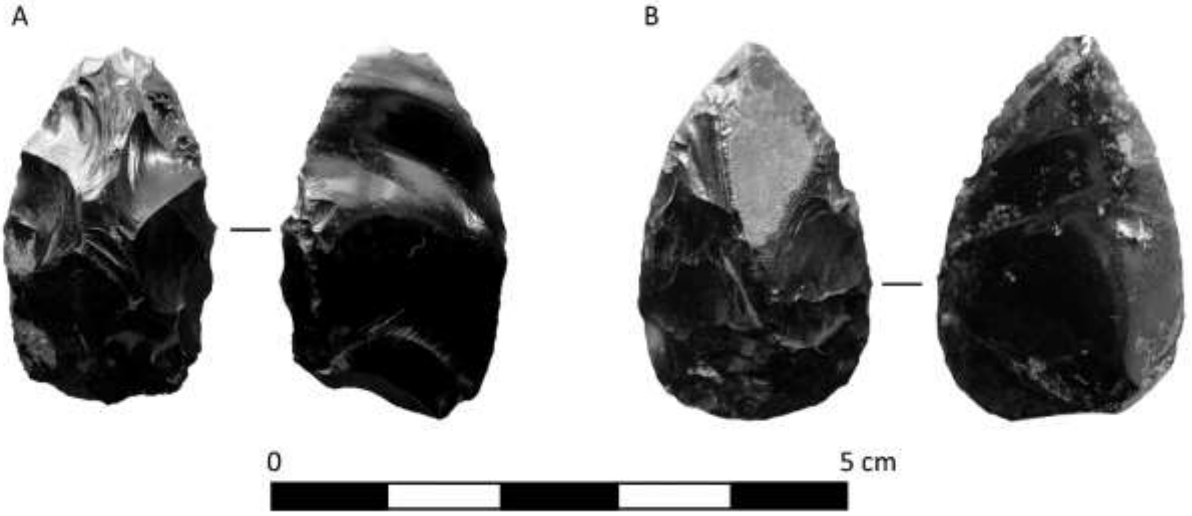

Fig. 17. *Unifacial points from Fincha Habera rock shelter.*

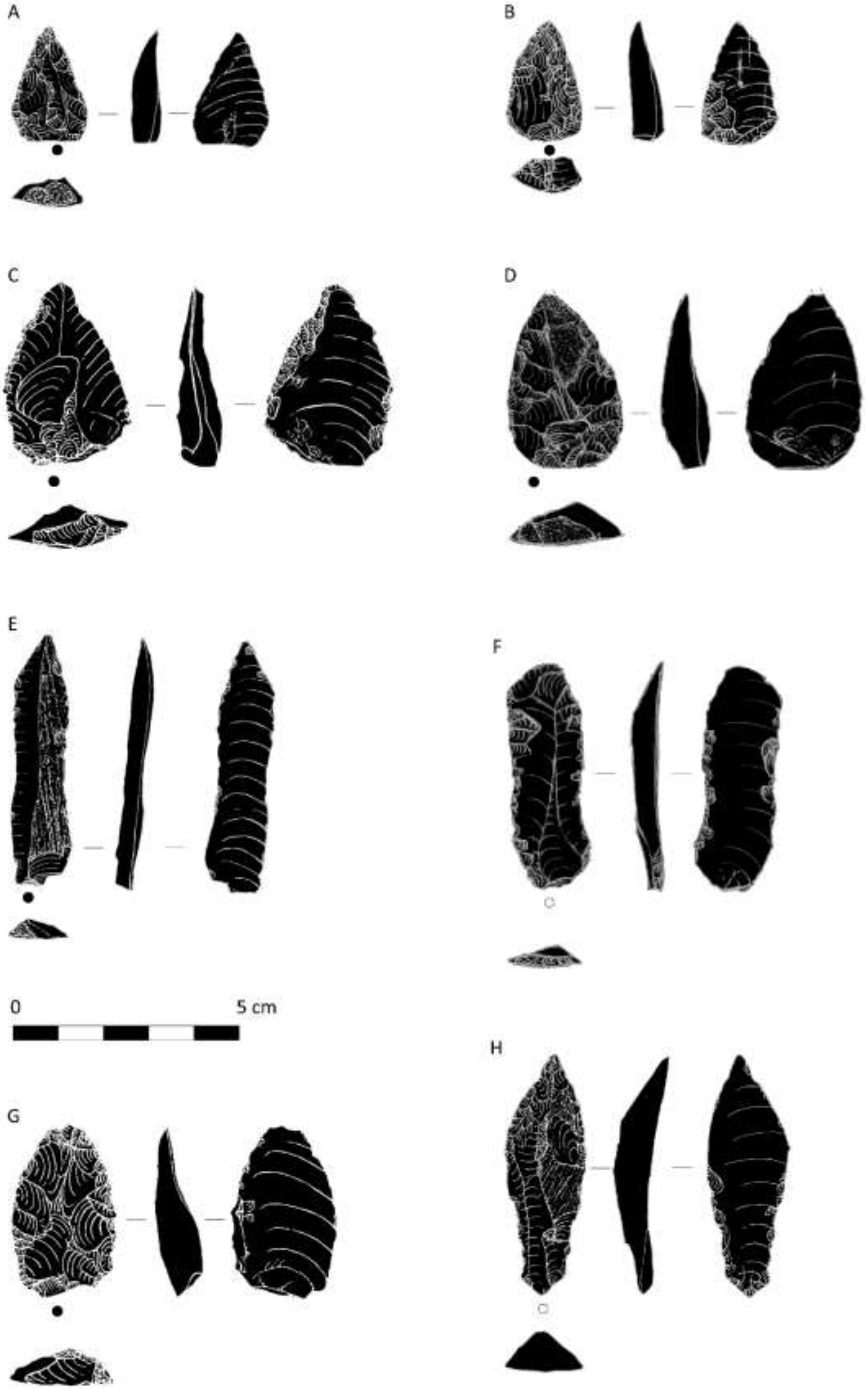

Fig. 18. *Drawings of retouched lithic tools from Fincha Habera rock shelter.*

Most of the points are complete (n=19). The longest complete point measures 33.1 mm in length compared to only 18.9 mm measured at the shortest point. The platforms of the points vary from facetted (n=8), dihedral (n=5) to plain (n=4), and show the use of a hard hammer in detaching the elongated flakes. Given the small size of shaping and edge modifications, these were probably implemented through soft hammer and by pressure flaking. The distribution of points also mirrors the distribution of other tools and debitage elements, however, with a higher concentration on stratigraphic unit FHLU-08 (**Table 3**).

Table 7. *Frequency and percentage of retouched tools according to archaeological layers at Fincha Habera rock shelter (combined data from excavation squares E8 and H11).*

Retouched tools	**Unifacial**		**Partifacial**		**Laterally retouched**		**Partially retouched**		**Total**	
	N	%	N	%	N	%	N	%	N	%
FHLU-07	3	37.5	3	50.0	4	33.3	-	0.0	10	38.5
FHLU-08/09	5	62.5	3	50.0	8	66.7	4	100.0	20	61.5
Total	**8**	**34.6**	**6**	**11.5**	**12**	**46.2**	**4**	**7.7**	**30**	**100.0**

Like other tools, the points regularly feature the modification of their proximal ends by thinning, possibly for hafting purposes. The thinning still preserved the proximal ends and the original morphology of the pieces. Some of these points exhibit an intact butt, showing that the proximal thinning mainly targeted the dorsal faces. However, few points at Fincha Habera also have retouch on the ventral proximal end (**Fig. 18B**). Currently, use-wear analyses are still in progress and the functions of the points are not known.

In summary, the recovered point samples of Fincha Habera show considerable technological and typological similarities, irrespective of their respective stratigraphic position in the Late Pleistocene sequence. All of them were made on elongated end-struck flakes which were detached from prepared cores. There are no points present in the assemblage with the characteristics of either Levallois or discoidal flake reduction techniques. At least two distinct types of late Middle Stone Age points can be identified at Fincha Habera. Both laterally retouched and facially retouched points appear to be the most dominant target of the tools production techniques. The laterally retouched points also show different retouch techniques such as alternate, alternating, inverse, obverse, and semi-invasive retouch on the edge(s) (**Table 7; Fig. 17; Fig. 18A–D, 18G**). Most of these tools had preserved modified proximal ends with clear convergent dorsal scars and platforms – mainly facetted and dihedral – which indicate that the points were removed from prepared cores. Hunter-gatherers at Fincha Habera appeared to be rather dependent on end-struck flake tools (retouched and unretouched). The proximal thinning pattern can be identified along both, the dorsal and the ventral proximal ends and is observed as the most common tradition for potential hafting of the point. The edge damage on the lateral edges of the points indicates the intense use of retouched points.

5.1.7.6.5. Blade tools

Blade tools are characterized by laterally retouched tools on preferentially produced blades from prismatic cores. All blades were made from obsidian. Like unretouched blade tools, retouched blades had dorsal negatives with parallel to semi-parallel lateral edges running along the technological axis to the distal end. Blade tools contribute 18.9% (n=15) to all lithic tools (**Table 3**). The majority of the blades are over 30 mm in length, with the longest blade tool measuring 47.6 mm (**Fig. 18E–F**).

The blade tools are often broken, mainly at the distal end. There are eight complete blade tools and the remaining pieces are only proximally preserved pieces. This pattern is comparable to tools made on elongated flakes. Almost all preserved proximal ends show a variety of platforms, but a clear representation of facetted (n=8) and dihedral (n=3) ones. On the other hand, the proximal ends of the blade tools show only minimal modifications. The absence of intensive proximal modification may be related to the function of the tools. Like other retouched and utilized tools, the blade tools were evenly distributed across all stratigraphic units of the shelter (**Table 6; Fig. 16**). The archaeological square H11 contained more blade tools (n=9) than E8 (**Table 4**). Blade tools at Fincha Habera are characterized by different lateral retouch: semi-invasive, dorsal (obverse), and ventral (inverse) retouch was identified on ten pieces, while alternate retouch (n=3), and alternating retouch (n=2) occur as well (**Table 8; Fig. 18E–F**). The lateral edges of these blade tools show considerable edge damage indicating that blade tools (besides points) were also intensively used at the shelter.

Table 8. *Frequency and percentage of laterally retouched blade tools at Fincha Habera rock shelter (combined data from excavation squares E8 and H11).*

Laterally retouched blades	**Semi-invasive, fine obverse and inverse**		**Alternate**		**Alternating**		**Total**	
	N	%	N	%	N	%	N	%
FHLU-07	4	40.0	1	33.3	2	100.0	7	46.7
FHLU-08/09	6	60.0	2	66.7	-	0.0	8	53.3
Total	**10**	**66.7**	**3**	**20**	**2**	**13.3**	**15**	**100.0**

In summary, the late MSA lithic assemblage of Fincha Habera contains blade tools made on specialized prismatic cores. These blade tools are characterized by the presence of lateral retouch and minimal basal thinning of their proximal ends. The platforms of these tools also show similar lithic reduction patterns to other retouched and utilized tools. In general, the blade tools are the second most preferred tools at the Fincha Habera rock shelter.

5.1.8. Summary

The hunter-gatherers of Fincha Habera were effective in exploiting high-altitude environments at the Bale Mountains, including the sourcing of high-quality obsidian raw material for lithic production. Most of the recovered tools came from nearby Wasama Ridge at above 4200 m asl, which at the time of human occupation during late OIS 3 was entirely surrounded by two valley glaciers, corresponding to the local LGM at the Bale Mountains. Based on the radiocarbon dating results, prehistoric hunter-gatherers repeatedly visited Wasama during the maximum extent of glaciation. Locally available basalt was additionally used to produce percussion implements and flaked tools. The presence of non-local obsidian and quartz in the lithic assemblage, the Nubian-like point, and especially the ostrich eggshell fragment indicate that the hunter-gatherers of Fincha Habera were in contact with lowland areas. Therefore, despite harsh and unique environments, the settlement and subsistence pattern visible at the Bale Mountains indicates wider regional contact and networks as well as the absence of an independently developed cultural tradition.

The Late Pleistocene archaeological record covers several millennia of repeated human use of the shelter, and the shallow deposits shed additional light on the kind of subsistence strategies that were applied at these unique high-altitude environments. The specialized lithic tools are associated with abundant faunal material, particularly remains of the endemic giant root-rat, and – to a lesser degree – remains of a variety of bovids. Whether a direct relationship exists between the production of unretouched and retouched tools with the processing of wild animals outside and inside the shelter at Fincha Habera is still to be addressed by future studies. However, probably the catching and definitely the processing of the abundant root-rats occurred without the implementation of lithic artifacts, as they were roasted on the open fire. The tools categories of Fincha Habera also document a significant number of unretouched tools from both elongated convergent flakes and prismatic blades. There is no clear explanation of why the hunter-gatherers at Fincha Habera used both unretouched and retouched tools in comparable frequencies. Both unretouched and utilized tools show a few signs of proximal modifications, hinting at potentially hafted tools among the identified tool groups. Most retouched tools at the site preserved modified proximal parts while the lateral edges show either extensive use or modification through repeated retouch. Based on the quantitative analysis, the lithic reduction at the site was geared towards the production of convergent points from end-struck flakes, followed by blades from prismatic cores.

In contrast, facial points – mainly unifacial and partifacial – were specialized tools most probably for hunting. On the other hand, the specialized blade tools characterized by lateral retouch with semi-invasive and fine retouch also indicate that hunter-gatherers had a certain degree of technological/cultural flexibility not only in the production of lithic artifacts but potentially also in using them to process different food sources, in particular Afroalpine giant root-rats, but also Afromontane bovid species.

Technologically, the retouched tools of Fincha Habera do not show any sign of a distinct regional identity. Moreover, only subtle changes from the bottom to the upper Late Pleistocene deposits can be identified with regard to the manifestation of the retouched tools, unifacial points, laterally retouched convergent points, and laterally retouched blades at the site. The only exception is the rather sudden decrease of tools at the uppermost part of the Late Pleistocene deposits. This change may be associated with the impact of hyenas or environmental changes at the upper Web Valley.

If the single piece of the Nubian Type I-point is confirmed, the hunter-gatherers at Fincha Habera may have had prior knowledge of other lithic reduction technologies. At the same time, the presence of this tool also suggests possible cultural connections to lowland dwellers particularly north of the Rift Valley where the Nubian Points were significantly documented.

Many of the late MSA lithic assemblages in the Horn of Africa, particularly from Ethiopia, show a high percentage of flaked tools such as points and blades made of elongated blanks. The predominance of elongated blank production with different lithic reduction techniques suggests that hunter-gatherers were flexible in producing and using different types of tools in different contexts. Fincha Habera's elongated points, facially and laterally retouched, as well as specialized blade tools fit well into the known regional technological traditions evident from sites as Goda Buticha (PLEURDEAU ET AL. 2014; LEPLONGEON ET AL. 2017; TRIBOLO ET AL. 2017) and Porc-Épic (PLEURDEAU 2006) in the Southeastern Ethiopian Highlands and K'one (KURASHINA 1978), Aladi Springs (GOSSA ET AL. 2012) and Deka Wede (BON ET AL. 2012; MÉNARD ET AL. 2014) in the Rift Valley (**Fig. 1**). However, these elongated flaked tools of these regional sites were separately treated as a marker tool for the MSA/LSA transition, a period which is still not very well understood due to the lack of reliable dating results, dependable stratigraphic sequences and published archaeological assemblages.

The retouched and unretouched tools at Fincha Habera were probably made and used by specialized groups of hunter-gatherers who may have similar cultural traditions like the neighboring high- and lowland cultural groups. The notable difference that can be observed is that the lithic assemblage at Fincha Habera had no sign of Levallois and discoidal lithic reduction techniques. The lithic production techniques of Fincha Habera were exclusively oriented towards the production of elongated flakes from end-struck flake blanks and laminar blanks to produce specialized blades. On the other hand, the dates of the Late Pleistocene deposits at Fincha Habera provide new chronological information from high-altitude environments. It is believed that the hunter-gatherers of the lowland from the Rift Valley with different knowledge in lithic production may have been able to reach the high altitudes of the Bale Mountains during environmental changes of OIS 3.

The unchanged cultural pattern might indicate that hunter-gatherers of Fincha Habera may not have faced major challenges which would have required new cultural adaptations to the harsh and unique environmental conditions including the unique subsistence focus. The presence of highly curated retouched tools and relatively diverse retouched tools in the shallow Late Pleistocene deposits indicate that the site might have been repeatedly used for longer stays. The lithic data from Fincha Habera show that artifact density is especially high in FHLU-08 and lower FHLU-07, opposed to upper FHLU-07 and FHLU-09. The abundance of retouched and unretouched tools in association with an extremely high frequency of faunal materials also indicates that the site may be used intensively for longer time periods within an annual subsistence circuit.

The hunter-gatherers of Fincha Habera were well-organized settlers in high-altitude environments and relied on using specialized tools as well as unretouched tools. These tools are omnipresent in the Late Pleistocene deposits, suggesting the presence of a clear cultural continuity, particularly at the end of the Middle Stone Age period. Fincha Habera's retouched points and blade tools appear to be an indicator of the site function and mobility patterns employed at the regional level.

5.2. SIMBERO ROCK SHELTER

5.2.1. Introduction

Simbero rock shelter is located in the northwest of the Bale Mountains (7,0125000° N; 39,7380280° E), approximately 3 km north of Fincha Habera rock shelter at an elevation of 3519 m asl (**Fig. 2**). The name Simbero means "bird" in the local Oromo language and refers to the abundance of birds in the eponymous valley around the shelter. It is one of several shelters that occurs in the eastern margin of the Web Valley opposite to the Habera Ridge (**Fig. 3**). The shelter is situated on an elevated basalt cliff formed from horizontally bedded layers of rocks and is positioned 200 m above the valley floor. The shelter was primarily formed by the impact of water infiltration coupled with mechanical and chemical weathering. Simbero rock shelter is a west-facing shelter, overlooking the wide valley with several swamps and the Web River to the west (**Fig. 19C**).

The shelter is a comparatively large cavity in the Bale Mountains, measuring approximately 30 m from the south to north and about 10 meters from the drip line to the rear of the shelter. The height of the shelter to its overhanging roof varies from seven to ten meters. The floor of the shelter is partially covered by big roof collapse, mainly at the margins of the shelter. Simbero rock shelter was first documented in the rock shelter inventory of the Bale Mountains (REBER ET AL. 2018). Like all other shelters, the walls of the Simbero rock shelter have no paintings or engravings.

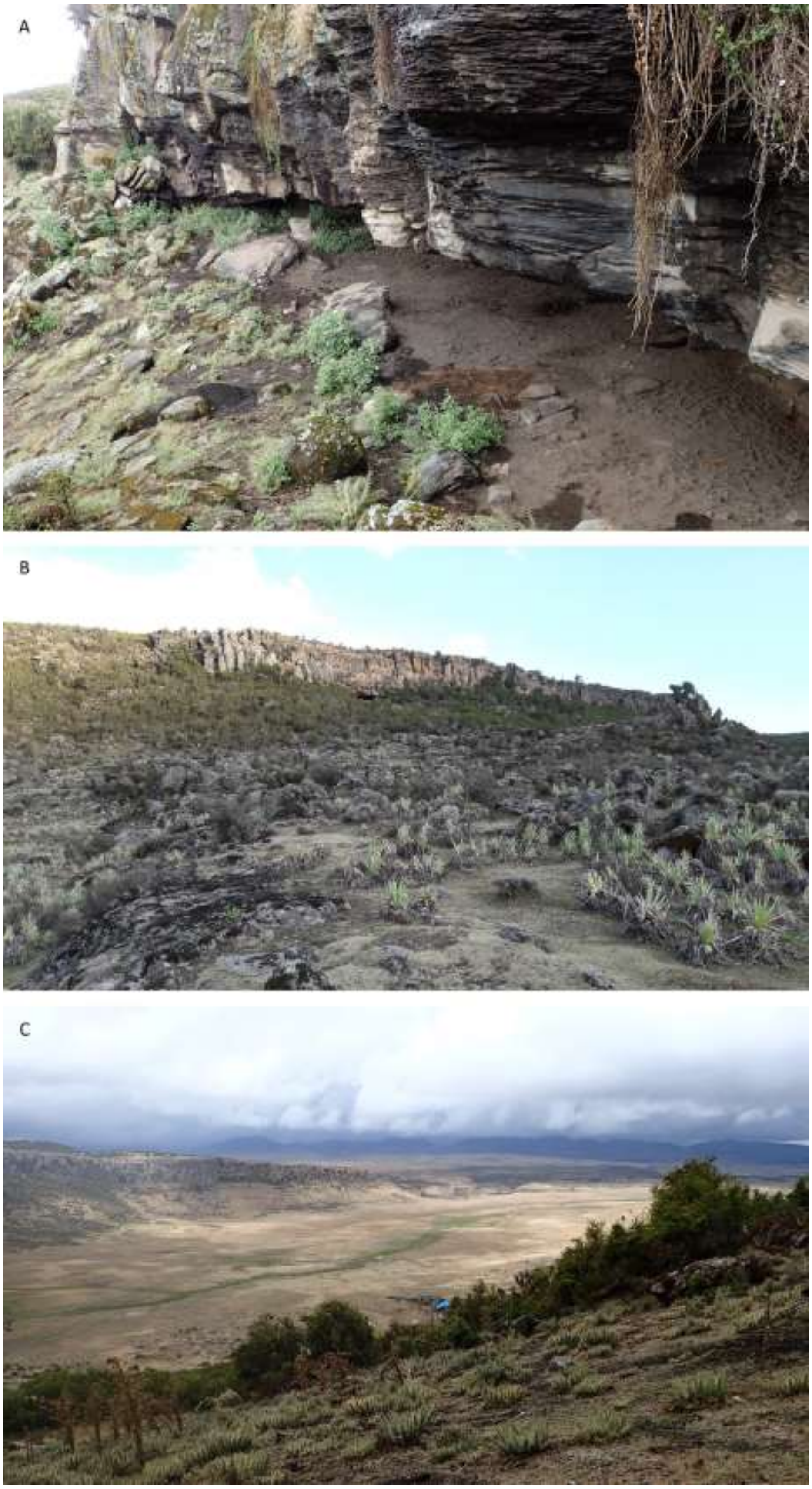

Fig. 19. *Views of Simbero rock shelter.*

5.2.2. Archaeological squares

Systematic test excavations were conducted at Simbero rock shelter given its rather unusual location high up in the cliffs and – closely related to this – its higher potential to yield deposits unaffected from recent pastoral activities. This seems to be a characteristic feature of the more easily accessible large rock shelters in the Bale Mountains. To expose a representative stratigraphic and cultural sequence, the investigation comprised of two 1×1 m squares, excavated to the maximum depth of 70 cm. The first excavation square (O6) is located at the center of the shelter and was excavated down to bedrock. The archaeological samples consisted of charcoal, faunal remains, and lithic artifacts. A second archaeological square (K4) is located at the rear of the shelter around 3 m to the southwest of O6. K4 is situated in a higher position than O6 and shows slightly thicker sediment deposits (**Fig. 20**).

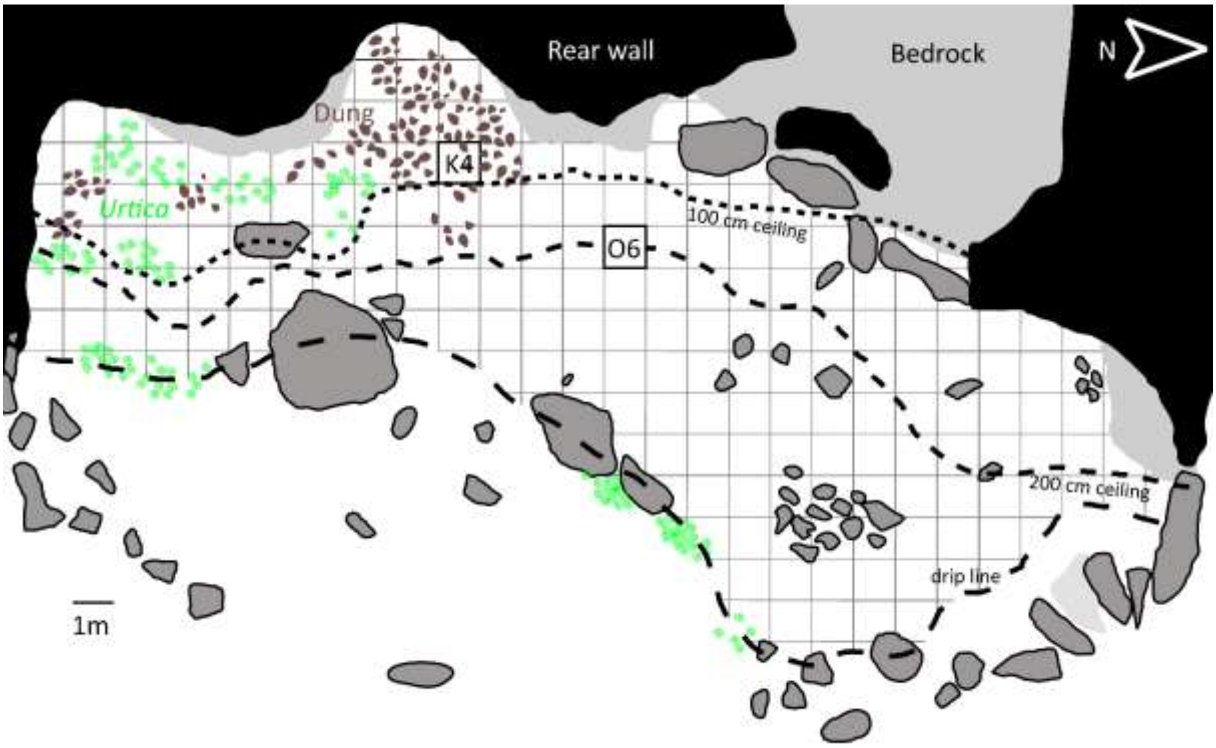

Fig. 20. *Plan view, excavation grid, and location of excavation units at Simbero rock shelter.*

5.2.3. Lithostratigraphic sequence

The lithostratigraphic units of Simbero were developed from the deposits excavated in both squares, K4 and O6. However, the sediments were not evenly distributed in the shelter. The back of the shelter had deeper deposits than the center and entrance of the shelter (**Fig. 20**). Moreover, the deposits at the back of the shelter show a considerable impact of fire on both sediments and cultural remains.

The lithostratigraphic units of Simbero rock shelter are summarized in groups from the surface to the lowest layer. A total of eight radiocarbon dates were obtained to reconstruct the chronology of the deposits (**Table 9. Fig. 21**). The charcoal samples were chosen to date representative layers of the encountered occupational phases

Table 9. *AMS radiocarbon dating results from Simbero rock shelter.*

Provenance	Material	Lab No.	14C Age BP	cal BP (1 Sigma)
O6/NE/L2	Charcoal	Beta - 552719	136.51 ± 0.51 pMC	1.975 - 1.976 [cal AD]
O6/NE/L3	Charcoal	Beta - 552720	2.230 ± 30	2.277 - 2.153
K4/SE/L4	Charcoal	Beta - 552721	2.680 ± 30	2.846 - 2.751
K4/NW/L6	Charcoal	Beta - 552722	2.900 ± 30	3.083 - 2.953
O6/NW/L6	Charcoal	COL5452.1.1	3.337 ± 42	3.509 - 3.630
K4/SW/L8	Charcoal	Beta - 552723	4.580 ± 30	5.327 - 5.272
O6/NW/L8	Charcoal	Beta - 490939	7.290 ± 30	8.056 - 8.151
K4/NW/L10	Charcoal	Beta - 552724	12.460 ± 40	14.960 - 14.265

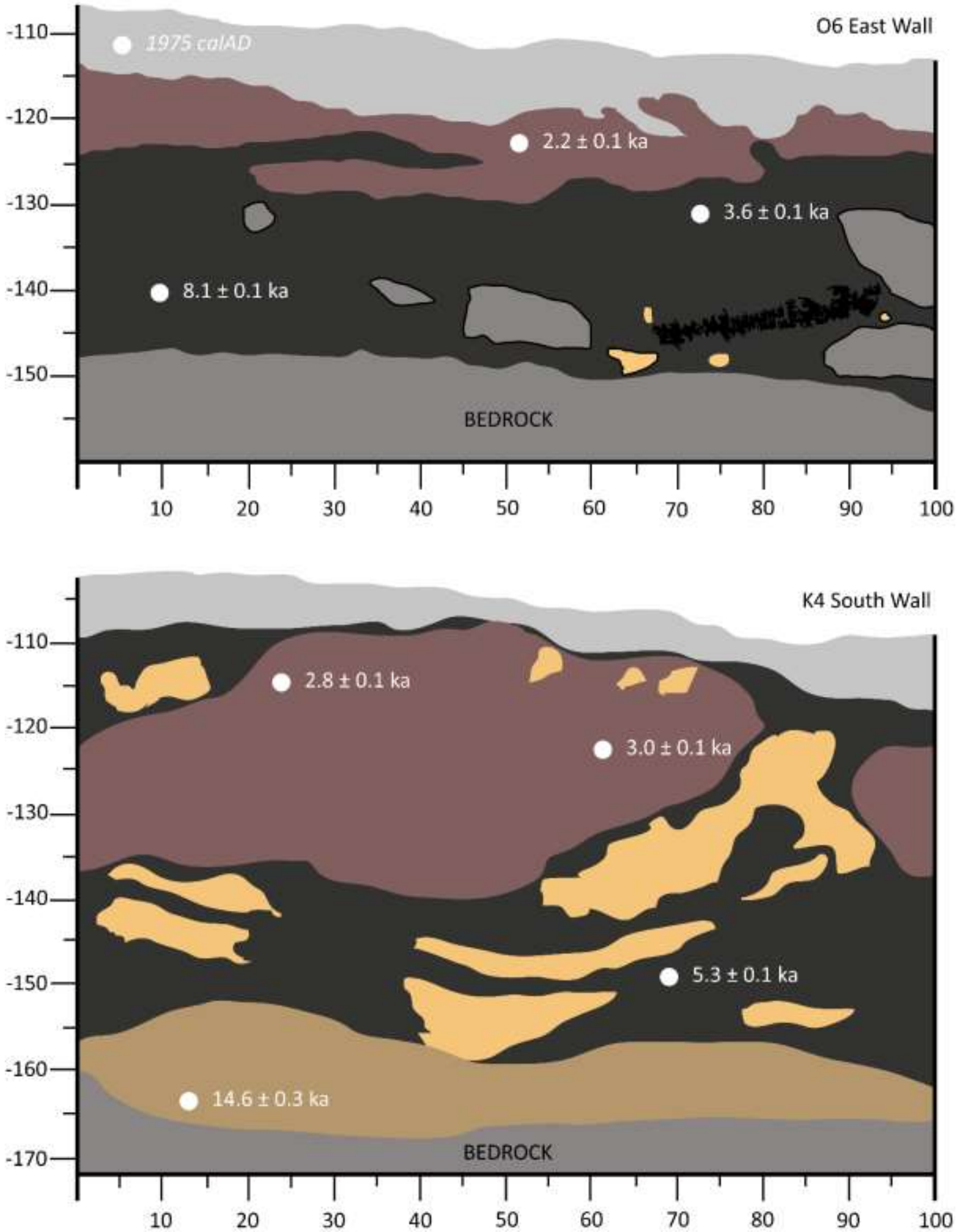

Fig. 21. *Stratigraphic sequence and projected radiocarbon dating results at Simbero rock shelter. East wall profile of square O6 (A) and south wall profile of square K4 (B). See **Fig. 20** for the location of the profiles.*

SLSU-01: Stratigraphic unit SLSU-01 forms the youngest sediment in the shelter and is characterized by gray loose soil with gravel. This topsoil has a thickness of >2 cm, covers the entire shelter and shows many signs of human (pottery) and animal (droppings) activities. *Urtica* plants (strong indicators for the presence of domesticated animals) cover the western edge of the shelter and occur along the drip line (**Fig. 20**).

SLSU-02: The underlying 2 cm-thick unit, SLSU-02, was conformably deposited over the lower layer SLSU-03. It is characterized by highly compacted gray dung, probably originating from cattle. This unit also contains a few charcoal pieces in contrast to the overlying unit. Like the upper unit, SLSU-02 corresponds to excavation level 1 and was not dated, but assumed to be accumulated by late pastoral groups in the region.

SLSU-03: Below the laminated dung unit, SLSU-03 is characterized by compact black organic and crumbly deposits. This unit appears to show a sharp contact with the above unit, but is unconformably deposited over the underlying layer, SLSU-04. The deposits also contain loamy components which are mixed with a high concentration of charcoal and faunal remains. Moreover, the recovered faunal remains in this unit also show the extensive use of fire during this occupational period (**Fig. 21**). Based on the radiocarbon dating results on charcoal samples, the upper part of this unit dates around 2.2 ka cal. BP while the lower parts are dated to 3.6 ka cal. BP. This unit corresponds to a Late Holocene occupation and is represented by the deposits and cultural materials of 4 archaeological levels (level 2 to level 5).

SLSU-04: The stratigraphic unit below the Late Holocene deposits contains charcoal-rich layers with burnt yellowish sediments indicating burning activities in the shelter. This unit yielded very few faunal remains. In contrast, the presence of a high frequency and density of lithic artifacts (including typical LSA microliths) was exceptional compared to other shelters excavated in the Bale Mountains. The impact of fire correlates well to the high number of burnt lithic artifacts and bones observed here. This unit is relatively wet. Within SLSU-04, the uppermost level has a date of 3.6 ka cal. BP while the lowest level dates to 8.1 ka cal. BP. This Middle Holocene occupation phase is represented by the archaeological levels 6, 7, and 8.

SLSU-05: The shallow stratigraphic unit 05 is documented only in the archaeological square of K4. This unit includes the oldest deposits, dated 14.9 ka cal. BP. The deposits were distinct; with reddish sediment that might be associated with the decomposed basalt bedrock. This unit is relatively compact and contains light brown sediments with few charcoals. The frequency of lithic artifacts was low and no faunal remains were recovered. The archaeological levels 9 and 10 of K4 represent the oldest deposits and a Terminal Pleistocene occupational phase at Simbero rock shelter.

5.2.4. Stratigraphic summary

The Simbero lithostratigraphic units (SLSU) represent different deposition events at the shelter. The uppermost lithostratigraphic units show pastoral activities while the lower units represent two Holocene hunter-gatherer occupational events. Only in square K4, an additional Terminal Pleistocene settlement phase might have been encountered. Although a thickness of max. 70 cm is not uncommon in the Bale Mountains, the shallow deposits are exceptional in covering different deposition and occupation events. The Middle and Late Holocene occupational layers show the presence of extensive fire within the rock shelter (**Fig. 20**). Archaeological square O6 featured a high frequency of lithic artifacts while K4 possessed almost the entire faunal assemblage alongside with a smaller number of lithic artifacts. The possible explanation for this different depositional pattern could be associated with a preference of hunter-gatherers to use the back of the shelter for processing hunted animals, including roasting meat.

5.2.5. Faunal remains

The deposits of Simbero rock shelter comprised a diverse fauna with several species of wild animals. The faunal sample consists of 1479 well-preserved macro- and micro-faunal remains including mammals, birds, and fish (**Table 10**). The analyzed finds came almost exclusively from archaeological square K4 (**Fig. 20**). The majority of finds can be attributed to the Late and Middle Holocene occupation phases. The preservation shows – compared to other shelter's remains – considerably less degradation and mineralization. Bones of domesticated animals are not represented in the recovered faunal remains.

Table 10 summarizes the distribution of macro- and micro-faunal remains of Simbero rock shelter. A total of 1168 specimens (78.9%) were broken, compared to only 25 complete pieces (1.7%) and 286 (19.3%) in an unidentifiable condition. Bone fragmentation seems to be related mainly to human activities. Post-depositional processes might have also increased the fragmentation of bones, especially of small animals such as rodents, hare, and hyrax. Mammal remains are numerous and internally diverse: small-sized mammals accounted for 52% (n=782) (**Fig. 22A, 22C, 22E, 22G**) of the total remains. They are followed by medium-sized mammals (19.5%, n=289) (**Fig. 22B, 22H, 22K**) and only 2.4% (n=36) of large mammals (**Fig. 22F**). Moreover, the inclusion of rodents, which represent 10.9% (n=161) (**Fig. 22A**), and birds, representing 1.3% (n=19), implies the possibility that small-sized animals in the Bale Mountains were effectively hunted by Middle and Late Holocene occupants. There were also few carnivores (**Fig. 22D, 22K**) and fish remains among the recovered faunal spectrum.

Fig. 22. *Photographs of faunal remains from Simbero rock shelter.*

The faunal material from all occupational phases was considerably altered by fire: 99.8% of all faunal remains show different degrees of fire impact, which indicates that hunter-gatherers were effectively processing wild animals meet through fire (**Fig. 22A–B, 22F, 22H**). The limb bones of large mammals with signs of lateral percussion and splinters appear to be broken at a fresh state (n=101), and account for 6.8% of the total faunal assemblage. This indicates that hunter-gatherers might have used tools to process both meat and bone of wild animals. Moreover, the surface of the bones with cut and percussion marks (**Fig. 22F, 22I–K**) evidenced intentional bone processing by humans in the shelter.

Table 10. *Identification of faunal remains from Simbero rock shelter (NISP). Unpublished data from Tariku (in prep.)*

Taxa	Terminal Pleistocene		Middle Holocene		Late Holocene		Total	
	N	%	N	%	N	%	N	%
Mammalia (unident. size)	-	-	24	12,6	96	8,8	120	9,3
Mammalia (large)	-	-	16	8,4	20	1,8	36	2,8
Mammalia (medium-sized)	-	-	3	1,6	80	7,3	83	6,4
Mammalia (small)	4	100	70	36,8	605	55,2	679	52,6
Rodentia	-	-	6	3,2	12	1,1	18	1,4
Lepus	-	-	13	6,8	87	7,9	100	7,8
Procavia	-	-	12	6,3	21	1,9	33	2,6
Lepus/Procavia	-	-	-	-	10	0,9	10	0,8
Bovidae size 3/2	-	-	13	6,8	60	5,5	76	5,9
Bovidae size 2	-	-	6	3,2	7	0,6	13	1,0
Bovidae size 1	-	-	20	10,5	83	7,6	103	8,0
Carnivora	-	-	1	0,5	1	0,1	2	0,2
Aves	-	-	6	3,2	13	1,2	19	1,5
Pisces	-	-	-	-	1	0,1	1	0,1
Identified	**4**	**80**	**190**	**86,8**	**1096**	**87,3**	**1290**	**87,2**
Unidentified	*1*	*20*	*29*	*13,2*	*159*	*12,7*	*189*	*12,8*
Total	**5**	**100**	**219**	**100**	**1255**	**100**	**1479**	**100**

Based on the analysis of the bone surfaces, the faunal remains show no sign of animal digestion, e.g. by carnivores. Parts of the long bones, particularly the ribs, show surface alteration caused by polishing, weathering, and burning. Most of the faunal remains appear to be altered through intentional breaking (**Fig. 22J**) and burning. As a result, the accumulation of bones at the shelter might predominantly be related to humans and not to other agents. The abundance of these bones also parallels the presence of a high frequency of lithic material, mainly in the Middle and Late Holocene occupational phases.

In summary, the faunal sample at Simbero is characterized by species diversity and a major focus on small-sized mammals/bovids. The presence of birds and fish in the assemblage suggests that the occupants of the shelter had employed different hunting strategies in the high-altitude environments. Currently, there is no evidence of how hunter-gatherers managed to capture different wild animals at the high-altitude of the Bale Mountains. Based on the taphonomic and lithostratigraphic review, the faunal remains were accumulated by humans and are characterized by the fact that almost the entire assemblage is in a burned condition. No domesticates are documented in the faunal assemblage.

5.2.6. Lithic assemblage

The lithic assemblage at Simbero rock shelter – despite its chronological depth – is entirely characterized by LSA technological features (**Appendix II**). The flaked stone tools and debitage were recovered from deposits of both archaeological squares, however, archaeological square O6 yielded 3590 stone artifacts compared to only 846 lithic artifacts recovered from square K4 (**Table 12**). Like the faunal remains, the lithic artifacts were highly exposed to the use of fire in the shelter. A significant number of obsidian flakes from the Middle and Late Holocene occupational phases including tools show heat impact and fire alteration (**Fig. 21**).

Table 11. *Frequency and percentage of lithic artifacts according to occupation phases at Simbero rock shelter.*

Flaked Stone	**Late Holocene**	**Middle Holocene**	**Terminal Pleistocene**	**Total**	
	N	N	N	N	%
Cores					
Conical	-	1	1	2	0,0
Prismatic	-	1	1	2	0,0
Bipolar	2	9	-	11	0,2
Core on flake	2	-	-	2	0,0
Fragment	-	-	2	2	0,0
Others & irregular	2	2	2	6	0,1
Total	**6**	**13**	**6**	**25**	**0,6**
Debitage					
Angular waste	486	806	50	1342	30,3
Bladelet/blades /flakes	460	975	58	1493	33,7
Blanks	108	227	18	353	8,0
Chips	167	517	20	704	15,9
Core trimming flakes	40	111	30	181	4,1
Tested nodules	12	45	2	59	1,3
Total	**1273**	**2681**	**178**	**4132**	**93,1**
Utilized tools					
Utiilized & modified	35	85	19	139	3,1
Total	**35**	**85**	**19**	**139**	**3,1**
Formal tools					
Segments	17	10	19	27	0,6
Crescents	5	8	1	14	0,3
Borers	6	13	3	22	0,5
Straight-backed	14	18	2	34	0,8
Retouched flakes/bladelets/blades	15	19	-	34	0,8
Scrapers	3	3	1	7	0,2
Total	**60**	**71**	**7**	**138**	**3,1**
Hammerstone					
Total	**1**	**-**	**1**	**2**	**0,0**
Total Lithics	**1375**	**2850**	**211**	**4436**	**100,0**

Table 12. *Frequency and percentage of artifact categories according to excavation squares at Simbero rock shelter.*

Flaked Stone		**K4**	**O6**	**Total**	
		N	N	N	%
Cores					
	Conical	2	-	2	8.0
	Prismatic	1	1	2	8.0
	Bipolar	6	5	11	44.0
	Core on flake	-	2	2	2.0
	Fragment	2	-	2	2.0
	Others & irregular	4	2	6	24.0
Total		**15**	**10**	**25**	**0.6**
Debitage					
	Angular waste	247	1095	1342	32.5
	Bladelet/blades /flakes	278	1215	1493	36.1
	Blanks	58	295	353	8.5
	Chips	70	634	704	17.0
	Core trimming flakes	70	111	181	4.4
	Tested nodules	8	51	59	1.4
Total		**731**	**3401**	**4132**	**93.1**
Utilized tools					
	Utilized & modified	64	75	139	3.1
Total		**64**	**75**	**139**	**3.1**
Formal tools					
	Segments	6	21	27	19.6
	Crescents	4	10	14	10.1
	Borers	12	10	22	15.9
	Straight-backed	7	21	28	20.3
	Retouched flakes/bladelets/blades	2	38	40	28.9
	Scrapers	4	3	7	5.1
Total		**35**	**103**	**138**	**3.1**
Hammerstones					
Total		**1**	**1**	**2**	**0.0**
Total Lithics		**846**	**3590**	**4436**	**100.0**

5.2.6.1. Raw materials

Obsidian was the dominant raw material for the production of lithic artifacts in all occupational layers (**Fig. 23**). A total of 4324 (97.4%) artifacts made of obsidian are followed by chert with 107 pieces (2.4%), three basalts (0.1%), and one lithic artifact of chalcedony and rhyolite each. **Table 13** shows the distribution of each raw material within the artifact categories. The artifacts from both archaeological squares show the same pattern of raw material exploitation.

