

**EARLY HUMAN SOCIAL TRANSMISSION DURING MARINE ISOTOPE  
STAGE 5: A PERSPECTIVE FROM THE KALAHARI BASIN.**



**BY**

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## ABSTRACT

The social transmission of cultural information is widely recognized as a crucial component contributing to the survival and prosperity of our species. This thesis studies lithic technological systems to assess the extent of the transmission of cultural information between different early human groups across the Kalahari Basin and adjoining regions during Marine Isotope Stage (MIS) 5 (~130-74 ka), a key time and place for understanding the emergence and expansion of complex behaviors in Africa. It has been proposed that glacial periods (e.g., MIS 4) in southern Africa were characterized by coalescence, while interglacial periods (e.g., MIS 5) were characterized by population fragmentation. While these previous hypotheses represent important examples for testing the degrees of population interconnectedness during MIS 5, they were based primarily on sites outside of the Kalahari Basin and its environs. Therefore, the central inquiry of this thesis is to investigate the presence and extent of cultural transmission among hunter-gatherer populations in and around the Kalahari Basin, assessing whether patterns of population fragmentation observed during MIS 5 are discernible in these regions. This inquiry is achieved by studying lithic assemblages from multiple sites and comparing them using a behavioral approach to cultural transmission. The samples studied are from Ga-Mohana Hill North Rockshelter, Kathu Pan 6, Erfkroon, and Florisbad in South Africa, and #Gi and White Paintings Rockshelter in Botswana. The results of this study indicate there are many technological similarities across most of the studied sites, including the predominant use of local raw materials, recurrent Levallois methods, hard hammer percussion technique, core maintenance primarily by *débordant* removals, manufacturing of similar products, mostly with faceted platforms, and a low frequency of formal tools. This homogeneity may reflect technological information exchange and connections between human groups at these sites. The connectivity is inferred to be closely linked to their adaptation to the drier climatic conditions that persisted in the Kalahari Basin and its adjoining regions, in contrast to coastal and other inland areas. The arid and semi-arid environments may have necessitated the formation of social ties to access scarce and potentially unpredictable resources. In contrast to some other regions that show fragmentation during interglacial periods, the Kalahari Basin and adjacent regions did not follow the same pattern.

**Keywords:** Kalahari Basin, Marine Isotope Stage (MIS) 5, Middle Stone Age, lithic technology, social transmission.

## **DECLARATION**

This is to certify that the work presented in this doctoral thesis is my own both in concept and execution. In cases where I have used the work of others, it has been properly referenced. This thesis has not been submitted for a degree at the University of Cape Town or any other institution of higher learning.


Signature:

Date: 13 December 2023

## SUPERVISORS' DECLARATION

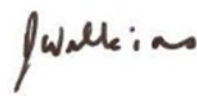
We hereby declare that we have checked this project and, in our opinion, it is satisfactory in terms of scope and quality for the award of the Degree of Doctor of Philosophy in Archaeology. Therefore, we agree with the submission of this thesis.

**Supervisor:** Dr. Yonatan Sahle

Signature: 

Date: 05 December 2023

**Co-Supervisor:** Dr Jayne Wilkins

Signature: 