Table 13. *Frequency and percentage of raw materials per artifact category at Simbero rock shelter.*

Raw material	Chips	Flakes & blades	Blanks	Angular waste	Tested nodules	Flake cores	Other cores	Retouched & utilized tools	Hammerstones	Total	
										N	%
Obsidian	700	1486	348	1265	59	181	25	260	-	4324	97.4
Chert	4	6	5	77	-	-	-	15	-	107	2.4
Chalcedony	-	-	-	-	-	-	-	1	-	1	0.0
Basalt	-	1	-	-	-	-	-	1	1	3	0.1
Rhyolite	-	-	-	-	-	-	-	-	1	1	0.0
Total	**704**	**1493**	**353**	**1342**	**59**	**181**	**25**	**277**	**2**	**4436**	**100,0**

Based on the electron microprobe analysis of selected obsidian samples, almost all the obsidian raw material – homogeneous black volcanic glass – was transported from Wasama Ridge. However, one single piece (ID109, **Appendix V**) is comparable with the geochemical composition of obsidian from Gara Boku 1 in the central Rift Valley (NEGASH ET AL. 2020) at approximately 170 km direct distance to Simbero (**Fig. 1**). Another single obsidian sample from archaeological square O6 (Level 7) shows a geochemical composition of unknown sources, not corresponding to the Wasama Ridge obsidian. However, even low-quality obsidian and rolled nodules were tested in the shelter. This attempt might point to restricted access to high-quality local resources at some periods. The obsidian raw material is absolutely dominant in the Middle and Late Holocene occupational layers. Most of the non-obsidian tools came from lower occupational layers. Except for chalcedony, these raw materials were also locally available. The possible source of chert that was identified during fieldwork is Genale plain, 5 km southwest of Simbero (**Fig. 2**). The presence of obsidian from the Rift Valley and a single tool from chalcedony indicates some form of interaction with the lowland LSA cultural groups.

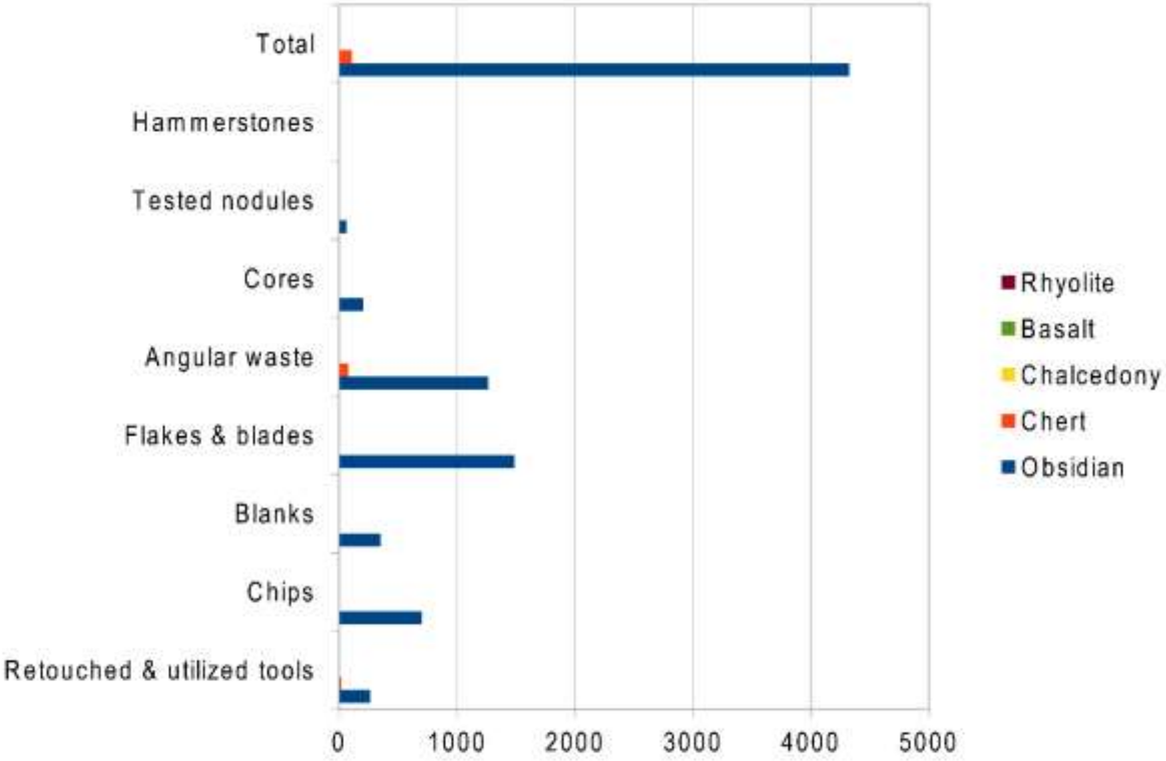

Fig. 23. *Chart of the frequency of raw material types according to artifact category at Simbero rock shelter (combined data of square K4 and O6).*

5.2.6.2. Hammerstones

Two hammerstones were documented from both archaeological squares (**Table 11**). The prismatic hammerstone (ID 566, K4, Level 9) made on rhyolite (**Fig. 24**) was recovered in the Terminal Pleistocene deposits of square K4. A second hammerstone was recovered from the Late Holocene deposits of O6. This piece is made of basalt and was broken during production. Both hammerstones show intensive use as a percussion tool, but ID 566 appears to have been additionally used as a grinding tool. The base of the latter has multiple negatives, probably configured for better handling of the tool (**Fig. 24C**). The entire body of this grinding stone was smooth, and visible ocher traces are embedded in the tiny holes and cracks (**Fig. 24A**). The tip of the tool also shows both, the intentional use for hammering and for grinding of other objects (**Fig. 24B**).

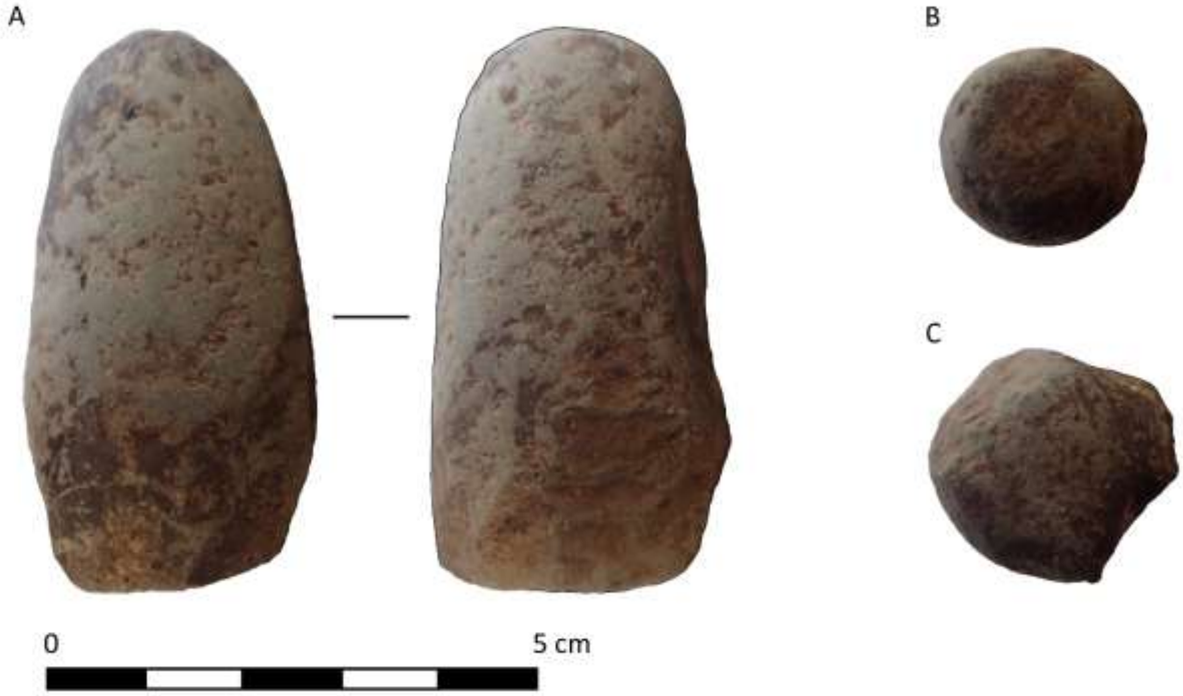

Fig. 24. *Photographs of a grinding stone from Simbero rock shelter. Lateral (A), top (B), and bottom view (C).*

5.2.6.3. Cores

The identified cores represent 0.6 % (n=25) of the total lithic assemblage. They were exclusively made of obsidian and are evenly distributed in all occupational layers. Cores at Simbero rock shelter consist of prismatic, conical, and tabular cores, as well as core-on-flakes (**Table 11**). Bipolar reduction techniques appear to be additionally implemented in detaching small flakes from cores. The presence of unidirectional step or hinge terminations indicates that laminar stone technology was effectively employed to produce small artifacts including bladelets and flakes. In particular, single-platform cores with non-elongated flake removals characterize the core reduction pattern at the Simbero rock shelter.

The size and diversity of cores indicate that lithic miniaturization was the main stone tool production strategy. Almost all cores at the shelter were small in size (diameter and length). The longest core is a bi-directionally flaked core-on-flake with a maximum length of 31 mm. Highly exhausted cores with a maximum length of 12.5 mm were also documented, while the average length of all cores is 19.8 mm. Prismatic cores (**Fig. 25E; Fig. 29M**) were used to produce bladelets in contrast to conical cores aimed for the removal of small flakes (**Fig. 26C–D; Fig. 27E; Fig. 29G; Fig. 30G**). Moreover, both prismatic and tabular cores have been used to detach laterally parallel-edged blade(let)s.

Out of the total core samples, 15 cores – including conical and prismatic cores – show unidirectional flaking from a single platform, followed by two cores with either bidirectional or multidirectional flaking negatives. Eight cores show a high degree of fragmentation. The size and flaking directions of the latter cores indicate that the primary core reductions seem to have started outside the shelter. Most of these cores were transported to the shelter after nodules were reduced to the preferred small size.

The cores show effective core management techniques. The diversity of cores also shows that the hunter-gatherers had knowledge of different core management techniques. Cores were exhaustively used before being discarded. Moreover, highly rolled obsidian nodules were also tested at the shelter before they were discarded.

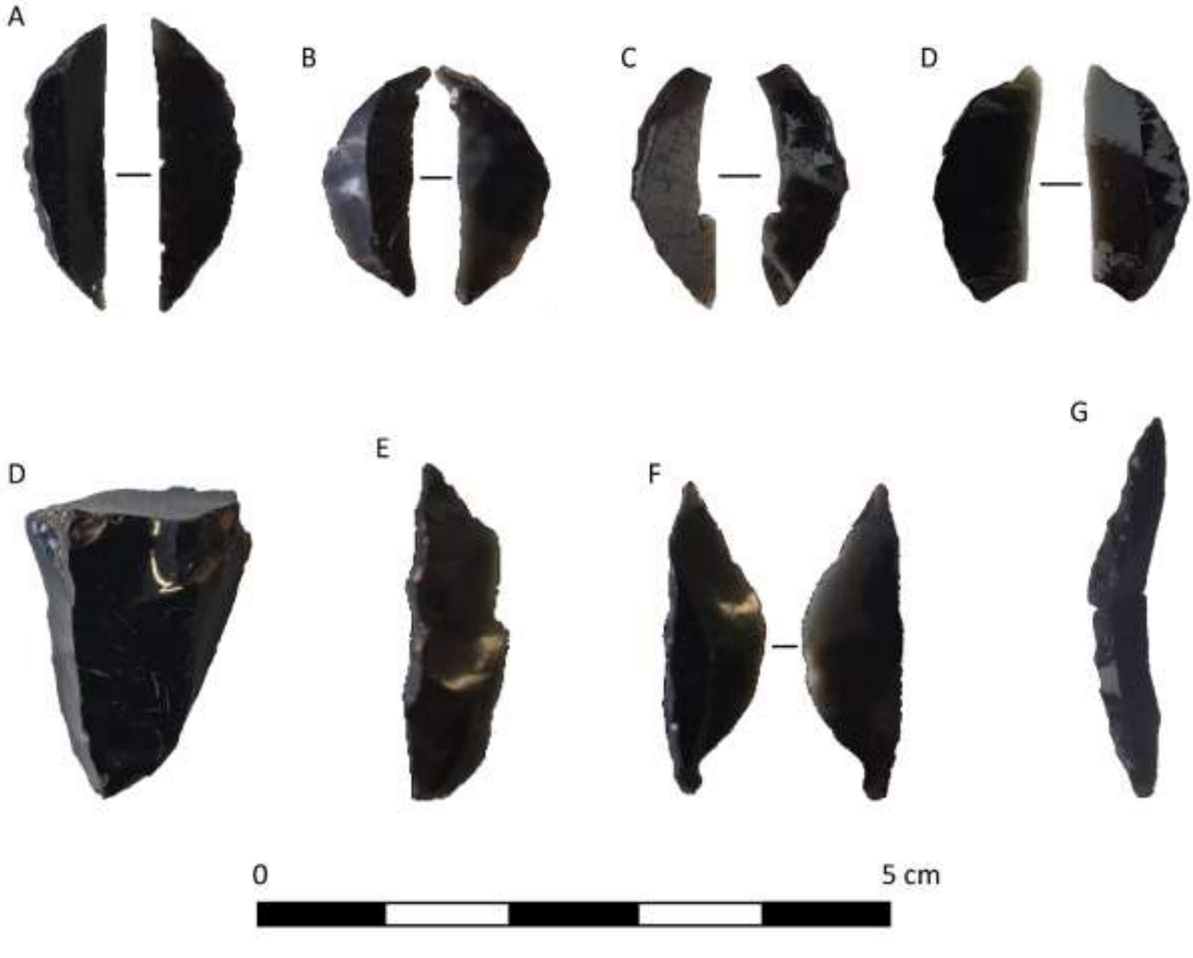

Fig. 25. *Photograph of microlithic artifacts from Simbero rock shelter.*

5.2.6.4. Debitage

The debitage is characterized by functional and non-functional debitage types. The functional debitage includes blanks, core trimming flakes, and tested nodules, while the non-functional debitage includes angular waste, chips, and small flakes (flaked bladelets, blades, and flakes). The non-functional debitage contains a high percentage of fragmented pieces suggesting intensive use of the shelter (human trampling) and/or post-depositional processes.

The two above mentioned types of debitage together represent 93.1 % (n=4132) of the whole lithic assemblage. The Middle Holocene occupation phase includes 2681 pieces of debitage, representing 64.8% of the total debitage assemblage. The Late Holocene phase follows with 1273 pieces, amounting to 30.8% of the total debitage assemblage. The oldest settlement phase at the shelter had a considerably lower total count of 178 pieces, accounting for only 4.3% of the total debitage assemblage (**Table 11**).

Most of the debitage at the shelter is comprised of broken pieces. Around 1525 (36.9%) broken flakes were documented and suggest intensive on-site activities and possibly trampling. However, most of the blanks also show production damage related to the production of small and thin flakes at the shelter. The complete flakes, which are represented by 520 pieces (6.1%), had both fresh negatives and dorsal cortex. Numerous core trimming flakes, angular waste, and tested rolled pieces (n=861) preserved cortex remains, from minimal trace up to 50% of the flake surface. This could indicate that both, the second stage of lithic reduction, as well as the tool production was simultaneously carried out at the shelter. The knapping pattern reveals a short lithic reduction sequence since cores underwent most decortification of their surfaces outside of the shelter.

The debitage type at Simbero represents behavioral changes in lithic production techniques compared to the MSA patterns detected at Fincha Habera. The Simbero hunter-gatherers were intentionally targeting non-elongated flakes to produce small flaked tools. The presence of a high percentage of complete and broken bladelets (>

70%) indicates that the reduction techniques were targeted towards the production of elongated blade(let)s. Moreover, convergent small flakes were produced from highly specialized conical cores. Blades are the third major component of flake production and were used for the production of microlithic tools. Both blades and bladelets were used for backed, retouched, and utilized microliths, while convergent flakes were used for retouched and utilized tools.

In summary, the debitage of Simbero rock shelter shows no clear diachronic change in technology. The lithic artifacts characterized by the common LSA tradition fairly started at the oldest deposits of the shelter. The concentration of the debitage that appears to be produced by similar techniques abruptly increases during the Middle Holocene and continues during the Late Holocene occupation. This makes Simbero rock shelter one of the most repeatedly used LSA occupational sites at the high altitudes of the Bale Mountains. The debitage is characterized by elongated blade(let)s and non-elongated flakes. The production of LSA bladelets/blade and small convergent flakes appears to be the main target of the reduction sequences. The presence of exhausted small cores and the predominance of small pieces in the debitage category shows that lithic miniaturization was a preferential and intentional process of lithic production among Simbero hunter-gatherers.

5.2.6.5. Tools

All identified tools (**Table 14**) demonstrate the presence of a major bladelet component compared to the minor production of blades. In general, the flaked tools can be summarized into three distinct microlithic categories: backed microliths, retouched microliths, and utilized tools. The counts of the latter dominate the tool assemblage by far, while backed microliths (geometric and non-geometric) are the major formal tools at the shelter.

Fig. 26. *Photograph of microlithic artifacts from Simbero rock shelter.*

Small-sized flakes, mainly convergent ones, were preferentially exploited to produce both general and specialized tools. These tools include scrapers, laterally retouched tools (**Fig. 26A–B**), including borers. Borers (**Fig. 26C–D**) as non-geometric tools seem to be the only regional special microlithic tool types and were continuously produced and used at the high altitudes of the Bale Mountains. Backed microliths (straight-backed, segments, crescents) are the most common backed tools in the lithic assemblage. This tool class contains curved-backed pieces with and without removal of proximal parts, particularly the bulb of percussion and the butt. The curved edges often show preferential dorsal (obverse) or ventral (inverse) retouch for blunting, while the opposed rectilinear edge remains sharp for use. The curved-backed microliths at Simbero show a distinct technological variability, especially with regard to the presence and absence of proximal parts.

5.2.6.5.1. Utilized tools

The distribution of unretouched tools is well comparable to the total count of all formal tools (**Table 11**). The unretouched tools were continuously produced in high numbers from the earliest occupation onward until the late periods (**Table 14**), with a maximum number in the Middle Holocene phase (**Table 15**). The unretouched tools were made from all types of flakes such as small convergent flakes, bladelets, and blades. They represent 49.8% of the total tools. A total of 49 bladelets were used for unretouched tools, followed by 15 blades and 14 small convergent flakes. The majority of unretouched tools are complete (n=84), while 55 pieces are broken. Some unretouched tools show irregular lateral edge damage from the proximal to the distal end. Edge damage on both sides was observed on 101 unretouched pieces, while edge damage on one side was identified on the remaining 38 pieces. A high number of unretouched tools also show an intentional proximal modification. A total of 57 tools were proximally altered with the dorsal retouch. This resulted in thinning of the artifacts, including parts of the platforms. The identifiable platforms varied from pointed (n=31), crushed (n=23), plain (n=23) to facetted (n=21). Most of these unretouched tools were made of obsidian.

The presence of a high percentage of unretouched tools in the tool assemblages (**Fig. 28**) suggests that Holocene occupants at the shelter may have had a broader activity spectrum that required employing both formal and informal tools. It is evident that hunter-gatherers started the production of a high number of unretouched tools already during the earliest settlement phase. The importance of unretouched tools also continued during the Middle and Late Holocene occupational phases. Like other retouched tools and debitage elements in the assemblage, square O6 contains a higher frequency of unretouched tools in the shelter (**Table 12**).

The intense edge damage of the unretouched tools also shows intense activities in the shelter during the identified three occupational phases. Unlike the retouched and backed tools, the proportion of unretouched tools is evenly distributed in all three occupational phases. Both residue and use-wear analysis are required to know whether the unretouched tools were used in the same manner and for similar functions as the retouched tools.

Table 14. *Frequency of retouched and utilized artifacts per archaeological levels at Simbero rock shelter (combined data from squares K4 and O6).*

Layer	**Backed microliths**			**Retouched microliths**			**Utilized**	**Hammer-stone**
	Segments	Crescents	Straight-backed	Borers	Lateral retouch	Scrapers		
2	-	1	-	1	-	-	4	1
3	-	-	-	1	2	2	7	-
4	8	3	9	1	5	1	9	-
5	9	1	5	3	8	-	15	-
6	7	5	5	5	11	1	26	-
7	3	3	7	2	7	1	20	-
8	-	-	6	6	1	1	39	-
9	-	1	2	3	-	-	16	1
10	-	-	-	-	-	1	3	-
Total	**27**	**14**	**34**	**22**	**34**	**7**	**139**	**2**

5.2.6.5.2. Retouched tools

The retouched tools are the second most frequent category of tools and represent 22.6% (n=63) of the total tools (**Table 15**). Retouched microliths are represented by borers (n=22), laterally retouched tools (n=34), and scrapers (n=7). Both prismatic and conical cores were used to produce these microliths. In most cases, retouch scars are fine and short, either on the dorsal or on the ventral side. Moreover, the edges and ends of the tools are often retouched with notches and truncation. Retouch that occurred either on the lateral edge(s) and the tip of the blank at least partially modified the shape of the tool.

The retouched tool category shows the presence of the most common and ubiquitous LSA microliths at the high-altitude of the Bale Mountains. In particular, the production of borers required more retouch, including fine retouch, notches, and truncations to obtain the tip of the tool. Moreover, most retouched tools show intentional proximal modification with facial retouch, truncation, and notches for the possible hafting and freehand use of the pieces. Most of the borers were made on convergent and semi-convergent flakes while laterally retouched tools were made from all small-sized flakes such as bladelets, blades, and convergent or semi-convergent flakes.

5.2.6.5.2.1. Scrapers

A total of only seven scrapers which account for 2.5% of the total tools were recovered from all three occupational phases (**Table 15**). Thus, scrapers are the least represented formal tool class in the Simbero lithic assemblage. Both the Late and Middle Holocene occupational phases yielded three scrapers, and a single piece was recovered from the Terminal Pleistocene deposits (**Table 14**).

All scrapers were made on small blanks, mainly convergent flakes (n=5), but also blades (n=2), while bladelets were not used. Scrapers with simultaneous retouch on their ends as well as on their sides (n=3) form the most common scraper type at the shelter, and side-, double-, end-, and notched scrapers are represented by a single piece each (**Fig. 26B; Fig. 29P**).

Almost all scrapers were retouched on their dorsal faces. The lateral edges and tips were altered by dorsal (obverse) retouch. The edges of the flakes were used to initiate retouching, probably through pressure flaking. The soft hammer technique may have been used for semi-invasive retouch and proximal thinning. Most of the scrapers show additional basal modification. Both retouch and edge damage occurred mostly on the lateral edges. The presence of notches evidences an additional retouch strategy applied to the tool edges. The working edges of the scrapers generally show that scrapers were intensely used before their discard. The possible explanation for the low proportion of scrapers at the shelter appears to be rather related to subsistence strategies but not to technological issues or raw material availability.

5.2.6.5.2.2. Laterally retouched tools

Laterally retouched tools include various small tools, constituting the largest proportion of retouched microliths in the analyzed sample. A total of 34 pieces (12.2%) were identified mainly from the Middle and Late Holocene occupational phases (**Table 11; Table 15**). The latter phase yielded 15 laterally retouched tools while the underlying phase contained 19 tools of this class. These tools were made mainly on bladelets (n=15), followed by pointed flakes (n=10), and blades (n=9) (**Fig. 26A; Fig. 27A–B; Fig. 29N; Fig. 29O**). Several laterally retouched tools were broken (n=14), while most complete tools show both variable techniques of retouch and intense signs of utilization.

Like other tools, laterally retouched tools correspond to the recovered blanks and cores in terms of their size and diversity. The platforms of these tools varied from plain (n=10), facetted (n=7), pointed (n=6), and crushed (n=5). The longest retouched tool measured to 38.2 mm, while the smallest one was 14.8 mm in length. Obsidian raw material was almost exclusively used to produce laterally retouched microliths at Simbero rock shelter.

Fig. 27. Photograph of microlithic artifacts from Simbero rock shelter.

The pattern and location of retouch are not uniform. Most tools have dorsal (obverse), and only few pieces have ventral (inverse) retouch. This was carried out either on one or both lateral edges. Most of the laterally retouched tools show fine retouch with notches and only four tools exhibited alternating retouch. The location of retouch mainly occurs on one edge (n=25) and rarely on two lateral edges (n=9) (**Fig. 27A–B;**

29N–O). The base of the retouched tools also exhibits a common proximal modification. In particular, the retouched tools made on pointed flakes preserved proximal dorsal thinning and retouch.

5.2.6.5.2.3. Borers

Morphologically, borers are small flakes or blades with intentionally prepared convex or concave lateral edges to form a pointed tip. The production of borers passes through the common LSA lithic reduction sequences from prepared cores to preferential blanks of either convergent flakes or blades. At least one notch is required to form the tip of the borer. The pointed end is usually located either on the distal and proximal end, but more irregular lateral tips also do occur (**Fig. 26C–D, Fig. 27D–E; Fig. 29G; Fig. 30G**).

A total of 22 borers, 7.9% of the total lithic tools, can be identified and originate mainly from the Middle (n=13) and Late Holocene (n=6) occupational phases. The Terminal Pleistocene occupation was represented by only three pieces, indicating a lesser degree of importance of borers compared to the younger occupational phases (**Table 14**). Complete borers are more common given only six broken pieces. Most of these borers were exhaustively used and show the intensive exploitation of the working edges and tips.

At least three types of borers were identified in the Simbero tools assemblage. The most common ones were those with a single tip (n=20), followed by borers with a double tip and multi-borer (**Fig. 27D**). Most of the borers show at least one notch and one truncation to form the tip. The tips of the borer are often created on the distal end, but even the proximal ends and the lateral edges were notched and finely retouched to obtain sharp pointed tips. Compared to other retouched and utilized tools, the base of the borers shows the most frequent instances of proximal modification, including truncation, and semi-invasive retouch to reduce the thickness of the base.

Currently, the function of borers is not known. Both use-wear and residue analysis could offer insights into the actual function of these tools during different occupational phases. Based on the testable assumption, the borers seem to represent more specific tools than the general ones, and probably have been used to process hide. However, the reason for the intensive modification of the bases of the borers is not known. If the borers were freehand tools, the proximal modification should be associated with the handling of the tool when the hide was under process.

5.2.6.5.3. Backed tools

Backed microliths are a major component of the LSA tool assemblage. These microliths are represented by 75 pieces, allowing for a further subdivision into geometric (n=36) and non-geometric (n=34) pieces (**Table 15**). The backing of the identified microliths (segments, crescents, and straight-backed pieces) appears to be uniform in displaying abrupt (stepped) retouch along one edge. Morphologically, backed tools are bladelets or blades with parallel edges and dorsal negatives to carry out the blunting on one edge and to keep its opposite side as a straight sharp edge.

Non-geometric backed (straight-backed and partially backed) pieces were almost exclusively made on bladelet blanks, mainly on obsidian and very few on chert. Geometric backed microliths (crescents and segments) were manufactured mainly from well-prepared cores and blanks through bipolar and laminar technologies.

5.2.6.5.3.1. Straight-backed microliths

Straight-backed microliths consist of bladelets bearing an abrupt retouch on one edge while the opposite lateral edge remains sharp. The backing is characterized by the unidirectional retouch of one edge and is sometimes supplied by bidirectional retouch with the systematic use of an anvil. Most of these straight-backed microliths preserved proximal ends with partial modification – without removal of the bulbs and butts. The preservation of the bases might be intentional for hafting the microliths within a composite tool.

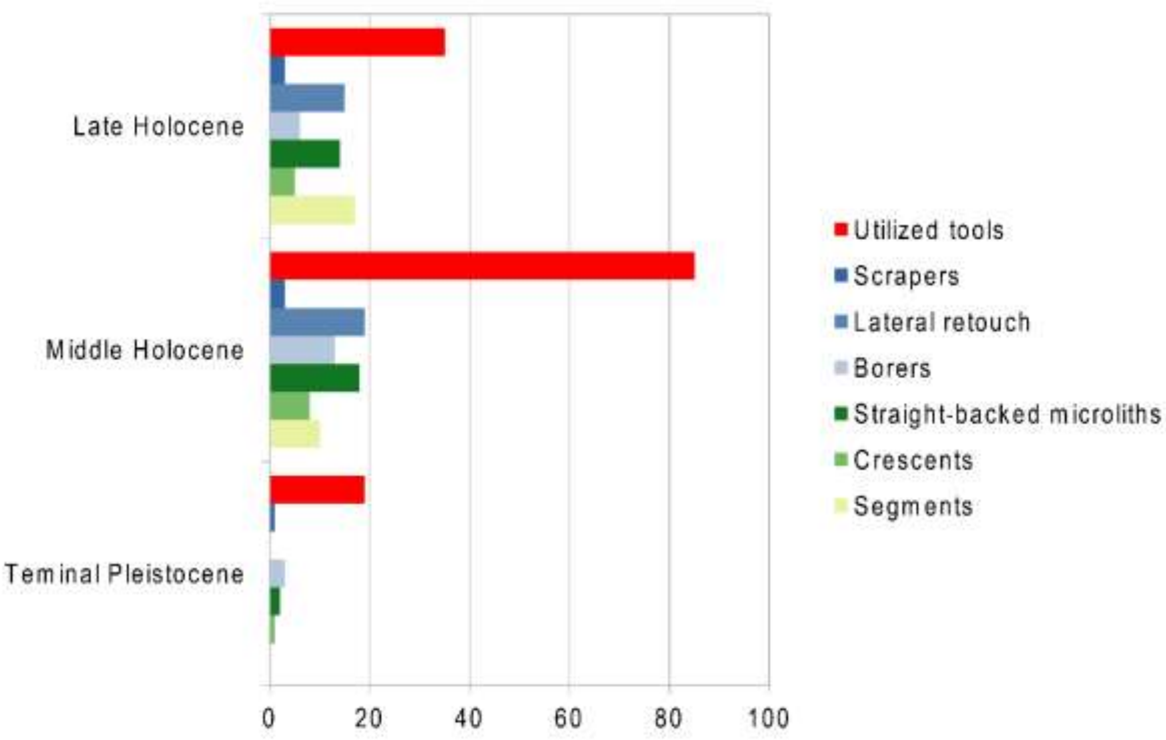

Fig. 28. *Chart of the frequency of LSA microliths according to occupational phases at Simbero rock shelter (combined data of excavation squares K4 and O6) with backed microliths (green), retouched microliths (blue), and utilized tools (red).*

Phase	Backed microliths						Retouched microliths						Utilized		Hammer-stone		Total	
	Segments		Crescents		Straight-backed		Borers		Lateral retouch		Scrapers							
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Late Holocene	17	62.9	5	35.7	14	41.2	6	27.3	15	44.1	3	42.9	35	25.2	1	50.0	96	34.4
Middle Holocene	10	37.0	8	57.1	18	52.9	13	59.0	19	55.9	3	42.9	85	61.2	-	-	156	55.9
Teminal Pleistocene	-	-	1	7.1	2	5.9	3	13.6	-	-	1	14.2	19	13.6	1	50.0	27	9.6
Total	**27**	**9.7**	**14**	**5.0**	**34**	**12.2**	**22**	**7.9**	**34**	**12.2**	**7**	**2.5**	**139**	**49.8**	**2**	**0.7**	**279**	**100,0**

Table 15. *Frequency and percentage of retouched and utilized artifacts.*

Straight-backed microliths are represented by 34 pieces, amounting to 12.2% of the total tools (Table 11; Fig. 25F–G; Fig. 29H, 29J, 29L; Fig. 30H). The majority of these is broken (n=18), but the complete ones display the extent of backing on the preferred edge of the blank. Moreover, very few partially curved-backed microliths are also present in the LSA lithic assemblage (Fig. 25H (refit); Fig. 27C; Fig. 29I, 29K). Left lateral edges (n=19) were preferred for blunting. The production of these small straight-backed microliths may have resulted in a higher fragmentation than activity-related damages. The longest straight-backed microlith measures 25.1 mm while the smallest one was 12.2 mm in length (**Fig. 25F–G**).

Retouch mostly occurs from ventral to dorsal. Both obverse and inverse retouch is evident on the single edges of backed tools. Usually, retouch spreads from the distal ends to parts of the proximal ends. Some of the straight-backed tools retain parts of the proximal end. Only eight pieces present proximal modification for possible hafting. This type of retouch is not altering the original shape of the blank. The edge opposite to the backed side always displays intensive edge damages, suggesting that these backed tools were the most intensively used functional tools at the shelter.

The distribution of straight-backed microliths is not uniform at the shelter. Like other retouched and unretouched tools, straight-backed microliths mainly came from Middle Holocene (n=18) and Late Holocene (n=14) layers. The earliest occupational phase is represented only by two straight-backed pieces.

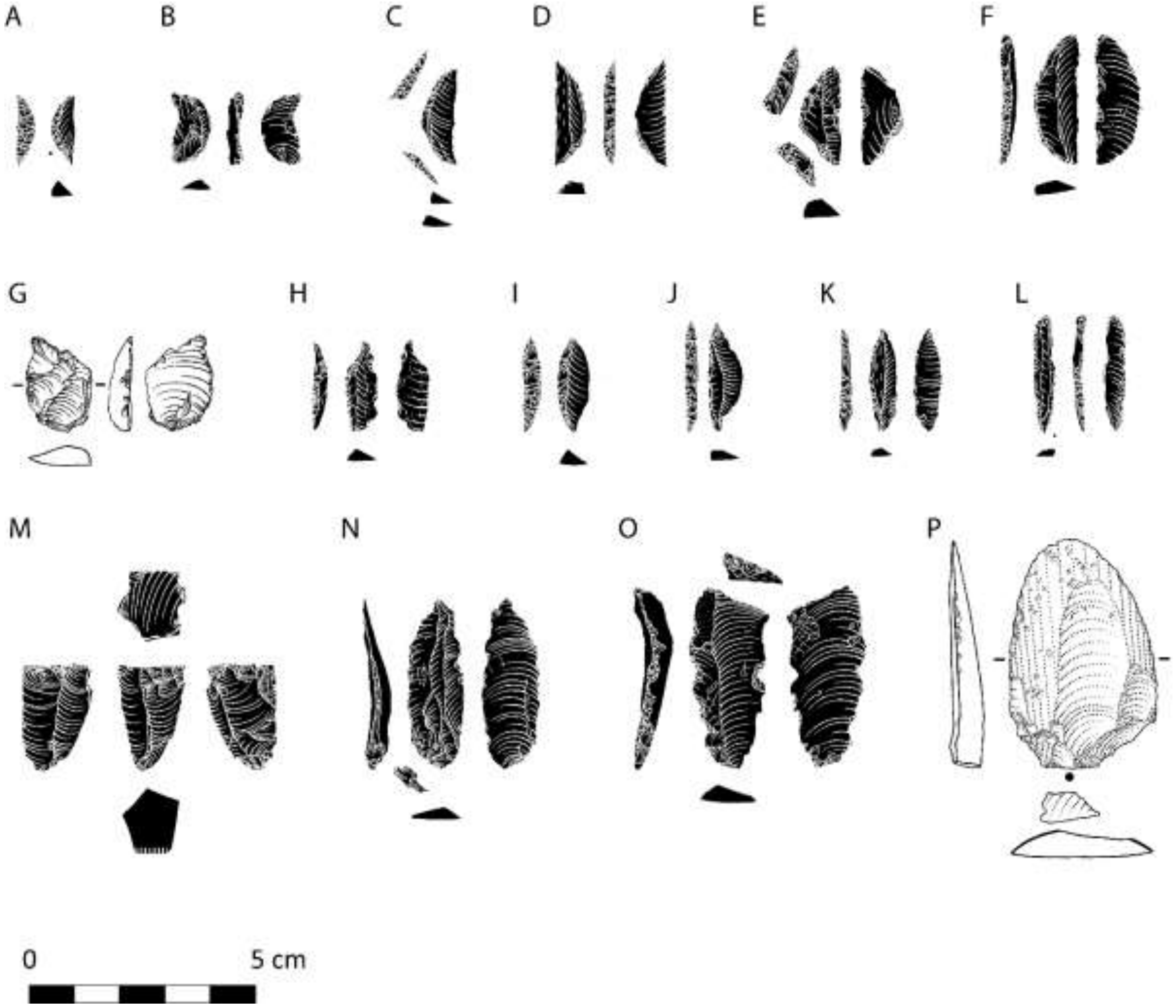

Fig. 29. *Drawing of retouched LSA microliths and scraper (P) from Simbero rock shelter.*

5.2.6.5.3.2. Crescents

The curved-backed microliths with typical crescent features (parts of proximal ends) represent 5% (n=14) of the total tool assemblage (**Table 11**). These crescents were produced on small elongated bladelet blanks based on laminar bipolar technology. The dimension of crescents also justifies the term microliths: the longest complete crescent is 29.4 mm, while the shortest one is 14.1 mm in length (**Fig. 25C–D; Fig. 29B; Fig. 30C**). Most of the crescents are complete (n=11), suggesting that they were little affected by post-depositional impacts at the shelter.

The backing techniques are not different from straight-backed microliths. The angles of backings are steep and cover the entire curved edge, except for parts of the proximal ends. The direction of backing also shows abrupt retouch either from dorsal to ventral or vice versa. The backing was more commonly carried out on the left edge (n=9) compared to the right (n=6). Almost all crescents show parts of proximal ends with some form of modifications. Both, the backed curved edge and the modified base might have been used for hafting the tool. In most cases, crescents with basal modifications may have been preferably used for hafting on the tip and the side (left or right) of the composite tool. Crescents occur concentrated during the Middle Holocene (n=8), while five pieces are associated with the Late Holocene occupational phase, similar to the distribution of straight-backed microliths (**Table 15**).

5.2.6.5.3.3. Segments

Segments are the second most dominant backed microliths, representing 9.7% (n=27) of the total tools. Out of the total counts of geometric microliths, segments were highly preferred specialized tools in the LSA lithic assemblages (**Table 11**). Like other backed tools, segments were made on both blades and bladelets, based on laminar bipolar technology (**Fig. 29E**). The segments at Simbero vary according to their size, ranging between 14 and 27 mm in length (**Fig. 25A–B; Fig. 27F; Fig. 29C–F; Fig. 30C–E)**. Among these, exceptionally small micro-segments (n=6) are nevertheless displaying both backing of the curved edge and a straight functional edge on the opposite side (**Fig. 29A–B, 29E; Fig. 30B)**. All segments show a regular backing that continuously covers the entire curved back with an abrupt retouch. The retouch is almost proportionally present on the left (n=15) compared to the right (n=12) edge, indicating that there might have been a careful concern on the production of both left and right edge-backed segments.

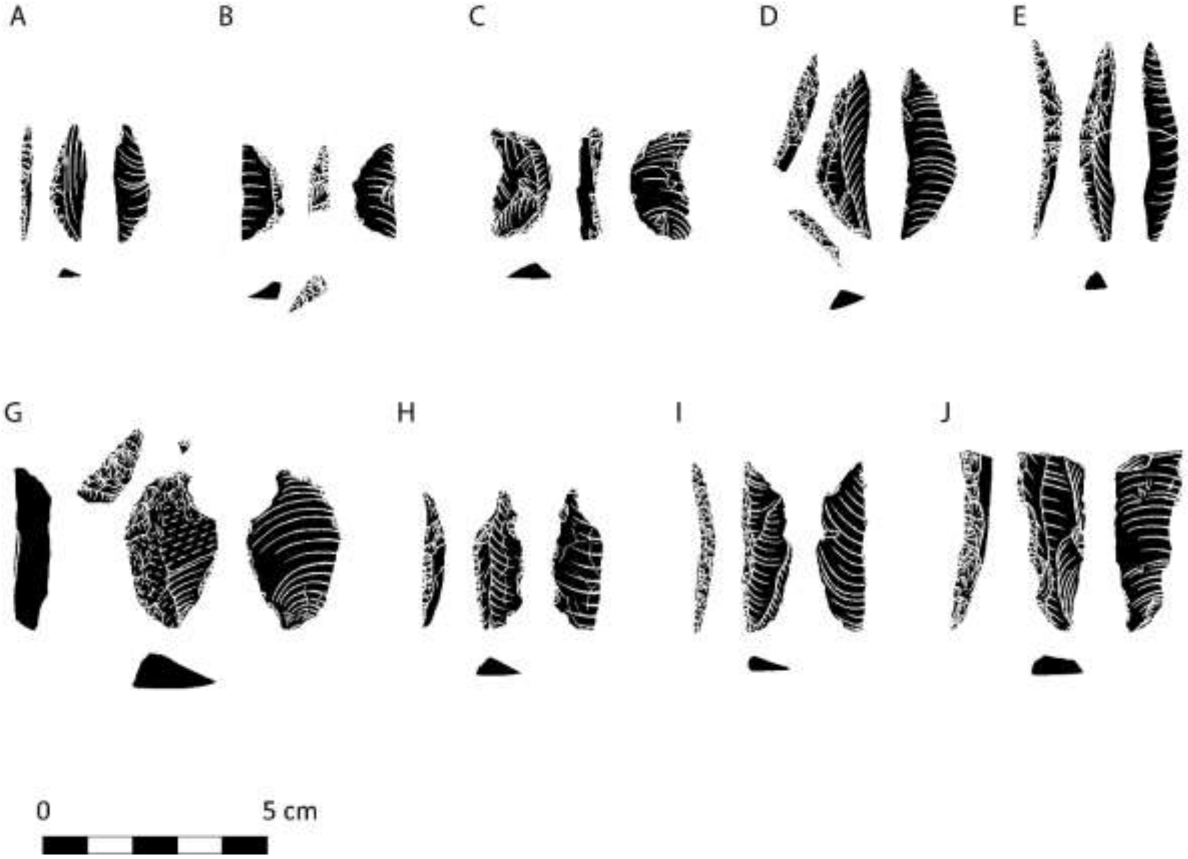

Fig. 30. *Drawings of microlithic artifacts from Simbero rock shelter.*

The distribution of segments parallels those of other retouched and unretouched tools. Segments were only present in the Middle and Late Holocene occupational phases (**Table 15**). The absence of segments at the bottom of the shelter indicates that hunter-gathers were engaged in tasks that required different tools. Most of the segments were exhaustively used before they were discarded. The damages on the straight edges of the segments can be related to activity impacts and not to post-depositional processes. In comparison to other backed microliths, the presence of regular segments at Simbero shows technological flexibility in producing different sizes and shapes of backed tools, probably for a similar function. However, the extent of backing on the curved edge changes the shape of the pieces. Like crescents, segments may have had a functional advantage in hafting on different positions such as transversal to or on the left/right sides of a composite tool. In most cases, all backed geometric and non-geometric microliths of Simbero show similar techno-typological characteristics.

5.2.7. Summary

In summary, the utilized and retouched tools at Simbero rock shelter typologically represent the most common LSA microliths of the Horn of Africa. These microliths are characterized by the production of small retouched and backed tools, often associated with composite tool technology. Microliths also include the unretouched tools produced through the common LSA lithic reduction methods. It is believed that most of the microlithic tools have been hafted into wood/bone to create specialized cutting implements.

The hunter-gatherers of Simbero probably had prior knowledge of LSA production techniques. The techno-typology of the tools indicates that a laminar stone technology was employed to remove bladelets, blades, and flakes from bipolar unidirectional volumetric cores. Moreover, the backed pieces at Simbero show the systematic use of the bipolar on anvil method mainly for the backing of geometric (segments, crescents) and non-geometric (straight-backed, partially curved) microliths. This type of lithic production technique was used from the beginning of the site`s occupation. The presence of a high frequency of fragmented lithics in the debitage is related to on-site activities of lithic production. The microliths of Simbero rock shelter were produced from prepared specialized cores namely tabular, prismatic and conical cores. The size of these cores is very small, suggesting that the production processes may have started outside of the shelter, probably at the quarrying site.

The size and diversity of the cores are paralleled by the recovered debitage and tool categories of the assemblage. Cores were fairly present in all occupational phases and were used to produce standardized blanks, consisting of bladelets, blades, and convergent flakes. Most of the tools were made on these blanks, prior detached by bipolar reduction (flakes) and freehand laminar reduction (bladelets, blades) techniques. This production technique corresponds to the concept of lithic miniaturization that appeared to be common already during the Terminal Pleistocene occupation. The microlithic assemblages at Simbero show no features of MSA or MSA/LSA transitional lithic assemblages of the Horn of Africa.

Based on the qualitative analysis, the microliths of the Simbero rock shelter can be categorized into three major tool classes namely, utilized, (laterally) retouched, and backed tools. In general, all of these tool classes fall under the categories of geometric (segments and crescents) and non-geometric (straight-backed, laterally retouched, and utilized tools) microliths. Most of the tools were made on bladelets, and followed by pointed flakes and blades.

The unretouched tools dominate the entire tool assemblages. These tools generally show a high degree of utilization at their edges and a moderate degree of modification at the proximal end for possible hafting purposes. Unlike the retouched tools, unretouched tools occurred continuously from the oldest occupational phase to the end of the Late Holocene. The hunter-gatherers might have preferred to use unretouched tools because the production of these tools required a shorter time than the production of retouched tools. Although we do not know the specific function, it is assumed that the unretouched tools – showing similar techno-typology with their retouched counterparts – may have been used for similar tasks at the respective periods.

The retouched tools at Simbero are heterogeneous and include all tools intentionally modified, especially either on distal ends or on lateral edges of predetermined blanks. Like the unretouched tools, the retouched tools were made on the same blank types: bladelets, blades, and pointed flakes. The frequency of the retouched tools varies depending on the preference of the hunter-gatherers but not due to raw material availability and quality. Scrapers are represented only by comparably small numbers, while borers appear to be a tool type of special local importance, occurring in all occupational phases for supposedly different tasks. The techno-typology of borers is relatively unparalleled by the production of other microliths at the shelter. Borers were made on all available flakes with notches to form the intended tip of the tool. The bases of these tools show more intense proximal modification than other microlithic tools, either for handling or for hafting of the tool.

At Simbero rock shelter, the abundance of small retouched tools might also contribute to the new debate on the variability of microliths of the Horn of Africa (MÉNARD ET AL. 2014; LEPLONGEON 2014). Laterally retouched microliths represent a high proportion of flaked tools and were overwhelmingly recovered from the Middle and Late Holocene occupational phases. The presence of a high frequency of retouched tools suggests that hunter-gatherers may have started new socio-economic activities at the beginning of the Middle Holocene. This assertion is based on the presence and absence of certain tool classes from the identified three occupational phases.

The economic base of the occupants seems to have been dependent on the production of backed microliths. Both geometric and non-geometric backed microliths represent the highest proportion of retouched tools. The backed microliths at Simbero are represented by straight-backed tools, crescents, and segments. The majority of these backed tools were produced on bladelets. The presence of a high frequency of laterally backed tools corresponds to the abundance of bladelet blanks and flake fragments in the debitage assemblages. Both geometric and non-geometric microliths were made at the shelter since the recovered backed tools contain a significant number of broken pieces that show production damage or failure.

In contrast to the youngest occupational phase, the Middle Holocene occupation yielded a high proportion of both tools and debitage elements. This high proportion of lithic materials was unparalleled by the recovered faunal remains. The Middle Holocene occupation contains only small amounts of the entire bone assemblage recovered at the archaeological square K4. The possible explanation for this variation might be related to the function of the shelter during the Middle Holocene period. Based on the presence of comparable faunal remains in association with abundant microliths and fire use, the Middle Holocene occupants appear to be less mobile than their predecessors and the shelter was apparently used for longer stays to produce lithic artifacts and to process animal meat.

Microliths remain the major components of functional tools during the Late Holocene occupations. However, the total number of microliths is much smaller, which might reflect the short duration of occupation compared to the Middle Holocene phase. In contrast, the Late Holocene occupation is associated with the majority of the faunal assemblage. Both geometric and non-geometric microliths were continuously employed from the early stages of the Late Holocene occupation phase, but were dramatically reduced at around 2 ka cal. BP. At this phase, the shelter also recorded the maximum use of fire as observed in the charcoal-rich sediments layers. This observed association of microlithic tools, faunal remains, and fire, suggests a function of the shelter as a permanent residence place during this younger occupational phase. The back of the shelter appears to be used for additional activities such as processing animal meat and skin. The K4 archaeological square which contains the entire faunal remains of the shelter indicates these intensive activities at the back of the shelter. Based on the chronological and stratigraphic data, the Simbero rock shelter appears to have been used from the Terminal Pleistocene to the Late Holocene. The deposition at the shelter started around 15 ka cal. BP. The shelter was more intensively used starting from around 8.1 ka cal. BP for specialized LSA hunter-gatherer's subsistence. The Middle Holocene occupants appeared to use the shelter for long stays mainly to produce lithic artifacts. The Late Holocene hunter-gatherers may have used the shelter for different settlement patterns. Since this period is characterized by the end of the African Humid Period, hunter-gatherers might have been required to deploy different subsistence strategies than before. The archaeological layers referring to this period yielded a high frequency of diverse faunal assemblages with a significant number of LSA microliths. Most of the faunal remains were also highly impacted by fire indicating that they are remains of meat consumption. The function of the shelter changed when the last Late Holocene occupants left the shelter. The deposits indicate some form of pastoral activities, which is, however, currently not only poorly dated, but also lacks sufficient cultural material.

5.3. MARARO ROCK SHELTER

5.3.1. Introduction

Mararo rock shelter is situated at 3779 m asl (6,954333° N; 39,737028° E) at the southeastern foothills of the Web Valley, bordering the central Sanetti Plateau of the Bale Mountains (**Fig. 2**). The landscape is highly dissected, emanating from the Mararo Mountain separating the Web and Wasama valleys (**Fig. 3**). The area where the shelter is located is currently characterized by the transition from the Ericaceous to the Afroalpine vegetation belts. The Mararo Ridge, which encircles the Web Valley, forms a small basin facing to the west with several water resources and is enriched with mixed vegetation of both vegetation belts. The already mentioned Wella stream (**Fig. 4A**) also starts from the base of the Mararo Ridge and drains to Fincha Habera. The plains around the Mararo basin are relatively spacious allowing rather easy animal and human movements. Most rock shelters – including Mararo – are concentrated along the basin margin, mainly on horizontally bedded basalt rocks. Unlike the other shelters, Mararo is a relatively big oval rock shelter, facing northwest (**Fig. 31**).

__Fig. 31.__ Views of Mararo rock shelter.

Located in an ideal position between the two vegetation belts, the formation of the shelter seems to be different from other shelters. Most of the shelters around the Mararo ridges were formed on the narrowly bedded basalt rocks while the Mararo rock shelter was formed within an exposed chain of boulders above the basin. These boulders have been altered by chemical and mechanical weathering and were probably impacted by the last deglaciation.

Mararo rock shelter is a large oval shelter, containing a wide interior space of approximately 27 m width at the mouth and 12 m deep to the back of the shelter. The height of the shelter from the overhanging roof to the surface amounts up to approximately 10 m. The floor of the shelter is covered with large rockfall boulders. The wall and the roof are witnessing both natural (cracks, weathered surface) and cultural impacts (fire) that also occur at other sites around the Mararo basin and ridges. The roof also shows the accumulated impact of fire use in the shelter. Although the shelter is located along the pathway to Wasama, the surface of the shelter was relatively undisturbed, which is therefore among the least affected shelter by recent Bale inhabitants. The sediments on the surface are loose gray and mixed with animal dung and plants (**Fig. 31; Fig. 32**).

Two archaeological squares were opened during the 2017 and 2018 excavation seasons. Archaeological square S8 is located to the north, towards the back of the shelter, while the more southerly square G8 is exposed to daylight (**Fig. 32**). The recovered samples include sediments, charcoal, lithic artifacts, pottery, and very few undiagnostic faunal remains.

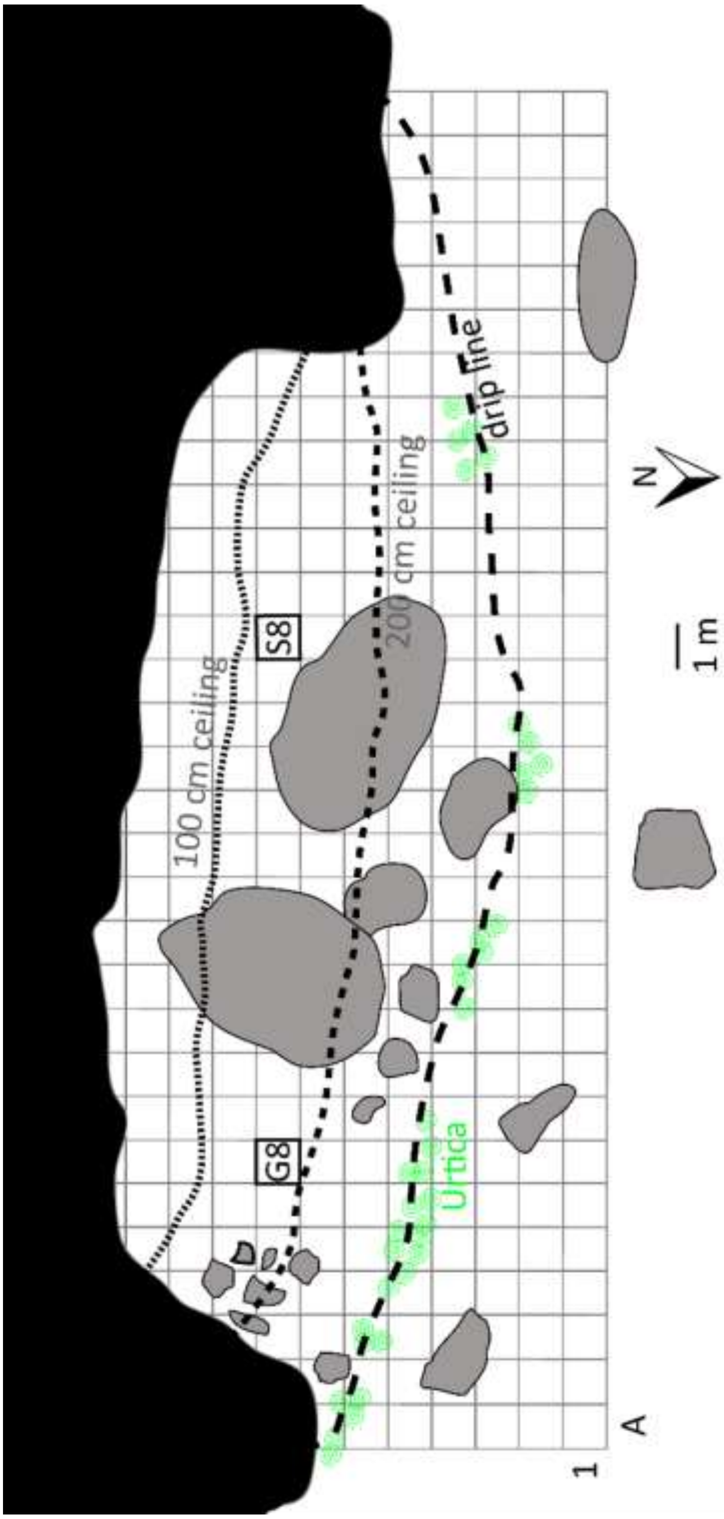

Fig. 32. *Plan view, excavation grid, and location of excavation units at Mararo rock shelter.*

5.3.2. Lithostratigraphic sequence

The Mararo lithostratigraphic units (MLSU) were reconstructed from the stratified deposits of both archaeological squares, S8 and G8 (**Fig. 32**). The chronology of the deposits (**Table 16, Fig. 33**) is based on seven radiocarbon dates from charcoal samples.

MLSU-01: The topsoil at Mararo is characterized by loose light brown sediments of around seven cm in thickness. It is relatively undisturbed by both humans and animals. The sediments at the southern parts of the shelter are compacted and exposed to sunlight as opposed to the back of the shelter, which contains loose light brown sediments. The northern parts of the shelter are covered with *Urtica* plants. The bottom of unit MLSU-01 features thin deposits of charcoal and grass beddings. The grasses were decomposed with sediments and appear to have covered larger areas of the shelter. The topsoil as well as the surface of the shelter yielded abundant diagnostic LSA microliths alongside few pottery shards. MLSU-01 was not dated and is represented by the archaeological level 0.

MLSU-02: This stratigraphic unit represents the deposition events related to the late pastoral occupations. The contact between MLSU-01 and -02 seems sharp and is marked by dark gray ash. The thickness of MLSU-02 varies from five to seven cm and comprises different events. The lower parts of this unit show massive fire events with burnt sediments which have altered the color of the sediments into yellowish. A high concentration of ashes is also documented in this unit. The single date from a charcoal sample yielded a modern age (**Fig. 33**). Archaeological levels 1 and 2 correspond to the late pastoral deposits.

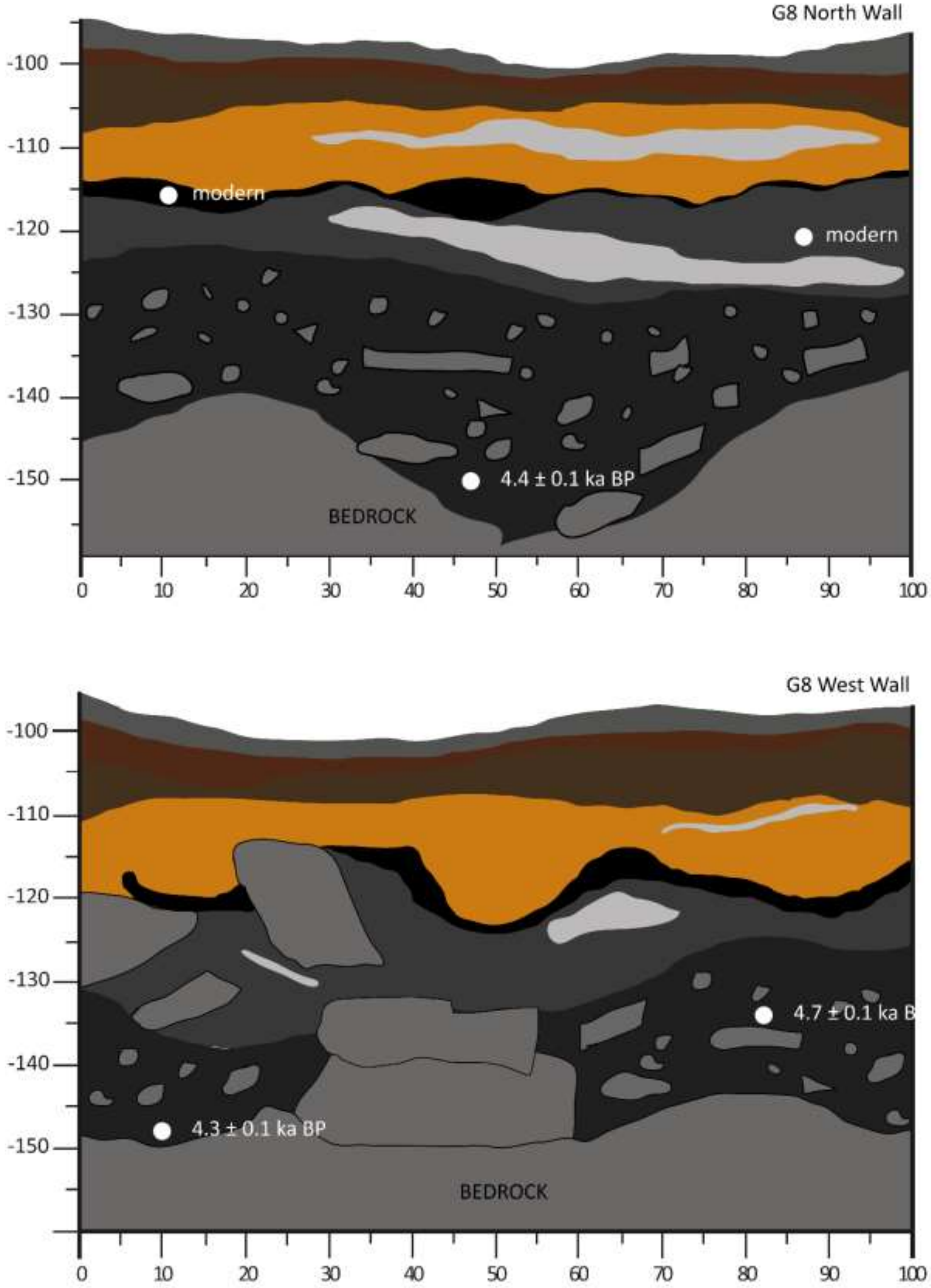

Fig. 33. *(caption on next page)*

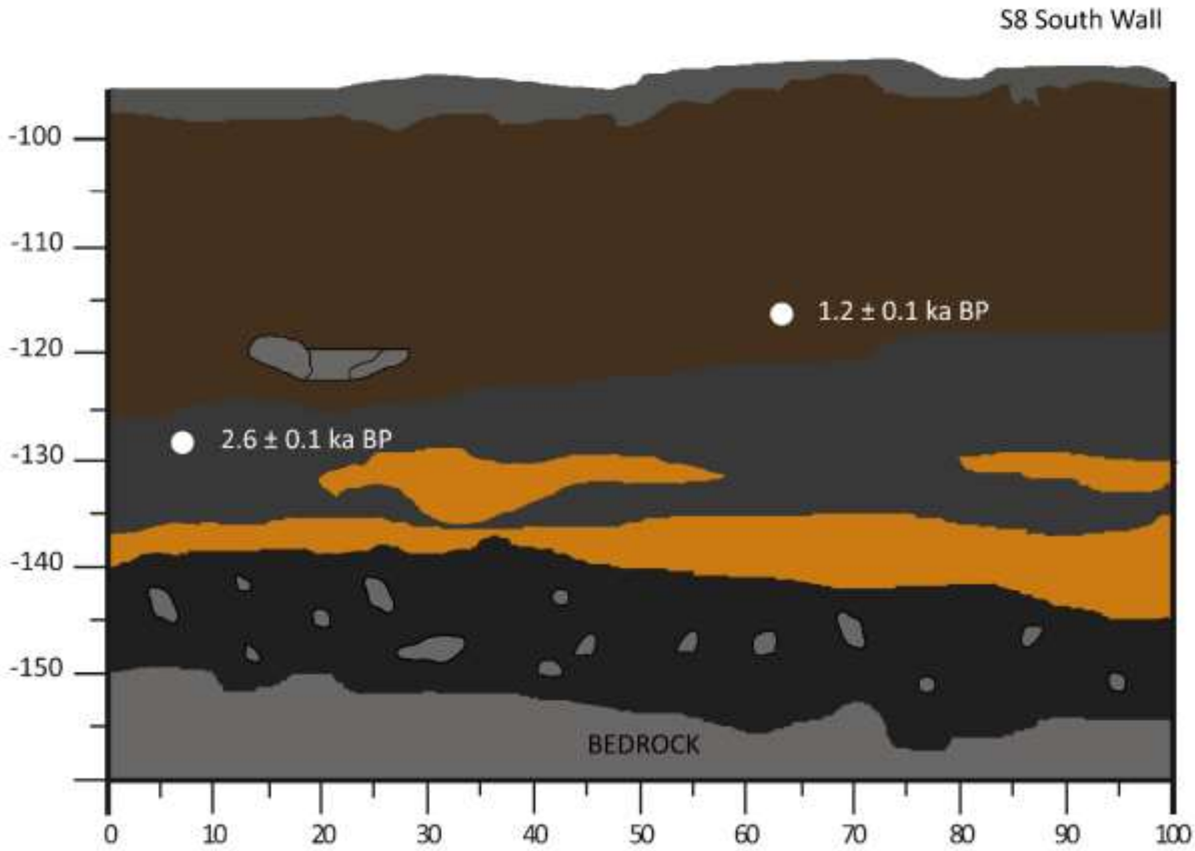

Fig. 33. *Stratigraphic sequence and projected radiocarbon dating results at Mararo rock shelter. North wall profile of square G8 (A), west wall profile of square G8 (B), and south wall of square S8 (C). See* ***Fig. 32*** *for the location of the profiles.*

Table 16. *AMS radiocarbon dates from Mararo rock shelter.*

Provenance	Material	Lab No.	14C Age BP	cal BP (1 Sigma)
S8/NW/-135	Charcoal	COL5189.1.1	-	-
S8/NE/-125	Charcoal	Beta - 461997	139.1 ± 0.5 pMC*	-
G8/NE/L5	Charcoal	COL5192.1.1	1.215 ± 37	1.092 - 1.218
G8/SE/L6	Charcoal	COL5193.1.1	2.467 ± 38	2.447 - 2.670
S8/SW/-150	Charcoal	COL5190.1.1	3.881 ± 43	4.251 - 4.389
S8/NE/-150	Charcoal	Beta - 461998	3.930 ± 30	4.315 - 4.420
P2 trench (25-30)	Charcoal	Beta – 503930	4.110 ± 30	4.572 - 4.779

MLSU-03: The unit below MLSU-02 is characterized by a single Late Holocene occupational phase. The upper part of this unit consists of black-gray sediments without gravel, while the lower part contains significant amounts of gravel. This unit is very dark because of the high content of organic material, mainly fine charcoal. The lower part of the unit is wet and mixed with loamy soil. The gravels in this unit seem to be roof fall. A thin ash layer also indicates the presence of a massive fire event, similar to the one observed in the upper pastoral unit (**Fig. 31**). This lower lithostratigraphic unit of the shelter is dated to 4.7 ± 0.2 ka cal. BP, originating from a charcoal sample of the lower layer of archaeological square S8. The same cultural group might have used the shelter until ca. 1.2 ± 0.6 ka cal. BP (**Table 16; Fig. 32**). All archaeological levels from 3 to 10 yielded the deposits of the Late Holocene occupational phase.

In summary, the archaeological square S8 contains sediment deposits that are distinct from G8, with higher concentrations of charcoal and lithic artifacts. However, both units show highly burnt sediments, suggesting that the impact of fire during the Late Holocene occupations was exceptionally intense (**Fig. 33**). The deposits below the surface appear to represent at least two distinct settlement events at the Bale Mountains. The late pastoral phase was short and insufficiently represented by finds for the reconstruction of the human settlement history. Two charcoal samples from this settlement yielded modern dates (**Table 16**). Based on the observed laminated dungs, probably from domesticated animals, the shelter was used intensively by animals during the pastoral phase. At the same time, the yellowish sediment and ash layers prove the intensity of the fire used by the occupants of the late pastoral group. The deposits below the pastoral settlement show stratified sediments referring to one cultural phase of hunter-gatherer settlement during the Late Holocene. The oldest phase from the bottom layer of the S8 archaeological square has an age of 4.7 ± 0.2 ka cal. BP. The upper part of the Late Holocene which dates around 1.2 ± 0.6 ka cal. BP belongs to different deposition events than the earlier phase (**Table 16**). The presence of a high concentration of charcoal is related to the intense use of fire in the shelter. The impacts of fire are also documented by numerous fire cracks and even melting of the surface of obsidian artifacts (**Fig. 34**). The bedrock below the oldest deposits consists partially of decomposed basalt rocks.

Fig. 34. *Photographs of obsidian artifacts with signs of fire impact from Simbero rock shelter.*

5.3.3. Lithic assemblage

The archaeological square S8 yielded 2009 stone artifacts as opposed to only 455 lithics in G8 (**Table 18; Appendix III**). The lithic artifacts were highly exposed to intensive fire in the shelter. Both debitage and flaked tools show the impacts of fire which sometimes considerably altered the shape and weight of the pieces (**Fig. 34**). Table 17 shows the concentration of the lithic artifacts within the Late Holocene occupational phase.

5.3.3.1. Raw materials

Two different lithic raw materials were identified in the lithic assemblage of the Mararo rock shelter. To a very small degree (n=6), chert was used to produce artifacts, and was recovered from both archaeological squares. The potential source for chert, the Genale Plain, is relatively far from the Mararo rock shelter (**Fig. 2**). Obsidian is the most dominant raw material (**Fig. 35; Table 19**). Electron microprobe analysis shows that almost all analyzed obsidian specimens from Mararo came from Wasama Ridge, only some 4 km east of the site (**Appendix V**). However, one single sample (ID70) shows a striking similarity of its geochemical composition with the obsidian occurrences at the Chebe/Korbeti volcanoes in the Rift Valley (NEGASH ET AL. 2020), in ~150 km direct distance to the site.

Table 17. *Frequency and percentage of artifact categories at Mararo rock shelter.*

Flaked Stone		**N**	**%**
Cores			
	Conical	6	13,9
	Prismatic	7	16,3
	Bipolar	7	16,3
	Core on flake	1	2,3
	Fragment	21	48,8
	Others & irregular	1	2,3
Total		**43**	**100,0**
Debitage			
	Angular waste	1136	50,6
	Bladelets/blades/flakes	588	26,2
	Blanks	120	5,3
	Chips	358	15,9
	Core trimming flakes	37	1,6
	Tested nodules	7	0,3
Total		**2246**	**100,0**
Utilized Tools			
	Utilized & modified	71	100,0
Total		**71**	**100,0**
Formal Tools			
	Segments	3	3,2
	Crescents	16	17,0
	Borers	42	44,7
	Straight-backed	6	6,4
	Retouched flakes/bladelets/blades	26	27,7
	Scrapers	1	1,1
Total		**94**	**100,0**
Total Lithics		**2454**	**100,0**

Table 18. *Frequency and percentage of artifact categories according to both archeological squares (G8 and S8) of Mararo rock shelter.*

Flaked Stone	**S8**	**G8**	**Total**	
	N	N	N	%
Cores				
Conical	4	2	6	13,9
Prismatic	6	1	7	16,3
Bipolar	5	2	7	16,3
Core on flake	-	-	1	2,3
Fragment	17	4	21	48,8
Others & irregular	1	-	1	2,3
Total	**34**	**9**	**43**	**1,8**
Debitage				
Angular waste	961	175	1136	50,6
Bladelets/blades/flakes	455	133	588	26,2
Blanks	101	19	120	5,3
Chips	312	46	358	15,9
Core trimming flakes	20	17	37	1,2
Tested nodules	3	4	7	0,3
Total	**1852**	**394**	**2246**	**91,5**
Utilized Tools				
Utilized & modified	55	16	71	43
Total	**55**	**16**	**71**	**2,9**
Formal Tools				
Segments	3	-	3	1,8
Crescents	15	1	16	9,7
Borers	29	13	42	25,5
Straight-backed	6	-	6	3,6
Retouched flakes/bladelets/blades	14	12	26	15,8
Scrapers	1	-	1	0,6
Total	**68**	**26**	**94**	**3,8**
Total Lithics	**2009**	**455**	**2454**	**100,0**

Table 19. *Frequency of debitage categories according to raw material in both archeological squares (G8 and S8) of Mararo rock shelter.*

Raw material	Chips	Flakes & blades	Blanks	Angular waste	Tested nodules	Core trimming flakes	Cores	Retouched/ utilized tools
Obsidian	358	588	120	1133	7	37	43	162
Chert	-	-	-	3	-	-	-	3

99.8% of all lithic artifacts in both archaeological squares are manufactured from obsidian (**Table 19; Fig. 35**). There are also very few banded obsidians included in the debitage category. Like other shelters at the Web Valley, the lithic assemblage of Mararo also contains few pieces of rolled, poor-quality obsidian (n=7) which appeared to have been tested before discard. However, both banded as well as patinated pieces proofed not to be geochemically distinct from the Wasama obsidian. In most cases, the quality of chert in the Bale Mountains seems poor and is represented by only 0.2% among the lithic artifacts (**Table 19; Fig. 35**). The lithic production processes therefore heavily relied on locally available obsidian. Obsidian is the most preferred raw material for all lithic classes while chert is limited to angular waste and flaked tools.

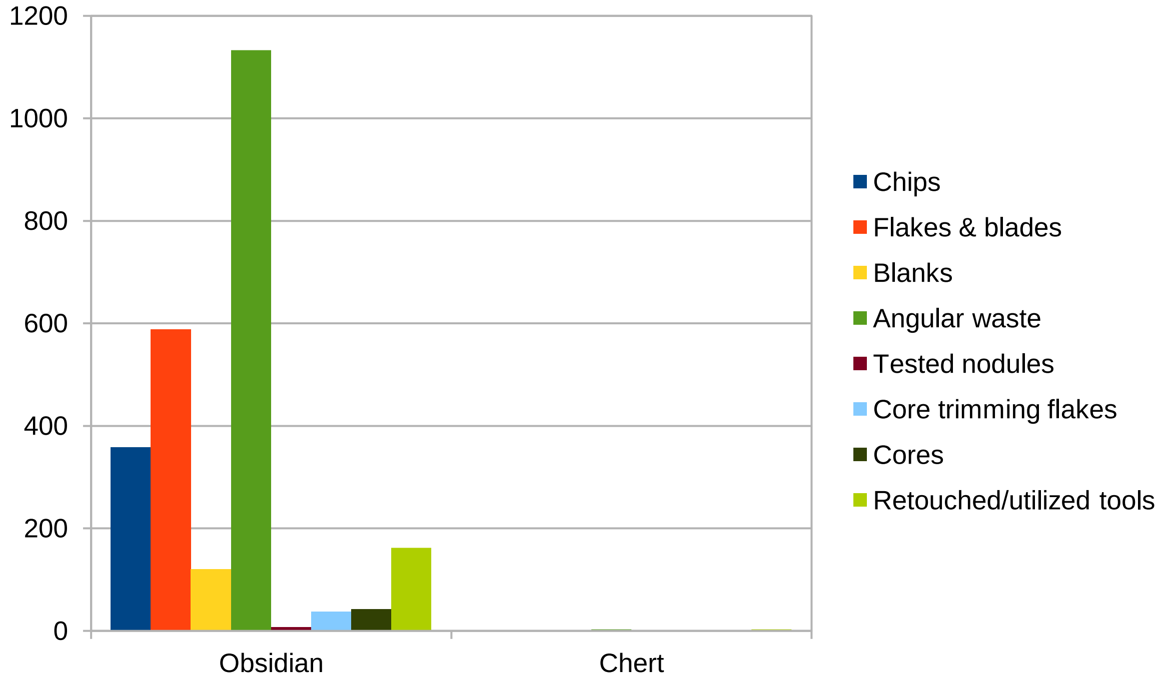

Fig. 35. *Chart of the frequency of raw material types according to artifact category at Mararo rock shelter (combined data of squares S8 and G8).*

5.3.3.2. Cores

The core sample is comprised of 43 pieces, accounting for 1.8% of the total assemblage (**Table 17**). Prismatic (n=7), bipolar (n=7), and conical cores (n=6) are the most common types, while bidirectional cores (n=4) were also identified. Many cores are fragmented (n=21), probably due to lithic production damages. Only one piece shows an irregular shape. All complete cores are characterized by small size; most of the flakes were detached from small prismatic, conical, and bipolar cores (**Fig. 36B–D**). All cores were made on obsidian and the possible explanation for the presence of small cores may be rather related to preferences due to technological reasons and not to the shortage of raw material given the vicinity of the obsidian outcrops.

The presence of abundant broken cores (n=21) suggests that intensive secondary core reductions were common practice at the shelter. This type of core reduction followed probably after the preferred cores were transported to the shelter (**Fig. 36A**). The cores are of small size regardless of whether they show fresh pieces with cortex or old negatives with highly rolled and patinated surfaces.

Only specific classes of debitage such as angular waste and core trimming flakes show a proportion of about 50% cortex on the surface. The size of the cores corresponds to the size of the recovered debitage and microliths. The archaeological square S8 contains more cores and core fragments than G8 (**Table 18**).

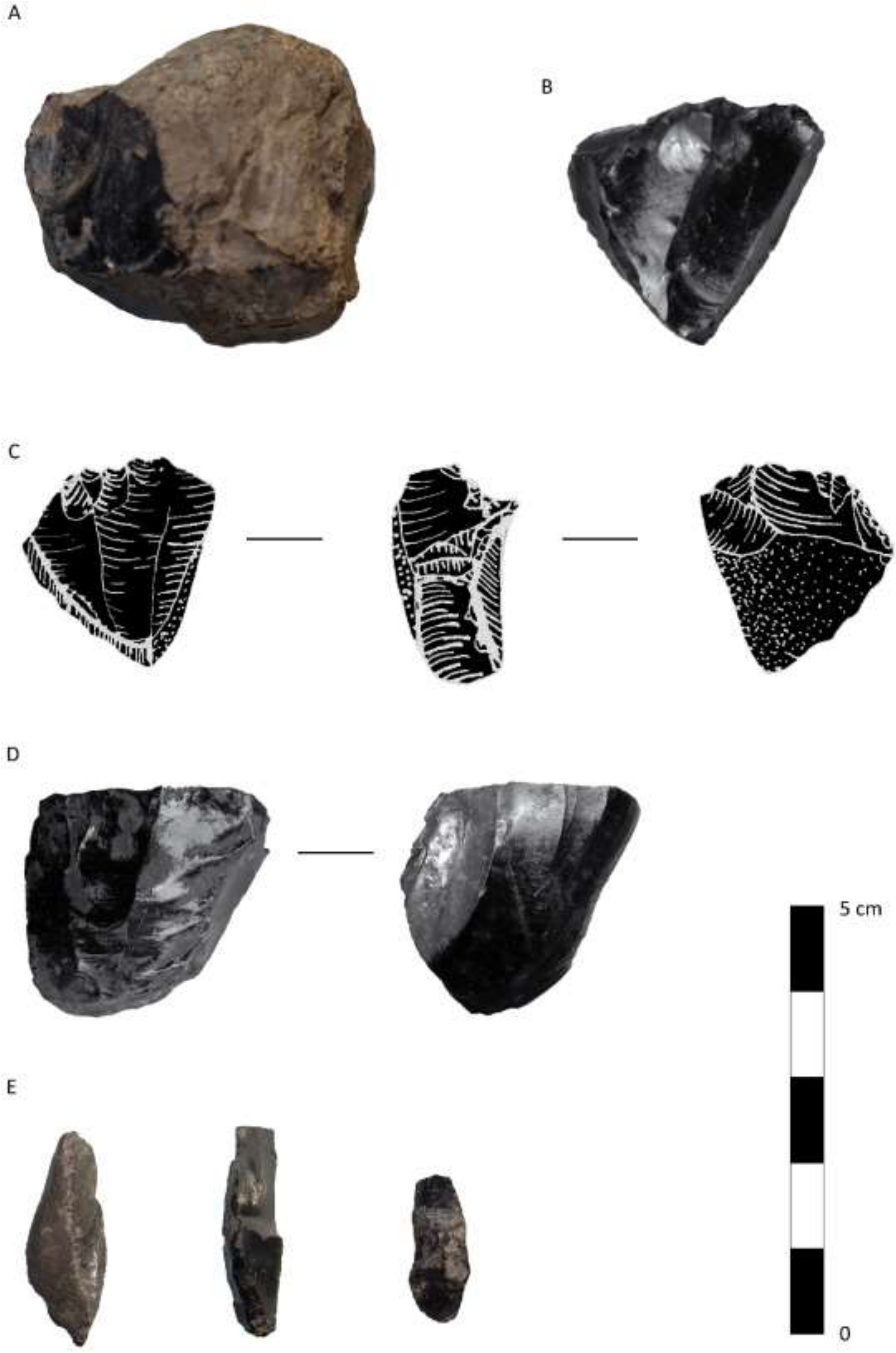

Fig. 36. *Photographs and drawings of selected cores and one blank from Mararo rock shelter.*

5.3.3.3. Debitage

The debitage, which represents 91.5% (n=2246) of the total lithic assemblage, is dominated by non-functional debitage such as unmodified flakes, angular waste, chips, and tested nodules (**Table 17**). The functional debitage (blanks and core trimming flakes) (**Fig. 36E**) is represented by a fair amount of 157 pieces, around 6.5% of the total lithic assemblage (**Table 17**). The Late Holocene occupation contains almost all debitage of the shelter (**Table 18**). Only three pieces of angular waste are made of chert, while the remaining pieces were on obsidian raw material (**Table 19**). A total of 101 flakes (4.5%) were complete blanks and around 340 flakes (15.1%) show some form of damage, either on the ends or on the edges. Around 350 lithic artifacts (15.6%, including flakes, core trimming flakes, and tested nodules) show a proportion of more than 50% cortex on their surface. There are also a few lithic debitage elements (n=25, 1.1%), which were highly impacted by fire in the shelter.

The debitage category is characterized by a high proportion of bladelets/blades and small convergent flakes. Comparisons among the debitage, cores, and tools suggest that the knapping patterns relied on the production of small artifacts largely produced by the bipolar lithic production technique. Moreover, the production of retouched and unretouched tools appeared to be the main target of the reduction sequences. The presence of exhausted small cores (**Fig. 36C**) and utilized retouched tools show that lithic miniaturization was a preferential and intentional process of lithic production among Mararo hunter-gatherers.

5.3.3.4. Tools

The tools at Mararo include both unretouched and retouched tools (**Table 17**). These microliths were made on specialized small mainly conical and prismatic cores from the locally available obsidian raw material. The lithic production techniques were dependent on laminar-based bipolar methods. Special tools, such as backed microliths, appear to be made preferentially on small parallel-edge blanks produced by the bipolar on anvil method. The few microliths recovered from the late pastoral layers (n=4) and the surface (n=5) are most probably re-deposited from the lower layers and therefore not considered here.

5.3.3.4.1. Utilized tools

Utilized tools are represented by 71 pieces, these are 2.9 % of the total lithic assemblage (**Table 19; Fig. 40**). These tools are laterally unretouched artifacts with a varying degree of edge damage due to utilization. The proximal ends of 20 of these pieces were intentionally modified, probably for hafting or handling the tool for freehand use. The most common basal modification is by dorsal retouch for thinning part of the platforms. The platforms vary from crushed (n=23) and pointed (n=10) to facetted (n=8) ones. The unretouched tools dominate the tool spectrum during the entire Late Holocene occupation.

All types of lithic blanks – such as small convergent flakes (n=13), bladelets (n=37), and blades (n=21) – were used to produce unretouched tools. Most of the unretouched tools are broken (n=43). These tools also show a varying degree of lateral edge damage, with the damage on both edges represented by 47 pieces while damage of single edges occurs on 24 pieces. The longest utilized tool measured up to 29.6 mm, while the smallest one was 14.3 mm in length. Like the debitage and other retouched tools, the S8 archaeological square contains most of the utilized tools of the shelter (**Table 18**).

Table 17 shows the relative frequency and percentage of utilized tools within the total lithic artifacts recovered from the Late Holocene occupation deposits. On the other hand, **Table 18** also presents the differences in the spatial distribution of unretouched tools between both archaeological squares.

In summary, the utilized tools show a high degree of lateral edge damage. Given the extent and regularity of damage documented from the unretouched tools, the function of the tools seems to be responsible for this pattern, rather than post-depositional changes. Most of the unretouched tools were not elongated tools and remained under 30 mm in length. The utilized tools also show intentional proximal modification with thinning and retouch for possible hafting or handling of the tools during use. Like other tools in the shelter, the functions of utilized tools are not known. The presence of a high frequency of utilized tools in the assemblage suggests that the occupants of Mararo were exploiting both formal and informal tools.

5.3.3.4.2. Retouched tools

The retouched tools form the largest component of microliths (**Table 20**). The retouched tools include heterogeneous non-geometric LSA microliths tools. The retouched microliths are the most dominant and represent 41.8% (n=69) of the microlithic tools. These microliths are represented by preferential tools such as borers, laterally retouched tools, and scrapers. Both prismatic and conical cores were used to produce retouched microliths.

All retouched tools in the current sample are made on small-sized blanks of bladelets, blades, and pointed flakes. In most cases, the edges and ends of the tools are often retouched with fine retouches including notches and truncation. Like the retouched microliths at Simbero (**Chapter 5.2.6.5.2**), most retouch scars are fine and short, either on the dorsal or on the ventral side. Since the sources of obsidian raw material are not far, almost all retouched microliths were made on good quality obsidian. Bladelets were highly exploited to produce retouched tools, followed by convergent flakes and blades. The length of the retouched tools remains below 50 mm in height.

The non-geometric retouched tools are dominated by borers and followed by laterally retouched tools. Only one scraper, a denticulate scraper, was documented from square S8 which suggests that the occupants of Mararo were dependent on other retouched tools. The presence of a high frequency of borers in the lithic assemblage indicates a shift of survival strategy that matches with the high-altitude environment of the Bale Mountains. Similar to the utilized tools, retouched tools reflect the size and diversity of cores and debitage of the shelter. The presence of retouched microliths at the bottom deposits suggests that early occupants of the shelter had prior knowledge in producing such specialized tools (**Table 20**).