## **DEDICATION**

*To my daughter Loshnee for the steadfast love*

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# CHAPTER ONE: INTRODUCTION

## 1.1 Models for cultural transmission, aim and study rationale

Marine Isotope Stage (MIS) 5, dated 74-130 thousand years ago (ka), is a key time and place for understanding the emergence and expansion of uniquely human behaviors in the Middle Stone Age (MSA) of Africa (Mackay *et al.*, 2014; Mcbrearty and Brooks, 2000; Pazan *et al.*, 2020; Sahle and Brooks, 2019). In southern Africa, many significant early human behavioral innovations first appeared during this phase (e.g., Porraz *et al.*, 2021; Wadley, 2015; Wilkins *et al.*, 2021; Wurz, 2013). These include, but are not limited to, the earliest known evidence for geometric engravings, the use of ostrich eggshell (OES) containers, the use of Abalone shells for mixing ochre, and the collection of non-utilitarian objects like calcite crystals (d’Errico *et al.*, 2012; Henshilwood *et al.*, 2009, 2011; Wilkins *et al.*, 2021). Several aspects about the timing, drivers, trajectories, and geographical extents of this suite of complex technological and social behaviors, however, remain as yet unanswered (see Sahle and Wilkins, 2024 for a recent overview). Thus, this research examines lithic technological systems to assess the presence and extent of the transmission of cultural information among various early human groups inhabiting discrete MIS 5 sites in the Kalahari and adjoining regions during this crucial period in African prehistory. In this thesis, the term “Kalahari and adjoining regions” refers to the Kalahari Basin and its immediate vicinity, roughly within an approximate radius of 200 km.

The MIS 5 period is a global-scale interglacial phase characterized by elevated sea levels resulting from the melting of ice sheets and glaciers due to rising temperatures. Some argue that these rising temperatures in Africa may have led to warm and moist environments conducive to human habitation (e.g., Cohen *et al.*, 2014; Lamb *et al.*, 2018; Maslin *et al.*, 1996; Trauth *et al.*, 2003

Ziegler *et al.*, 2013). However, evidence from the Kalahari depicts that it exhibited a varied environment during MIS 5, with most of the region, particularly the northern and southwestern parts of the basin, experiencing extremely dry conditions (see Helgren and Brooks, 1983; Lukich and Ecker, 2022; Robbins *et al.*, 2000, 2016; Telfer and Thomas, 2007; Thomas *et al.*, 2022). Fewer locales in the southern Kalahari and regions just at the limit of the Kalahari exhibited wetter conditions at the beginning of MIS 5, suggesting that the MIS 5 period was not uniformly moist across the Kalahari and southern Africa at large. On the other hand, glacial phases, such as MIS 6, MIS 4, and MIS 2, are characterized by lower sea levels. Some researchers have emphasized the prevalence of harsh glacial environments, which were cold and may have led to increased aridity, making human habitation difficult (Ambrose and Lorenz, 1990; Deacon 1979; Mackay *et al.*, 2014; Quick *et al.*, 2016). Conversely, there is also increasing evidence showing that glacial periods were not uniformly arid (Chase, 2010; Chase and Meadows, 2007; Esteban *et al.*, 2020; Wadley, 2013).

It has been suggested that during glacial periods (MIS 4 and 2) in southern Africa, cold and harsh environments may have led to the scarcity and unpredictability of resources, resulting in populations engaging in higher information exchange, fostering coalescence and intergroup connectedness (Ambrose and Lorenz, 1990; Mackay *et al.*, 2014). Conversely, during interglacial phases, for example MIS 5, warm and moist environments may have provided abundant and predictable resources, resulting in a reduced need for information exchange and independent activities, ultimately leading to population fragmentation and reduced intergroup connectedness (Ambrose and Lorenz, 1990; Mackay *et al.*, 2014; Pazan *et al.*, 2020). Thus, interconnectedness and the social transmission of cultural information are argued to be coping mechanisms and risk

minimization strategies during times of environmental stress (Ambrose and Lorenz, 1990; Bousman 2005; Mackay *et al.*, 2014; Romano *et al.*, 2022; Wiessner, 1982).

Humans rely on each other when responding to harsh environments with scarce and unpredictable resources to determine the location of these vital necessities. For instance, ethnographic studies of hunter-gatherer groups in challenging environments, such as those present in southern Africa and the Arctic regions, have revealed the formation and sustenance of social ties that enable the exchange of knowledge among widely dispersed social groups (Whallon, 2006; Whallon *et al.*, 2011). This information exchange is a pivotal aspect of adapting to uncertain environments, serving as survival skills and “safety nets” during instances of limited local resources and aiding in the identification of available resources (Whallon, 2006; Whallon *et al.*, 2011). Our understanding of the presence and role of social connections as a means of survival has been refined through the study of these groups (Whallon, 2006; Whallon *et al.*, 2011).