5.3.3.4.2.1. Laterally retouched tools

Laterally retouched microliths constitute the second largest portion of retouched tools. A total of 26 pieces, which account for 15.8% of the total tools, were identified from the Late Holocene occupational phase (**Table 17; Table 20**). Only one retouched tool was additionally recovered from the uppermost layers. These tools were made mainly on blades (n=12), pointed flakes (n=10), as well as on bladelets (n=4) (**Fig. 37B; Fig. 38D; Fig. 39B**). The proportion of complete and broken retouched tools is almost equal: a total of 14 pieces are complete, while the remaining 12 tools were broken, either during production or functioning or even by post-depositional impacts

Table 20. *Frequency of backed microliths; retouched microliths, and utilized tools according to vertical excavation levels in both archaeological squares (G8 and S8) of Mararo rock shelter.*

Layer	Backed Microliths			Retouched Microliths			Utilized	Total
	Segments	Crescents	Straight-backed	Borer	Lateral retouch	Scraper		
0	-	-	-	1	-	-	4	5
-110 (1)	-	-	-	1	-	-	1	2
-115 (2)	-	-	-	1	1	-	-	2
-120 (3)	-	-	-	1	-	-	1	2
-125 (4)	-	-	1	1	-	-	2	4
-130 (5)	-	6	2	15	2	-	18	43
-135 (6)	-	3	1	12	5	-	4	25
-140 (7)	1	2	-	2	6	-	9	20
-145 (8)	2	3	1	6	10	1	17	40
-150 (9)	-	2	1	2	2	-	15	22
Total	3	16	6	42	26	1	71	165

Based on the morphology of the laterally retouched tools, the (semi-)convergently retouched tools resemble points with intense proximal modification. Like other laterally retouched tools, most of these points bear retouch on one edge. The lateral edge, located opposite to the retouched side, displays intense edge damage, similar to those of unretouched tools.

Like other microliths, the dimension of retouched tools corresponds to the size and diversity of cores and debitage. The longest laterally retouched tool measures 32.9 mm, while the smallest one is 11.2 mm in length. Most of the laterally retouched microliths were not altered at the proximal end. The platforms of these tools show intensive preparation of cores with a soft hammer and anvil.

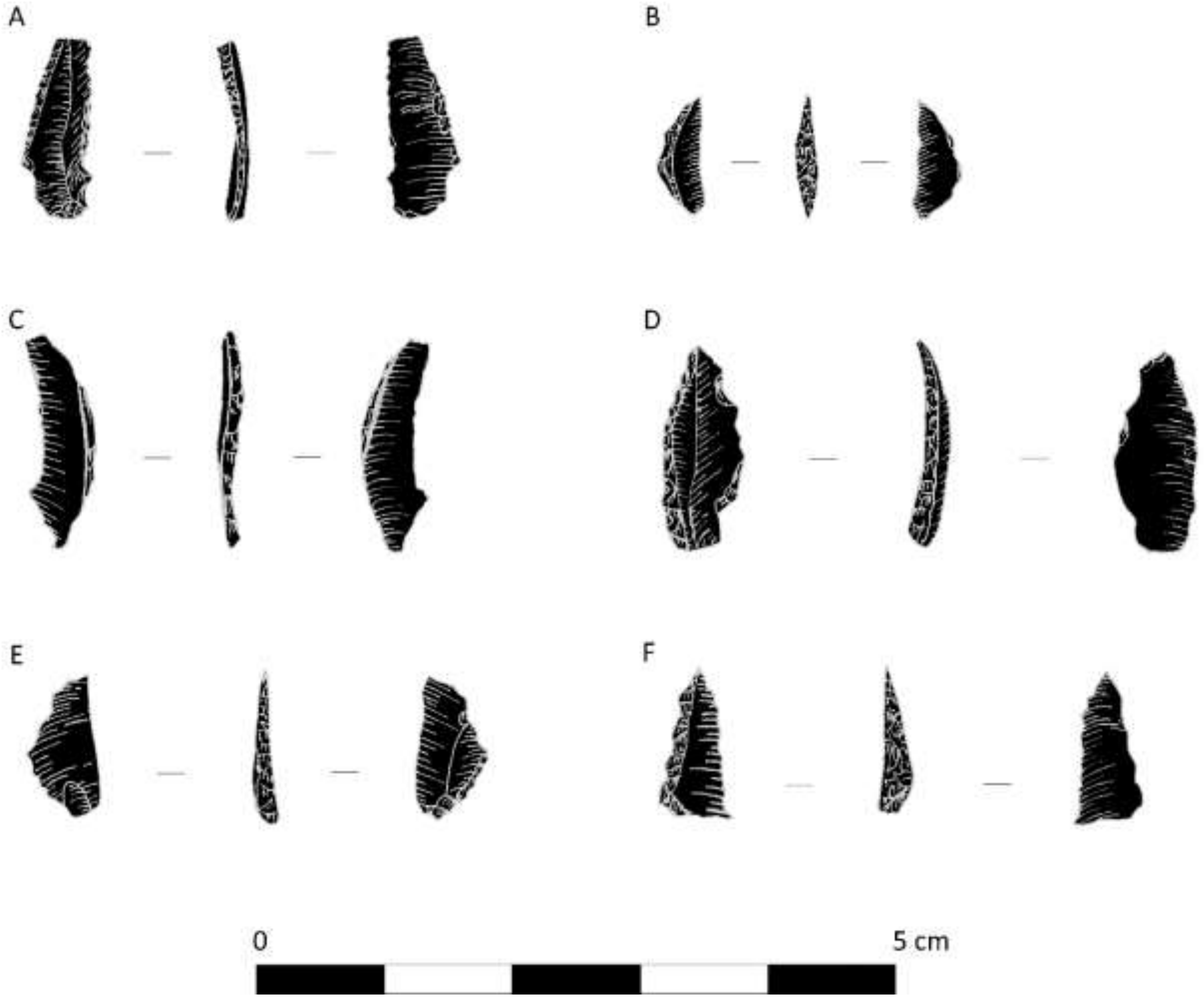

Fig. 37. *Drawings of retouched LSA microliths from Mararo rock shelter.*

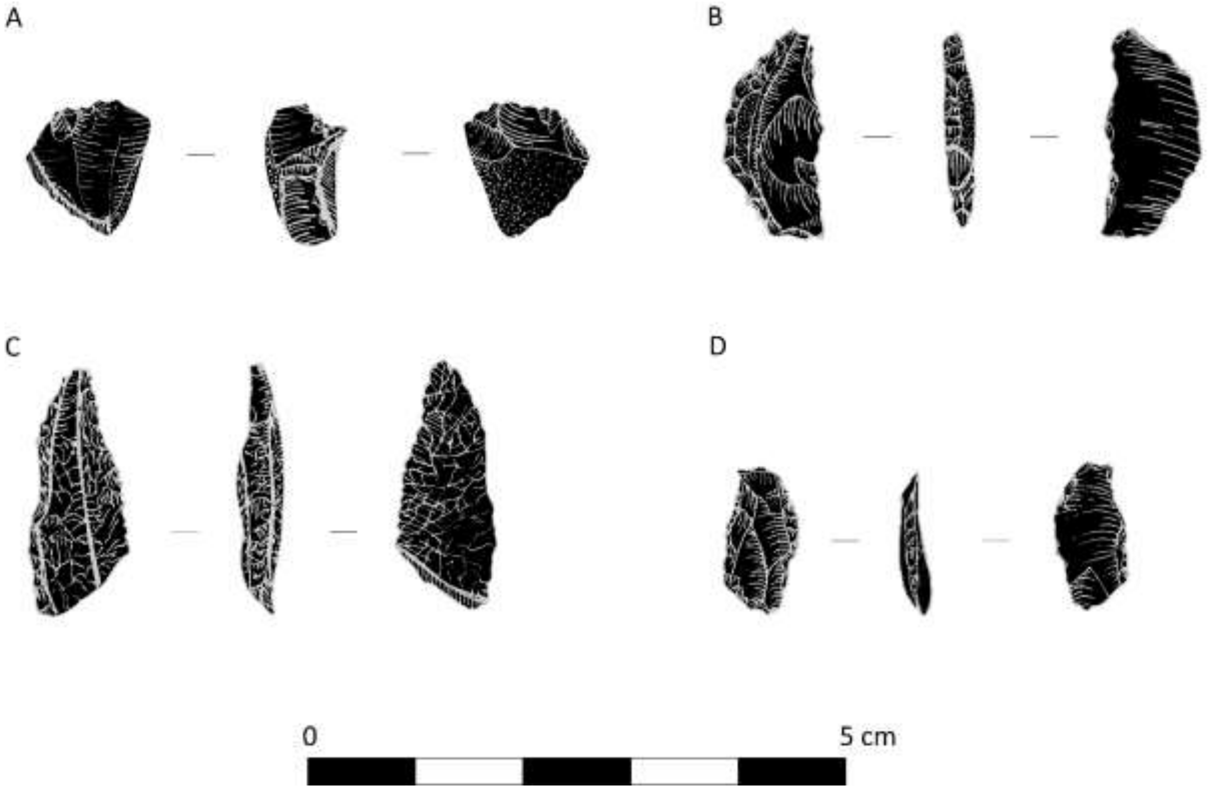

Fig. 38. *Drawings of retouched LSA microliths from Mararo rock shelter.*

The laterally retouched microliths show a uniform pattern of retouch on the edges and the dorsal faces. The direction of retouch occurred mainly from ventral to dorsal. Most of these retouched tools show a range of retouch, including inverse, fine, rough, semi-invasive retouch, and notches. Retouch often occurred on one edge with the opposite edge displaying different degrees of edge damages. The retouch (and use) did not alter the original shape of the blanks. The retouch on the proximal ends shows intentional modification similar to the lateral sides but is limited to a few tools. Currently, there is no sufficient information on whether the proximal thinning was intended for hafting or for other purposes.

5.3.3.4.2.2. Borers

A total of 42 borers, 25.5 % of all retouched tools, were identified from both archaeological squares (**Table 16; Table 20**). Thus, borers dominate the total of retouched microlithic tools. Most of these were recovered from square S8 (n=29), while the remaining 13 pieces originated from G8 (**Table 18**). The Late Holocene occupational phase contains almost all borers except for three pieces from the late pastoral phase (**Table 19**). These three borers seem to be re-deposited into the upper layers. Most of the borers show single-pointed tips (**Fig. 39A, 39C–D**) while a few feature more tips (multi-borers). Five borers were exhaustively used on their working edges before being discarded (**Fig. 39C**). Only one borer was made on chert while the remaining 41 pieces were from the locally available obsidian raw material.

Table 21. *Frequency and percentage of tools in the Late Holocene occupational phase at Mararo rock shelter.*

	Backed Microliths						**Retouched Microliths**						**Utilized**		**Total**	
Late Holocene	Segment		Crescent		Straight-backed		Borer		Lateral retouch		Scraper					
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Total	**3**	**1,8**	**16**	**9,7**	**6**	**3,6**	**42**	**25,5**	**26**	**15,8**	**1**	**0,6**	**71**	**43,0**	**165**	**100,0**

Most of the borers show at least one notch to form the tip of the borer. The distal end of the blank was often chosen to form the tip of the borer. In most cases, retouch by notching was the first prerequisite to form the tip of the borer. Some of these notches were additionally finely retouched. In addition to the notch, retouching of the tip, especially the curved convex edge, appears to be a common tradition in the production of borers (**Fig. 39A; 39C–E**). Moreover, the edges opposite to notched tips were also finely retouched, probably to sharpen the tip. On the other hand, the proximal parts of most borers were modified by truncation, retouch, and thinning, while still retaining the platforms. The borers have mainly facetted platforms (n=13), besides pointed (n=6), and crushed (n=4). 18 borers were modified with semi-invasive retouch at the proximal ends, probably to reduce the thickness of the base.

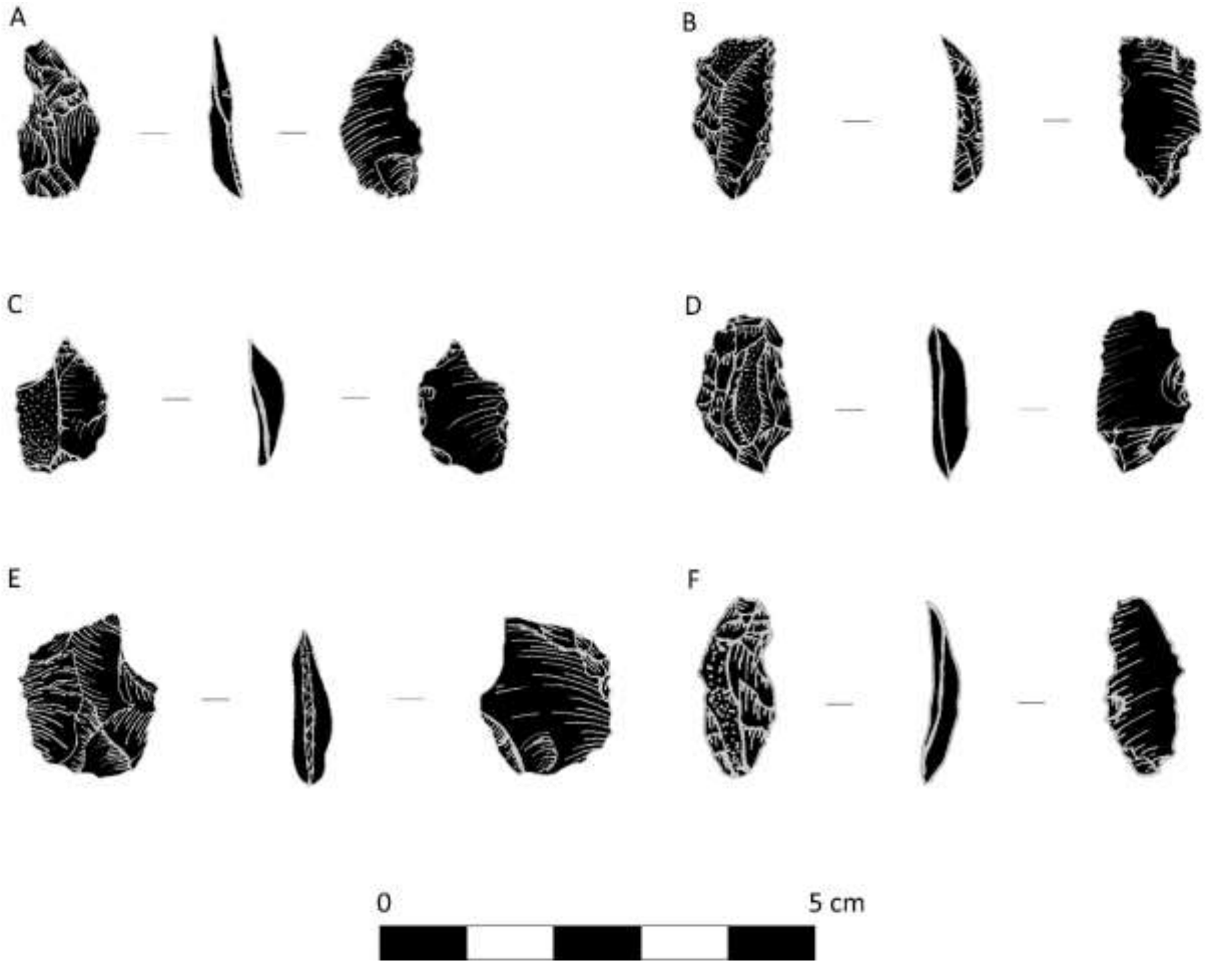

Fig. 39. *Drawings of microlithic tools from Mararo rock shelter.*

Comparable to other retouched and unretouched tools, the functions of the borers are not known. The presence of abundant borers in the flaked tool assemblage suggests that the occupants of Mararo may have had an additional concern within the common subsistence activities. The techno-typology of borers shows complex features such as the combination of different retouch. In terms of the presence of intensive proximal modifications on the borers, it should be clarified whether the shaping was for hafting. In most cases, borers appear to be freehand tools to process animal hides. If that was the case, the proximal modification should be associated with the handling of the tool during hide-working.

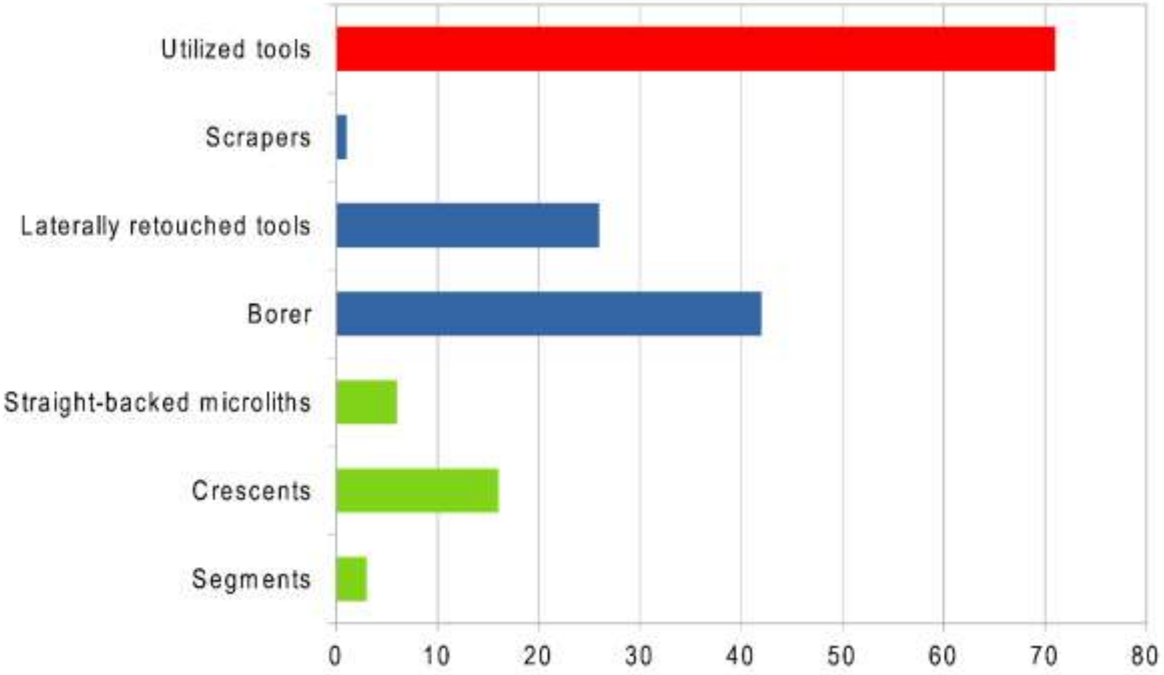

Fig. 40. *Chart of the total frequency of LSA microliths from Mararo rock shelter (combined data of excavation squares S8 and G8) with backed microliths (green), retouched microliths (blue,) and utilized tools (red).*

5.3.3.4.3. Backed tools

Backed tools are the third major component of LSA microliths at the Mararo rock shelter. A total of 25 pieces that accounted for 25.6 % of all tools were identified from the Late Holocene occupational phase (**Table 17; Table 20**). There are no backed microliths from the subsequent pastoral phase. Both geometric and non-geometric backed microliths were used at the shelter. The backing of microliths was uniform, especially in displaying abrupt retouch only on one edge. All backed microliths were made either on bladelets or blades that feature parallel edges and dorsal negatives up to the distal end. The backing of microliths occurred on one edge (curved or straight) to achieve the blunting, while the opposite rectilinear edge remained sharp for use.

The backed tools are represented by geometric (crescents, segments) and non-geometric (straight-backed, partially curved) backed microliths. Almost all of them were made on blades/bladelets of obsidian, except for one crescent on chert (**Fig. 37; Fig. 38**). In contrast, the distribution of backed microliths is not uniform. Segments and straight-backed pieces are the least represented, while crescents (n=16) are dominant in the counts of backed tools.

The production of backed tools passes the entire complex lithic reduction sequences of the common LSA production techniques. All backed microliths were manufactured mainly from well-prepared cores through the bipolar and laminar techniques. The techno-typology of these microliths corresponds to the size and diversity of cores, blanks, and other retouched and unretouched tools in the shelter.

5.3.3.4.3.1. Straight-backed microliths

Straight-backed tools show an abrupt retouch on one straight or only minimally curved edge. The edge opposite to the backed side remains sharp for cutting (**Fig. 37A; Fig. 39F**). The backing often runs from the proximal to the distal end, either bi- or unidirectional, and was applied to one edge with the use of a steep angle. All straight-backed microliths indicate the production of blanks from small-sized prismatic and conical cores. Some of the straight-backed microliths show partial basal modifications, however without the removal of bulbs and butts. Proximal modification and backing could have been associated with the hafting of straight-backed microliths.

This tool class represents 3.6% (n=6) of the total tools (**Table 21**), composed of four straight-backed and two pieces with backing on partially curved edges. Among this limited sample, only three pieces are complete. This might be the result of knapping accidents during the production of extremely small bladelets. The longest straight-backed microliths measured 16 mm, while the smallest one was 13 mm in length. Most of the straight-backed microliths were recovered from the archaeological square S8 (**Table 18**). All straight-backed microliths were produced on the locally available obsidian raw material.

Technologically, the straight-backed microliths of Mararo resemble those from Simbero rock shelter. Retouch occurs mostly from ventral to dorsal, while the reverse direction is very rare. There is no preference for the backing side, as three pieces show backing on the right as well as three on the left side. Backing and basal modification did not alter the original shape of the blank. Like the Simbero straight-backed microliths, almost all pieces had parallel lateral edges. Moreover, the edges opposite of the backing show intense edge damages, suggesting that straight-backed tools were actively used as functional tools.

In contrast to retouched and utilized tools, the total count of straight-backed microliths is very small. These microliths might have been used in combination with other geometric-backed microliths. In most cases, straight- and partially curved-backed microliths were probably used on the lateral side of a composite tool.

5.3.3.4.3.2. Crescents

Crescents account for 9.7 % (n=16) of the total retouched tools (**Table 17; Table 21**). While two pieces can be classified as micro-crescents, the remaining 14 crescents are more of common size and shape (**Fig. 37C, 37E**). A total of 10 crescents were complete. Most crescents were produced on small bladelets with the use of laminar-based bipolar reduction techniques. The longest complete crescent was 26.5 mm and the shortest one is 13.9 mm in length. Almost all crescents of the shelter were recovered from archaeological square S8 (**Table 18**). Only one crescent was made on chert while for the remaining pieces locally available obsidian was used.

The production process in finishing crescents passes the same backing techniques applied for other backed microliths. Like other backed microliths, all crescents show the use of the systematic bipolar method on an anvil for the backing. With the exception of the proximal ends, the backing covers the entire curved edge of the tool. The angles of backing were steep, blunting the curved edge while the opposite rectilinear edge remained straight and sharp. The backing shows an abrupt retouch from ventral to dorsal and very few vice versa. Most of the crescents show unidirectional (n=14) backing, and only two pieces exhibit bidirectional backing. The backing occurs slightly more often on the right edge (n=9) than the left (n=7).

In contrast to other geometric tools, the proximal ends of the crescents show little alteration on the proximal ends. Only six pieces had some form of proximal modifications, however without the removal of proximal features such as the bulb, or parts of the platforms. Crushed platforms were observed on seven crescents and three pieces have pointed platforms. Besides the backings of the one edge, the basal modifications altered the original shape of the tool. The backing of crescents either on the right or left edges is probably related to the hafting position of the tool on a composite tool. Most of the crescents show no sign of curation but seem to have been discarded after considerable edge damages on the straight edge have occurred.

The distribution of crescents was clearly concentrated in the middle layers within the Late Holocene occupational phase. Currently, there is no possible explanation for the disproportional representation of the crescents compared to segments and straight-backed microliths. Since all curved-backed microliths were produced with the same lithic production techniques, the abundance of crescents appears to be rather connected to the preference of the knappers, while the shortage of raw material can be excluded as the crescents of Mararo were made on the obsidian from the nearby Wasama Ridge.

5.3.3.4.3.3. Segments

Segments were the least represented backed microliths, accounting for only 1.8 % (n=3) of the total tools (**Table 17; Table 21**). Like other backed tools, segments were made on both blades and bladelets based on laminar and bipolar technologies.

The size of the identified segments differed: one segment (ID72; **Fig. 38C)** was exceptionally large, measuring 30.8 mm in length. This segment is partially burnt, and the entire dorsal and ventral faces show fire cracks. All segments exhibit the most common features of microliths: the backing of the curved edge while the straight functional edge remains sharp (**Fig. 38B**). Micro-segments are also included in the geometric microlith assemblage (**Fig. 37B**). All segments had a regular backing, covering the entire back with abrupt retouch, either obverse or inverse. These types of retouch may have been carried out with the bipolar technique, using an anvil. The backing is present on the right edge of the tool exclusively.

The distribution of segments is not parallel to other retouched and unretouched tools. The recovered segments were limited to the bottom of the Late Holocene layers (**Table 20**). All segments were also exhaustively used before they were discarded. The straight edges of both smaller segments show activity-related damages, while the surface of the giant segment shows the impact of fire. The presence of these very regular segments shows the presence of prior knowledge in producing backed tools. It is believed that the segments may have been used as functional tools with hafting in different positions of the composite tools.

5.3.4. Summary

In summary, the flaked tools at Mararo are not continuous samples but rather a snapshot in the understanding of human adaptation in the central parts of the Bale Mountains. The recovered lithic assemblages represent a distinct occupational event within the Late Holocene. The deposits above the Late Holocene occupation yielded insufficient material evidence about the late pastoral activities at the high-altitude of the Bale Mountains. The size and location of the Mararo rock shelter seem to be ideal for hunter-gatherer’s subsistence. The lithic artifacts of Mararo are characterized by the production of small functional tools. This includes utilized as well as retouched tools, the latter including backed microliths. These tools were produced through a laminar-based bipolar lithic production method. The presence of abundant small-sized cores suggests that the lithic production process appears to have started outside the shelter, probably at the Wasama Ridge quarry site.

Almost all blanks were detached from well-prepared, specialized cores such as prismatic, conical, and tabular cores. These predetermined blanks were further modified through retouch and backing until different microlithic tools were produced. Both soft hammer and pressure flaking may have been used for the production and shaping of the microliths. Both, the bipolar technique and pressure flaking may have been used for the backing of the microliths. Geometric and non-geometric backed microliths show the systematic use of the bipolar on anvil method especially for the backing of the lateral edges. Like the microliths of Simbero, the microliths of Mararo show intentional proximal modification for possible hafting and freehand use.

The microliths can be categorized into three major tool classes: utilized, (laterally) retouched, and backed tools. Techno-typologically, segments and crescents represent the geometric microliths while utilized, retouched, and straight-backed tools represent non-geometric microliths. These microliths show similar techniques of lithic production used at Simbero rock shelter but also from the sites in the Ethiopian Rift Valley and the Southeastern Ethiopian Highlands. These production techniques entail the concept of lithic miniaturization, which appears to be widespread at least during the Mid-Holocene. Most of the retouched and unretouched tools were made on bladelets, blades, and pointed flakes. There were no flaked tools with MSA characteristics within the Mararo lithic assemblage.

The tool assemblage of Mararo is dominated by the abundance of unretouched tools. These tools are characterized by a high degree of utilization with only moderate and occasional modification of the base, possibly for hafting. Around 25% of the recovered unretouched tools show some form of basal modification either by thinning, or retouch on the dorsal face of the base. The high frequency of unretouched tools (45% of all tools) in the basal archaeological layers suggests that the hunter-gatherers may have been forced to produce a high number of tools in a short time. Moreover, the proximity of the Mararo rock shelter to the obsidian source area might have favored the production of more formal tools than informal ones. Based on the distribution of both tool classes, the production of both the retouched and unretouched tools was in an advanced stage before the early occupants settled at the Mararo rock shelter.

The production of microliths is characterized by the abundance of specific retouched tools, rather than by backed microliths. The frequency of borers and laterally retouched tools suggests that the occupants of Mararo were engaged in different domestic activities. The highland environment might have required the production of a higher number of borers and laterally retouched tools compared to backed microliths and scrapers. Currently, there is no explanation why scrapers are represented only by a single piece in the lithic assemblage. Especially borers appear to be of special local importance, occurring in all archaeological layers.

The production of borers differs from those of other microlithic productions. Most of the borers were made on convergent and semi-convergent flake blanks, followed by blades. Not a single piece was made on a bladelet blank. At least two types of borers were common at the Mararo retouched tool classes. Single-pointed borers were abundant, followed by a few multi-borers. The tips of the borers were specially prepared by at least a single notch and supplemented by additional retouch such as truncation. In most cases, the distal ends were prepared to form the tip of the borer. In some instances, the proximal end and the lateral edges of irregular blanks were used to form the tip of the borer. The bases of the borers show intensive modification with notches, truncation, and fine and semi-invasive retouch, either for handling the tool or hafting. Whereas micro-wear analysis is still in process, their function is not known, but it is assumed that they are related to the processing of animal hides, probably for making clothes.

Laterally retouched microliths were the second most frequent retouched tools and may have been used as a point or knife. Most of these retouched tools show intentional retouch mostly on one edge, including fine, rough, semi-invasive retouch, and notches. The edge opposite to the retouched one often displays intensive utilization of the tool. The proximal ends of the laterally retouched tools show only minimal modification. The production and use of laterally retouched tools can be continuously observed, from the earliest phase of the hunter-gatherer's settlement onwards.

The backed microliths of Mararo include straight-backed microliths, as well as crescents and segments. Most of these backed tools were produced on bladelets and blades. The presence of extensive edge damage opposite of the backed edge suggests that they were intensively used. The heyday of backed microliths was during the Middle and the Late Holocene occupation. The earliest occupants of the shelter seem to be dependent on the non-geometric microliths: mainly borers, laterally retouched, and unretouched tools. The presence of a low frequency of backed retouched tools at the Late Holocene occupation seems to be related to the subsistence strategy employed by the occupants then technological reasons. Unlike the Late Holocene occupants at Simbero, the Mararo occupants may have used the shelter only for the production of microliths. This might be due to the fact that the Mararo rock shelter contains no faunal remains and due to its proximity to the local obsidian sources.

The occupants of the Mararo rock shelter produced and used the tools already known from earlier occupations, such as at Simbero. They were not required to develop new technologies when they moved to the higher elevation of the summit plateau. The settlers effectively employed their prior knowledge to produce the preferred functional tools from the available local obsidian. The recovered debitage and flaked tools show a notable lithic production and less curation, suggesting that the occupants of the Late Holocene may have used the shelter for seasonal stays instead of permanent residential places. Like the debitage that was observed at Simbero rock shelter, the debitage at Mararo also contains a large proportion of broken pieces and exhausted cores and flaked tools. The possible explanation for the lithic damage may be related to the production processes, since the size of the blanks was small for both freehand and anvil methods. The presence of a high frequency of fragmented lithics in the debitage might also be related to on-site lithic production. Most of the retouched tools were not exhaustively used before being discarded to the surface. The debitage at Mararo, which shares the common tradition of LSA lithic production tradition in the Horn of Africa. The lithic production techniques, which started at approximately 4.7 ka cal. BP ended abruptly around 2 ka cal. BP.

6. PREHISTORIC HUMAN SETTLEMENT AND ADAPTATION IN THE HIGH-ALTITUDE BALE MOUNTAINS

6.1. CULTURE-HISTORICAL SEQUENCE OF THE BALE MOUNTAINS

This chapter summarizes the history of prehistoric human high-altitude occupation and adaptation in the Bale Mountains from OIS 3 to OIS 1, manifested in the MSA and LSA archaeological records of the upper Web Valley. In addition to the existing climatic and paleoenvironmental data, the archaeological results indicate that hunter-gatherers successfully used the Afroalpine and Afromontane habitats and exploited the available resources of the upper Web Valley, the central Plateau as well as the escarpments. The archaeological records from the studied sites suggest that at least four major hunter-gatherer occupational phases have occurred. These time periods appear to correspond to the wet conditions that occurred at the high-altitude of the Bale Mountains; firstly, during late OIS 3, and secondly, after the onset of the African Humid Period. These occupations most probably have been related to contemporary settlements in the central Rift Valley and the Southeastern Ethiopian Highlands.

The presence of abundant local obsidian raw material from Wasama Ridge (**Fig. 2**) in all investigated late MSA and LSA assemblages, from late OIS 3 until the Late Holocene, suggest that the central Plateau of the Bale Mountains was well known to prehistoric hunter-gatherers although they clearly preferred to use rock shelters in lower altitudes, especially in the upper Web Valley. Moreover, obsidian raw materials chemically not related to the Wasama outcrops, point to several volcanoes in the central Rift Valley (Dalecchia, Chebe, Gara Boku 1, Kersa, Welela; **Fig. 1**).

Additionally, other non-local raw materials such as quartz and chalcedony show the presence of contact/exchange with lowland cultural groups during all settlement phases in the high-altitude Bale Mountains. These prehistoric networks could have been maintained through comparably easy access to the Bale massif via the northeastern corridor adjacent to the Kotera and Genale plains (**Fig. 2**).

6.1.1. Late Pleistocene MSA

The evidence for the late MSA occupation at the high-altitude of the Bale Mountains solely rests upon the archaeological record of Fincha Habera rock shelter. According to the associated radiocarbon dates obtained from a range of different materials, including charcoal, bone collagen, coprolite as well as on black carbon samples, this occupation started around 47 and lasted until 31 ka cal. BP. The lithic assemblage of Fincha Habera features a production of elongated and pointed blanks from prepared single, double, and multiple-platform cores (SDM cores), and is characterized by late MSA formal tools, in particular unifacial tools. Moreover, the MSA lithic assemblage does not include a single artifact which might be attributed to the range of LSA formal tools or generally to LSA production techniques. The technology and typology of the lithic artifacts hardly show any significant change throughout the Late Pleistocene deposits.

The early occupation of the high altitudes of the Bale Mountains by hunter-gatherers is associated with the intense on-site production and use of lithic artifacts. Pointed tools, particularly with unifacial or partifacial retouch, followed by laterally retouched points dominate the formal tools in the lithic assemblage. Moreover, laterally retouched blades, scrapers, as well as a range of utilized tools have been frequently produced by the prehistoric knappers. The production of late MSA lithic artifacts at Fincha Habera might have been related to already preexisting production techniques around the Southeastern Ethiopian Highlands and the Rift Valley. It should be noted that the preferred formal tools were manufactured without the application of the Levallois or discoidal production techniques. The absence of these lithic production techniques cannot be related to a shortage of raw material, this rather seems to reflect the preference of the hunter-gatherers in high-altitude environments. It seems that the same cultural groups may have used the shelter repeatedly during different long-term occupational events and with a similar range of activities, including subsistence strategies.

The movements of these hunter-gatherers could have been related to the wet phase that was observed at the Web Valley during OIS 3. The presence of a prominent glaciation – covering almost the entire extent of the central Sanetti Plateau of the Bale Mountains – and also parts of the northern valleys including Wasama (OSSENDORF ET AL. 2019; GROOS ET AL. 2021) did not prevent early hunter-gatherers from procuring themselves with obsidian raw material at Wasama Ridge. This might also hint at the possibility that these early occupants of Fincha Habera already had prior knowledge of the Bale Mountain landscapes and environments, including the obsidian source area. Human occupation at Fincha Habera during this period was connected to maximum exploitation (94.6% of the entire faunal remains) of a locally available and abundant rodent species, the giant root-rat (*Tachyoryctes macrocephalus*) (**Table 2**). The Bale Mountains worldwide host the only population of this endemic Afroalpine species. The presence of abundant giant root-rat remains as well as their preparation – roasting upon the open fire without direct contact with the embers – suggests that hunter-gatherers heavily relied on the hunting of this species. The occupants of Fincha Habera might have used a specialized hunting strategy, most probably trapping, to catch the large amounts of this fossorial animal. Such a strategy would require only little energy expenditure in high altitudes, compared to the active hunt on woodland species such as the mountain nyala (*Tragelaphus buxtoni*) or other bovids. A significant amount of recovered bones with impacts from fire and signs of breakage at early stages show the processing of hunted wild animals in the shelter. Moreover, large bovids such as the mountain nyala, a high-altitude and montane woodland-adapted species, were also included in the faunal spectrum at Fincha Habera, alongside with medium- and small-sized bovids.

Human occupation at Fincha Habera seems to be affected by regular visits of carnivores, apparently spotted hyenas (*Crocuta crocuta*). This occurred in particular during the youngest MSA phase, evidenced by the presence of abundant coprolites and by long bones with clear carnivore digestion and gnawing marks in the faunal assemblage of the respective layers. This shows that both hunter-gatherers and hyenas might have used the shelter alternately, while cohabitation can be ruled out. The presence of giant root-rat and bovid bones within single coprolite specimens also indicates that humans and carnivores may have competed for the same food sources in the surroundings of the shelter. This type of competition might have occurred when the local resources were depleted due to climate changes which affected the Bale Mountains. The potential competition between carnivores and hunter-gatherers ended abruptly after 31 ka cal. BP. The absence of any archaeological evidence younger than this date, suggests that the last MSA occupants may have been forced to abandon the upper Web Valley due to a potentially drastic environmental change that occurred in these altitudes of the Bale Mountains. However, erosion or other site-specific events such as flooding of the cave might also have been responsible for the missing of sediments attributable to OIS 2.

Currently, the archaeological evidence of Fincha Habera forms the earliest human residential site in high altitudes and the earliest source of information on hunter-gatherer exploitation of the Afroalpine ecozone. The presence of ostrich (*Struthio* *camelus*) eggshell in the faunal assemblages of Fincha Habera forms a strong indicator for contact with lowland groups, as this species is neither adapted to Afromontane nor Afroalpine vegetation zones (FREITAG & ROBINSON 1993). Finally, the presence of non-local obsidian raw material – the geochemical composition of which closely resembling obsidian from the central (Kersa, Welela) and northern (Dalecchia) Rift Valley – shows possible source regions and inter-regional relations among prehistoric MSA hunter-gatherers.

6.1.2. Terminal Pleistocene LSA

The Terminal Pleistocene occupation in the Bale Mountains is associated with wet conditions after 15 ka cal. BP, usually connected to the onset of the African Humid Period. Locally, the deglaciation and the melting of the ice cap on the central Sanetti Plateau – starting after 15.3 ka (OSSENDORF ET AL. 2019; GROOS ET AL. 2021) – was probably at an advanced stage when hunter-gatherers (re-)settled in the upper Web Valley. The occupational phase within the lowermost deposits of Simbero rock shelter has been dated to 14.6 ka cal. BP. Although this early settlement phase seems to be short, human occupation during this period has also been verified at other Bale Mountain sites. This period corresponds to a change of vegetation from the high-mountainous desert-like grasses to a new vegetation cover (*Podocarpus, Erica*) in response to the warming and humidification of the region (KUZMICHEVA ET AL. 2017). Possibly, it might reflect a short settlement episode in between the harsh conditions imposed by the prior Heinrich 1-event and the ensuing Younger Dryas.

The Terminal Pleistocene archaeological record at Simbero rock shelter is characterized by the introduction of a range of typical LSA technologies and mainly features informal, utilized tools, apart from a small number of elongated tools, such as backed and retouched microliths including few borers. The lithic assemblage is dominated by obsidian and contained chert artifacts to a much smaller degree. Both raw materials are locally available in the vicinity of all rock shelters in the upper Web Valley. Based on the observed patterns of lithic production at Simbero, the early occupants of the shelter appear to have well-established raw material procurement strategies as well as consolidated technological knowledge on the production of LSA lithic artifacts. These artifacts were made from highly prepared prismatic and conical cores through laminar-based bipolar lithic production techniques, marking a sharp contrast to the prior late MSA technologies in the same region. However, the presence of a limited number of artifacts in general and tool types in particular, indicate that this phase was rather of short duration and low intensity.

The occurrence of Terminal Pleistocene LSA lithic assemblages at Simbero rock shelter indicates that hunter-gatherer groups successfully exploited the high-altitude of the Bale Mountains with the use of a microlithic toolkit. These microliths were produced with the notion of lithic miniaturization from raw material procurement to the final formal and utilized functional tools. The subsistence strategies associated with this early occupational phase are not known since almost no faunal remains were associated with the respective lithic assemblage. Moreover, the function of LSA tools is yet not fully understood, especially with regard to their contribution to potential subsistence strategies around the upper Web Valley.

6.1.3. Middle Holocene LSA

A Middle Holocene settlement is well represented in the deposits of Simbero rock shelter in the upper Web Valley of the Bale Mountains. This occupational phase appears to have started around 8.1 ka cal. BP and could have been related to pronounced and stable humid conditions prevailing during the AHP. The vegetation cover during this period was dominated by *Podocarpus*, *Poaceae*, *Apiaceae*, and *Erica*, and other tree forest communities which probably increased the diversity of food resources for wild animals. The rate of sediment accumulation at Simbero rock shelter during this time increased and the deposits include more sediment with a denser distribution of artifacts and faunal remains compared to the Terminal Pleistocene parts of the sequence. The combination of abundant LSA artifacts covering all phases of the knapping process with the diverse faunal remains of wild animals suggests that the occupants of the shelter experienced favorable conditions during the Middle Holocene. This behavior was also accompanied by the extensive use of fire at the shelter. A significant number of faunal remains show a high impact of fire, including calcination, which goes beyond simple preparation of meat.

The lithic assemblage of the Middle Holocene occupational phase shows firm cultural continuity with the preexisting lithic production techniques of the Terminal Pleistocene occupation. However, the Middle Holocene assemblage reveals a much higher diversity of LSA tools which are predominantly made on locally available obsidian. This assemblage also includes artifacts made on local non-obsidian raw material, such as chert from Genale, non-local chalcedony from an unknown source, as well as obsidian from a volcanic source in the lowland (Gara Boku 1 in the central Rift Valley; **Fig. 1**). The presence of the exotic raw materials suggests that the Middle Holocene occupants of Simbero rock shelter were part of a large settlement group which included both areas, or at least had established contacts with neighboring low-altitude cultural groups. The Middle Holocene lithic assemblage of Simbero shows methods for the production of microliths that are similar to the Terminal Pleistocene assemblage. In this respect, the technical behavior of Middle Holocene groups seems to reflect a rather high degree of cultural continuity with previously established patterns.

The LSA lithic assemblage is represented by a high frequency of backed microliths, in combination with retouched formal tools such as borers, laterally retouched tools, and additional utilized tools. Compared to the previous occupation, the frequency of formal and utilized tools considerably increases during this occupational phase. Both formal and utilized tools were made from highly prepared prismatic and conical cores through laminar and bipolar lithic production. The presence of abundant debitage indicates the intensity of knapping activities in the shelter during the Middle Holocene. The abundance of both formal and utilized tools appears to be related to the significant number of faunal remains. The Middle Holocene occupational phase yielded faunal remains of different size: large and medium-sized mammals, particularly bovids, but also *Hyracoidea* and *Lagomorpha*, as well as rodents and birds. The total counts of the faunal remains are dominated by small-sized bovids, suggesting that the Middle Holocene hunter-gatherers were involved in active terrestrial game hunting. Moreover, the presence of birds and rodents in the faunal assemblages indicates that the occupants of the Middle Holocene used additional hunting strategies for avian and aquatic species. The evidence for a well-established Middle Holocene subsistence is confirmed by the intentional use of fire for processing animal meat in the shelter. Most of the bones associated with the LSA microliths show signs of cut marks and the impact of intense fires. In this respect, the abundance of LSA microliths in association with the diversity of faunal remains and the intense use of fire at Simbero rock shelter suggests a long-term occupation during the Middle Holocene.