In their study, Mackay *et al.* (2014) compared lithic assemblages across southern Africa, hypothesizing that the MIS 5 period in the region was generally characterized by fragmentation and diminished intergroup connectedness. To test their hypothesis, they compared assemblages from southern African sites across three different rainfall regions (i.e., winter, summer, and year-round zones), beginning with MIS 5. In comparison to later “glacial” periods, such as MIS 4 and MIS 2, Mackay and colleagues (2014: 21) state that “there is little coherence in flaking systems within climate regions during MIS 5, and material selection often appears highly localized, both of which imply localized spheres of interaction.” For instance, they observed that within the region

characterized by year-round rainfall, the flaking system at Blombos Cave is focused on producing flakes rather than convergent pieces and blades. In contrast, the Cape St. Blaize Cave assemblage exhibits non-standardized and more irregular blades resembling those found in the Klasies River main site's younger MSA (~80-100 ka), and it lacks evidence for the production of convergent pieces. Additionally, pointed stone artifacts are frequently found at MIS 5 sites in summer rainfall zones, while denticulates predominantly occur at winter rainfall sites. Taken together with evidence for localized raw material selection, these traits are used to suggest that MIS 5 marked a phase characterized by adaptive diversity and limited intergroup connectivity. The observed technological heterogeneity across sites aligns with the notion of greater population fragmentation during MIS 5 (Mackay *et al.*, 2014).

In a related vein, recent work by Pazan *et al.* (2020) at the site of Melikane Rockshelter in Lesotho has also hypothesized the presence of population fragmentation during MIS 5. Pazan *et al.* (2020) argue that the inhabitants of Melikane employed a combination of blade-focused and bipolar flaking techniques, carefully producing a versatile toolkit suitable for frequent residential mobility and tailored to their local environment. When comparing Melikane Rockshelter with other MIS 5 sites across the subcontinent, including Blombos Cave, Border Cave, Bushman Rockshelter, Diepkloof Rockshelter, Hoedjiespunt 1, Klasies River main site, Pinnacle Point 5-6, Putslaagte 8, Sibudu Cave, and Ysterfontein 1, the researchers found evidence of heterogeneity in lithic technology. Their analysis indicated that the highland populations at Melikane were notably isolated from their low-lying contemporaries during MIS 5. This entails less interaction, with humans adjusting to specific regional environments instead of following shared technological

practices that are geared toward narrower resource bases and resultant ecological necessities (Pazan *et al.*, 2020).

The works discussed above (Mackay *et al.*, 2014; Pazan *et al.*, 2020) represent important examples testing the degrees of population interconnectedness across MIS 5. However, they were confined to assemblages from sites outside of the Kalahari Basin and its environs. While acknowledging the importance of these related works, the goal of this thesis is to expand the investigation of the presence and extent of cultural transmission among MSA hunter-gatherer populations across previously unstudied regions. The study assesses whether patterns suggestive of population fragmentation (such as the lack of coherence in flaking systems) observed in other regions of southern Africa during MIS 5 are also discernible in the Kalahari and nearby regions, which were not included in earlier studies. In this regard, the present research fills a significant research gap. By incorporating well-dated and well-documented sites from the Kalahari and its environs, this thesis contributes to existing knowledge on the degree of population interconnectedness and enhances our understanding of the dynamics of early hunter-gatherer populations during MIS 5.