6.1.4. Late Holocene LSA

The Late Holocene human occupation is well represented in the deposits of Simbero and Mararo rock shelters. The LSA archaeological record of the Late Holocene events starts around 5 ka cal. BP and ends around 2 ka cal. BP. These deposits might be related to the climate changes that probably occurred after the end of the African Humid Period around 5 ka cal. BP (KUZMICHEVA ET AL. 2017). The paleoenvironmental data of the Bale Mountains – particularly in the northwest Web Valley and the central Sanetti Plateau – indicate that the types of vegetation show drastic changes starting from 4.6 ka cal. BP. It appears that the condition was more arid compared to the Middle Holocene period, although during the last glacial cycle the Bale Mountains had always been more humid and ecologically stable than the surrounding lowlands (OSSENDORF ET AL. 2019). This change might also be reflected by the reduced deposition rates during the Late Holocene phase at both investigated rock shelters. However, the presence of two gravelly layers at the Mararo rock shelter indicates that the Late Holocene conditions might have been still rather humid around the summit of the Bale Mountains. More importantly, the number and spectrum of faunal remains of this occupational phase, especially at Simbero rock shelter, challenge the notion of a significant Late Holocene aridity in the Bale Mountains.

During the Late Holocene human occupations, the LSA microliths are well documented at both shelters. These lithic assemblages feature all production techniques already documented during the Terminal Pleistocene and Middle Holocene. The lithic production techniques during the Late Holocene period were dominated by bipolar lithic production. Like the Middle Holocene backed microliths from Simbero, the Mararo lithic assemblage shows the systematic use of the bipolar on anvil method for blunting the edge of the microliths. Almost all Late Holocene LSA microliths were made on highly prepared prismatic and conical cores dominantly from the locally available obsidian source. The formal tools comprised of all backed microliths, borers, and laterally retouched tools. Especially borers and a range of utilized tools were more abundant during the Late Holocene occupation, particularly in comparison to backed microliths. Borers appear to be the locally favored microliths in the Holocene occupations of the Bale Mountains. At the moment, it can only be speculated that they played an important role in hide-working. The continuous, albeit shifting, use of borers and backed microliths during all post-glacial occupational phases indicates that humans seemed to have been heavily relying on the use of these formal tools. On the other hand, the variable presence of utilized tools shows a certain degree of flexibility in the Holocene subsistence of the Bale Mountains.

The Late Holocene archaeological records of the two shelters indicate that different settlement patterns may have occurred after the termination of the African Humid Period. The Late Holocene cultural groups of the Bale Mountains seem to have extended their preferred areas to central parts of the massif. The presence of abundant faunal remains of diverse animals with a significant amount of LSA microliths and the extensive use of fire indicate that the Late Holocene occupants at Simbero and Mararo rock shelter had access to sufficient resources to continue their occupations of the Bale Mountains.

6.2. THE ARCHAEOLOGICAL RECORD OF THE BALE MOUNTAINS IN SUPRA-REGIONAL CONTEXT

The MSA and LSA archaeological record of the Horn of Africa is characterized by considerable spatial (**Fig. 1**) and temporal gaps. In general, the concentration of Stone Age sites shows an almost exclusive focus on the central Rift Valley and the Afar Rift (SAHLE 2020), and a non-consideration of the Arsi-Bale Mountains of the Southeastern Ethiopian Highlands. Large chronological gaps exist, especially the LGM can be seen as a "dark age" with no reliably dated sites so far. Although archaeological sites in Ethiopia play a central role in the understanding of modern humans' dispersal within and across Africa, most are only poorly dated. This hinders intra-regional comparisons on the nature and timing of human behavioral changes during the MSA and LSA.

Among the archaeological sites discussed in the following, only a few late MSA sites such as Mochena Borago from the Southwestern, and Goda Buticha from the Southeastern Ethiopian Highlands (**Fig. 1**) are well dated. The major research questions guiding the investigation of these sites are orientated towards human adaptation to unpredictable environmental changes between OIS 4 to OIS 1, rather than addressing prehistoric movements and mobility of people within the Horn of Africa. Regarding the LSA, the DW2s1 and B1s1 localities of the Ziway-Shale basin, Goda Buticha in the Southeastern Ethiopian Highlands, and Dendi rock shelter in the western central part of the Ethiopian Plateau (**Fig. 1**) yielded only few solidly dated Holocene archaeological records.

The archaeological sites presented in this section are located in different environmental settings, ranging from the lowland of the Rift Valley to moderate altitudes of the Southwestern and Southeastern Ethiopian Highlands. The review of archaeological sites from the surrounding areas of the Bale Mountains below 2500 m asl is important in the understanding of adaptations to both arid and high altitudes in the Horn of Africa.

6.2.1. Mochena Borago

The archaeological record of Mochena Borago, located in the southwest Ethiopian Highlands (2200 m asl), yielded lithic assemblages dated to between about 55 and 33 ka cal. BP (FISHER 2010; BRANDT ET AL. 2012, 2017). There were only few lithic artifacts made on so-called classical MSA cores such as discoidal or Levallois cores, the latter including Nubian core types. The oldest assemblages (T Group) contain only few points (unifacial, bifacial, and partifacial), scrapers, and awls. The S-Group, which is dated to approximately 43 ka cal. BP, yielded a reduced frequency of unifacial and bifacial points which were produced from small SDM-cores and occasionally with bipolar technology. Both T- and S-Group lithic assemblages contain some backed pieces and scrapers. The youngest assemblage (R-Group) at Mochena Borago dates to 38–42 ka cal. BP is not yet fully understood since part of the deposits and lithic artifacts might have been re-deposited, particularly in the central parts of the shelter. The MSA formal tools of Mochena Borago are characterized by a high frequency of retouched pointed tools. Among these, only pointed facial tools exhibit a typological similarity with Fincha Habera formal tools. Additionally, the production of convergent blanks with the SDM-core management in the T-Group assemblage could be considered as a technological similarity between the two assemblages. However, the laterally retouched convergent points and blade tools of Fincha Habera have no typological and technological relation with Mochena Borago formal tools.

6.2.2. K'one

The site Locality 5 extension at K'one in the southern Afar Rift (**Fig. 1**) was identified as an archaeological site possibly dating to OIS 3 in the Horn of Africa (KURASHINA 1978). As it was common in earlier archaeological investigations, most of the K'one sites were not directly dated. The Locality 5 extension site was dated to between 50 and 30 ka BP based on stratigraphic extrapolation from neighboring early MSA sites. Although the lithic material recovered from the long trench of this obsidian quarry site show a technological variation of late MSA industries, the site yielded relatively few retouched tools of which most were made on Levallois cores. The retouched tools in the assemblage were invasively retouched and shaped to partifacial, unifacial, and bifacial points. The MSA lithic assemblage at K'one also includes a high frequency of scrapers, opposed to only few burins, awls, and backed flakes. Another unique characteristic of the K'one Locality 5 extension lithic assemblage was the presence of variable cores documenting the removal of conjoinable/triangular flakes. The Nubian core type 1 and respective flakes appeared to be the main technological variation in removing two narrow flakes opposite to the core striking orientation (VAN PEER 1988). This type of lithic production was also observed from a few sites in northeast Africa mainly at Sodmein Cave in northeast Egypt (BRANDT ET AL. 2012). Moreover, the Locality 5 extension lithic assemblage shows a classic Levallois core reduction method to produce especially elongated blades and flakes. Most of the elongated blank which used to produce the retouched tools had a close affinity with other late MSA sites in the Horn of Africa.

Despite the distinct lithic production techniques, such as Levallois and Nubian type I, the main focus was on the production of elongated flake and blade blanks, as could also be observed in the assemblage from Fincha Habera. Moreover, if we consider the presence of a single Nubian type I-point in the Fincha Habera lithic assemblage, there may be the possibility of coalescence between the hunter-gatherers of the Rift Valley and the high-altitude Bale Mountains. This assumption should be verified by data from the high-altitude context.

6.2.3. Midhishi 2/Laas Geel

The Midhishi 2 site in Somalia represents another OIS 3 archaeological site in the Horn of Africa (**Fig. 1**) (BRANDT 1986). Based on the result of a single charcoal sample, the site's lower levels date to > 40 ka uncal. BP. These have delivered a considerable number of retouched points, predominantly unifacial, especially at the lower level, while both partifacial and bifacial are fairly represented. The retouched tools at the Midhishi 2 site are few and appear to have less typological diversity. All formal tools at the Midhishi 2 site were exclusively made on chert flakes removed from Levallois centripetal cores. Moreover, Nubian Type I-flakes were used to produce points. Like other OIS 3 archaeological findings at lower elevation, the facial points of the Midhishi 2 site have typological similarities with the formal tools of Fincha Habera but only few technological similarities. The lithic assemblage at the middle unit of Midhishi 2 dates to around 18.8 ka uncal. BP and shows that both Levallois and prismatic blade production techniques were employed to produce retouched points. This type of technological change was also observed on the Terminal Pleistocene site of Shelter 7 of Laas Geel in Somaliland (**Fig. 1**) (BRANDT 1986). The respective lithic assemblage of Shelter 7 was later renamed Hargeisan and shows both MSA and LSA tools such as retouched points as well as microliths (PLEURDEAU ET AL. 2014).

6.2.4. Aladi Springs

The archaeological record of Aladi Springs in the central part of the southern Afar Rift (**Fig. 1**) yielded another lithic assemblage with MSA and LSA characteristics. The recently re-studied lithic material (GOSSA ET AL. 2012) shows in the lower MSA and the upper LSA horizons laminar lithic reduction methods to produce both elongated and non-elongated tools. Moreover, the site of Aladi Springs was identified as one of the sites containing assemblages indicative of the MSA/LSA transition. However, the chronology of the deposits lacks sufficient dates. The probable MSA horizon was not dated at all, while a single sample of gastropod shell sample delivered an approximate 11.1 ka uncal. BP for the LSA occupations. All formal tool classes at Aladi Springs occur within the MSA as well as the LSA occupational horizons. The differences between the MSA and LSA lithic assemblages only consist of techno-morphological aspects of the artifacts. The MSA horizon had relatively abundant big blades and non-blade scrapers produced from prepared cores such as discoidal, pyramidal, and single-platform blade/bladelet cores. In contrast, the LSA horizon shows the production of smaller blades and micro-blade tools. Scrapers were the only dominant retouched tools in both MSA- and LSA-horizons and are followed by bladelet tools and backed pieces. Retouched points were identified in both horizons, but are represented only with very few numbers. Based on this revisited account, the lower horizon of Aladi Springs had a mixed lithic assemblage with both MSA and LSA characteristics. The lithic production techniques targeted mainly towards the production of blade-based tools and flakes for predetermined tools such as scrapers, drills/bores, and burins. Like at other late MSA sites in the Ethiopian Rift and the southern Ethiopian Highlands, retouched points were not the characteristic tools at Aladi Springs due to their very low frequencies. An additional feature of these sites and Aladi Springs is the absence of a significant number of tools and cores with Levallois and Nubian type I features. The MSA lithic assemblage of Aladi Springs indicates that hunter-gatherers from the lowland had also produced facial points, retouched blades, and other formal tools without an elaborated core reduction technique. This corresponds to the preference of hunter-gatherers which is commonly observed in the lithic assemblage of Fincha Habera rock shelter.

6.2.5. Porc-Épic

In the eastern part of the Southeastern Ethiopian Highlands, the Porc-Épic cave (**Fig. 1**) delivered lithic assemblages with MSA and LSA features (ASSEFA 2006; PLEURDEAU 2006). Even though the unresolved concerns about the context and dating results remain a problematic issue at the site, Porc-Épic cave provides unique data, particularly on lithic variability and modern human behavioral changes during MSA and LSA. The lowermost units (IV and III) are considered as MSA while unit II shows mixed material of MSA and LSA. The upper part of the cave was capped by a thin brownish layer containing few LSA elements. The entire sequence is characterized by similar typo-technological features. Most of the MSA retouched tools were produced through Levallois and discoidal core reduction methods. The MSA lithic assemblages were oriented towards the production of the laminar blades and flakes. The production of retouched tools was dominated by different types of points, particularly elongated unifacial and bifacial points, as well as typologically distinct scrapers. The presence of abundant retouched points distinguishes the Porc-Épic cave assemblages from other MSA sites in the Ethiopian Rift Valley. The retouched points of Fincha Habera have a significant similarity with the pieces from Porc-Épic. Whereas the production of blanks employed different techniques, the finished points show similar invasive and semi-invasive retouch with soft hammer and pressure flaking methods. The lithic assemblages of both sites have abundant retouched points made on exceptionally elongated flake and blade blanks. In the light of other typo-technological aspects, the diversity of retouched points is highly comparable in the lithic assemblages of both sites. Like the Porc-Épic assemblages, the formal tools of Fincha Habera include scrapers and pointed tools. Another specificity of the assemblage of Porc-Épic was the occurrence of backed tools in all stratigraphic levels that are traditionally considered as markers of the LSA. The LSA elements consist of backed bladelets, geometric pieces, and small retouched points. It was this combination of

LSA elements and the strong presence of laminar products in all assemblages that questions whether MSA and LSA knappers used different or similar knapping methods to produce lithic artifacts. As PLEURDEAU (2006) has suggested, the occurrence of homogeneous MSA and LSA elements at Porc-Épic may have resulted from local environmental adaptations.

6.2.6. Goda Buticha

Located about thirty kilometers southwest of Porc-Épic, the site of Goda Buticha (**Fig. 1**) provides additional information regarding regional specificity on how hunter-gatherers successfully expanded to the northern parts of the Southeastern Ethiopian Highlands (PLEURDEAU ET AL. 2014; ASSEFA ET AL. 2014; TRIBOLO ET AL 2017). The lower layers of the stratigraphy (Complex II) were determined through radiocarbon dating between 46 to 33 ka cal. BP, while the upper layers (Complex I) yielded mid- to Late Holocene dates. Complex II of Goda Buticha represents occupational events associated with lithic artifacts with mixed MSA and LSA attributes. Similar to Fincha Habera, the dates also indicate an occupational hiatus of almost 30,000 years until the mid-Holocene re-settlement at the top of the sequence. A recent chronostratigraphic review shows that Late Pleistocene and Holocene sediments were only slightly mixed by human and animal activities. This is all the more worth mentioning, as LSA lithic elements occur rather commonly within late MSA assemblages in Ethiopia (CLARK 1988; PLEURDEAU 2006; PLEURDEAU ET AL. 2014; BRANDT ET AL. 2012, 2017; LEPLONGEON ET AL. 2017), and sedimentological and/or micromorphological studies of post-depositional processes have rarely been undertaken. The late MSA assemblage of Goda Buticha is characterized by retouched formal tools, mainly unifacial and bifacial points and few partifacial points, on elongated blades and flakes. Elongated blades were manufactured more preferential than (semi-)convergent flakes. The points had regular convergent edges and were facially retouched, ranging from invasive to covering. The base of the points is rounded with the proximal parts. Scrapers are the second dominant tool class of the total lithic assemblage. Like retouched points, scrapers were made on both blade and flake blanks and are concentrated at the lower layers of Complex II and the transitional phase, IIc. Like the lithic assemblages of Porc-Épic, the retouched points recovered from IId/IIf layers of Goda Buticha exhibit exceptional typological similarities with the Fincha Habera points. Moreover, the presence of scrapers and pointed tools made on elongated flakes and blades appears to be a regional specificity. The existing data lack the answer to why hunter-gatherers employed different core reduction techniques to produce morphologically similar formal tools. Out of all OIS 3 archaeological sites in the Horn of Africa, the MSA lithic assemblages from archaeological sites from the eastern parts of the Southeastern Ethiopian Highlands have shown the closest similarity with the late MSA retouched points of the high-altitude Bale Mountains.

The deposits of Goda Buticha also delivered a continuous sequence of microliths with LSA affinity. The frequency of microliths was very low at the bottom layers of Complex II and then abruptly increased at the transitional phase (IIc). The middle and Late Holocene occupational phases (Complex I) also delivered a large number of geometric microliths. Large backed pieces and small retouched flake and blade tools were also recovered at these Holocene layers. One single side scraper was identified from the upper phase, while retouched points are not present in the Holocene occupations. The production technology of microliths shows different methods between the lower MSA and the upper LSA phase of occupations. The blanks of the microliths in the Holocene and transitional phases were elongated blade(let)s while those recovered from the Late Pleistocene (layers IId-IIf) were mainly flakes. The microliths from layer IIc are dominated by retouched microliths, while backed microliths occur to a small degree only. The LSA assemblages of the Complex I show a shift in production techniques and yielded a large number of crescents (geometric microliths).

Other technological attributes to distinguish the above-mentioned occupations were the type and location of retouch on the microliths. Most microliths of Complex II show mainly scaled retouch on one or two edges including invasive retouch, while the artifacts from the upper Complex I are dominated by abrupt, stepped, and retouch on one edge. The microlithic assemblages of Simbero and Mararo are more comparable to the Complex I assemblages of Goda Buticha than any other site in Ethiopia. Moreover, the LSA assemblages of Simbero and Mararo include a high frequency of retouched, backed, and utilized microliths. However, the microliths of the Bale Mountains (both geometric and non-geometric) were more diverse and abundant than at any other site, especially the frequency of borers is unparalleled at any LSA site in the Horn of Africa.

6.2.7. Ziway-Shala Basin

Archaeological sequences from the Ziway-Shala Basin (**Fig. 1**), particularly from Deka Wede 1 (DW1) are key sites for the understanding of human Terminal Pleistocene or early Holocene occupations. The findings of an LSA lithic assemblage at DW1 in a paleosol dated to about 27 ka uncal. BP increased the debate on the apparent continuity in the production of lithic tools in the Horn of Africa. The retouched tools are blade-based LSA types, such as non-geometric microliths, scrapers, and blade tools. The lithic assemblages of DW1 were lost during the Ethiopian revolution and the recent attempts to relocate and excavate the same locality turned out unsuccessful (MÉNARD ET AL. 2014). The lithic material that was recently collected around the old DW1 locality however provided new insights on possible OIS 2 occupations at the southern central parts of the Main Ethiopian Rift. The DW1 surface collections were analyzed in comparison to the lithics recently recovered at the B1s3 locality, along the edge of the modern Bulbula River. The B1s3 lithic assemblage was dated by stratigraphic correlation to 22 ka uncal. BP and show similar characteristics with the old surface collection of the DW1 assemblages (BRANDT 1986; MÉNARD ET AL. 2014). In both lithic assemblages, microliths were not recovered, and the production sequence was oriented towards the manufacture of laminar blades (or elongated blanks) through the recurrent bipolar Levallois method. Most of the blade tools show parallel edges and an unmodified sharp distal end. Most of the *débordant* products and full-cutting tools were produced from carefully prepared cores, largely with faceted platforms. The Ziway-Shala Basin archaeological record is particularly characterized by the presence of abundant proximally retouched pieces. Basal retouch on the elongated pieces appears to be intentional and transformed the tools to handled or hafted tools. The Ziway-Shala Basin sites delivered only a few retouched tools comparable to the Fincha Habera late MSA formal tools. Only two unifacial points from DW1 – with a single radiocarbon dating result of around 33 ka cal. BP – show more continuous and even covering retouch on their dorsal faces while the proximal thinning involve both dorsal and ventral sides. This type of proximal modification on points occurred probably to facilitate hafting on other tools. The entirety of these unique characteristics on the retouched tools led to the attribution of the Ziway-Shala Basin assemblages to a Late MSA rather than to an Early LSA complex (MÉNARD ET AL. 2014).

The Holocene archaeological record of the region came from localities DW2s2 and DW2s1 (**Fig. 1**), dating to around 10 ka uncal. BP. These two sites are located further south of B1s3 but very near to BW1 within the Bulbula River confluence. The lithic assemblage of DW2s2 is exclusively dominated by elongated diamond-shaped tanged points. The lithic production method is characterized by laminar production from curved bipolar cores. The objective of the production system was to obtain elongated blades from a reduced striking surface. The blades were further retouched into small retouched tanged points. Proximal retouch also affected the triangular base of these points. The formal tools of DW2s2 include very few end scrapers and burin-like tools but backed microliths were not represented at all. The microlithic industries in the Ziway-Shala Basin are not clearly comparable with Goda Buticha or the Bale Mountains. Only the DW2s1 locality delivered abundant burin-like cores, burin spalls, and backed bladelets which are probably produced by the use of bipolar percussion. Retouched microliths with slightly larger dimensions than the dominant bladelet tools and burin spalls were also present. Like other sites at the Ziway-Shala Basin, geometric microliths were not included in the toolkit. It should be noted that the lithic assemblage of DW2s1 is associated with intense fish exploitation.

6.2.8. Dendi

The chrono-cultural sequence of Dendi rock shelter (DEN12-A01) at almost 2990 m asl in the western central Ethiopian Highlands (**Fig. 1**) shows cultural remains of continuous occupations from the Middle Holocene to the end of the Late Holocene. The lithic assemblage is oriented towards the production of the laminar blade(let) blanks with centripetal flaking concepts from specialized small cores. Backed geometric microliths dominate the entire assemblage with the exception of the lower- and uppermost layers, where retouched pieces are characteristic. The retouched tools are characterized by a heterogeneous spectrum of geometric microliths such as micro-points, trapezoids, triangles, and heterogeneous segments. Moreover, the lithic assemblages of Dendi include burins, scrapers, denticulated, and notched pieces. These microliths are associated with faunal remains of mainly bovids and rodents. The occupants of the Dendi rock shelter may have used the shelter repeatedly for short stays during hunting trips within the Mt. Dendi caldera_(SCHEPERS ET AL. 2020). The LSA retouched tools of Dendi, therefore, represent other variants of microliths in the

Horn of Africa, different from the contemporaneous microlithic assemblages in the Ethiopian Rift Valley and the southern Ethiopian Highlands including the Bale Mountains LSA assemblages.

6.2.9. Summary

Even though it is problematic to compare the late MSA finds recovered from extremely different climatic and geographic regions, and additionally with partly diverging sample size, most of the known late MSA archaeological records contain a significant number of LSA tools, including microliths. In contrast, the assemblage of Fincha Habera is unique in lacking any LSA element, neither microlithic tools nor bladelet cores or any other technological characteristic. It should also be stressed that Fincha Habera is the only late MSA site in the region featuring a stratigraphic sequence without younger deposits with LSA assemblages. The mixing of MSA and LSA artifacts due to post-depositional processes can be ruled out as a cause for putative “transitional” assemblages. Apart from the absence of LSA elements, the complete lack of evidence for core preparation according to the Levallois or discoidal methods forms another unique characteristic of the Fincha Habera late MSA assemblage. Typologically, the Bale Mountains late MSA lithics at Fincha Habera resemble the assemblages from IId/IIf of Goda Buticha and units IV/III of Porc-Épic cave in the Southeastern Ethiopian Highlands. The type of retouch on facial points and blade tools shows a strong connection. The abundance and homogeneity of these tools at Fincha Habera could be considered the major differences to the late MSA assemblage of the afore-mentioned sites. Moreover, the facial points of Fincha Habera can also be related to two facial points of the B1s3 Locality within the Ziway-Shala Basin. If we consider the single seemingly Nubian Type I-tool as a diagnostic tool in the Bale high altitudes, the late MSA assemblage of Fincha Habera would also have a techno-typological relation to the Locality 5 extension site of K’one in the southern

Afar Rift. However, the abundance and the diversity of retouched points and retouched blade tools is comparably high at Fincha Habera and seems to represent a regional specificity of its late MSA assemblage. Additionally, the points of Fincha Habera show a high degree of intentional basal modifications, which is unmatched at other broadly contemporary sites in the Horn of Africa.

The LSA lithic assemblages of the Bale Mountains from Simbero and Mararo show close technological affinity to the known LSA traditions of the Horn of Africa. At the Bale Mountains, their first appearance is already during the Terminal Pleistocene, and many technological LSA features continue to be present until at least 2 ka cal. BP. Generally, the laminar and volumetric blade technologies with additional use of the bipolar technique were employed to produce elongated bladelets and small flakes from highly prepared cores (mainly prismatic and conical). The production of bladelets and their processing into formal tools appear to be the main intention of the lithic production system in the Bale Mountains. In most cases, systematic bipolar on anvil methods were used to produce backed geometric and non-geometric microliths. Techno-typologically, the LSA microliths of Simbero and Mararo are closely related to those recovered at Complex I of Goda Buticha cave, with the notable exception of borers, which dominate the entire LSA formal tool class at the Bale Mountains, but are rare or absent at all other sites. Moreover, the microliths of the Bale Mountains seem less comparable to those recovered from the Dendi rock shelter and the Ziway-Shala basin. The former is unique and techno-typologically unparalleled to all LSA microliths to the southeast of the Ethiopian Rift, while the Ziway-Shala material is mainly characterized by small, non-geometric backed bladelets. In contrast to other LSA microliths, the Simbero and Mararo assemblages are characterized by the abundance of backed microliths and laterally retouched tools, especially borers.

Generally, the archaeological records recovered from higher elevated environments (above 2500 m asl) show the presence of more complex cultural or behavioral strategies of survival, irrespective of the cultural and chronological background. As mentioned before, the microlithic assemblages at the Bale Mountains are distinguished from others in their production of abundant borers. The production of these includes a distinct typology and hints at a possible behavioral shift of hunter-gatherers when they encountered the challenges of the high altitudes of the Bale Mountains. The production and use of lithic artifacts seemed to change as hunter-gatherer’s occupation and exploitation expanded to the new environments

6.3. THE BALE MOUNTAINS AS A PREHISTORIC REFUGIUM: SETTLEMENT AND ENVIRONMENT

The available climatic and archaeological data indicate that past ecological changes had a decisive impact on hunter-gatherer adaptations in the Ethiopian Highlands and the Rift Valley during OIS 4–2 (TRIBOLO ET AL. 2017; TRAUTH ET AL. 2019). The period between OIS 4 and OIS 2 is usually labeled as the 'Big Dry', even though intermediate moist and/or unstable climatic conditions occurred during OIS 3 (WILLOUGHBY 2007; BARHAM & MITCHELL 2008; BLOME ET AL. 2012; BRANDT ET AL. 2012; TRIBOLO ET AL. 2017; TRAUTH ET AL. 2019). However, the highlands of Southeastern Ethiopia, particularly the Arsi-Bale Mountains complex have experienced their glacial maximum with very cold and relatively wet conditions already at 42–28 ka BP, much earlier than the global LGM (GROOS ET AL. 2021). Since the high-altitude of the Arsi-Bale Mountains were uniquely positioned for orographic effects, both West African and Southwest Asian monsoonal precipitation contributed to the monsoonal activity of the region with comparably moist conditions (MOHAMMED ET AL. 2004), whereas the lowlands experienced rapid climatic variation resulting in aridification, already at the beginning of OIS 3 (AMBROSE 2001; BASELL 2008; TRIBOLO ET AL. 2017). During such conditions, hunter-gatherers were possibly forced to move to moist environments, probably to the neighboring high-altitude environments including the Arsi-Bale Mountains with its ecological more stable conditions and abundant natural resources for the subsistence of hunter-gatherers (OSSENDORF ET AL. 2019).

The high-altitude of the Bale Mountains is profoundly rich in geological, topographical, and biological diversity (HILLMAN 1988; WILLIAMS 2006). The Bale Mountains complex is characterized by plateaus, valleys, escarpment, and plains represent the largest alpine environment in Africa (MIEHE & MIEHE 1994). According to a new study, the high altitudes of the Bale Mountains complex also have the largest spatial extent above 3000 m asl due to its "pagoda shape" (GROOS ET AL. 2021), compared to all other, rather insular high elevation regions of East Africa. The recovered faunal remains and coprolites at Fincha Habera show the presence of a relatively open habitat with enough vegetation cover and (glacial melt) water resources. The valleys around the major peaks of the Bale Mountains, particularly at the upper Web Valley, were supported by permanent water sources such as rivers, ponds, and swamps. The plains of these valleys also show notable fossorial impacts that could be related to rodents, mice, and carnivore activities. Noteworthy, both the Afroalpine ecozone (water, obsidian, giant root-rats) as well as the Afromontane ecozone (nyala, firewood) were actively used by prehistoric hunter-gatherers. The earliest land use that was documented in the Bale Mountains may have been related to the wetter periods of the OIS 3. This is supported by two thin channel-fill deposits in the lower and upper parts of the Fincha Habera sequences (upper FHLU-07 and lower FHLU-09) indicating that the high altitudes of the Bale Mountains were wet during most of the late MSA settlement events.

The apparent wet events at the Bale Mountains can be related to the climatic records from Lake Abhe (**Fig. 1**) of the Ethiopian Rift which suggests that the period between ~50–31 ka was relatively moister than before (GASSE 1977). Moreover, the climatic data from Lake Chew Bahir (**Fig. 1**), South Ethiopia, further confirm that the 45-35 ka BP interval was characterized by an 'intermediate' wet period (FOERSTER ET AL. 2012). On the other hand, similar research from the Ethiopian Rift also suggests that the period between ~50–31 ka BP was punctuated by multiple drier episodes and even more pronounced aridity between 35–19 ka BP (GASSE 1977; TRIBOLO ET AL. 2017). These abrupt events which apparently occurred about every thousand years as it was documented from Chew Bahir deposits (FOERSTER ET AL. 2012) may have triggered multiple hunter-gatherer movements from the Ethiopian Rift towards ecologically stable high-altitude environments. The Bale Mountains were significantly wetter than other parts of the Horn of Africa and offered high biodiversity that permitted the aggregation of different groups of culturally diverse hunter-gatherers especially during OIS 3 and OIS 1. The presence of Late Pleistocene settlement at Finch Habera rock shelter with highly specialized late MSA artifacts in association to abundant faunal remains of endemic mountain species suggests that the high-altitude of the Bale Mountains could have acted as a paleoenvironmental refugium for hunter-gatherers during OIS 3.

If we consider the pronounced arid period of the Big Dry that was documented in the Ethiopian Rift between 35–19 ka corresponding to the global LGM, the climatic conditions even around the high-altitude of the Bale Mountains become unfavorable for humans. This might be the reason for the occupational gap after the end of the late MSA occupation in the Fincha Habera rock shelter. An abrupt climatic change may have drastically affected the vegetation, animals, and also the subsistence of hunter-gatherers.

Arid conditions during much of the global LGM can be assumed for the Ethiopian Highlands, as until today not a single reliably dated archaeological site is known in the region (TRIBOLO ET AL. 2017). However, to answer the question of whether the high-altitude region of the Bale Mountains was inhibited or not during this period requires more data, particularly from the potential shelters in the regions. An archaeologically visible (re-)settlement of the Bale Mountains coincides with the effects of two climatic events: Firstly, the onset of the African Humid Period at approximately 15 ka probably facilitated a new wave of hunter-gatherer movements in the Ethiopian Rift Valley and particularly in the Southeastern Ethiopian Highlands (FOERSTER ET AL. 2012). Secondly, the start of the local deglaciation at around the same time (after 15.3 ± 1.2 ka; OSSENDORF ET AL. 2019) corresponds to the humidification and warming that occurred at the beginning of the African Humid Period. Moreover, the types of vegetation around the upper Web Valley were subsequently dominated by woodland trees such as *Podocarpus* and other new herbaceous palynotypes in contrast to the previous high-mountainous desert-like grasses, asters, and *Juniperus* (KUZMICHEVA ET AL. 2017). The wetter periods of the early African Humid Period were represented by few early Holocene group activities in the stratigraphy of Simbero rock shelter and other Terminal Pleistocene sites, concentrating around 14.6 ka cal. BP. The bottom occupational unit (SLSU-05) at Simbero rock shelter with the aforementioned date supplied very few LSA artifacts without faunal remains. The presence of a few archaeological findings at the bottom layers rather suggests that human occupation at the high-altitude of the Bale Mountains was not intense. It appears that the conditions significantly declined again at about 13 ka cal BP. This change coincides with the impacts of the Younger Dryas on a global scale (KUZMICHEVA ET AL. 2017). Following the termination of the Younger Dryas, the return of wet conditions at about 10 ka cal BP, allowed an increase in *Podocarpus*, *Poaceae*, *Apiaceae*, and a widespread expansion of the ericaceous vegetation to the higher elevation above 4000 m asl, including in the upper Web Valley (KUZMICHEVA ET AL. 2017). Moreover, these changes in the dominant tree pollen such as *Podocarpus*, *Poaceae*, and a wider distribution of forest communities that are also concluded from 10 ka cal. BP on, suggests that the conditions at the high-altitude of the Bale Mountains were very humid and warm until this event was abruptly interrupted by the 8.2 ka cal. BP arid episode (UMER ET AL. 2007; KUZMICHEVA ET AL. 2017). Particularly at beginning of the Middle Holocene, hunter-gatherers had successfully reached both the western and eastern parts of the Bale Mountains. The Middle Holocene archaeological records at Simbero rock shelter confirm that a large group of hunter-gatherers appear to settle and produced abundant LSA microliths around 8.1 ka cal. BP. The presence of relatively abundant faunal remains of diverse wild animals with intentional fire use at the shelter also suggests that the wet condition during the Middle Holocene was favorable for hunter-gatherer subsistence.

Even though there is no conclusive agreement on the termination of the African Humid period at the high-altitudes of the Bale Mountains, the climatic conditions from around 4.6 ka cal. BP onward seem to be more arid as indicated by the change in vegetation types around the Web Valley and the Sanetti Plateau. Pollen analysis of the sediments from the high-altitude Lake Garba Guracha (**Fig. 2; Fig. 3**) confirms the predominance of dry mountain juniper forests, Asteraceae shrubs, and other drought resistance plants (UMER ET AL. 2007). Currently, it is difficult to see major changes in the deposits of Simbero rock shelter except for a notable decrease in the sedimentation rate around 4 ka cal. BP. The major change in contrast to the Middle Holocene occupations is the abundance of faunal remains during the Late Holocene occupational phase which can be bracketed by radiocarbon dates between ~5–2 ka cal. BP. The presence of a high proportion of faunal remains coupled with LSA microliths and intensive use of fire suggests that the Late Holocene occupants of Simbero may have stayed for extended periods in the shelter. The deposits of the Mararo rock shelter also show a relatively low sedimentation rate that could be connected to the prevalence of aridity around the Sanetti Plateau.

Our knowledge of the established periods of aridity between the end of OIS 4 and LGM is limited, especially with regard to the consequences on local vegetation. The reviewed occupations in the Bale Mountains correspond to the wetter periods during OIS 3 and within the African Humid Period. The presence of abundant natural resources, mainly freshwater, vegetation, and wild animals around the studied sites may have permitted not only the aggregation of hunter-gatherers but also supported their subsistence. The archaeological evidence from the studied sites also suggests that the high altitude of the Bale Mountains has supported larger groups of LSA hunter-gatherers than during the late MSA, especially during the Middle and Late Holocene phases. Based on the existing archaeological and paleoenvironment data, it is possible to infer that the high altitudes of the Bale Mountains probably functioned as a paleoenvironmental refuge for both MSA and LSA cultural groups during the environmental changes at lower altitudes between OIS 3 and OIS 1.

Currently, it is unknown whether the high altitudes of the Bale Mountains were continually inhibited by both MSA and LSA cultural groups. In particular, the abrupt disappearance of late MSA lithic assemblages and the prominent occupational hiatus around 31 ka cal. BP at Fincha Habera rock shelter may suggest discontinuity of human occupations. The Bale Mountains appear to have been more suitable for human occupation again when the wetter conditions rapidly returned after 15 ka cal. BP. In turn, these conditions might also have been responsible for the erosion of respective deposits, that might have been accumulated in the period in between.

On the other hand, the archaeological evidence from the studied three shelters suggests that there was a remote technical continuity in the Bale Mountains lithic assemblages from the late MSA to the LSA, especially with regard to the continued production and use of borers and utilized tools. The LSA lithic assemblages of Simbero rock shelter show occupational continuity from the Terminal Pleistocene up to the Late Holocene, probably with fluctuations in the intensity of site use and associated activities. The absence of enough data on both the local and regional paleoenvironment and archaeology does not allow to suggest whether the high-altitude of the Bale Mountains or other Ethiopian regions were continually occupied by hunter-gatherers and additional data are required to clarify this question.

6.4. HUNTER-GATHERER BEHAVIORAL CHANGE AND CULTURAL ADAPTATION

Prior to the current study, human impact on the ecosystem of the Bale Mountains was long assumed to have been limited only to the Late Holocene period. This was based on the indirect evidence of paleoenvironmental and -vegetation studies derived from sediment cores of the Afroalpine lake Garba Guracha on the Bale Mountains' central Plateau (MOHAMMED & BONNEFILLE 1998; UMER ET AL. 2007). Recent publications on the ecological history of the Bale Mountains also proposed a similar age depth for the significant impact of humans, but additionally dated the earliest sporadic human activities to 15 ka cal. BP (KUZMICHEVA ET AL. 2013, 2017). This date was presumably deduced from the presence of charcoal in zoogenic deposits. However, no direct archaeological evidence for human presence was recorded in the above-mentioned studies. Fieldwork and excavations of the current research project show that human settlement already started well before the previously proposed dates and produced reliable evidence for both late MSA and LSA human occupations. Moreover, it was demonstrated that hunter-gatherers were successful in exploiting different landscapes and ecozones in the Bale Mountains during different settlement phases. Finally, these major settlement events are characterized by considerable differences in their timing and nature, including the cultural adaptations chosen by humans at different times. This chapter presents a diachronic synthesis of the behavioral changes during the hunter-gatherer occupation periods at the Bale Mountains.

While the occupations of hunter-gatherers at the high-altitude of the Bale Mountains are of diverging nature, a certain degree of continuity is especially visible in terms of the spatial occupation: throughout time, the upper Web Valley formed the most important area for human settlement and residence. The upper Web Valley was profoundly rich in geological, topographical, and biological diversity and supported hunter-gatherer subsistence, potentially beyond purely seasonal occupations. Ecologically, this valley is favored with a high variety of biodiversity (including micro- and macro-mammals) and abundant water resources such as swamps, ponds, and big streams such as the Web River. The latter is embedded in the more dissected northern escarpment with the formation of more open landscapes. The presence of different types of vegetation which is characterized by ericaceous and limited Afroalpine species with abundant grasses may have supported a heterogeneous spectrum of different animals within the Web Valley complex. According to the available evidence, giant root-rats (*Tachyoryctes macrocephalus*) and Ethiopian Wolves (*Canis simensis*), both endemic to the high-altitude environment, were abundant and modified the landscape of the upper Web Valley (STEPHENS ET AL. 2001; KUZMICHEVA ET AL. 2017).

Topographically, the Bale Mountains complex was open for movements of hunter-gatherers within and out of the Bale Mountains. Since the Arsi-Bale Mountains are bordering the eastern margin of the Main Ethiopian Rift, the two major openings in the northwest – the Kotera and Genale plains – may have functioned as a corridor for movements (**Fig. 2**). Moreover, the northeastern part of the Bale Mountains is also relatively open to the eastern part of the Southeastern Ethiopian Highlands and the Ogaden lowlands. The location of the upper Web Valley is therefore strategically important, particularly in connecting the Bale Mountains with the Ethiopian Rift to the west, the Southeastern Ethiopian Highlands to the north, and the Ogaden lowlands to the east (**Fig. 1**). These passages have also functioned later as major entrances for the pastoralist Oromo groups practicing their transhumant subsistence (*Godantu*) to access the resources of the Bale Mountains, including those of the Sanetti Plateau (**Fig. 2**). The potential relevance of the Bale Mountains as a barrier for migrations might have occurred to the more southerly regions, but this can currently neither be refuted nor approved.

The Late Pleistocene site of Fincha Habera delivered abundant late MSA artifacts in association with a high frequency of faunal remains, coprolites, and charcoal samples. These findings currently represent the earliest phase of hunter-gatherer occupations at the high-altitude Bale Mountains. The occupants of Fincha Habera produced typically late MSA elongated formal tools such as unifacial, partifacial, and laterally retouched points and in addition retouched blades and scrapers from highly prepared cores. These formal tools were associated with faunal remains of endemic species of high-altitude environments. The faunal remains at Fincha Habera are exceptionally dominated by giant root-rat (*Tachyoryctes macrocephalus*) but also include differently sized bovids. The scale of hunter-gatherer reliance on giant root-rats hunting is represented by the abundance of their remains in all Late Pleistocene deposits. Most of the giant root-rat faunal remains show a deliberate heat treatment. Limb bones of large mammals, showing lateral percussion and splinters at the fresh state, indicate that the occupants of Fincha Habera exploited different choices of food sources.

Direct evidence for repeated Terminal Pleistocene and Holocene LSA occupations around the upper Web Valley is visible at Simbero rock shelter. Like other rock shelters in the high-altitude of the Bale Mountains, the deposits at Simbero are shallow, but in contrast to most test excavations, the basal layers prove a Terminal Pleistocene occupation. However, this phase seems to reflect rather occasional events. The presence of a high frequency of utilized tools as opposed to very few formal tools as well as the almost total lack of faunal remains suggests that the shelter may have functioned for different activities than in the upper layers. The production and use of a range of LSA microliths abruptly increased – alongside with the number of faunal remains – during the Middle Holocene occupation. This might indicate that hunter-gatherers exploited different natural resources such as a diverse spectrum of macro- and micro-animals including birds and fish on a much larger scale than before. The emphasis on small mammals suggests a certain degree of intensification and specialization in hunting. On the other hand, the Late Holocene occupants of the Mararo rock shelter appear to employ different strategies in exploiting the resources of the Plateau. The Late Holocene deposits of Mararo contain the entire spectrum of LSA microliths without faunal remains. The notable absence of faunal remains suggests a different function of the site. Based on the recovered archaeological records, the shelter may have been used only for producing LSA lithic artifacts. Like in other Holocene sites in the region, the occupation of the Mararo rock shelter ended after 2 ka cal. BP.

The actual abundance of wild animals at the upper Web Valley may have determined the mobility and social organization of the hunter-gatherers. The deposits and archaeological findings of the studied shelters show that the duration of stays differed between long-term occupations and short-termed stays. If we consider the abundance of lithic artifacts in association with a high frequency of faunal remains, the late MSA site of Fincha Habera may have served as a functional site for permanent-like settlement for large bands. On the other hand, the Simbero rock shelter seems to represent short stays during the early, Terminal Pleistocene stage as opposed to permanent settlements from the mid to Late Holocene. The Late Holocene site of the Mararo rock shelter shows a settlement pattern characterized by short activity-related stays.

Based on the archaeological findings from the Bale Mountains, the successful adaptations of hunter-gatherers to high-altitude did not require technological innovations in the production of lithic artifacts. Both MSA and LSA formal tools at the Bale Mountains have several characteristic features similar to the lithic assemblages in the lowlands and more moderately elevated areas (as the Southeastern Ethiopian Highlands). Although the high-altitude of the Bale Mountains was characterized by a hostile environment for human living, especially hypoxia and the presence of glaciers and significant temperature depressions during the MSA occupation, the presence of abundant resources throughout the year, including raw material for lithic production, might have encouraged frequent movements of hunter-gatherers to and in the Bale Mountains. They used their prior knowledge to produce lithic tools that were suitable for their subsistence strategy in response to the high-altitude environments. Since the lithic assemblages even at the lower archaeological levels were highly dominated by the locally available raw material, particularly by the obsidian from Wasama Ridge, the hunter-gathers of the late MSA but also latter periods probably benefited from prior knowledge of the landscape.

However, the high-altitude subsistence at the Bale Mountains also included new or additional functional tools besides the range of rather common late MSA and LSA tools. The presence of elongated drills at Fincha Habera suggests that the occupants were intentionally producing pointed tools probably related to non-hunting, such as hide-working. Likewise, the LSA lithic assemblages contain a high frequency of borers which can be defined as locally preferred microlithic tools. Notably, the Terminal Pleistocene, mid-and Late Holocene subsistence at the upper Web Valley appears to have been dependent on the production of borers and suggests that these form a major adaptation to the high-altitude environments. If these tools were used for processing animal hides for clothes or housing, this would imply an important adaptation to the cold temperatures, especially at night, during all occupation phases.

Apart from the typology of some formal tools, significant changes can also be observed in the settlement and subsistence strategies, including divergent prey choices, which appear to have been developed in response to the new settlement in the high-altitude environments. During the late MSA, a major dietary focus was on hunting abundant and easy-to-catch giant root-rats at least at the residential site of Fincha Habera. This prey is of no importance in the faunal assemblages of Holocene age, which are generally characterized by the hunting of small-sized mammals, with a diachronic trend towards more avian and aquatic species. The intense use of fire within the rock shelters seems to form an additional strategy, probably not only to process animal meat but also for heating at the shelter.

The analyzed lithic records of the Bale Mountains do not show any notable change in lithic production techniques within the respective late MSA and LSA occupations. The plausible explanation for the presence of uniform late MSA and LSA lithic assemblages might be related to the hunter-gatherer's settlement and subsistence strategies, which probably did not require technological changes. At the same time, the uniform technological presence of both late MSA and LSA methods hints at a certain degree of continuity of human occupation in the respective periods. Comparable to other regions in Ethiopia, human occupation at the Bale Mountains during the global LGM remains unconfirmed, and there seems to be a long occupational gap. Although the chronological gap punctuates the chrono-cultural sequence, in general, the significant presence of comparable late MSA and LSA lithic artifacts in the Southeastern Ethiopian Highlands and the Ethiopian Rift indicates a cultural continuity, particularly between the Bale Mountains sites and the records of Goda Buticha and Porc-Épic. This conclusion is also corroborated by the results of the geochemical obsidian composition which hint at various volcanoes in the northern and central parts of the Rift Valley (**Fig. 1**), stressing its possible function as a "corridor" of human migrations and material exchange during the investigated time periods. The existence of a long-distance network is supported by the presence of a single Nubian Type I-point in the late MSA lithic assemblage of the Bale Mountains, also indicating a connection between the Ethiopian Rift and the Southeastern Ethiopian Highlands with the Bale Mountains. Other non-local raw materials such as obsidian, quartz, chalcedony in the lithic assemblages – apart from the unique fragment of ostrich eggshell – clearly indicate the presence of close economic exchange and interaction networks with lowland hunter-gatherers during all investigated occupation phases and at all sites.

6.5. CONCLUSIONS

Archaeological research in the high-altitude environments of the Horn of Africa, particularly the Ethiopian Highlands above 2500 m asl, has been marginalized in the past because human occupation of these ecozones was not expected. This dissertation provides the results of the first archaeological exploration at the high altitudes of the Southeastern Ethiopian Highlands. The newly discovered Bale Mountains sites above 3400 m asl provide new insights into the understanding of human occupation in the Horn of Africa between OIS 3 and OIS 1. Archaeological studies on three selected rock shelters in the upper Web Valley in the northwestern escarpment of the Bale Mountains provide evidence for repeated prehistoric hunter-gatherer occupations, dating back to almost 47 ka cal. BP and continuing until the end of Holocene around 2 ka cal. BP. The presence of abundant late MSA and LSA lithic artifacts which were dominantly produced from locally available obsidian proves repeated human occupations and exploitation of the local resources at the Bale Mountains.

Four major Paleolithic occupational events, namely during the Late Pleistocene, Terminal Pleistocene, Middle, and Late Holocene, were identified from the stratified deposits and the archaeological findings in the rock shelters. Late MSA lithic assemblages, which are the earliest human traces in the Bale Mountains, are characterized by a notable specificity, the absence of Levallois, and discoidal production techniques. The presence of abundant elongated pointed and blade tools, that were produced with pre-existing lithic production techniques indicates that the late MSA occupants at the Bale Mountains were technically flexible to produce specific formal tools. If we consider the frequency of retouched tools such as unifacial, partifacial, and laterally retouched points and blade tools, the techno-typology of the Bale Mountains MSA artifacts corresponds to those from the Ethiopian Rift and northern parts of the Southeastern Ethiopian Highlands. The possible explanation for the occurrence of MSA lithic artifact specificity at the Bale Mountains appears to be related to the potential cultural adaptation in response to the high-altitude environments. In particular, these late MSA lithic artifacts are associated with the processing and hunting of ecologically favored wildlife, especially endemic species including giant root-rat (*Tachyoryctes macrocephalus*) and mountain nyala (*Tragelaphus buxtoni*). Like in all other regions in Ethiopia, there is no evidence of human occupation in the Bale Mountains during the global LGM. Human occupation at the Bale Mountains seems to be interrupted during the LGM until ~15 ka cal. BP. The late MSA and LSA assemblages are related to the humid periods of OIS 3 and 1, and it is an open question of where and how humans survived during these long dry intervening periods.

Lithic assemblages that can be techno-typologically assigned to the LSA started during the Terminal Pleistocene and significantly increased from the Middle to the Late Holocene. They also show a notable similarity with adjacent archeological sites, particularly to those at the northern parts of the Southeastern Ethiopian Highlands. However, the occupations at the high-altitude of the Bale Mountains obviously required additional retouched tools for subsistence, such as borers. The abundant backed microliths are associated with hunting activities, characterized by the opportunistic exploitation of different types of macro-and micro-mammals, including birds and fish. The very heterogeneous spectrum of the game seems to represent the specificity of regional phenomena that are related to the high-altitude environments. Like other parts of the Southeastern Ethiopian Highlands, the production of microliths of the Bale Mountains abruptly ended around 2 ka cal. BP. It is not clear whether the Late Holocene settlements at the Bale Mountains were completely abandoned or replaced by early pastoral groups that left no traces in the rock shelters. The nature of subsistence changes from hunting and gathering to pastoral activities has yet to be explored through environmental, archaeological, anthropological, and linguistic research in the Bale Mountains.

The absence of detailed local paleoenvironmental data between OIS 3 and OIS 1 is a limiting factor in the discussion of specific high-altitude behavioral flexibility. Besides the presence of special lithic artifacts and elaborate hunting strategies related to abundant endemic wildlife, new behaviors are also manifested by the extensive use of fire in the shelters. A significant number of faunal remains show a high impact of fires, indicating the roasting of meat. The thick layer of ash indicates large fires most probably for heating the shelter.

At the regional level, the archaeological data of the Bale Mountains provide new information regarding the dispersal of anatomically modern humans across and within Africa during OIS 3. The plains of Kotera and Genale and the opening in the northeast of the Bale Mountains served as a potential corridor for hunter-gatherer's movements and interaction with neighboring groups. This makes high-altitude environments of the Bale Mountains an accessible region and potential ecological refugium for hunter-gatherers during arid periods. In this regard, abundant resources, particularly animals, water, and vegetation during environmental changes between OIS 3 and OIS 1 may have allowed the aggregation of hunter-gatherers at the Bale Mountains. However, additional paleoenvironmental and archaeological data at the local level, particularly from the neighboring Arsi Mountains, are required for a better understanding of human behavioral changes and biological adaptations during OIS 3, OIS 2, and OIS 1. Especially, human DNA analysis has a great potential to provide what role genetic adaptations played for the successful adaptation of the early Late Pleistocene and Holocene hunter-gatherers to the new environment. At this stage, the presentation of this dissertation provides unique information about human cultural responses to the high-altitude environment of the Bale Mountains during OIS 3 and OIS 1.

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APPENDICES

Appendix I: Results of the lithic attribute analysis (Fincha Habera)

ID	m²	½ m²	Level	Raw Material	Debitage	Completeness	Length (mm)	Width (mm)	Thick-ness (mm)	Weight (g)	Cross section	Physical condition	Raw material quality	Cortex	No. Dorsal neg.	Direction dorsal negatives	Outline dorsal negatives	Platform type	Edge form (left)	Edge form (right)	Retouch	Tool type
368	H11	NW	13	black obsidian	core	*n/a*	36,0	21,6	20,5	16,8	*n/a*	heavy abrasion	fine	1-25%	5	bi-directional	parallel	cortical	*indet.*	*indet.*	*n/a*	-
369	H11	NW	13	black obsidian	blade	complete	28,5	13,5	4,5	1,7	triangular	fresh	fine	no cortex	3	bi-directional	parallel	facetted	straight	straight	*indet.*	-
370	H11	NE	13	black obsidian	flake	complete	23,7	17,1	2,6	0,3	lenticular	fresh	fine	no cortex	4	uni-directional	curved	facetted	convex	convex	utilized	-
371	H11	NW	12	black obsidian	flake	distal	17,6	17,1	4,1	1,2	triangular	fresh	fine	1-25%	1	irregular	convergent	n/a	triangular	triangular	fine	-
372	H11	SW	12	yellow chert	blade	complete	31,4	13,6	7,8	3,6	trapezoid	fresh	fine	no cortex	3	uni-directional	parallel	plain	straight	straight	*indet.*	-
373	H11	SW	12	black obsidian	flake	complete	39,5	17,8	7,9	5,4	triangular	slight abrasion	coarse	26-50%	2	uni-directional	parallel	facetted	convex	irregular	*indet.*	-
374	H11	SW	12	black obsidian	blade	complete	27,6	7,7	4,8	0,8	triangular	fresh	fine	no cortex	2	uni-directional	parallel	plain	straight	straight	*indet.*	-
375	H11	SW	12	black obsidian	blade	complete	29,7	10,5	2,9	1,9	*indet.*	slight abrasion	with inclusions	1-25%	4	irregular	irregular	cortical	convex	concave	*indet.*	-
376	H11	NE	12	black obsidian	flake	complete	18,3	6,7	3,9	0,4	triangular	fresh	fine	no cortex	2	uni-directional	convergent	facetted	straight	convex	*indet.*	-
377	H11	NE	11	black obsidian	flake	complete	20,1	14,6	6,2	2,7	trapezoid	slight abrasion	fine	no cortex	1	uni-directional	convergent	facetted	triangular	triangular	fine & invasive	-
378	H11	NE	12	black obsidian	core	*n/a*	35,9	33,0	20,2	22,6	*n/a*	fresh	fine	no cortex	4	irregular	irregular	facetted	*indet.*	*indet.*	*n/a*	-
379	H11	NE	12	black obsidian	flake	complete	25,2	12,9	6,6	2,1	*indet.*	fresh	fine	1-25%	4	uni-directional	convergent	dihedral	convex	concave	fine & invasive	-
380	H11	NE	12	black obsidian	flake	complete	25,5	15,6	2,6	1,4	*indet.*	fresh	fine	no cortex	2	bi-directional	parallel	crushed	straight	straight	*indet.*	-
381	H11	SW	11	black obsidian	flake	complete	31,1	12,5	3,9	0,9	triangular	fresh	fine	no cortex	4	uni-directional	convergent	facetted	triangular	triangular	*indet.*	-
382	H11	SW	11	black obsidian	flake	complete	30,2	14,1	8,9	1,5	triangular	fresh	fine	no cortex	2	uni-directional	convergent	crushed	triangular	triangular	fine & facial	unifacial point
383	H11	NW	10	black obsidian	core	*n/a*	19,2	14,0	10,1	3,1	*n/a*	fresh	fine	1-25%	3	irregular	parallel	plain	*indet.*	*indet.*	*n/a*	-
384	H11	NW	10	black obsidian	blade	proximal-midsection	30,6	16,4	4,4	1,7	triangular	fresh	fine	no cortex	2	uni-directional	parallel	plain	straight	straight	fine & notched	-
385	H11	NW	10	black obsidian	flake	complete	25,2	18,1	6,4	2,2	*indet.*	fresh	fine	no cortex	2	uni-directional	convergent	dihedral	triangular	triangular	fine & utilized	-
386	H11	NE	10	black obsidian	blade	complete	48,8	13,2	3,2	2,2	triangular	fresh	fine	1-25%	2	uni-directional	parallel	facetted	straight	straight	*indet.*	-
387	H11	NE	10	black obsidian	blade	complete	44,4	14,2	7,1	3,7	triangular	fresh	fine	1-25%	4	uni-directional	parallel	point	convex	convex	fine & invasive	-
388	H11	NE	10	black obsidian	blade	complete	46,1	9,2	4,1	1,8	triangular	slight abrasion	with inclusions	26-50%	1	uni-directional	parallel	crushed	straight	straight	fine & utilized	-
389	H11	NE	10	black obsidian	flake	complete	38,4	14,4	5,3	2,8	*indet.*	fresh	fine	1-25%	1	uni-directional	parallel	crushed	straight	triangular	fine	-
390	H11	NE	9	black obsidian	blade	proximal	16,5	12,8	3,8	0,9	triangular	fresh	fine	1-25%	2	uni-directional	parallel	plain	straight	straight	fine	-
391	H11	NE	9	black obsidian	blade	complete	28,9	9,8	2,7	1,5	triangular	fresh	fine	1-25%	3	bi-directional	parallel	facetted	straight	straight	utilized	-
392	H11	NE	9	black obsidian	blade	proximal	16,1	14,3	2,7	1,0	prallelogram	fresh	fine	no cortex	2	uni-directional	parallel	facetted	straight	straight	fine	-
393	H11	SW	9	black obsidian	blade	proximal-midsection	26,6	7,4	3,1	0,6	triangular	fresh	fine	1-25%	3	bi-directional	parallel	crushed	straight	straight	*indet.*	-
394	H11	NE	8	black obsidian	flake	complete	21,1	13,4	5,3	3,5	triangular	fresh	with inclusions	no cortex	-	*indet.*	convergent	facetted	triangular	triangular	fine & invasive	-
395	H11	SW	8	black obsidian	blade	complete	35,1	8,7	2,8	1,1	triangular	fresh	fine	no cortex	3	bi-directional	parallel	facetted	straight	straight	utilized	-
396	H11	SW	8	black obsidian	blade	proximal-midsection	27,5	11,4	4,6	1,3	triangular	fresh	with inclusions	no cortex	4	bi-directional	parallel	facetted	straight	straight	*indet.*	-

ID	m²	½ m²	Level	Raw Material	Debitage	Completeness	Length (mm)	Width (mm)	Thick-ness (mm)	Weight (g)	Cross section	Physical condition	Raw material quality	Cortex	No. Dorsal neg.	Direction dorsal negatives	Outline dorsal negatives	Platform type	Edge form (left)	Edge form (right)	Retouch	Tool type
397	H11	SE	8	black obsidian	blade	proximal	18,5	11,2	4,1	1,1	trapezoidal	fresh	fine	1-25%	2	uni-directional	parallel	crushed	straight	straight	fine	-
398	H11	NE	7	black obsidian	blade	complete	43,5	15,7	7,1	4,7	triangular	fresh	fine	patinated	2	opposite	parallel	crushed	straight	straight	fine & utilized & invas	-
399	H11	NW	7	black obsidian	flake	complete	32,3	14,8	4,8	1,5	triangular	fresh	fine	1-25%	2	uni-directional	convergent	facetted	triangular	triangular	fine & invasive	-
400	H11	NW	7	black obsidian	flake	complete	21,9	17,0	3,6	1,7	triangular	fresh	fine	no cortex	2	uni-directional	convergent	facetted	triangular	triangular	fine & facial	unifacial point
401	H11	NW	7	black obsidian	blade	complete	26,8	8,8	2,6	0,7	triangular	fresh	fine	no cortex	4	bi-directional	irregular	crushed	straight	straight	utilized	-
402	H11	SW	7	basalt	hammer	complete	62,8	66,5	55,4	318,2	circular	heavy abrasion	with inclusions	no cortex	0	*indet.*	*indet.*	none	convex	convex	utilized	n/a
403	H11	SE	7	black obsidian	blade	proximal-midsection	27,6	12,2	4,1	1,7	trapezoidal	heavy abrasion	with inclusions	no cortex	2	bi-directional	parallel	plain	straight	straight	fine & stepped	-
404	H11	SW	6	black obsidian	blade	complete	43,8	18,5	6,4	4,3	triangular	fresh	fine	1-25%	3	bi-directional	parallel	facetted	convex	straight	fine & utilized	-
405	H11	SE	5	black obsidian	flake	complete	24,8	14,8	6,9	2,5	triangular	fresh	fine	1-25%	-	*indet.*	irregular	facetted	triangular	triangular	fine & facial	unifacial point
406	H11	SW	5	black obsidian	flake	complete	25,3	14,9	6,4	2,0	triangular	fresh	fine	1-25%	2	uni-directional	convergent	facetted	triangular	triangular	Utilized & stepped	-
407	H11	SW	5	black obsidian	core	*n/a*	17,8	29,8	18,2	12,4	*n/a*	fresh	fine	1-25%	4	uni-directional	parallel	plain	straight	straight	*n/a*	-
408	H11	SW	5	black obsidian	core	*n/a*	31,5	16,3	8,2	5,2	*n/a*	fresh	fine	no cortex	5	bi-directional	parallel	facetted	straight	straight	*n/a*	-
409	H11	SE	4	black obsidian	flake	complete	34,4	17,3	9,2	4,8	triangular	fresh	fine	1-25%	-	*indet.*	irregular	point	triangular	straight	invasive	-
410	H11	East profile	-	black obsidian	blade	complete	36,3	10,4	3,2	1,2	triangular	fresh	fine	no cortex	3	uni-directional	parallel	facetted	straight	straight	utilized	-
411	E8	NE	12	black obsidian	flake	complete	25,5	22,9	8,2	3,9	trapezoidal	fresh	fine	no cortex	2	unidirectional &	irregular	facetted	convex	convex	utilized	-
412	E8	NE	12	black obsidian	flake	complete	31,5	18,7	7,2	4,0	plano-convex	fresh	fine	no cortex	*indet.*	*indet.*	*indet.*	dihedral	convex	convex	facial	unifacial point
414	E8	NW	11	black obsidian	flake	complete	32,6	17,6	5,6	2,9	triangular	fresh	fine	no cortex	2	uni-directional	parallel	facetted	convergent	convergent	utilized	-
415	E8	NW	11	black obsidian	flake	complete	35,6	2,9	11,8	11,3	triangular	fresh	fine	26-50%	1	uni-directional	parallel	cortical	straight	straight	stepped	(end-) scraper
416	E8	NW	11	black obsidian	flake	distal-midsection	29,8	15,6	3,1	1,4	triangular	fresh	fine	no cortex	2	uni-directional	parallel	plain	irregular	irregular	notch	scraper fragment
417	E8	NW	11	black obsidian	flake	proximal-midsection	35,8	16,7	3,0	2,1	trapezoidal	fresh	fine	1-25%	2	uni-directional	ovoid	cortical	irregular	irregular	utilized	scraper fragment
418	E8	NW	11	black obsidian	flake	complete	22,1	12,9	6,1	1,7	plano-convex	fresh	fine	no cortex	*indet.*	*indet.*	*indet.*	facetted	convergent	convergent	facial	unifacial point
420	E8	NE	11	black obsidian	flake	distal-midsection	30,7	20,7	6,9	2,9	triangular	fresh	fine	no cortex	2	opposite	parallel	plain	irregular	irregular	utilized	-
421	E8	NE	11	black obsidian	flake	complete	36,1	19,7	7,9	6,0	trapezoidal	fresh	fine	no cortex	1	transverse	parallel	punctiform	convex	convex	facial	scraper
422	E8	NE	11	black obsidian	flake	complete	28,8	18,0	6,0	2,3	irregular	fresh	fine	no cortex	4	irregular	irregular	facetted	irregular	irregular	utilized	-
423	E8	NE	11	black obsidian	flake	complete	25,5	21,6	6,9	3,1	triangular	fresh	fine	no cortex	2	unidirectional &	irregular	facetted	convergent	convergent	utilized	-
424	E8	NW	10	black obsidian	flake	complete	28,2	17,8	6,4	2,9	triangular	fresh	fine	no cortex	2	opposite	parallel	crushed	straight	straight	utilized	-
425	E8	NW	10	black obsidian	flake	complete	18,9	12,5	4,6	1,1	triangular	fresh	fine	no cortex	2	uni-directional	convergent	cortical	convergent	convergent	facial/prox. thinning	unifacial point
426	E8	NW	10	black obsidian	blade	complete	24,1	8,7	2,6	0,5	triangular	fresh	fine	no cortex	2	uni-directional	parallel	punctiform	straight	straight	utilized	-

ID	m²	½ m²	Level	Raw Material	Debitage	Completeness	Length (mm)	Width (mm)	Thick-ness (mm)	Weight (g)	Cross section	Physical condition	Raw material quality	Cortex	No. Dorsal neg.	Direction dorsal negatives	Outline dorsal negatives	Platform type	Edge form (left)	Edge form (right)	Retouch	Tool type
428	E8	SW	10	black obsidian	blade	proximal-midsection	35,2	14,2	7,8	4,9	trapezoidal	fresh	fine	1-25%	3	bi-directional	parallel	facetted	straight	straight	utilized	-
429	E8	SW	10	black obsidian	flake	distal-midsection	22,4	26,9	8,4	6,6	triangular	heavy abrasion	fine	patinated	1	uni-directional	parallel	plain	convex	convex	utilized	scraper fragment
430	E8	SW	10	black obsidian	blade	proximal-midsection	22,4	14,8	5,4	1,8	triangular	fresh	fine	patinated	1	uni-directional	parallel	plain	straight	straight	utilized	-
432	E8	SW	10	black obsidian	flake	complete	20,4	16,9	7,5	2,4	triangular	fresh	with inclusions	1-25%	1	irregular	irregular	cortical	convex	convex	utilized	-
433	E8	SW	10	black obsidian	flake	complete	15,9	15,2	5,9	0,9	triangular	fresh	fine	no cortex	2	uni-directional	convergent	plain	irregular	irregular	notch	Borer
434	E8	NW	9	black obsidian	flake	proximal-midsection	25,8	23,5	6,1	3,9	lenticular	fresh	with inclusions	no cortex	3	uni-directional	convergent	facetted	convex	convex	utilized	-
435	E8	NW	9	black obsidian	flake	complete	33,1	21,8	7,9	4,8	triangular	fresh	fine	no cortex	2	uni-directional	convergent	facetted	convergent	convergent	fine & facial	unifacial point
436	E8	NW	9	black obsidian	flake	complete	26,1	13,7	8,2	2,4	triangular	fresh	fine	no cortex	4	uni-directional	convergent	plain	convergent	convergent	notches	-
437	E8	NE	9	black obsidian	flake	complete	23,5	12,2	4,7	1,2	triangular	fresh	fine	no cortex	2	uni-directional	convergent	plain	convergent	convergent	utilized	-
438	E8	SE	9	black obsidian	flake	complete	30,4	14,6	5,0	2,4	triangular	fresh	fine	1-25%	2	uni-directional	convergent	facetted	convergent	convergent	utilized	-
439	E8	SE	9	black obsidian	flake	distal-midsection	30,4	19,1	8,1	4,1	triangular	fresh	fine	patinated	1	uni-directional	parallel	plain	irregular	irregular	utilized	-
440	E8	SE	9	black obsidian	flake	complete	45,2	21,6	9,2	9,2	plano-convex	fresh	fine	patinated	*indet.*	*indet.*	*indet.*	cortical	irregular	irregular	utilized	-
441	E8	SW	9	black obsidian	flake	complete	36,2	34,3	7,2	9,6	bi-convex	fresh	fine	patinated	2	uni-directional	parallel	cortical	convex	convex	utilized	-
442	E8	SW	9	black obsidian	flake	complete	27,7	18,5	6,2	3,3	triangular	fresh	fine	1-25%	4	irregular	irregular	cortical	straight	straight	utilized	-
443	E8	SW	9	black obsidian	blade	complete	24,9	7,3	2,9	0,5	triangular	fresh	fine	no cortex	2	uni-directional	convergent	punctiform	convergent	convergent	facial	unifacial point
444	E8	SW	9	black obsidian	flake	midsection	17,1	10,5	1,7	0,4	lenticular	fresh	fine	no cortex	3	uni-directional	parallel	plain	straight	straight	utilized	-
445	E8	SW	9	black obsidian	flake	distal-midsection	27,5	25,2	4,1	2,3	triangular	fresh	fine	no cortex	3	uni-directional	convergent	plain	convergent	convergent	utilized	-
446	E8	NE	8	black obsidian	flake	complete	28,9	15,6	5,3	2,4	triangular	fresh	coarse	1-25%	3	uni-directional	convergent	facetted	convergent	convergent	facial	unifacial point
447	E8	NE	8	black obsidian	blade	complete	41,0	13,7	4,7	2,8	triangular	fresh	fine	no cortex	3	uni-directional	parallel	facetted	straight	straight	facial	unifacial point
448	E8	NE	8	black obsidian	blade	complete	25,2	10,4	1,8	0,7	lenticular	fresh	fine	no cortex	3	uni-directional	parallel	crushed	straight	straight	utilized	-
449	E8	NE	8	black obsidian	flake	complete	27,8	17,4	3,6	1,7	triangular	slight abrasion	fine	no cortex	2	uni-directional	parallel	crushed	convex	convex	utilized	-
450	E8	NE	8	black obsidian	flake	distal-midsection	24,3	12,3	2,8	0,9	trapezoidal	fresh	fine	patinated	1	uni-directional	parallel	none	irregular	irregular	utilized	-
451	E8	NW	8	black obsidian	blade	complete	33,3	10,6	3,5	1,1	triangular	fresh	fine	patinated	4	uni-directional	irregular	crushed	convergent	convergent	utilized	-
452	E8	SE	8	black obsidian	chunk	broken indet.	23,7	11,0	3,1	1,1	*n/a*	fresh	fine	no cortex	*n/a*	*n/a*	*n/a*	*n/a*	irregular	irregular	utilized	-
453	E8	SW	7	black obsidian	flake	complete	32,1	20,8	8,3	4,6	plano-convex	fresh	fine	1-25%	*indet.*	*indet.*	*indet.*	cortical	convergent	convergent	facial	unifacial point
454	E8	NW	7	black obsidian	flake	complete	19,6	17,9	7,5	2,7	plano-convex	fresh	fine	1-25%	1	irregular	irregular	cortical	convex	convex	utilized	scraper
455	E8	NW	7	black obsidian	blade	proximal-midsection	23,9	11,7	2,9	0,9	triangular	fresh	fine	no cortex	3	uni-directional	parallel	plain	convex	concave	utilized	-
457	E8	SE	7	black obsidian	chunk	broken indet.	23,3	19,6	14,0	7,8	*n/a*	slight abrasion	coarse	no cortex	*n/a*	*n/a*	*n/a*	*n/a*	irregular	irregular	utilized	-

ID	m²	½ m²	Level	Raw Material	Debitage	Completeness	Length (mm)	Width (mm)	Thick-ness (mm)	Weight (g)	Cross section	Physical condition	Raw material quality	Cortex	No. Dorsal neg.	Direction dorsal negatives	Outline dorsal negatives	Platform type	Edge form (left)	Edge form (right)	Retouch	Tool type
458	E8	NW	6	black obsidian	flake	complete	32,5	14,2	5,1	2,3	plano-convex	fresh	fine	26-50%	2	uni-directional	parallel	crushed	irregular	irregular	utilized	-
459	E8	SE	6	black obsidian	flake	complete	30,3	14,4	7,9	2,3	triangular	fresh	fine	1-25%	1	uni-directional	ovoid	crushed	convex	convex	proximal thinning	-
460	E8	NE	6	black obsidian	flake	complete	34,2	12,9	3,1	2,8	triangular	fresh	fine	1-25%	2	uni-directional	ovoid	crushed	straight	straight	notch	-
461	E8	SW	5	black obsidian	bladelet	complete	16,5	7,9	1,9	0,3	lenticular	fresh	fine	1-25%	1	uni-directional	parallel	crushed	straight	convex	facial	unifacial point
462	E8	NE	5	black obsidian	flake	complete	20,8	15,8	2,8	1,0	lenticular	fresh	fine	no cortex	3	uni-directional	parallel	plain	irregular	irregular	utilized	-
463	E8	SE	5	black obsidian	blade	proximal-midsection	26,4	14,6	5,4	1,8	trapezoidal	fresh	with inclusions	no cortex	3	bi-directional	irregular	plain	concave	convex	utilized	-
464	E8	SE	5	black obsidian	blade	complete	27,3	9,3	2,0	0,6	triangular	fresh	fine	no cortex	2	uni-directional	parallel	crushed	convex	convex	utilized	-
466	E8	West profile	6	black obsidian	blade	complete	39,6	13,9	4,9	2,7	trapezoidal	fresh	fine	1-25%	2	uni-directional	parallel	facetted	straight	straight	utilized	-
467	E8	West profile	6	black obsidian	flake	complete	40,4	15,3	5,7	2,2	plano-convex	fresh	fine	no cortex	4	uni-directional	parallel	facetted	convex	convex	utilized	-
468	E8	West profile	6	black obsidian	flake	complete	33,7	18,5	6,2	2,5	triangular	fresh	fine	no cortex	2	uni-directional	parallel	facetted	convex	concave	utilized	-
883	H11	SW	9	black obsidian	blade	complete	43,2	17,3	5,8	4,5	triangular	fresh	fine	no cortex	5	irregular	irregular	facetted	straight	straight	utilized	-
884	H11	NW	11	black obsidian	core	*n/a*	33,5	15,5	7,7	3,0	*n/a*	fresh	fine	no cortex	5	bi-directional	parallel	point	*n/a*	*n/a*	*n/a*	-
885	H11	NW	11	black obsidian	core	*n/a*	18,2	31,9	13,0	7,0	*n/a*	fresh	fine	no cortex	4	uni-directional	irregular	plain	*n/a*	*n/a*	*n/a*	-
886	H11	SW	11	black obsidian	blade	complete	47,9	17,1	7,3	6,4	plano-convex	slight abrasion	fine	1-25%	2	uni-directional	parallel	crushed	straight	straight	utilized	-
887	H11	NE	7	black obsidian	flake	complete	28,5	17,5	3,7	1,6	lenticular	fresh	fine	no cortex	2	uni-directional	convergent	facetted	convex	convex	utilized	-
888	H11	NE	12	black obsidian	blade	complete	32,2	24,2	11,8	9,0	plano-convex	fresh	fine	26-50%	0	*indet.*	irregular	facetted	straight	straight	rough	-
889	H11	NW	11	black obsidian	blade	complete	47,6	17,3	7,1	5,7	triangular	heavy abrasion	fine	patinated	2	*indet.*	parallel	cortical	straight	straight	utilized	-
890	H11	SW	5	black obsidian	flake	complete	49,9	29,4	9,4	12,8	triangular	fresh	fine	1-25%	2	uni-directional	convergent	crushed	convex	convex	utilized	-
891	H11	SE	6	black obsidian	flake	complete	47,9	38,1	8,7	12,4	triangular	fresh	fine	51-75%	1	uni-directional	parallel	cortical	convex	convex	utilized	-
892	H11	NE	10	yellow chert	blade	complete	37,1	17,9	6,5	3,6	triangular	fresh	fine	26-50%	1	uni-directional	parallel	cortical	straight	straight	utilized	-
901	H11	SW	9	black obsidian	blade	complete	43,2	17,3	5,8	3,5	triangular	fresh	fine	1-25%	5	bi-directional	parallel	facetted	straight	straight	utilized	-

Appendix II: Results of the lithic attribute analysis (Simbero)

ID	m^2	½ m^2	Level	Raw Material	Debitage	Completeness	Length (mm)	Width (mm)	Thick-ness (mm)	Weight (g)	Cross section	Physical Condition	Raw Material Quality	Cortex	No. dorsal neg.	Direction dorsal negatives	Outline dorsal negatives	Platform Type	Edge Form (left)	Edge Form (right)	Retouch	Tool Type
867	O6	NW	2	rhyolith	hammer	broken indet.	48,1	58,6	44,3	198,6	triangular	heavy abrasion	fine	no cortex	0	*indet.*	*indet.*	*indet.*	convex	convex	*indet.*	-
831	O6	SW	4	black obsidian	bladelet	distal	12,8	8,5	2,8	0,2	triangular	fresh	fine	no cortex	2	unidirectional	convergent	none	triangular	triangular	utilized	-
690	O6	NW	8	black obsidian	bladelet	distal-midsection	21,2	2,2	2,4	0,5	triangular	slight abrasion	with inclus	no cortex	2	unidirectional	convergent	crushed	triangular	triangular	fine	-
692	O6	NW	8	black obsidian	bladelet	distal-midsection	24,2	7,9	2,9	0,7	plano-convex	fresh	fine	no cortex	6	bi-directional	parallel	none	straight	straight	utilized	-
694	O6	NW	8	black obsidian	bladelet	distal-midsection	15,3	8,2	2,6	0,4	triangular	fresh	fine	no cortex	3	bi-directional	parallel	none	straight	straight	utilized	-
708	O6	NW	5	black obsidian	blade	distal-midsection	17,9	10,6	2,3	0,4	lenticular	fresh	fine	no cortex	3	bi-directional	parallel	none	straight	straight	Utilized/trunc.	-
710	O6	NW	5	black obsidian	bladelet	distal-midsection	13,6	7,9	2,7	0,2	lenticular	fresh	fine	no cortex	2	unidirectional	parallel	none	straight	straight	utilized	-
717	O6	SE	5	black obsidian	blade	distal-midsection	42,0	13,6	8,3	4,5	triangular	slight abrasion	with inclus	1-25%	1	unidirectional	parallel	none	straight	straight	fine	-
725	O6	NE	5	black obsidian	bladelet	distal-midsection	17,8	6,6	2,3	0,2	triangular	fresh	fine	no cortex	1	unidirectional	parallel	none	straight	straight	backed/utilized	backed bladelet
739	O6	SW	5	black obsidian	blade	distal-midsection	16,1	8,7	3,0	0,3	triangular	fresh	fine	no cortex	2	unidirectional	parallel	none	convex	straight	backed/utilized	½ crescent
771	O6	NW	6	black obsidian	bladelet	distal-midsection	11,6	5,3	2,4	0,1	lenticular	fresh	fine	no cortex	2	unidirectional	parallel	none	convex	straight	fine/utilized	crescent
791	O6	NE	6	black obsidian	bladelet	distal-midsection	15,1	6,8	1,7	0,1	lenticular	fresh	fine	no cortex	2	unidirectional	parallel	none	straight	straight	utilized	-
806	O6	SW	6	black obsidian	bladelet	distal-midsection	21,8	7,4	5,1	0,5	parallelogram	fresh	fine	no cortex	1	unidirectional	parallel	none	straight	straight	fine/notched	-
808	O6	SW	6	black obsidian	bladelet	distal-midsection	17,8	6,4	2,4	0,2	triangular	fresh	fine	no cortex	2	unidirectional	parallel	none	straight	straight	utilized	-
820	O6	SE	6	black obsidian	bladelet	distal-midsection	17,0	8,1	2,7	0,3	triangular	fresh	fine	no cortex	2	unidirectional	parallel	pointed	straight	straight	Utilized/trunc.	-
828	O6	SW	4	black obsidian	bladelet	distal-midsection	15,8	6,6	2,3	0,2	triangular	fresh	fine	no cortex	2	unidirectional	parallel	none	straight	straight	utilized	-
841	O6	SE	4	black obsidian	bladelet	distal-midsection	15,5	5,8	3,2	0,2	triangular	fresh	fine	no cortex	2	unidirectional	parallel	none	straight	convex	utilized	-
849	O6	NW	4	black obsidian	bladelet	distal-midsection	21,1	7,3	2,6	0,4	lenticular	fresh	fine	no cortex	2	unidirectional	parallel	none	straight	straight	backed/utilized	backed bladelet
856	O6	SW	3	black obsidian	blade	distal-midsection	20,2	9,5	3,7	0,6	triangular	fresh	fine	no cortex	2	unidirectional	convergent	none	triangular	triangular	fine/trunc.	-
857	O6	SW	3	black obsidian	flake	distal-midsection	21,9	13,1	3,9	0,9	triangular	fresh	fine	no cortex	2	unidirectional	convergent	none	concave	convex	notch/utilized	borer
896	O6	NW	6	black obsidian	blade	distal-midsection	18,3	10,0	2,8	0,6	lenticular	fresh	fine	no cortex	4	unidirectional	parallel	none	straight	straight	utilized	-
719	O6	SE	5	black obsidian	core	*indet.*	26,4	21,1	8,1	5,7	*indet.*	slight abrasion	fine	patinated	5	bi-directional	parallel	*indet.*	*indet.*	*indet.*	*indet.*	-
768	O6	SW	7	black obsidian	core	*indet.*	15,5	15,7	12,2	3,5	*indet.*	fresh	fine	1-25%	6	bi-dir. & transverse	*indet.*	*indet.*	*indet.*	*indet.*	*indet.*	-
782	O6	NW	6	black obsidian	core	*indet.*	12,7	19,9	14,4	4,5	*indet.*	*indet.*	fine	no cortex	0	*indet.*	*indet.*	plain	*indet.*	*indet.*	*indet.*	-
802	O6	NE	6	black obsidian	core	*indet.*	16,1	14,5	7,5	2,1	*indet.*	*indet.*	fine	no cortex	0	*indet.*	*indet.*	*indet.*	*indet.*	*indet.*	*indet.*	-
823	O6	SE	6	black obsidian	core	*indet.*	19,9	13,8	7,9	2,3	polygonal	fresh	fine	26-50%	6	bi-directional	parallel	plain	straight	straight	*indet.*	-
826	O6	SW	4	black obsidian	core	*indet.*	14,2	13,4	7,0	1,5	*indet.*	*indet.*	fine	no cortex	0	bi-directional	*indet.*	*indet.*	*indet.*	*indet.*	*indet.*	-
827	O6	SW	4	black obsidian	core	*indet.*	18,8	12,1	6,0	1,3	*indet.*	*indet.*	fine	no cortex	0	*indet.*	*indet.*	*indet.*	*indet.*	*indet.*	*indet.*	-
756	O6	SE	7	black obsidian	flake	longitudinal	19,0	9,0	5,1	1,1	triangular	fresh	fine	no cortex	4	bi-directional	convergent	plain	straight	triangular	utilized	-
760	O6	NE	7	black obsidian	blade	longitudinal	32,2	8,9	3,5	1,1	parallelogram	fresh	fine	no cortex	2	unidirectional	parallel	crushed	straight	straight	utilized	-
777	O6	NW	6	black obsidian	flake	longitudinal	16,3	7,9	2,5	0,5	polygonal	fresh	fine	no cortex	1	unidirectional	convergent	plain	straight	triangular	fine	borer
801	O6	NE	6	yellow chert	bladelet	longitudinal	27,1	8,1	3,3	0,6	polygonal	slight abrasion	fine	no cortex	1	unidirectional	parallel	crushed	straight	straight	rough	backed bladelet
855	O6	SE	3	black obsidian	flake	longitudinal	22,9	12,9	3,7	1,2	triangular	fresh	fine	no cortex	3	unidirectional	convergent	facetted	straight	triangular	notch/utilized	-
681	O6	NW	8	black obsidian	bladelet	midsection	10,3	7,2	2,5	0,2	triangular	fresh	fine	no cortex	1	unidirectional	parallel	none	straight	straight	backed/utilized	backed bladelet
691	O6	NW	8	black obsidian	bladelet	midsection	26,1	9,9	2,8	0,7	triangular	fresh	fine	no cortex	2	unidirectional	parallel	plain	straight	straight	utilized	-
711	O6	NW	5	black obsidian	bladelet	midsection	14,7	10,8	2,5	0,5	triangular	slight abrasion	fine	no cortex	4	bi-dir. & transverse	irregular	none	straight	straight	utilized	-
723	O6	NE	5	black obsidian	bladelet	midsection	18,5	10,5	3,7	0,6	triangular	fresh	fine	no cortex	1	unidirectional	parallel	none	straight	convex	backed/utilized	crescent