In coastal, near-coastal, and some interior regions of southern Africa, MIS 5 is marked by more humid and warmer climatic conditions, along with predictable and abundant resources, including coastal shellfish, savanna, and grassland biomes, as well as large herds of migratory ungulates (Ambrose and Lorenz, 1990; Marean, 2016; Parkington, 2010). However, several environmental and paleoenvironmental studies have depicted the deep interior, including the Kalahari and its environs, as having a unique macroclimate characterized by arid and semi-arid conditions with

limited resources, even during MIS 5 (see Helgren and Brooks, 1983; Lukich and Ecker, 2022; Robbins *et al.*, 2000, 2016; Telfer and Thomas, 2007; Thomas *et al.*, 2022; Wroth *et al.*, 2022). The mode and magnitude to which such peculiarities of the Kalahari and environs may have affected early human technology and behavior have long remained unexplored. Thus, this study investigates how past lithic technological systems are organized and maintained in relation to macroclimatic and environmental conditions in the Kalahari and nearby areas. Specifically, the thesis examines the presence and extent of human interactions and group interconnectedness in the arid and semi-arid Kalahari and its environs. This investigation is against the backdrop of the argument that interconnectedness and the social transmission of cultural information may be coping mechanisms and risk minimization strategies that are adopted when populations are confronted with harsh environments and unpredictable resource availability (Ambrose and Lorenz, 1990; Bousman, 2005; Mackay *et al.*, 2014; Romano *et al.*, 2022; Wiessner, 1982).

The study examines the extent of the transmission of cultural information by analyzing MIS 5 lithic artifact assemblages from multiple sites in and around the Kalahari Basin. Lithic artifacts are crucial elements that are well preserved in the archaeological record, often serving as the most abundant evidence of past human behaviors (Wilkins *et al.*, 2017). Analyzing lithic artifacts is one of the fundamental sources of information used by archaeologists to empirically investigate and address critical questions about complex human behaviors in the past (Wilkins *et al.*, 2017). Numerous researchers emphasize that similarities and differences in various aspects of lithic technology can be used to infer the presence and degree of transmission of cultural information among past hunter-gatherer groups (Ambrose and Lorenz, 1990; Mackay *et al.*, 2014; Pazan *et al.*, 2020; Porter, 2019; Ranhorn, 2017; Ranhorn *et al.*, 2020; Tostevin, 2012; Way *et al.*, 2022).

In addition, several studies have suggested that lithic technologies may develop in response to ecological demands and constraints (Ambrose and Lorenz, 1990; Mackay *et al.*, 2014; Pazan *et al.*, 2020; Wilkins *et al.*, 2017). For example, in their study of coalescence and fragmentation in southern Africa, Mackay *et al.*, (2014) utilized various attributes of lithic artifacts to illustrate technological variability and information exchange as a response to environmental conditions. They considered “provisioning systems, raw material selection, flaking systems, and implement types” as key indicators. Provisioning systems encompass activities such as raw material procurement and transportation to manufacturing sites. These systems were examined to assess technological variability and information exchange, as they represent adaptive responses to local environmental conditions aimed at ensuring a consistent supply of tools when needed (Mackay *et al.*, 2014). Furthermore, material selection, which involves the choice of raw materials for artifact production, was used as a trait for assessing variability. The preference for the use of certain specific raw material types often has the potential for transfer between geographically separated groups while taking into consideration geological differences (Mackay *et al.*, 2014).

Moreover, Mackay *et al.* (2014) utilized flaking systems (that is, methods of reducing cores) as a trait for assessing coalescence. Flaking systems are described as intricate processes involving decision-making during lithic reduction (Mackay *et al.*, 2014). Given the complexity and diversity of stone reduction methods, it is likely that flaking was a skill taught over a lengthy period, with experienced toolmakers passing down their knowledge to apprentices (Eren *et al.*, 2011; Hiscock, 2014; Mackay *et al.*, 2014; Pargeter *et al.*, 2019; Pazan *et al.*, 2020, Stout, 2002; Tostevin, 2012). Consequently, similarities in flaking systems among different assemblages are considered indicative of shared traditions among geographically separated groups (Mackay *et al.*, 2014;

Tostevin, 2012). Furthermore, Mackay *et al.* (2014) also compared retouched artifact types, suggesting that similar designs and morphologies might indicate the transfer of design information through product imitation, sometimes without extensive training.