ID	m²	½ m²	Level	Raw Material	Debitage	Completeness	Length (mm)	Width (mm)	Thick-ness (mm)	Weight (g)	Cross section	Physical Condition	Raw Material Quality	Cortex	No. dorsal neg.	Direction dorsal negatives	Outline dorsal negatives	Platform Type	Edge Form (left)	Edge Form (right)	Retouch	Tool Type
727	O6	NE	5	black obsidian	bladelet	midsection	14,7	6,8	1,7	0,1	lenticular	fresh	fine	no cortex	2	unidirectional	parallel	none	straight	straight	utilized	-
780	O6	NW	6	white chalced.	blade	midsection	19,1	11,0	3,4	0,5	triangular	fresh	fine	no cortex	2	unidirectional	parallel	none	straight	straight	utilized	-
781	O6	NW	6	brown chert	bladelet	midsection	17,7	8,7	1,7	0,3	lenticular	slight abrasion	with inclus	no cortex	2	unidirectional	parallel	none	straight	straight	utilized	-
792	O6	NE	6	black obsidian	bladelet	midsection	18,5	7,8	2,1	0,2	lenticular	fresh	fine	no cortex	2	unidirectional	parallel	plain	straight	straight	notch/utilized	-
829	O6	SW	4	black obsidian	bladelet	midsection	13,5	7,5	1,5	0,2	lenticular	slight abrasion	fine	no cortex	2	unidirectional	parallel	none	straight	straight	fine/utilized	backed bladelet
842	O6	SE	4	black obsidian	bladelet	midsection	11,2	6,6	2,9	0,2	triangular	fresh	fine	no cortex	1	unidirectional	parallel	none	straight	straight	backed/utilized	backed bladelet
850	O6	NW	4	black obsidian	bladelet	midsection	16,4	6,3	1,7	0,2	lenticular	fresh	fine	no cortex	2	unidirectional	parallel	none	straight	straight	backed/utilized	backed bladelet
685	O6	NW	8	black obsidian	bladelet	prox.-midsection	14,1	6,8	2,2	0,3	lenticular	fresh	fine	no cortex	3	unidirectional	parallel	facetted	straight	straight	fine/backed/utilized	backed bladelet
686	O6	NW	8	black obsidian	bladelet	prox.-midsection	13,3	7,8	2,6	0,3	lenticular	fresh	fine	no cortex	2	unidirectional	parallel	facetted	straight	straight	utilized	-
689	O6	NW	8	black obsidian	bladelet	prox.-midsection	15,4	8,8	2,7	0,5	triangular	fresh	fine	no cortex	2	unidirectional	parallel	pointed	straight	straight	utilized	-
696	O6	NW	8	black obsidian	flake	prox.-midsection	21,7	13,8	4,2	1,2	triangular	slight abrasion	fine	no cortex	2	unidirectional	convergent	facetted	straight	straight	utilized	-
698	O6	NW	8	black obsidian	flake	prox.-midsection	18,8	13,5	2,4	0,6	triangular	slight abrasion	fine	no cortex	2	unidirectional	convergent	plain	concave	concave	utilized	-
702	O6	NW	8	black obsidian	blade	prox.-midsection	17,4	10,2	2,6	0,5	plano-convex	fresh	fine	no cortex	3	unidirectional	parallel	pointed	straight	straight	Facial/utilized	-
715	O6	SE	5	black obsidian	blade	prox.-midsection	28,5	8,7	3,4	0,8	triangular	fresh	fine	1-25%	2	unidirectional	parallel	facetted	straight	straight	utilized	-
726	O6	NE	5	black obsidian	bladelet	prox.-midsection	19,7	10,2	2,9	0,6	lenticular	fresh	fine	no cortex	3	unidirectional	parallel	facetted	straight	straight	fine/trunc.	-
730	O6	NE	5	black obsidian	bladelet	prox.-midsection	15,0	8,7	4,5	0,4	triangular	fresh	fine	1-25%	2	unidirectional	parallel	none	triangular	triangular	utilized	-
732	O6	NE	5	black obsidian	bladelet	prox.-midsection	14,5	7,5	1,8	0,1	lenticular	fresh	fine	no cortex	2	unidirectional	parallel	pointed	straight	straight	utilized	-
734	O6	NE	5	black obsidian	blade	prox.-midsection	28,3	13,3	7,6	3,1	triangular	fresh	fine	no cortex	2	unidirectional	parallel	plain	straight	straight	fine	-
748	O6	NW	7	black obsidian	flake	prox.-midsection	22,0	10,9	4,0	0,9	triangular	fresh	fine	no cortex	3	bi-directional	convergent	plain	triangular	triangular	fine/utilized	-
750	O6	NW	7	black obsidian	bladelet	prox.-midsection	16,2	8,6	2,7	0,4	triangular	fresh	fine	1-25%	1	unidirectional	parallel	pointed	straight	straight	fine/backed/utilized	-
767	O6	SW	7	black obsidian	bladelet	prox.-midsection	20,8	9,5	2,5	0,5	triangular	fresh	fine	no cortex	3	unidirectional	parallel	facetted	straight	straight	utilized	-
775	O6	NW	6	black obsidian	bladelet	prox.-midsection	20,4	9,1	2,4	0,4	lenticular	fresh	fine	no cortex	2	bi-directional	parallel	facetted	straight	straight	utilized	-
778	O6	NW	6	black obsidian	blade	prox.-midsection	27,6	13,3	7,0	2,7	triangular	slight abrasion	fine	no cortex	2	unidirectional	parallel	plain	straight	straight	fine	-
787	O6	NE	6	black obsidian	bladelet	prox.-midsection	21,9	8,5	2,9	0,5	triangular	fresh	fine	no cortex	3	unidirectional	parallel	pointed	straight	straight	backed/utilized/invasive	backed bladelet
790	O6	NE	6	black obsidian	blade	prox.-midsection	16,7	6,5	2,7	0,3	triangular	fresh	fine	no cortex	2	unidirectional	parallel	pointed	straight	straight	fine/backed/utilized	backed bladelet
793	O6	NE	6	black obsidian	bladelet	prox.-midsection	13,7	8,2	1,8	0,2	lenticular	fresh	fine	no cortex	2	unidirectional	parallel	pointed	straight	straight	utilized	-
800	O6	NE	6	black obsidian	flake	prox.-midsection	18,5	12,8	5,7	1,0	plano-convex	fresh	fine	no cortex	3	unidirectional	parallel	none	straight	convex	utilized	-
804	O6	SW	6	black obsidian	bladelet	prox.-midsection	16,7	5,2	2,3	0,2	parallelogram	fresh	fine	no cortex	2	unidirectional	parallel	none	straight	straight	backed/utilized	backed bladelet
807	O6	SW	6	black obsidian	bladelet	prox.-midsection	18,9	6,9	2,2	0,4	triangular	fresh	fine	no cortex	2	unidirectional	parallel	facetted	straight	straight	fine/notch/utilized	-
822	O6	SE	6	black obsidian	bladelet	prox.-midsection	15,4	9,2	2,5	0,3	triangular	fresh	fine	no cortex	2	unidirectional	parallel	none	straight	straight	fine/utilized	-
837	O6	NE	4	black obsidian	bladelet	prox.-midsection	14,1	8,8	3,6	0,4	triangular	fresh	fine	no cortex	2	unidirectional	parallel	none	convex	straight	backed	borer/backed bladelet
838	O6	NE	4	black obsidian	blade	prox.-midsection	18,8	11,9	3,4	0,5	triangular	fresh	fine	no cortex	2	unidirectional	parallel	facetted	straight	straight	utilized	-
851	O6	NW	4	black obsidian	bladelet	prox.-midsection	15,0	6,0	2,9	0,2	triangular	fresh	fine	no cortex	2	unidirectional	parallel	pointed	straight	straight	fine/utilized/trunc.	-
852	O6	NW	4	black obsidian	blade	prox.-midsection	17,6	10,4	3,6	0,8	triangular	fresh	fine	no cortex	2	unidirectional	parallel	plain	straight	straight	utilized	-
860	O6	NE	3	black obsidian	blade	prox.-midsection	27,1	13,4	6,3	2,0	triangular	fresh	fine	no cortex	3	unidirectional	parallel	plain	straight	straight	utilized	-
868	O6	NW	2	black obsidian	bladelet	prox.-midsection	11,1	4,6	0,4	0,2	triangular	fresh	fine	no cortex	2	unidirectional	parallel	pointed	straight	straight	utilized	-
688	O6	NW	8	black obsidian	flake	proximal	10,9	9,9	3,6	0,5	triangular	fresh	fine	no cortex	2	unidirectional	convergent	facetted	straight	straight	utilized	-

ID	m^2	½ m^2	Level	Raw Material	Debitage	Completeness	Length (mm)	Width (mm)	Thick-ness (mm)	Weight (g)	Cross section	Physical Condition	Raw Material Quality	Cortex	No. dorsal neg.	Direction dorsal negatives	Outline dorsal negatives	Platform Type	Edge Form (left)	Edge Form (right)	Retouch	Tool Type
709	O6	NW	5	black obsidian	blade	proximal	13,4	9,7	2,2	0,2	lenticular	fresh	fine	no cortex	3	unidirectional	parallel	pointed	straight	straight	Utilized/trunc.	Borer (?)
720	O6	NE	5	black obsidian	bladelet	proximal	11,6	10,7	2,8	0,4	triangular	fresh	fine	no cortex	2	unidirectional	parallel	facetted	straight	straight	backed	backed bladelet
721	O6	NE	5	black obsidian	bladelet	proximal	10,7	7,5	1,9	0,2	triangular	fresh	fine	no cortex	2	unidirectional	parallel	plain	straight	straight	fine/utilized	-
731	O6	NE	5	black obsidian	bladelet	proximal	13,3	8,0	1,8	0,2	lenticular	fresh	fine	no cortex	2	unidirectional	convergent	pointed	concave	concave	notch/utilized	-
819	O6	SE	6	black obsidian	bladelet	proximal	14,7	6,5	2,5	0,2	triangular	fresh	fine	no cortex	1	unidirectional	parallel	none	convex	straight	fine/backed/utilized	backed bladelet
898	O6	NW	6	black obsidian	bladelet	proximal	12,8	8,8	3,3	1,6	triangular	fresh	fine	no cortex	2	unidirectional	parallel	plain	straight	straight	fine/utilized	-
520	O6	NW	6	black obsidian	bladelet	complete	19,8	6,8	2,8	0,3	lenticular	fresh	fine	no cortex	1	unidirectional	curved	none	straight	convex	backed/utilized	crescent
521	O6	NW	6	black obsidian	bladelet	complete	20,8	8,8	4,7	0,8	triangular	fresh	fine	no cortex	2	unidirectional	parallel	none	triangular	straight	backed/utilized/invasive	crescent
522	O6	NE	5	black obsidian	blade	complete	38,2	16,3	5,3	2,8	triangular	fresh	fine	1-25%	2	unidirectional	parallel	plain	straight	straight	fine/notch/utilized	-
523	O6	SE	4	black obsidian	bladelet	complete	14,1	5,5	2,4	0,1	triangular	fresh	fine	no cortex	2	unidirectional	parallel	none	straight	convex	backed	crescent
524	O6	SE	4	black obsidian	bladelet	complete	13,8	3,7	2,1	0,0	triangular	fresh	fine	no cortex	1	unidirectional	curved	none	convex	straight	backed/utilized	crescent
539	O6	SW	4	black obsidian	bladelet	complete	15,5	6,2	3,1	0,2	triangular	fresh	fine	no cortex	1	unidirectional	parallel	none	straight	convex	backed/utilized	crescent
540	O6	SE	4	black obsidian	bladelet	complete	35,1	27,3	5,5	6,1	plano-convex	fresh	fine	no cortex	4	bi-dir. & transverse	irregular	facetted	straight	straight	fine/notch/utilized	scraper
541	O6	SW	5	black obsidian	blade	complete	24,8	10,5	2,1	0,7	lenticular	fresh	fine	no cortex	3	unidirectional	curved	none	convex	straight	rough/backed/utilized	crescent
542	O6	SW	5	black obsidian	bladelet	complete	12,7	5,7	3,2	0,2	triangular	fresh	fine	no cortex	1	unidirectional	parallel	none	straight	convex	notch/back/utilized	crescent
543	O6	SW	5	black obsidian	flake	complete	9,6	19,9	2,5	0,4	lenticular	fresh	fine	no cortex	2	opposite	irregular	facetted	straight	concave	notch/utilized	borer
544	O6	SW	6	black obsidian	bladelet	complete	17,9	5,2	1,9	0,2	lenticular	fresh	fine	no cortex	4	bi-directional	parallel	pointed	straight	straight	fine/utilized	-
545	O6	NE	7	black obsidian	flake	complete	37,6	13,9	2,8	1,7	lenticular	fresh	fine	no cortex	4	unidirectional	convergent	crushed	triangular	triangular	utilized	-
546	O6	NE	5	black obsidian	bladelet	complete	14,4	5,4	2,5	0,2	triangular	fresh	fine	no cortex	2	unidirectional	curved	none	convex	straight	backed	crescent
682	O6	NW	8	black obsidian	bladelet	complete	15,3	6,0	2,6	0,2	triangular	fresh	fine	no cortex	2	unidirectional	parallel	facetted	straight	straight	facial/utilized	-
683	O6	NW	8	black obsidian	bladelet	complete	15,5	6,9	2,0	0,2	lenticular	fresh	fine	no cortex	2	unidirectional	parallel	pointed	convex	convex	fine/backed/utilized	backed bladelet
684	O6	NW	8	black obsidian	bladelet	complete	16,2	5,8	2,0	0,2	lenticular	fresh	fine	no cortex	2	unidirectional	parallel	pointed	straight	straight	fine/backed/utilized	backed bladelet
687	O6	NW	8	black obsidian	bladelet	complete	12,4	6,5	2,1	0,2	triangular	fresh	fine	no cortex	2	unidirectional	parallel	plain	straight	straight	utilized	-
693	O6	NW	8	black obsidian	bladelet	complete	27,5	8,6	3,8	0,9	triangular	fresh	fine	patinated	4	bi-directional	irregular	facetted	straight	straight	utilized	-
695	O6	NW	8	black obsidian	bladelet	complete	19,6	5,8	1,7	0,2	lenticular	fresh	fine	no cortex	3	bi-directional	parallel	pointed	straight	straight	utilized	-
697	O6	NW	8	black obsidian	flake	complete	28,3	14,7	5,6	1,7	triangular	fresh	fine	no cortex	2	unidirectional	convergent	plain	triangular	triangular	utilized	-
699	O6	NW	8	black obsidian	flake	complete	18,5	13,4	3,7	0,9	triangular	fresh	fine	no cortex	2	unidirectional	parallel	cortical	convex	straight	rough/trunc.	borer
700	O6	NW	8	black obsidian	flake	complete	24,1	12,8	6,7	1,8	plano-convex	fresh	fine	patinated	3	unidir. & transverse	irregular	plain	straight	convex	rough/utilized	borer
703	O6	NW	5	black obsidian	flake	complete	18,9	10,7	3,2	0,6	triangular	fresh	fine	no cortex	4	bi-directional	irregular	crushed	convex	straight	notch/utilized	borer
704	O6	NW	5	black obsidian	bladelet	complete	20,5	7,8	2,2	0,4	lenticular	fresh	fine	no cortex	4	bi-directional	parallel	plain	straight	straight	backed/utilized/invasive	backed bladelet
705	O6	NW	5	black obsidian	flake	complete	21,2	9,7	4,2	0,8	triangular	fresh	fine	patinated	1	unidirectional	convergent	plain	straight	convex	utilized	-
706	O6	NW	5	black obsidian	blade	complete	31,1	9,7	4,2	1,4	plano-convex	fresh	fine	no cortex	3	bi-directional	parallel	crushed	straight	straight	fine/utilized	-
707	O6	NW	5	black obsidian	bladelet	complete	22,2	8,2	5,1	0,9	triangular	slight abrasion	fine	patinated	3	unidirectional	parallel	crushed	straight	straight	utilized	-
712	O6	NW	5	black obsidian	bladelet	complete	15,3	7,4	2,6	0,4	triangular	slight abrasion	fine	no cortex	2	unidirectional	curved	plain	concave	convex	rough/notch	crescent
714	O6	SE	5	black obsidian	flake	complete	28,9	19,4	9,1	4,5	plano-convex	fresh	fine	no cortex	5	bi-directional	convergent	plain	triangular	triangular	*indet.*	-
716	O6	SE	5	black obsidian	bladelet	complete	24,8	8,3	3,3	0,5	triangular	fresh	fine	no cortex	4	unidirectional	parallel	facetted	straight	straight	utilized	-
722	O6	NE	5	black obsidian	bladelet	complete	16,4	8,4	2,7	0,4	triangular	fresh	fine	1-25%	1	bi-directional	parallel	pointed	triangular	convex	backed/utilized	backed bladelet

ID	m²	½ m²	Level	Raw Material	Debitage	Completeness	Length (mm)	Width (mm)	Thick-ness (mm)	Weight (g)	Cross section	Physical Condition	Raw Material Quality	Cortex	No. dorsal neg.	Direction dorsal negatives	Outline dorsal negatives	Platform Type	Edge Form (left)	Edge Form (right)	Retouch	Tool Type
724	O6	NE	5	black obsidian	bladelet	complete	17,1	6,3	4,8	0,4	triangular	fresh	fine	no cortex	1	unidirectional	curved	none	convex	concave	backed/utilized	crescent
728	O6	NE	5	black obsidian	bladelet	complete	21,9	9,9	5,3	0,8	triangular	fresh	fine	1-25%	3	bi-directional	parallel	facetted	straight	straight	utilized	-
729	O6	NE	5	black obsidian	flake	complete	18,1	12,8	4,2	0,6	triangular	slight abrasion	fine	patinated	3	unidirectional	convergent	plain	triangular	triangular	notch/utilized	-
733	O6	NE	5	black obsidian	blade	complete	27,3	12,8	5,9	1,9	triangular	slight abrasion	fine	patinated	3	bi-directional	parallel	plain	straight	straight	fine/notch/utilized	-
737	O6	SW	5	black obsidian	bladelet	complete	20,1	7,8	2,9	0,4	triangular	fresh	fine	no cortex	2	unidirectional	parallel	crushed	straight	straight	backed/utilized	backed bladelet
738	O6	SW	5	black obsidian	bladelet	complete	15,7	4,4	1,7	0,1	lenticular	fresh	fine	no cortex	2	unidirectional	curved	none	straight	convex	backed/utilized	crescent
740	O6	SW	5	black obsidian	bladelet	complete	14,1	6,5	2,1	0,1	lenticular	fresh	fine	1-25%	1	unidirectional	curved	none	convex	straight	backed/utilized	crescent
741	O6	SW	5	black obsidian	blade	complete	26,3	10,1	3,6	1,0	lenticular	slight abrasion	fine	no cortex	3	unidirectional	parallel	facetted	convex	straight	fine/utilized	-
745	O6	NW	7	black obsidian	flake	complete	22,7	15,9	3,5	0,9	triangular	fresh	fine	no cortex	2	unidirectional	curved	facetted	straight	convex	fine/utilized	-
746	O6	NW	7	black obsidian	blade	complete	24,8	10,6	2,4	0,5	lenticular	fire -cracked	fine	no cortex	2	unidirectional	parallel	crushed	straight	convex	utilized	-
747	O6	NW	7	black obsidian	flake	complete	22,9	10,7	3,3	0,7	triangular	fresh	fine	1-25%	4	unidirectional	convergent	crushed	triangular	triangular	fine/utilized	-
749	O6	NW	7	black obsidian	bladelet	complete	23,2	5,2	2,0	0,2	triangular	fresh	fine	no cortex	2	unidirectional	parallel	pointed	straight	straight	utilized	-
751	O6	NW	7	black obsidian	bladelet	complete	15,2	9,4	3,5	0,3	parallelogram	fresh	fine	no cortex	1	unidirectional	convergent	facetted	convex	concave	backed/utilized	½ crescent
752	O6	NW	7	black obsidian	bladelet	complete	17,6	6,2	1,3	0,2	lenticular	fresh	fine	no cortex	2	unidirectional	parallel	pointed	straight	straight	utilized	-
753	O6	NW	7	black obsidian	bladelet	complete	19,2	6,9	2,9	0,3	lenticular	fresh	fine	1-25%	1	unidirectional	parallel	plain	straight	straight	fine/utilized	-
754	O6	NW	7	black obsidian	bladelet	complete	29,4	4,1	2,1	0,3	triangular	fresh	fine	no cortex	2	unidirectional	parallel	none	straight	convex	fine/backed/utilized	crescent
755	O6	NW	7	black obsidian	bladelet	complete	23,0	7,3	2,8	0,3	lenticular	fresh	fine	no cortex	2	unidirectional	parallel	none	convex	straight	fine/backed/utilized	backed bladelet
757	O6	SE	7	black obsidian	flake	complete	20,8	11,6	3,6	0,9	triangular	fresh	fine	no cortex	3	unidirectional	convergent	plain	triangular	triangular	utilized	-
761	O6	NE	7	black obsidian	bladelet	complete	25,1	4,9	1,9	0,2	lenticular	fresh	fine	no cortex	2	unidirectional	parallel	pointed	straight	straight	fine/backed	backed bladelet
762	O6	NE	7	black obsidian	bladelet	complete	24,0	6,1	2,1	0,2	triangular	fresh	fine	no cortex	2	unidirectional	parallel	pointed	straight	straight	utilized	-
763	O6	NE	7	black obsidian	bladelet	complete	23,5	6,7	2,2	0,3	lenticular	fresh	fine	no cortex	3	irregular	parallel	pointed	convex	straight	backed/utilized	backed bladelet
766	O6	SW	7	black obsidian	bladelet	complete	18,8	6,7	2,4	0,3	parallelogram	fresh	fine	no cortex	2	unidirectional	parallel	pointed	straight	straight	fine/notch/trunc.	-
772	O6	NW	6	black obsidian	bladelet	complete	16,0	6,6	2,7	0,3	triangular	fresh	fine	no cortex	2	unidirectional	parallel	none	convex	straight	fine/backed/utilized	crescent
773	O6	NW	6	black obsidian	bladelet	complete	17,5	7,2	2,1	0,2	lenticular	fresh	fine	no cortex	2	unidirectional	parallel	pointed	straight	convex	backed/utilized	crescent
774	O6	NW	6	black obsidian	bladelet	complete	15,9	6,6	1,9	0,1	lenticular	fresh	fine	no cortex	1	unidirectional	parallel	pointed	straight	convex	notch/back/utilized	crescent
776	O6	NW	6	black obsidian	bladelet	complete	21,9	6,7	2,3	0,2	lenticular	fresh	fine	no cortex	5	bi-directional	parallel	crushed	straight	straight	utilized	-
779	O6	NW	6	brown chert	bladelet	complete	18,1	9,1	3,7	0,5	triangular	fresh	fine	no cortex	1	unidirectional	curved	plain	straight	convex	backed/utilized/invasive	backed bladelet
786	O6	NE	6	black obsidian	bladelet	complete	15,9	9,7	2,1	0,2	lenticular	fresh	fine	no cortex	3	bi-directional	parallel	pointed	triangular	triangular	fine/utilized/trunc.	-
788	O6	NE	6	black obsidian	bladelet	complete	13,5	7,1	1,7	0,1	lenticular	fresh	fine	no cortex	3	unidirectional	parallel	plain	convex	straight	fine/backed/utilized	crescent
789	O6	NE	6	black obsidian	bladelet	complete	23,1	6,6	2,9	0,4	lenticular	fresh	fine	no cortex	2	unidirectional	curved	none	convex	straight	backed/utilized	crescent
794	O6	NE	6	black obsidian	bladelet	complete	20,5	8,2	4,5	0,7	lenticular	fresh	fine	no cortex	3	unidirectional	parallel	plain	straight	straight	utilized	-
795	O6	NE	6	black obsidian	flake	complete	22,6	10,5	2,5	0,4	lenticular	fresh	fine	no cortex	2	unidirectional	convergent	plain	straight	straight	utilized	-
796	O6	NE	6	black obsidian	blade	complete	23,3	11,1	4,1	1,2	triangular	fresh	fine	no cortex	2	unidirectional	parallel	facetted	straight	straight	fine/backed/utilized	backed bladelet
797	O6	NE	6	black obsidian	bladelet	complete	26,2	8,6	4,3	0,8	triangular	fresh	fine	patinated	1	unidirectional	parallel	plain	straight	straight	utilized	-
798	O6	NE	6	black obsidian	bladelet	complete	20,3	6,8	2,9	0,3	triangular	fresh	fine	no cortex	3	unidirectional	parallel	pointed	straight	straight	utilized	-

ID	m²	½ m²	Level	Raw Material	Debitage	Completeness	Length (mm)	Width (mm)	Thick-ness (mm)	Weight (g)	Cross section	Physical Condition	Raw Material Quality	Cortex	No. dorsal neg.	Direction dorsal negatives	Outline dorsal negatives	Platform Type	Edge Form (left)	Edge Form (right)	Retouch	Tool Type
799	O6	NE	6	black obsidian	bladelet	complete	22,6	7,2	2,9	0,3	triangular	fresh	fine	no cortex	3	unidirectional	convergent	facetted	triangular	triangular	utilized	-
805	O6	SW	6	black obsidian	flake	complete	12,4	16,3	4,1	0,6	plano-convex	fresh	fine	no cortex	1	unidirectional	parallel	facetted	convex	convex	fine/utilized	-
809	O6	SW	6	black obsidian	bladelet	complete	16,8	7,3	2,4	0,2	triangular	fresh	fine	no cortex	2	unidirectional	parallel	pointed	convex	convex	backed/utilized	backed bladelet
810	O6	SW	6	black obsidian	flake	complete	24,9	16,5	4,2	1,6	plano-convex	fresh	fine	no cortex	3	unidirectional	convergent	plain	concave	convex	rough/notch	borer
811	O6	SW	6	black obsidian	blade	complete	31,5	10,2	2,2	0,8	triangular	fresh	fine	no cortex	3	unidirectional	parallel	crushed	straight	straight	utilized	-
812	O6	SW	6	black obsidian	blade	complete	27,3	9,8	2,7	0,9	triangular	fresh	fine	1-25%	1	unidirectional	parallel	plain	straight	straight	utilized	-
813	O6	SW	6	black obsidian	bladelet	complete	27,4	9,6	2,9	0,9	parallelogram	fresh	fine	patinated	2	unidirectional	parallel	crushed	straight	straight	utilized	-
815	O6	SE	6	black obsidian	flake	complete	20,8	14,1	4,4	1,2	plano-convex	fresh	fine	no cortex	2	opposite	irregular	facetted	convex	convex	fine/notched	borer
816	O6	SE	6	black obsidian	flake	complete	20,9	12,9	7,0	2,0	plano-convex	fresh	fine	1-25%	4	unidir. & transverse	convergent	crushed	convex	straight	rough	scraper
817	O6	SE	6	black obsidian	bladelet	complete	18,4	7,9	2,3	0,2	lenticular	fresh	fine	no cortex	2	unidirectional	convergent	plain	straight	convex	fine/utilized	-
818	O6	SE	6	black obsidian	bladelet	complete	16,6	6,7	3,3	0,3	triangular	fresh	fine	no cortex	1	unidirectional	parallel	pointed	convex	straight	utilized	-
821	O6	SE	6	black obsidian	bladelet	complete	16,7	9,5	3,0	0,5	plano-convex	fresh	fine	1-25%	2	unidirectional	parallel	crushed	straight	straight	utilized	-
825	O6	SW	4	black obsidian	bladelet	complete	20,1	9,8	4,8	0,9	parallelogram	slight abrasion	fine	1-25%	2	unidirectional	parallel	crushed	straight	convex	utilized	crescent
830	O6	SW	4	black obsidian	bladelet	complete	16,9	7,1	2,7	2,0	lenticular	fresh	fine	no cortex	2	unidirectional	parallel	crushed	straight	straight	notch/utilized	-
832	O6	NE	4	black obsidian	bladelet	complete	21,6	5,4	2,6	0,4	parallelogram	fresh	fine	no cortex	2	unidirectional	parallel	none	convex	straight	backed/utilized	crescent
833	O6	NE	4	black obsidian	bladelet	complete	21,9	5,8	2,2	0,3	triangular	fresh	fine	no cortex	2	unidirectional	parallel	none	straight	straight	backed/utilized	backed bladelet
834	O6	NE	4	black obsidian	bladelet	complete	21,3	9,5	3,8	0,9	parallelogram	fresh	fine	no cortex	3	unidirectional	parallel	plain	straight	straight	fine/notch/utilized	-
835	O6	NE	4	black obsidian	bladelet	complete	17,4	7,9	2,0	0,2	triangular	fresh	fine	no cortex	2	unidirectional	parallel	pointed	straight	straight	notch/utilized	-
836	O6	NE	4	black obsidian	bladelet	complete	15,1	6,7	3,5	0,3	triangular	fresh	fine	no cortex	1	unidirectional	curved	pointed	straight	convex	backed/utilized	crescent
839	O6	NE	4	black obsidian	flake	complete	22,9	9,9	4,1	0,9	triangular	fresh	fine	no cortex	3	unidirectional	parallel	plain	triangular	triangular	fine	point
843	O6	SE	4	black obsidian	bladelet	complete	15,5	5,5	1,2	0,1	lenticular	fresh	fine	no cortex	2	unidirectional	parallel	none	straight	convex	backed/utilized	crescent
844	O6	SE	4	black obsidian	bladelet	complete	18,6	8,7	4,1	0,5	triangular	fresh	fine	no cortex	1	unidirectional	curved	facetted	convex	straight	backed/utilized	crescent
845	O6	SE	4	black obsidian	flake	complete	20,8	10,3	2,9	0,6	parallelogram	fresh	fine	no cortex	3	unidirectional	parallel	crushed	triangular	triangular	fine/notch/utilized	-
847	O6	SE	4	red chert	bladelet	complete	18,7	10,5	3,2	0,6	lenticular	slight abrasion	with inclus	no cortex	2	unidirectional	parallel	crushed	straight	straight	backed/utilized	backed bladelet
848	O6	NW	4	black obsidian	bladelet	complete	16,6	4,9	3,7	0,2	triangular	fresh	fine	no cortex	1	unidirectional	curved	none	straight	convex	backed/utilized	crescent
854	O6	SE	3	black obsidian	flake	complete	20,9	18,8	5,4	2,1	triangular	fresh	fine	no cortex	4	unidirectional	convergent	plain	triangular	triangular	stepped	scraper
858	O6	SW	3	black obsidian	bladelet	complete	14,8	7,0	2,4	0,2	triangular	fresh	fine	1-25%	2	unidirectional	parallel	pointed	straight	straight	utilized	-
859	O6	NE	3	black obsidian	blade	complete	18,8	12,8	2,5	0,5	lenticular	slight abrasion	fine	no cortex	3	unidirectional	parallel	plain	convex	straight	utilized	-
862	O6	SW	2	black obsidian	flake	complete	27,7	17,3	3,8	2,1	lenticular	fresh	fine	no cortex	4	unidirectional	convergent	plain	triangular	triangular	utilized	-
863	O6	SW	2	black obsidian	blade	complete	19,9	12,5	3,5	0,8	triangular	fresh	fine	no cortex	1	unidirectional	parallel	facetted	convex	straight	backed/utilized	crescent
865	O6	NE	2	black obsidian	bladelet	complete	17,1	9,4	2,9	0,4	lenticular	fresh	fine	no cortex	2	unidirectional	parallel	crushed	convex	convex	utilized	-
897	O6	NW	6	black obsidian	bladelet	complete	14,8	7,2	3,6	2,7	triangular	slight abrasion	fine	patinated	2	unidirectional	parallel	facetted	straight	straight	rough	-
899	O6	SW	6	yellow chert	bladelet	complete	17,8	10,3	2,8	2,2	lenticular	fresh	fine	no cortex	2	unidirectional	convergent	plain	triangular	triangular	utilized	-
900	O6	SW	6	black obsidian	bladelet	complete	16,9	4,9	1,9	0,2	lenticular	fresh	fine	no cortex	1	unidirectional	convergent	pointed	straight	convex	backed/utilized	crescent
905	O6	NW	6	black obsidian	core	complete	22,1	20,9	15,7	7,2	*indet.*	fresh	fine	1-25%	4	bi-directional	parallel	facetted	*indet.*	*indet.*	*indet.*	-
906	O6	NW	6	black obsidian	core	complete	22,1	20,2	14,4	6,2	*indet.*	fresh	fine	1-25%	5	unidirectional	parallel	plain	*indet.*	*indet.*	*indet.*	-
907	O6	NW	6	black obsidian	flake	complete	14,8	12,0	3,7	0,6	plano-convex	fresh	fine	no cortex	0	bi-directional	irregular	facetted	convex	convex	utilized	borer
908	O6	NW	4	black obsidian	flake	complete	22,4	14,2	3,6	1,2	*indet.*	fresh	fine	1-25%	2	unidirectional	parallel	crushed	irregular	convex	rough/trunc.	borer

ID	m^2	½ m^2	Level	Raw Material	Debitage	Completeness	Length (mm)	Width (mm)	Thick-ness (mm)	Weight (g)	Cross section	Physical Condition	Raw Material Quality	Cortex	No. dorsal neg.	Direction dorsal negatives	Outline dorsal negatives	Platform Type	Edge Form (left)	Edge Form (right)	Retouch	Tool Type
909	O6	SW	5	black obsidian	flake	complete	19,9	9,9	3,3	0,9	parallelogram	fresh	fine	no cortex	1	unidirectional	parallel	plain	concave	straight	truncated	borer
910	O6	SW	5	black obsidian	flake	complete	14,8	10,1	5,2	0,6	triangular	fresh	fine	no cortex	2	unidirectional	parallel	crushed	convex	concave	notched	borer
911	O6	SW	5	black obsidian	core	complete	31,3	18,2	11,8	6,3	*indet.*	fresh	fine	patinated	6	unidirectional	parallel	plain	*indet.*	*indet.*	*indet.*	-
912	O6	SW	6	black obsidian	flake	complete	19,5	13,6	4,3	1,0	triangular	fresh	fine	no cortex	2	unidirectional	parallel	*indet.*	irregular	irregular	fine	-
913	O6	NE	6	black obsidian	flake	complete	19,2	37,2	10,2	5,9	*indet.*	fresh	fine	no cortex	2	unidir. & transverse	parallel	plain	irregular	irregular	fine	-
914	O6	NE	6	black obsidian	flake	complete	24,6	17,0	6,5	2,8	triangular	fresh	fine	no cortex	3	bi-dir. & transverse	irregular	plain	straight	straight	fine	-
915	O6	NE	4	black obsidian	flake	complete	31,6	17,0	5,4	3,6	triangular	fresh	fine	no cortex	4	unidirectional	parallel	plain	straight	straight	notched	-
916	O6	NW	6	black obsidian	bladelet	complete	27,8	11,6	6,3	2,1	triangular	fresh	fine	no cortex	1	*indet.*	irregular	plain	straight	straight	notched	-
917	O6	SE	6	black obsidian	flake	complete	22,2	13,1	4,5	1,2	triangular	fresh	fine	1-25%	1	unidirectional	parallel	none	convex	straight	utilized	crescent

Appendix III: Results of the lithic attribute analysis (Mararo)

ID	m²	½ m²	Level	Raw Material	Debitage	Completeness	Length (mm)	Width (mm)	Thick-ness (mm)	Weight (g)	Cross section	Physical Condition	Raw Material Quality	Cortex	No. dorsal neg.	Direction dorsal negatives	Outline dorsal negatives	Platform Type	Edge Form (left)	Edge Form (right)	Retouch	Tool Type
1	S8	NE	/-150	black obsidian	bladelet	complete	17,8	6,9	3,2	0,3	triangular	slight abrasion	fine	no cortex	2	unidirectional	curved	crushed	convex	concave	notch/utilized	-
2	S8	NE	/-150	black obsidian	bladelet	prox.-midsection	12,3	5,6	2,5	0,1	triangular	fresh	fine	no cortex	2	unidirectional	parallel	crushed	straight	straight	utilized	-
3	S8	NE	/-150	black obsidian	blade	distal	12,9	10,1	3,6	0,6	parallelogram	fresh	fine	no cortex	3	unidirectional	parallel	none	straight	straight	utilized	-
4	S8	NE	/-150	black obsidian	bladelet	prox.-midsection	17,5	5,5	3,2	0,3	*indet.*	fresh	fine	no cortex	2	*indet.*	curved	crushed	convex	concave	utilized	-
5	S8	NW	/-150	black obsidian	flake	distal-midsection	17,9	10,9	4,3	0,9	plano-convex	fresh	fine	patinated	5	unidirectional	parallel	none	convex	convex	trunc./utilized	borer
6	S8	NW	/-150	black obsidian	bladelet	distal-midsection	23,8	10,1	2,4	0,4	triangular	fresh	fine	no cortex	3	*indet.*	irregular	crushed	triangular	triangular	utilized	-
7	S8	NW	/-150	black obsidian	bladelet	distal-midsection	14,9	9,5	2,7	0,3	triangular	fresh	fine	no cortex	2	*indet.*	irregular	none	irregular	straight	rough/notched	-
8	S8	NW	/-150	black obsidian	bladelet	midsection	13,2	7,0	4,0	0,4	parallelogram	fresh	with inclusions	1-25%	1	unidirectional	parallel	facetted	irregular	straight	utilized	-
9	S8	NW	/-150	black obsidian	bladelet	distal	9,7	12,6	3,4	0,4	irregular	fresh	fine	no cortex	1	unidirectional	parallel	none	straight	straight	utilized	-
10	S8	NW	/-150	black obsidian	core	broken indet.	14,6	13,9	5,6	1,5	irregular	fresh	fine	no cortex	4	bi-directional	parallel	facetted	irregular	irregular	*indet.*	-
11	S8	NW	/-150	black obsidian	core	complete	14,8	20,2	14,7	6,7	irregular	slight abrasion	fine	no cortex	3	unidirectional	parallel	plain	irregular	irregular	*indet.*	-
12	S8	SW	/-150	black obsidian	bladelet	complete	21,3	9,3	3,6	0,7	triangular	fresh	fine	no cortex	2	unidirectional	parallel	pointed	convex	convex	notch/utilized	-
13	S8	SW	/-150	black obsidian	bladelet	prox.-midsection	18,2	10,3	3,8	0,6	triangular	fresh	fine	no cortex	3	bi-directional	irregular	crushed	straight	convex	backed/utilized	½ crescent
14	S8	SW	/-150	black obsidian	flake	complete	19,8	9,4	5,2	0,8	*indet.*	fresh	fine	no cortex	1	none	*indet.*	indet.	convex	convex	utilized	-
15	S8	SW	/-150	black obsidian	flake	complete	17,3	12,9	6,1	1,2	triangular	fresh	fine	no cortex	2	unidirectional	convergent	facetted	straight	irregular	fine/notch/utilized	borer
16	S8	SW	/-150	black obsidian	bladelet	complete	21,8	8,1	3,5	0,5	triangular	slight abrasion	with inclusions	patinated	1	unidirectional	parallel	crushed	triangular	straight	utilized	-
17	S8	SW	/-150	black obsidian	bladelet	complete	16,6	8,6	3,8	0,5	triangular	fresh	fine	patinated	1	none	parallel	pointed	convex	straight	backed/utilized	½ crescent
18	S8	SW	/-150	black obsidian	bladelet	distal-midsection	19,8	8,9	4,7	0,9	triangular	fresh	fine	patinated	1	unidirectional	parallel	facetted	straight	straight	notch/utilized	-
19	S8	SW	/-150	black obsidian	bladelet	midsection	11,5	4,5	1,5	1,1	parallelogram	fresh	fine	no cortex	1	unidirectional	none	none	straight	straight	backed	-
20	S8	SW	/-150	black obsidian	bladelet	complete	14,6	7,7	2,3	0,3	triangular	fresh	fine	no cortex	2	unidirectional	parallel	pointed	straight	straight	utilized	-
21	S8	SW	/-150	black obsidian	flake	midsection	20,3	9,9	2,9	0,6	*indet.*	fresh	fine	no cortex	3	unidirectional	parallel	none	irregular	irregular	*indet.*	-
22	S8	SW	/-150	black obsidian	bladelet	prox.-midsection	19,4	10,6	3,2	0,5	triangular	fresh	fine	no cortex	2	unidirectional	parallel	pointed	concave	straight	notch/utilized	-
23	S8	SW	/-150	black obsidian	blade	broken indet.	17,5	11,2	3,8	10,0	triangular	fresh	fine	patinated	1	*indet.*	irregular	none	straight	straight	*indet.*	-
24	S8	SW	/-150	black obsidian	blade	prox.-midsection	26,4	10,4	4,2	1,4	triangular	slight abrasion	with inclusions	patinated	*indet.*	*indet.*	irregular	plain	straight	straight	utilized	-
25	S8	SW	/-150	black obsidian	blade	midsection	26,3	12,5	7,8	2,8	triangular	fresh	fine	no cortex	2	Unidir./transvers	irregular	none	straight	straight	*indet.*	-
26	S8	SW	/-150	black obsidian	core	complete	16,2	24,9	14,2	7,5	irregular	fresh	fine	1-25%	3	unidirectional	parallel	plain	irregular	irregular	*indet.*	-
27	S8	SW	/-150	black obsidian	core	*indet.*	13,9	11,6	10,9	2,5	irregular	fresh	fine	patinated	3	Unidir./transvers	parallel	plain	irregular	irregular	*indet.*	-
28	S8	NE	/-145	black obsidian	flake	complete	22,4	12,5	5,5	1,0	plano-convex	fresh	fine	no cortex	4	unidirectional	convergent	dihedral	triangular	triangular	utilized	-
29	S8	NE	/-145	black obsidian	bladelet	complete	16,6	9,3	3,4	0,5	lenticular	slight abrasion	fine	patinated	2	*indet.*	parallel	pointed	convex	straight	utilized	-
30	S8	NE	/-145	black obsidian	flake	complete	11,2	6,4	0,2	0,6	triangular	fresh	fine	no cortex	3	unidirectional	parallel	plain	convex	convex	fine/backed	-
31	S8	NE	/-145	black obsidian	flake	distal-midsection	14,7	10,1	4,3	0,6	triangular	fresh	fine	1-25%	1	unidirectional	parallel	none	convex	convex	notch/utilized	borer
32	S8	NE	/-145	black obsidian	flake	complete	13,8	9,4	5,4	0,5	plano-convex	fresh	fine	no cortex	1	unidirectional	parallel	plain	triangular	triangular	notch/trunc.	borer
33	S8	NE	/-145	black obsidian	flake	complete	20,9	21,3	4,7	1,7	plano-convex	slight abrasion	fine	no cortex	*indet.*	*indet.*	irregular	facetted	triangular	triangular	fine/notch	borer (multi-)
34	S8	NE	/-145	black obsidian	bladelet	prox.-midsection	18,8	12,1	2,5	0,4	triangular	fresh	fine	no cortex	1	unidirectional	curved	pointed	straight	triangular	backed/utilized	½ crescent ?
35	S8	NE	/-145	black obsidian	bladelet	midsection	14,5	7,1	4,3	0,4	triangular	slight abrasion	fine	patinated	*indet.*	*indet.*	irregular	none	straight	straight	*indet.*	-
36	S8	NE	/-145	black obsidian	bladelet	distal	15,1	7,0	5,4	0,6	triangular	slight abrasion	fine	no cortex	2	unidirectional	parallel	none	straight	straight	*indet.*	-
37	S8	NE	/-145	black obsidian	bladelet	distal	24,1	5,8	3,7	0,7	triangular	fresh	fine	patinated	3	unidirectional	parallel	none	straight	straight	*indet.*	-
38	S8	NE	/-145	black obsidian	bladelet	complete	21,6	6,2	4,8	0,3	triangular	fresh	fine	no cortex	3	Unidir./transvers	irregular	pointed	triangular	triangular	*indet.*	-