However, this thesis acknowledges from the onset that any research studying social transmission has to contend with convergence (where comparable aspects of material culture emerge independently in different sites due to local populations' independent innovations) as an alternative hypothesis. On the other hand, proving convergence is equally difficult as proving cultural transmission. Hence, the question of whether comparable lithic technologies arise from cultural transmission of ideas through interactions and learning or convergence has long been a focal point among scholars in lithic studies (see Byrne, 2007; Eren *et al.*, 2018; Groucutt, 2020; Kuhn and Zwyns, 2018; Lucas *et al.*, 2020; Ranhorn, 2017; Will and Mackay, 2020; Zwyns, 2021). This is because the extent of variation in lithic products resulting from independent invention or cultural transmission was not fully understood (Tostevin, 2012; Ranhorn, 2017; Will and Mackay, 2020; Groucutt, 2020).

Recognizing the challenge of determining whether comparable lithic technologies arise from cultural transmission or convergence, Tostevin (2007, 2012, and 2019) developed a behavioral approach to cultural transmission for the Pleistocene epoch. Although Tostevin's approach is limited by its primary reliance on experimental archaeology literature (e.g., Bradbury and Carr 1999; Dibble and Whittaker 1981; Dibble and Pelcin 1995; Dibble and Rezek 2009; Shott *et al.*, 2011), which, while effective in demonstrating the complexity of certain lithic reduction systems,

do not specifically test for convergence and are chance-based, it is one of the methodologies designed to test for knowledge transmission using lithic artifacts. Despite this limitation, Tostevin's (2007, 2012, and 2019) behavioral approach to cultural transmission operates on the assumption that some domains and schemes of lithic reduction are less likely to have resulted from convergence but rather require careful copying of each stage to be fully expressed. Therefore, the lithic artifact domains Tostevin identified are considered to have arguably resulted from cultural transmission rather than convergence. This study uses the behavioral approach to cultural transmission with the same assumption to test for knowledge transmission in the Kalahari and its environs.

In the behavioral approach to cultural transmission, Tostevin (2007, 2012, and 2019) isolated five domains or stages of stone tool production that are often passed on through social transmission. These domains encompass the following: (1) core modification, which includes raw material selection, knapping techniques, core maintenance, and lithic reduction methods; (2) platform maintenance, which includes platform preparation and measurable datasets such as platform angles and thickness; (3) direction of core exploitation; (4) dorsal convexity systems, which include technological dimensions but also consider the impact of different raw material types on artifact dimensions; and (5) retouched toolkit morphology. A detailed description of each of these domains is provided in the methods chapter.

The high levels of similarity across the aforementioned five domains or stages of lithic artifact production signify the presence and extent of shared or transmitted knowledge among groups, even

when operating within the limitations imposed by the geological context. This rules out other potential influencing factors and driving forces, such as convergence, as explanations for the occurrence of similar technological patterns in different regions (see Clarkson *et al.*, 2018; Wilkins, 2018, 2020a; Will *et al.*, 2015; Tostevin, 2007, 2012, 2019). Therefore, in this thesis, I aim to assess the transmission of cultural ideas by identifying similarities in these domains or stages of lithic artifact manufacture across the studied MIS 5 sites in and around the Kalahari Basin.

Given that the behavioral approach to cultural transmission identifies traits related to social transmission, it facilitates the exclusion of independent innovations and produces results free from interpretive pitfalls caused by equifinality. This approach therefore transcends the traditional shape-based and techno-complex comparative approach normally used in southern African MSA lithic analysis. The traditional approach assumes that if two assemblages possess similar tool types or shapes, it may indicate cultural connectedness, despite the potential for independent innovations (e.g., Mackay *et al.*, 2014; Pazan *et al.*, 2020). Thus, by using this approach, the study reduces the possibility of misinterpreting convergence as social transmission.

The behavioral approach to cultural transmission aimed to incorporate ideas from processual archaeology, particularly middle-range theory (e.g., Binford 1965, 1977, 1978, 1981; Deetz 1965, 1977). In the field of lithic analysis, middle-range research primarily involves knapping experiments, such as reproducing ancient technologies. Tostevin's (2012) behavioral approach included experimental data on known knapping mechanisms, for example, those mentioned earlier

by Bradbury and Carr (1999), Dibble and Whittaker (1981), Dibble and Pelcin (1995), Dibble and Rezek (2009), and Shott *et al.* (2011), into the study of cultural transmission. The concept of middle-range in the behavioral approach is grounded in the idea that by analyzing the skill levels and learning processes involved in knapping, we gain a better understanding of the mechanisms of knowledge transmission.

With the aforementioned premise that the behavioral approach to cultural transmission can serve as a valuable method to assess the transmission of cultural information, this thesis employs the typo-technological approach to record lithic traits from multiple sites in and around the Kalahari Basin. Furthermore, it compares the studied lithic assemblages, utilizing Tostevin's (2007, 2012, and 2019) behavioral approach to cultural transmission, with the aim of investigating the presence and extent of information exchange across different early human groups inhabiting discrete MIS 5 sites.

To achieve the aforementioned aim, the main MIS 5 lithic assemblage examined in this study comes from Ga-Mohana Hill North Rockshelter (GHN; 27°47' N, 23°43' E), located on the eastern periphery of the Kuruman Hills, approximately 12 kilometers (km) northwest of Kuruman town in the Northern Cape province of South Africa (Wilkins, 2023). The GHN assemblage is dated by optically stimulated luminescence (OSL) techniques to  $105.3 \pm 3.7$  ka (Wilkins *et al.*, 2021). For comparative analysis, I examined five additional MIS 5 lithic assemblages from the Kalahari Basin and its environs. The first of these comes from Kathu Pan 6 (KP6; 27°40' S, 23°0' E), an open-air site located 45 km southwest of GHN, on the outskirts of Kathu town in the Northern Cape

province. The KP6 assemblage is dated to  $74 \pm 5$  ka (Lukich *et al.*, 2019). The second and third assemblages derive from two open-air sites in the Free State province: Erfkroon (EFK;  $28^{\circ}52'$  S,  $25^{\circ}36'$  E) and Florisbad (FLB;  $28^{\circ}46'$  S,  $26^{\circ}04'$  E), positioned 330 and 341 km southeast of GHN, respectively. EFK and FLB are the two sites considered part of the adjoining regions of the Kalahari Basin, with MIS 5 assemblages dating to  $99.4 \pm 6.6$  ka and  $121 \pm 6$  ka respectively (Bousman *et al.*, 2023; Kuman *et al.*, 1999; Morris, 2019). The fourth lithic artifact sample comes from #Gi ( $19^{\circ}01'$  S,  $21^{\circ}01'$  E), an open-air site located 900 km northwest of GHN, on the periphery of a pan in the Dobe valley in western Botswana. The #Gi sample is dated to  $77 \pm 11$  ka (Brooks *et al.*, 2006). The fifth assemblage derives from White Paintings Rockshelter (WPS;  $18^{\circ}45'$  S,  $21^{\circ}44'$  E), situated 1300 km northwest of GHN, within the Tsodilo Hills in western Botswana. The WPS assemblage is dated to  $94.3 \pm 9.4$  ka (Robbins *et al.*, 2000; Ivester *et al.*, 2010; see Figure 1 for geographic locations).