ID	m²	½ m²	Level	Raw Material	Debitage	Completeness	Length (mm)	Width (mm)	Thick-ness (mm)	Weight (g)	Cross section	Physical Condition	Raw Material Quality	Cortex	No. dorsal neg.	Direction dorsal negatives	Outline dorsal negatives	Platform Type	Edge Form (left)	Edge Form (right)	Retouch	Tool Type
39	S8	NE	/-145	black obsidian	bladelet	complete	24,5	8,4	4,7	0,9	triangular	slight abrasion	fine	patinated	2	*indet.*	parallel	facetted	straight	convex	utilized	-
40	S8	NE	/-145	black obsidian	bladelet	complete	12,4	4,3	3,8	0,7	irregular	fresh	fine	no cortex	*indet.*	*indet.*	irregular	pointed	straight	straight	*indet.*	-
41	S8	NE	/-145	black obsidian	bladelet	complete	19,1	6,5	3,9	0,4	irregular	fresh	fine	no cortex	*indet.*	irregular	irregular	crushed	irregular	straight	rough	-
42	S8	NE	/-145	black obsidian	bladelet	complete	17,7	6,3	3,8	0,4	lenticular	fresh	fine	patinated	3	unidirectional	parallel	pointed	straight	straight	*indet.*	-
43	S8	NE	/-145	black obsidian	bladelet	complete	18,8	5,7	2,4	2,9	lenticular	slight abrasion	fine	patinated	2	unidirectional	parallel	crushed	straight	straight	*indet.*	-
44	S8	NE	/-145	black obsidian	bladelet	broken indet.	18,8	9,6	2,3	0,7	plano-convex	slight abrasion	fine	patinated	*indet.*	*indet.*	irregular	none	straight	straight	*indet.*	-
45	S8	NE	/-145	black obsidian	core	complete	31,8	32,6	17,6	16,7	irregular	fresh	fine	1-25%	3	unidirectional	parallel	cortical	irregular	irregular	*indet.*	-
46	S8	NE	/-145	black obsidian	core	complete	31,9	24,8	16,1	13,6	irregular	fresh	fine	26-50%	5	irregular	irregular	cortical	irregular	irregular	*indet.*	-
47	S8	NE	/-145	black obsidian	blade	complete	29,6	11,4	8,6	2,9	triangular	slight abrasion	fine	patinated	*indet.*	*indet.*	irregular	crushed	straight	straight	utilized	-
48	S8	NW	/-145	black obsidian	flake	complete	14,9	13,7	4,8	1,0	parallelogram	fresh	fine	no cortex	4	unidirectional	convergent	dihedral	convex	convex	notch/stepped	borer
49	S8	NW	/-145	black obsidian	bladelet	complete	16,4	8,2	1,5	0,2	lenticular	fresh	fine	no cortex	2	unidirectional	curved	crushed	straight	convex	backed	crescent
50	S8	NW	/-145	black obsidian	flake	midsection	20,1	14,8	4,3	1,2	parallelogram	fresh	fine	no cortex	4	irregular	parallel	none	irregular	irregular	fine/notch/trunc.	borer
51	S8	NW	/-145	black obsidian	bladelet	distal-midsection	21,2	9,1	3,6	0,6	triangular	fresh	fine	no cortex	2	unidirectional	convergent	none	convex	convex	backed/utilized	backed bladelet
52	S8	NW	/-145	black obsidian	bladelet	complete	19,1	10,9	2,9	0,8	lenticular	fresh	fine	no cortex	3	bi-directional	parallel	crushed	triangular	triangular	utilized	-
53	S8	NW	/-145	black obsidian	bladelet	prox.-midsection	20,6	10,8	2,7	0,7	plano-convex	fresh	fine	patinated	2	unidirectional	curved	crushed	triangular	triangular	utilized	-
54	S8	NW	/-145	black obsidian	bladelet	prox.-midsection	16,5	6,6	2,5	0,5	parallelogram	slight abrasion	fine	no cortex	2	unidirectional	curved	facetted	straight	convex	utilized	-
55	S8	NW	/-145	black obsidian	bladelet	whole	19,6	8,7	2,6	0,4	lenticular	fresh	fine	no cortex	3	unidirectional	parallel	pointed	irregular	straight	notch/utilized	-
56	S8	NW	/-145	black obsidian	bladelet	whole	18,9	9,9	5,9	0,9	triangular	fresh	fine	no cortex	3	Oppsite/transver	irregular	crushed	convex	convex	utilized	borer
57	S8	NW	/-145	black obsidian	bladelet	whole	18,1	8,0	3,9	0,7	triangular	fresh	fine	no cortex	3	irregular	parallel	crushed	straight	straight	fine/backed	-
58	S8	NW	/-145	black obsidian	bladelet	complete	21,5	1,6	2,4	0,6	*indet.*	slight abrasion	fine	patinated	*indet.*	irregular	irregular	crushed	*indet.*	*indet.*	*indet.*	-
59	S8	NW	/-145	black obsidian	bladelet	complete	20,5	2,4	3,3	1,0	*indet.*	slight abrasion	fine	patinated	*indet.*	irregular	irregular	pointed	*indet.*	*indet.*	*indet.*	-
60	S8	NW	/-145	black obsidian	bladelet	prox.-midsection	17,1	7,2	3,8	0,7	*indet.*	slight abrasion	fine	no cortex	*indet.*	irregular	irregular	facetted	convex	concave	*indet.*	-
61	S8	NW	/-145	black obsidian	bladelet	prox.-midsection	18,6	7,3	2,6	0,4	parallelogram	fresh	fine	no cortex	3	bi-directional	parallel	none	straight	straight	utilized	-
62	S8	NW	/-145	black obsidian	bladelet	midsection	17,2	8,7	1,9	0,4	lenticular	fresh	fine	no cortex	4	irregular	irregular	none	straight	straight	utilized	-
63	S8	NW	/-145	black obsidian	bladelet	distal-midsection	16,9	7,1	3,5	0,3	triangular	fresh	fine	no cortex	1	unidirectional	parallel	none	straight	straight	backed	½ crescent
64	S8	NW	/-145	black obsidian	blade	prox.-midsection	19,9	9,6	3,9	0,8	triangular	fresh	fine	no cortex	2	unidirectional	parallel	pointed	straight	straight	utilized	-
65	S8	NW	/-145	black obsidian	blade	midsection	17,6	8,3	2,5	0,8	triangular	fresh	fine	no cortex	2	irregular	irregular	none	concave	convex	utilized	-
66	S8	NW	/-145	black obsidian	blade	prox.-midsection	28,9	13,9	6,2	2,2	triangular	fresh	fine	no cortex	3	unidirectional	parallel	facetted	straight	straight	utilized	-
67	S8	NW	/-145	black obsidian	blade	prox.-midsection	22,5	13,0	6,5	2,1	triangular	slight abrasion	fine	patinated	2	unidirectional	curved	plain	straight	straight	utilized	-
68	S8	NW	/-145	black obsidian	blade	complete	28,5	12,1	4,4	1,2	triangular	fresh	fine	no cortex	4	irregular	irregular	crushed	straight	straight	fine	-
69	S8	NW	/-145	black obsidian	flake	complete	29,1	14,2	5,4	1,8	triangular	fresh	with inclusions	no cortex	3	irregular	convergent	facetted	straight	irregular	notch/utilized	borer
70	S8	NW	/-145	black obsidian	bladelet	complete	27,5	5,3	2,7	0,5	triangular	fresh	fine	no cortex	3	bi-directional	curved	pointed	concave	convex	utilized	-
71	S8	NW	/-145	black obsidian	blade	prox.-midsection	30,3	13,2	5,6	2,1	triangular	fire crack	*n/a*	no cortex	2	indet.	irregular	pointed	straight	convex	backed/utilized	crescent
72	S8	NW	/-145	black obsidian	core	longitud.	26,1	12,3	12,1	2,1	*indet.*	fresh	fine	patinated	2	Opposite/transve	irregular	pointed	*indet.*	convex	*indet.*	-
73	S8	SW	/-145	black obsidian	bladelet	complete	18,1	7,6	3,5	0,4	triangular	fresh	fine	no cortex	1	unidirectional	curved	pointed	straight	convex	backed/utilized	crescent
74	S8	SW	/-145	black obsidian	bladelet	complete	21,1	10,8	2,9	0,8	parallelogram	fresh	fine	patinated	3	unidirectional	parallel	crushed	convex	convex	utilized	-
75	S8	SW	/-145	black obsidian	blade	complete	31,1	15,4	5,6	2,7	triangular	slight abrasion	fine	no cortex	2	unidirectional	parallel	plain	straight	straight	rough/notched	-
76	S8	SW	/-145	black obsidian	blade	prox.-midsection	23,5	12,4	8,8	2,4	triangular	slight abrasion	fine	patinated	2	opposite	parallel	pointed	convex	straight	utilized	-

ID	m²	½ m²	Level	Raw Material	Debitage	Completeness	Length (mm)	Width (mm)	Thick-ness (mm)	Weight (g)	Cross section	Physical Condition	Raw Material Quality	Cortex	No. dorsal neg.	Direction dorsal negatives	Outline dorsal negatives	Platform Type	Edge Form (left)	Edge Form (right)	Retouch	Tool Type
77	S8	SW	/-145	black obsidian	flake	complete	37,7	20,4	8,9	6,2	triangular	fresh	fine	patinated	2	unidirectional	irregular	facetted	convex	convex	fine/serrated	scraper
78	S8	NE	/-140	black obsidian	flake	prox.-midsection	20,5	11,4	5,1	1,3	triangular	slight abrasion	fine	patinated	*indet.*	none	*indet.*	facetted	convex	convex	notched	-
79	S8	NE	/-140	black obsidian	bladelet	distal-midsection	9,1	0,7	3,9	0,4	parallelogram	fresh	fine	no cortex	3	unidirectional	parallel	none	straight	straight	*indet.*	-
80	S8	NE	/-140	black obsidian	bladelet	complete	22,1	7,9	3,7	0,5	triangular	fresh	fine	patinated	4	unidirectional	irregular	crushed	straight	convex	utilized	-
81	S8	NE	/-140	black obsidian	blade	complete	36,9	18,1	7,1	6,9	parallelogram	fresh	fine	patinated	2	unidirectional	parallel	crushed	straight	straight	fine	-
82	S8	NE	/-140	black obsidian	flake	proximal	12,9	9,9	5,5	2,1	plano-convex	fresh	fine	no cortex	2	irregular	irregular	facetted	straight	concave	fine/stepped	borer
83	S8	NE	/-140	black obsidian	blade	distal-midsection	26,2	15,3	4,1	1,1	parallelogram	fresh	fine	patinated	2	unidirectional	parallel	none	concave	irregular	utilized	-
84	S8	NE	/-140	black obsidian	flake	complete	22,3	14,4	4,8	1,8	parallelogram	fresh	fine	51-75%	*indet.*	none	*indet.*	cortical	convex	straight	fine/backed	borer
85	S8	NE	/-140	black obsidian	bladelet	flake	21,5	9,7	6,2	1,6	parallelogram	fresh	fine	patinated	1	unidirectional	curved	cortical	convex	concave	fine	borer
86	S8	NE	/-140	black obsidian	flake	complete	21,3	18,3	5,2	1,6	plano-convex	slight abrasion	fine	no cortex	5	irregular	irregular	facetted	convex	irregular	notch/trunc.	borer
87	S8	NE	/-140	black obsidian	bladelet	midsection	20,6	7,8	3,2	0,5	lenticular	fresh	fine	no cortex	2	unidirectional	parallel	none	straight	straight	utilized	-
88	S8	NE	/-140	black obsidian	bladelet	complete	17,9	6,7	3,3	0,5	lenticular	fresh	fine	no cortex	2	bi-directional	curved	crushed	straight	straight	*indet.*	-
89	S8	NE	/-140	black obsidian	core	*indet.*	19,3	24,9	15,5	7,6	irregular	fresh	fine	1-25%	3	bi-directional	parallel	plain	irregular	irregular	*indet.*	-
90	S8	NE	/-140	black obsidian	core	*indet.*	16,6	15,8	10,9	3,1	irregular	fresh	fine	patinated	4	bi-directional	curved	plain	irregular	irregular	*indet.*	-
91	S8	SW	/-140	black obsidian	bladelet	complete	23,6	6,2	1,5	0,2	lenticular	fresh	fine	no cortex	1	unidirectional	curved	crushed	straight	convex	backed/utilized	crescent
92	S8	SW	/-140	black obsidian	bladelet	distal-midsection	18,5	9,7	4,3	1,1	parallelogram	fresh	with inclusions	no cortex	2	*indet.*	irregular	none	convex	triangular	backed/utilized	-
93	S8	SW	/-140	black obsidian	bladelet	complete	19,7	8,2	3,2	0,5	lenticular	fresh	fine	no cortex	4	unidirectional	curved	pointed	convex	concave	notch/utilized	-
94	S8	SW	/-140	black obsidian	bladelet	complete	19,4	6,3	2,9	0,3	triangular	fresh	fine	26-50%	*indet.*	none	none	pointed	convex	concave	*indet.*	-
95	S8	SW	/-140	black obsidian	bladelet	midsection	18,6	7,4	3,6	0,5	triangular	slight abrasion	fine	no cortex	2	unidirectional	curved	none	convex	straight	fine/backed	-
96	S8	SW	/-140	black obsidian	blade	distal-midsection	25,2	12,5	4,4	1,4	triangular	fresh	with inclusions	patinated	2	unidirectional	parallel	none	straight	irregular	utilized	-
97	S8	SW	/-140	black obsidian	core	broken indet.	18,5	12,1	10,5	2,9	irregular	slight abrasion	fine	1-25%	3	unidirectional	parallel	none	irregular	irregular	*indet.*	-
98	S8	SW	/-140	black obsidian	core	complete	24,2	19,2	9,6	4,4	irregular	fresh	fine	no cortex	7	bi-directional	parallel	plain	irregular	irregular	*indet.*	-
99	S8	SW	/-140	black obsidian	core	complete	21,1	19,4	14,9	7,4	irregular	fresh	fine	26-50%	5	unidirectional	parallel	cortical	irregular	irregular	*indet.*	-
100	S8	NE	/-135	black obsidian	blade	complete	26,5	12,8	4,3	2,7	triangular	fresh	fine	patinated	2	unidirectional	curved	pointed	straight	convex	notch/backed/utilized	crescent
101	S8	NE	/-135	black obsidian	bladelet	distal-midsection	18,8	8,6	5,3	0,8	triangular	slight abrasion	fine	patinated	4	bi-directional	irregular	none	concave	convex	fine/notch/trunc.	borer
102	S8	NE	/-135	black obsidian	bladelet	distal-midsection	19,4	11,8	5,5	1,1	triangular	fresh	fine	no cortex	1	irregular	irregular	none	triangular	convex	rough/notched	borer
103	S8	NE	/-135	black obsidian	bladelet	distal-midsection	17,6	6,1	3,8	0,2	triangular	fresh	fine	no cortex	2	bi-directional	parallel	none	convex	concave	backed/utilized	backed bladelet
104	S8	NE	/-135	black obsidian	bladelet	complete	13,2	7,2	2,1	0,2	lenticular	fresh	fine	no cortex	3	unidirectional	curved	crushed	convex	straight	backed	crescent
105	S8	NE	/-135	black obsidian	bladelet	prox.-midsection	12,3	5,8	2,5	0,2	triangular	fresh	fine	no cortex	1	unidirectional	parallel	pointed	convex	straight	backed	crescent
106	S8	NE	/-135	black obsidian	bladelet	prox.-midsection	14,8	8,4	2,7	0,4	plano-convex	fresh	fine	no cortex	3	irregular	irregular	pointed	convex	concave	fine/backed	-
107	S8	NE	/-135	black obsidian	bladelet	complete	18,5	10,2	4,7	0,9	irregular	fresh	fine	no cortex	5	*indet.*	irregular	indet.	straight	straight	fine/backed	-
108	S8	NE	/-135	black obsidian	bladelet	complete	19,3	6,5	2,2	0,3	triangular	fresh	fine	no cortex	2	unidirectional	parallel	pointed	straight	straight	notch/utilized	-
109	S8	NE	/-135	black obsidian	bladelet	complete	18,6	6,1	2,8	0,4	triangular	fresh	fine	no cortex	*indet.*	irregular	irregular	none	straight	straight	*indet.*	-
110	S8	NE	/-135	black obsidian	blade	broken indet.	31,6	13,3	6,0	8,1	*indet.*	fresh	fine	no cortex	5	irregular	irregular	pointed	convex	concave	*indet.*	-
111	S8	NE	/-135	black obsidian	flake	complete	24,7	17,9	5,9	2,1	triangular	fresh	fine	patinated	4	unidirectional	irregular	cortical	triangular	triangular	fine	borer
112	S8	NE	/-135	black obsidian	blade	complete	36,9	21,3	6,8	6,3	parallelogram	fresh	with inclusions	no cortex	2	*indet.*	parallel	pointed	straight	straight	fine/trunc.	-
113	S8	NE	/-135	black obsidian	core	complete	20,4	14,9	6,1	1,9	irregular	fresh	fine	26-50%	5	unidirectional	parallel	cortical	irregular	irregular	*indet.*	-
114	S8	NE	/-135	black obsidian	core	complete	19,5	16,1	9,4	3,1	irregular	fresh	fine	26-50%	4	bi-directional	parallel	plain	irregular	irregular	*indet.*	-

ID	m²	½ m²	Level	Raw Material	Debitage	Completeness	Length (mm)	Width (mm)	Thick-ness (mm)	Weight (g)	Cross section	Physical Condition	Raw Material Quality	Cortex	No. dorsal neg.	Direction dorsal negatives	Outline dorsal negatives	Platform Type	Edge Form (left)	Edge Form (right)	Retouch	Tool Type
115	S8	NE	/-135	black obsidian	core	complete	18,1	16,4	8,5	2,8	irregular	fresh	fine	26-50%	4	unidirectional	convergent	plain	irregular	irregular	*indet.*	-
116	S8	NW	/-135	black obsidian	bladelet	distal-midsection	17,7	8,8	4,9	0,7	triangular	fresh	fine	no cortex	2	unidirectional	curved	none	concave	convex	fine	borer
117	S8	NW	/-135	black obsidian	flake	complete	21,2	9,9	4,3	0,7	triangular	fresh	fine	patinated	2	unidirectional	curved	pointed	irregular	convex	notch/utilized	borer
118	S8	NW	/-135	black obsidian	flake	complete	27,9	9,1	5,3	1,7	triangular	fresh	fine	patinated	1	unidirectional	parallel	cortical	convex	straight	*indet.*	-
119	S8	SW	/-135	black obsidian	flake	complete	29,1	15,1	7,7	2,9	Trape-zoid	fresh	coarse	patinated	1	bi-directional	convergent	crushed	triangular	triangular	*indet.*	-
120	S8	SW	/-130	black obsidian	bladelet	complete	18,2	9,8	4,9	0,8	triangular	fresh	fine	no cortex	1	unidirectional	curved	pointed	convex	straight	fine/notch/utilized	crescent
121	S8	SW	/-130	black obsidian	bladelet	prox.-midsection	14,6	7,3	3,8	0,4	parallelogram	fresh	fine	no cortex	4	bi-directional	parallel	crushed	straight	straight	utilized	-
122	S8	SW	/-130	black obsidian	bladelet	distal-midsection	14,4	7,3	2,2	0,2	lenticular	fresh	fine	no cortex	2	unidirectional	curved	none	straight	convex	backed/utilized	½ crescent
123	S8	SW	/-130	black obsidian	flake	complete	21,9	9,7	7,7	1,4	triangular	fresh	fine	1-25%	1	unidirectional	curved	cortical	straight	convex	*indet.*	-
124	S8	SW	/-130	black obsidian	bladelet	complete	16,0	6,2	4,4	0,4	triangular	fresh	fine	patinated	1	unidirectional	curved	plain	straight	convex	backed	backed bladelet
125	S8	SW	/-130	black obsidian	flake	distal-midsection	11,6	11,3	5,2	0,6	triangular	fresh	fine	patinated	1	unidirectional	parallel	crushed	convex	concave	fine/notch	borer
126	S8	SW	/-130	black obsidian	bladelet	midsection	12,4	7,4	2,1	0,2	triangular	fresh	fine	no cortex	2	unidirectional	parallel	none	straight	straight	trunc./utilized	-
127	S8	SW	/-130	black obsidian	bladelet	complete	16,8	6,1	2,5	0,3	triangular	slight abrasion	with inclusions	1-25%	2	irregular	curved	crushed	convex	straight	*indet.*	-
128	S8	SW	/-130	black obsidian	core	*indet.*	20,5	28,9	15,3	10,1	irregular	fresh	fine	26-50%	3	Unidir./transvers	parallel	cortical	irregular	irregular	*indet.*	-
129	S8	SW	/-130	black obsidian	core	complete	22,1	22,7	13,0	3,3	*indet.*	fresh	fine	1-25%	4	irregular	irregular	indet.	irregular	irregular	*indet.*	-
130	S8	NE	/-130	black obsidian	bladelet	complete	18,7	11,3	3,1	0,5	lenticular	slight abrasion	with inclusions	no cortex	3	unidirectional	convergent	pointed	triangular	triangular	notched	borer
131	S8	NE	/-130	black obsidian	flake	complete	23,0	15,0	6,4	1,6	*indet.*	slight abrasion	fine	26-50%	2	unidirectional	curved	plain	triangular	irregular	fine/notch	borer
132	S8	NE	/-130	black obsidian	flake	complete	20,3	12,3	7,7	1,1	triangular	slight abrasion	fine	patinated	3	unidirectional	irregular	pointed	convex	straight	fine/notch	borer
133	S8	NE	/-130	black obsidian	bladelet	prox.-midsection	17,3	10,1	2,9	0,6	triangular	fresh	fine	no cortex	3	unidirectional	parallel	pointed	convex	straight	notched	borer
134	S8	NE	/-130	black obsidian	bladelet	prox.-midsection	17,5	6,6	3,3	0,4	triangular	fresh	fine	1-25%	3	unidirectional	parallel	pointed	straight	straight	notch/utilized	-
135	S8	NE	/-130	black obsidian	bladelet	complete	19,8	10,1	3,2	0,7	plano-convex	fresh	fine	no cortex	4	bi-directional	convergent	cortical	straight	concave	fine/notch/utilized	-
136	S8	NE	/-130	black obsidian	flake	complete	13,9	12,4	3,5	0,5	plano-convex	fresh	fine	no cortex	4	bi-directional	convergent	dihedral	concave	convex	notch/backed	borer
137	S8	NE	/-130	black obsidian	flake	complete	18,5	11,8	4,4	0,9	Rhom-boid	fresh	fine	patinated	4	unidirectional	parallel	pointed	triangular	triangular	notched	borer
138	S8	NE	/-130	black obsidian	bladelet	complete	18,9	9,9	2,7	0,4	triangular	fresh	fine	no cortex	2	unidirectional	curved	crushed	concave	convex	notch/backed/trunc.	borer
139	S8	NE	/-130	black obsidian	bladelet	complete	19,1	9,5	2,8	0,7	parallelogram	fresh	fine	no cortex	3	unidirectional	convergent	pointed	straight	convex	notch/utilized	borer
140	S8	NE	/-130	black obsidian	flake	prox.-midsection	17,5	11,8	4,9	1,1	triangular	fresh	fine	1-25%	2	unidirectional	curved	facetted	concave	convex	fine/notch/utilized	-
141	S8	NE	/-130	black obsidian	flake	prox.-midsection	15,5	13,5	8,7	1,8	triangular	fresh	fine	patinated	3	irregular	irregular	facetted	convex	convex	fine/notch/trunc.	borer
142	S8	NE	/-130	black obsidian	flake	complete	18,8	11,4	7,8	1,3	irregular	slight abrasion	fine	no cortex	3	unidirectional	curved	plain	convex	straight	notched	borer
143	S8	NE	/-130	black obsidian	bladelet	prox.-midsection	15,8	9,3	1,7	0,3	lenticular	fresh	fine	no cortex	2	unidirectional	parallel	pointed	convex	straight	backed/utilized	½ crescent
144	S8	NE	/-130	black obsidian	bladelet	distal-midsection	12,2	7,7	2,6	0,3	triangular	slight abrasion	with inclusions	no cortex	1	unidirectional	curved	none	concave	convex	notch/backed	borer
145	S8	NE	/-130	yellow chert	bladelet	complete	13,9	6,8	3,3	0,3	triangular	fresh	fine	no cortex	1	bi-directional	curved	crushed	straight	convex	backed/utilized	crescent
146	S8	NE	/-130	black obsidian	bladelet	distal	13,1	8,5	2,3	0,2	lenticular	fresh	fine	no cortex	4	irregular	irregular	none	straight	convex	backed/utilized	½ crescent
147	S8	NE	/-130	black obsidian	bladelet	prox.-midsection	16,9	8,9	2,4	0,4	parallelogram	fresh	fine	patinated	3	unidirectional	parallel	crushed	straight	triangular	utilized	-
148	S8	NE	/-130	black obsidian	bladelet	complete	16,3	7,3	2,8	0,2	triangular	fresh	fine	no cortex	3	unidirectional	convergent	plain	triangular	triangular	utilized	borer
149	S8	NE	/-130	black obsidian	bladelet	prox.-midsection	16,7	7,3	1,9	0,2	parallelogram	fresh	fine	no cortex	3	unidirectional	curved	pointed	straight	convex	fine/backed	-
150	S8	NE	/-130	black obsidian	bladelet	prox.-midsection	19,4	11,1	3,1	0,6	triangular	fresh	fine	no cortex	3	unidirectional	parallel	crushed	straight	straight	utilized	-
151	S8	NE	/-130	black obsidian	bladelet	whole	22,8	7,9	2,2	0,3	lenticular	fresh	fine	no cortex	4	irregular	irregular	pointed	straight	straight	utilized	-
152	S8	NE	/-130	black obsidian	bladelet	prox.-midsection	16,9	7,1	2,4	0,3	triangular	fresh	fine	no cortex	2	unidirectional	parallel	crushed	straight	straight	trunc./utilized	-

ID	m²	½ m²	Level	Raw Material	Debitage	Completeness	Length (mm)	Width (mm)	Thick-ness (mm)	Weight (g)	Cross section	Physical Condition	Raw Material Quality	Cortex	No. dorsal neg.	Direction dorsal negatives	Outline dorsal negatives	Platform Type	Edge Form (left)	Edge Form (right)	Retouch	Tool Type
153	S8	NE	/-130	black obsidian	bladelet	complete	15,2	6,4	1,8	0,1	lenticular	fresh	fine	no cortex	2	unidirectional	curved	pointed	convex	concave	utilized	-
154	S8	NE	/-130	black obsidian	bladelet	distal-midsection	16,2	6,6	1,9	0,1	triangular	fresh	fine	no cortex	3	unidirectional	curved	crushed	concave	convex	utilized	-
155	S8	NE	/-130	black obsidian	bladelet	complete	18,5	7,7	5,5	0,9	triangular	slight abrasion	with inclusions	no cortex	2	*indet.*	irregular	facetted	straight	straight	*indet.*	-
156	S8	NE	/-130	black obsidian	blade	complete	24,2	13,1	4,2	1,6	parallelogram	slight abrasion	with inclusions	no cortex	4	bi-directional	parallel	cortical	straight	straight	utilized	-
157	S8	NE	/-130	black obsidian	core	complete	17,6	13,2	9,3	2,3	irregular	fresh	fine	26-50%	4	unidirectional	parallel	facetted	irregular	irregular	*indet.*	-
158	S8	NE	/-130	black obsidian	bladelet	complete	17,0	9,5	2,6	0,5	triangular	fresh	fine	no cortex	4	irregular	irregular	crushed	convex	convex	trunc./utilized	borer
159	S8	NE	/-130	black obsidian	bladelet	complete	17,7	5,4	4,2	0,3	triangular	slight abrasion	fine	patinated	2	*indet.*	irregular	crushed	straight	convex	*indet.*	-
160	S8	NE	/-130	black obsidian	flake	distal-midsection	20,7	12,3	5,8	1,2	plano-convex	fresh	fine	26-50%	*indet.*	none	none	none	convex	convex	truncated	-
161	S8	NE	/-130	black obsidian	flake	prox.-midsection	17,7	10,1	4,3	0,8	triangular	fresh	fine	patinated	*indet.*	*indet.*	none	plain	triangular	triangular	*indet.*	-
162	S8	NE	/-130	black obsidian	flake	complete	21,2	13,1	5,8	1,7	plano-convex	fresh	fine	26-50%	*indet.*	none	none	plain	convex	convex	*indet.*	-
163	S8	NE	/-130	black obsidian	flake	complete	19,6	13,3	5,4	1,3	plano-convex	fresh	fine	26-50%	*indet.*	none	none	cortical	convex	convex	*indet.*	-
164	S8	NE	/-130	black obsidian	flake	complete	19,8	11,4	9,1	2,0	plano-convex	slight abrasion	with inclusions	26-50%	*indet.*	none	none	cortical	convex	concave	*indet.*	-
165	S8	NE	/-130	black obsidian	flake	complete	21,9	11,1	4,5	1,1	triangular	fresh	fine	26-50%	1	none	none	facetted	convex	straight	*indet.*	-
166	S8	NW	/-130	black obsidian	bladelet	complete	23,7	5,9	3,9	0,4	triangular	fresh	fine	no cortex	2	unidirectional	curved	pointed	convex	concave	backed/utilized	crescent
167	S8	NW	/-130	black obsidian	bladelet	complete	13,5	8,5	3,3	0,3	triangular	fresh	fine	no cortex	2	bi-directional	irregular	crushed	convex	straight	backed/utilized	backed bladelet
168	S8	NE	/-125	black obsidian	blade	midsection	21,2	20,9	9,9	4,6	triangular	fresh	fine	no cortex	3	*indet.*	irregular	none	straight	straight	utilized	-
169	S8	NE	/-125	black obsidian	bladelet	complete	14,4	7,9	2,6	0,2	triangular	fresh	fine	no cortex	1	unidirectional	parallel	crushed	straight	convex	rough/backed/utilized	backed bladelet
170	S8	SW	/-120	black obsidian	flake	complete	11,3	14,1	2,5	0,4	triangular	slight abrasion	fine	no cortex	2	unidirectional	parallel	crushed	straight	straight	notched	borer
171	S8	SW	/-120	black obsidian	blade	prox.-midsection	16,7	11,3	3,1	0,9	triangular	fresh	fine	no cortex	3	unidirectional	parallel	crushed	concave	straight	utilized	-
172	S8	SW	/-115	black obsidian	flake	complete	22,3	14,1	6,8	1,7	triangular	fresh	fine	1-25%	3	unidirectional	convergent	cortical	convex	triangular	utilized	-
173	S8	SE	/-115	black obsidian	flake	complete	32,9	17,1	7,4	4,3	triangular	fresh	fine	no cortex	6	irregular	irregular	facetted	straight	straight	fine	-
174	S8	SE	/-115	black obsidian	flake	midsection	27,7	37,9	9,4	9,5	parallelogram	slight abrasion	with inclusions	1-25%	2	*indet.*	convergent	dihedral	triangular	triangular	rough/trunc.	borer
175	S8	SW	/-110	black obsidian	flake	complete	27,1	11,6	4,9	1,6	triangular	fresh	fine	1-25%	2	unidirectional	parallel	pointed	convex	straight	notch/utilized	borer
176	S8	SW	/-110	black obsidian	core	complete	14,8	28,4	7,3	2,8	irregular	fresh	fine	patinated	6	unidirectional	parallel	cortical	irregular	irregular	*indet.*	borer ?
177	S8	SE	/-110	black obsidian	flake	prox.-midsection	16,0	14,8	3,1	1,4	triangular	fresh	fine	1-25%	2	unidirectional	parallel	cortical	convex	triangular	notch/utilized	-

Appendix IV: Biogeochemical results of the sediment analysis (Fincha Habera)

Sampling Depth	Total Organic Carbon	Black Carbon	Black Carbon rel. TOC	N	P	Ca	K	Coprostanol	Epi-coprostanol	5β-stigmastanol	Epi-5β-stigmastanol
[cm]	[g kg^{-1}]	[g C_{bc} kg^{-1}]	[g C_{bc} kg^{-1} TOC]	[g kg^{-1}]	[g kg^{-1}]	[g kg^{-1}]	[g kg^{-1}]	[µg kg^{-1}]	[µg kg^{-1}]	[µg kg^{-1}]	[µg kg^{-1}]
0-2	100,4	17,7	175,8	13,5	9,4	14,3	7,5	239	515	392,7	710,5
2-4	210,4	79,4	377,3	7,4	7,3	16,2	4,2	204,5	188,1	1111	1624,7
4-6	207,3	82,6	398,4	6,5	9,6	17,6	5	298,4	265,2	981,9	1463,3
6-7	122,5	46,1	376,2	6,1	13	22,2	6,2	161,6	113,8	267,8	282,7
7-9	26,1	7,8	300,1	1,9	41,5	63,5	7,3	68,2	83,4	29,8	57
9-17	270	81,8	302,8	10,5	3,4	12,6	3,1	205,6	165	433,1	519,8
17-19	21,5	6,8	315,6	1,3	23,7	31	7,7	58,6	39,2	61,4	44,2
19-21	12,6	3,5	281,6	1,1	33,6	34,1	6,8	80,6	51,9	46	29,4
21-23	13,5	3,2	236,1	1,2	29,3	45,9	6	98,5	68,5	41,6	20
23-25	10,7	2	190,8	1,1	31,6	63,5	4,7	230,9	47,8	60,9	54,7
25-27	11,1	1,3	115,9	1,1	33,7	80,2	11,1	304,2	70,8	161,2	81,4
27-29	11,1	2,1	184,8	1,2	36,4	100,7	4,6	101,7	54,1	15,5	6,9
29-34	12,7	2,4	192,1	1,4	35,8	85	4,8	209,9	50,4	81,2	37,6
34-36	18	3,4	187,6	2,2	43,9	102,3	4,1	465,9	55,9	74,6	39,2
36-39	21,4	2	94,8	1,8	84,4	192,4	2,7	713,4	189,1	5,9	13,9
39-41	25,6	5,5	213,9	2	53	135,9	3,7	192,4	64,4	36	43,9
41-43	20,9	5,7	274,8	1,8	19,3	42,8	5,5	79,8	64	18,1	20,8
43-45	13,1	2,7	206,1	1,4	27,5	52	4,4	392,6	87,6	69,4	48,6
45-47	12,8	2,5	196,7	1,4	27,5	52,1	4,1	320,0 *	44,6 *	150,4 *	55,1 *
47-49	10,7	2	190	1,2	21	40	3,9	320,0 *	44,6 *	150,4 *	55,1 *
49-51	1,6	0	0	0,2	3,6	13	3,1	39,7	32,5	5,4	8,6
51-53	1,2	0	0	0,2	2,9	8,9	2,6	40	48,5	3,1	9,2

Appendix V: Electron microprobe results (Fincha Habera)

				Wt %														Wt %															
Site		Provenance	Sample ID	O	F	Na	Si	Al	Mg	K	Ca	Cl	Zr	Ti	Mn	Fe	Total	SiO2	TiO2	ZrO2	Al2O3	Fe2O3	MnO	MgO	CaO	Na2O	K2O	F	Cl	Sum	O	Sum	H2O	Total
A05	Mararo	S8/-150	Bale 1	47,44	0,46	4,39	33,66	5,25	0,01	3,72	0,13	0,43	0,29	0,14	0,26	3,51	99,69	72,02	0,23	0,40	9,91	5,01	0,33	0,02	0,18	5,91	4,49	0,46	0,43	99,39	0,29	99,10	0,78	99,88
A05	Mararo	S8/-145	Bale 2	46,73	0,45	4,40	33,68	5,22	0,01	3,67	0,13	0,44	0,32	0,15	0,25	3,45	98,88	72,04	0,24	0,43	9,86	4,93	0,33	0,02	0,18	5,93	4,42	0,45	0,44	99,27	0,29	98,98	0,01	98,99
A05	Mararo	S8/-140	Bale 3	47,05	0,44	4,47	33,88	5,23	0,02	3,65	0,14	0,44	0,29	0,14	0,27	3,49	99,50	72,48	0,24	0,40	9,88	4,99	0,34	0,02	0,20	6,02	4,40	0,44	0,44	99,84	0,28	99,56	0,05	99,61
A05	Mararo	S8/-135	Bale 4	46,92	0,51	4,43	33,93	5,19	0,02	3,66	0,12	0,44	0,33	0,14	0,25	3,48	99,42	72,58	0,23	0,45	9,81	4,97	0,32	0,03	0,17	5,97	4,41	0,51	0,44	99,89	0,31	99,58	0,00	99,58
A05	Mararo	S8/-130	Bale 5	47,21	0,44	4,45	33,26	5,29	0,03	3,72	0,16	0,42	0,31	0,17	0,25	3,68	99,39	71,15	0,28	0,42	10,00	5,26	0,32	0,05	0,22	6,00	4,48	0,44	0,42	99,05	0,28	98,77	0,82	99,59
A05	Mararo	S8/-120	Bale 6	47,39	0,10	3,99	34,61	5,02	0,00	3,89	0,12	0,18	0,18	0,14	0,17	3,73	99,67	74,03	0,24	0,24	9,49	5,34	0,21	0,00	0,17	5,38	4,69	0,25	0,18	100,21	0,15	100,07	0,00	100,07
A05	Mararo	S8/-110	Bale 7	47,10	0,44	4,43	33,82	5,19	0,01	3,67	0,13	0,44	0,31	0,16	0,25	3,49	99,46	72,35	0,27	0,42	9,81	5,00	0,32	0,02	0,18	5,98	4,42	0,44	0,44	99,66	0,29	99,38	0,21	99,59
A45	Fincha Habera	H11L13	Bale 8	47,02	0,48	4,35	33,78	5,22	0,02	3,71	0,13	0,45	0,30	0,14	0,24	3,46	99,31	72,26	0,24	0,41	9,87	4,95	0,31	0,03	0,18	5,87	4,47	0,48	0,45	99,51	0,30	99,21	0,22	99,43
A45	Fincha Habera	H11L12	Bale 9	47,06	0,55	4,46	33,88	5,18	0,01	3,73	0,13	0,44	0,30	0,16	0,27	3,45	99,62	72,47	0,26	0,41	9,80	4,94	0,35	0,02	0,18	6,01	4,49	0,55	0,44	99,91	0,33	99,58	0,16	99,74
A45	Fincha Habera	H11L11	Bale 10	47,13	0,49	4,34	33,85	5,24	0,02	3,70	0,13	0,43	0,30	0,15	0,25	3,47	99,50	72,40	0,26	0,41	9,90	4,96	0,32	0,03	0,19	5,85	4,46	0,49	0,43	99,69	0,30	99,39	0,24	99,63
A45	Fincha Habera	H11L10	Bale 11	47,24	0,51	4,36	33,90	5,20	0,02	3,69	0,13	0,43	0,30	0,16	0,25	3,53	99,71	72,53	0,27	0,41	9,83	5,04	0,32	0,03	0,18	5,87	4,44	0,51	0,43	99,86	0,31	99,55	0,30	99,85
A45	Fincha Habera	H11L9	Bale 12	47,37	0,36	4,37	34,04	5,26	0,02	3,58	0,12	0,43	0,28	0,14	0,26	3,51	99,74	72,81	0,24	0,38	9,94	5,02	0,33	0,03	0,17	5,89	4,31	0,36	0,43	99,92	0,25	99,67	0,19	99,86
A45	Fincha Habera	H11L8	Bale 13	47,49	0,50	4,39	33,94	5,28	0,02	3,70	0,14	0,44	0,30	0,14	0,25	3,50	100,07	72,60	0,24	0,41	9,97	5,00	0,32	0,03	0,19	5,92	4,46	0,50	0,44	100,06	0,31	99,75	0,48	100,23
A45	Fincha Habera	H11L7	Bale 14	47,77	0,52	4,09	34,62	5,53	0,02	3,76	0,12	0,42	0,22	0,13	0,22	2,80	100,33	74,05	0,21	0,30	10,45	4,00	0,29	0,03	0,17	5,51	4,53	0,63	0,42	100,59	0,36	100,23	0,19	100,42
A45	Fincha Habera	H11L6	Bale 15	47,33	0,50	4,31	33,77	5,20	0,02	3,81	0,13	0,43	0,31	0,16	0,25	3,50	99,72	72,24	0,26	0,43	9,83	5,01	0,32	0,03	0,18	5,81	4,59	0,50	0,43	99,62	0,31	99,32	0,57	99,89
A45	Fincha Habera	H11L5	Bale 16	48,26	0,42	4,36	34,42	5,32	0,01	3,51	0,14	0,38	0,28	0,14	0,23	3,14	100,60	73,63	0,23	0,39	10,05	4,48	0,30	0,02	0,19	5,87	4,23	0,42	0,38	100,18	0,26	99,92	0,87	100,80
B06	Wasama	Outcrop	Bale 17	47,37	0,48	4,51	33,93	5,27	0,02	3,70	0,14	0,42	0,31	0,14	0,27	3,47	100,05	72,58	0,24	0,43	9,97	4,96	0,35	0,03	0,20	6,08	4,46	0,48	0,42	100,20	0,30	99,90	0,29	100,19
B04	Wasama	Outcrop	Bale 18	47,58	0,43	4,37	33,92	5,26	0,02	3,74	0,10	0,43	0,30	0,15	0,25	3,42	99,99	72,57	0,25	0,40	9,95	4,90	0,33	0,04	0,14	5,90	4,50	0,43	0,43	99,83	0,28	99,55	0,61	100,16
B04	Wasama	Outcrop	Bale 19	47,08	0,43	4,25	33,83	5,20	0,01	3,87	0,13	0,42	0,29	0,14	0,25	3,49	99,40	72,37	0,24	0,39	9,83	4,99	0,33	0,02	0,18	5,73	4,66	0,43	0,42	99,58	0,28	99,31	0,21	99,52
B08	Wasama	Outcrop	Bale 20	47,58	0,39	4,32	33,97	5,30	0,02	3,87	0,11	0,24	0,28	0,14	0,26	3,44	99,93	72,66	0,24	0,39	10,01	4,91	0,34	0,03	0,16	5,82	4,67	0,39	0,24	99,87	0,22	99,65	0,42	100,08
B08	Wasama	Outcrop	Bale 21	47,31	0,43	4,21	33,88	5,30	0,02	3,91	0,12	0,27	0,31	0,15	0,25	3,39	99,54	72,48	0,24	0,43	10,01	4,85	0,32	0,03	0,17	5,67	4,71	0,43	0,27	99,60	0,24	99,36	0,32	99,68
A58	Simbero	O6NW/L2	Bale 36	47,49	0,47	4,44	33,44	5,15	0,01	3,73	0,13	0,45	0,39	0,14	0,27	3,54	99,65	71,53	0,24	0,52	9,74	5,06	0,34	0,02	0,18	5,99	4,49	0,47	0,45	99,03	0,30	98,73	1,18	99,91
A58	Simbero	O6NE/L3	Bale 37	47,49	0,41	4,44	33,42	5,26	0,01	3,77	0,13	0,44	0,40	0,14	0,26	3,53	99,70	71,49	0,24	0,54	9,94	5,05	0,34	0,02	0,18	5,98	4,54	0,41	0,44	99,17	0,27	98,89	1,06	99,96
A58	Simbero	O6SE/L4	Bale 38	47,57	0,44	4,38	33,54	5,12	0,02	3,70	0,14	0,44	0,40	0,15	0,27	3,56	99,72	71,74	0,25	0,54	9,67	5,09	0,35	0,03	0,19	5,91	4,45	0,44	0,44	99,11	0,28	98,83	1,16	99,99
A58	Simbero	O6NW/L5	Bale 39	47,66	0,47	4,43	33,77	5,21	0,01	3,67	0,14	0,45	0,37	0,15	0,27	3,57	100,18	72,24	0,25	0,50	9,85	5,10	0,35	0,02	0,20	5,97	4,42	0,47	0,45	99,82	0,30	99,53	0,87	100,40
A58	Simbero	O6SW/L6	Bale 40	47,53	0,40	4,41	33,29	5,25	0,01	3,73	0,12	0,43	0,38	0,16	0,26	3,61	99,58	71,22	0,26	0,52	9,91	5,16	0,33	0,02	0,17	5,94	4,49	0,40	0,43	98,87	0,27	98,60	1,25	99,85
A58	Simbero	O6SW/L7	Bale 41	47,60	0,41	4,55	32,86	5,30	0,03	3,78	0,16	0,43	0,38	0,16	0,27	3,80	99,73	70,30	0,27	0,52	10,01	5,43	0,35	0,04	0,22	6,13	4,56	0,41	0,43	98,67	0,27	98,40	1,65	100,04
A58	Simbero	O6NW/L8	Bale 42	47,74	0,45	4,36	33,60	5,26	0,02	3,85	0,13	0,32	0,37	0,14	0,25	3,56	100,04	71,88	0,23	0,50	9,93	5,09	0,33	0,03	0,18	5,88	4,64	0,45	0,32	99,46	0,26	99,20	1,09	100,29