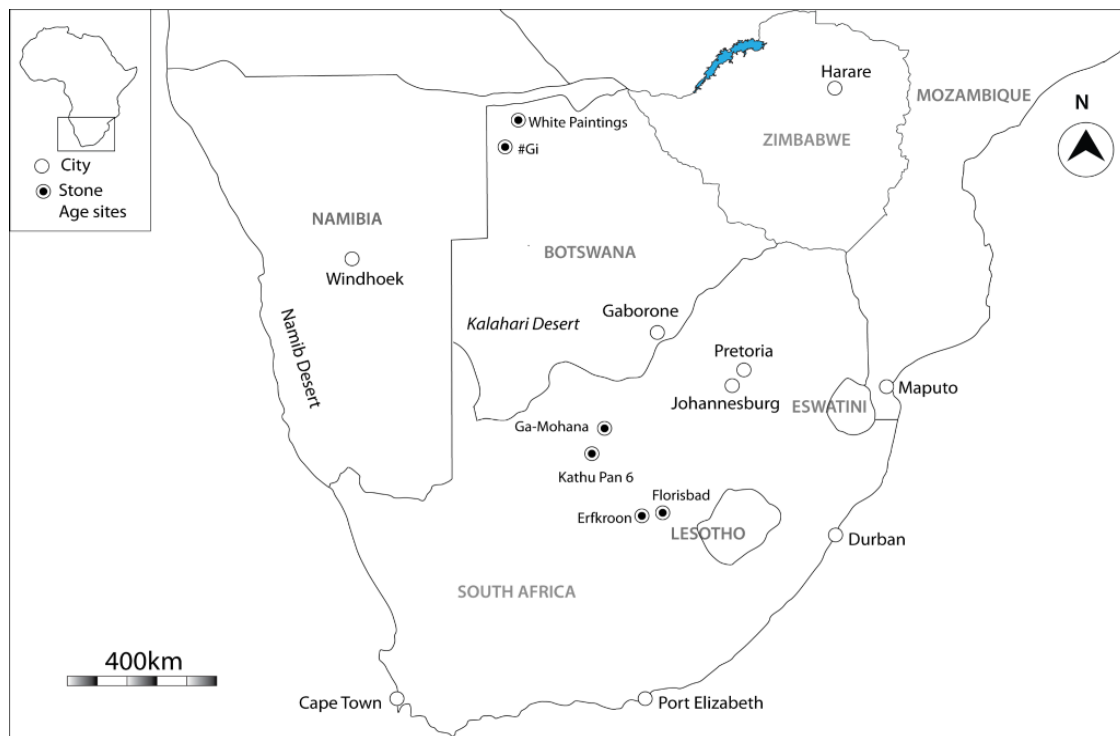


Figure 1: Locations of MIS 5 sites studied in and around the Kalahari Basin - Ga-Mohana Hill North Rockshelter, Kathu Pan 6, Erfkroon, Florisbad, #Gi, and White Paintings Rockshelter.

Undoubtedly, there are inherent limitations associated with using lithic artifacts to infer cultural transmission. Inferring social transmission using stone tools is particularly challenging due to the gap between the detailed predictions of theoretical models and the available empirical data. This discrepancy is partly influenced by taphonomic processes and biases inherent in archaeological sampling (Liu and Stout, 2023). Additionally, the temporal and spatial resolution of archaeological sites can be uneven, with gaps in the record obscuring continuous cultural practices and variations across regions, which may reflect environmental adaptations rather than social learning. However, the study mitigates these challenges by employing the behavioral approach to cultural transmission, specifically designed to identify aspects of lithic artifact production passed on through social transmission, as explained in previous sections of the thesis.

In addition, the age estimates for the studied sites span different substages of MIS 5 (i.e., MIS 5a to 5e), which represents another limitation of this study. However, the lack of sites dated to similar substages within the Kalahari and its environs has necessitated the use of comparable sites from different MIS 5 substages. Thus, a stage-level rather than a substage-level comparison was conducted. The fact that these sites derive from various substages means that the study covers almost the entire length of MIS 5. On the other hand, even if these sites were dated to roughly similar ages, the differential dating techniques and associated error ranges for each of these sites would still make the estimated dates comparable only to a given extent, as the levels of confidence range vary. Furthermore, despite the study's limitations arising from variations in the dates of the sites under investigation, spanning from MIS 5a to e, this study also leverages them as an opportunity to test whether there was continuity or change in technological patterns through time, specifically throughout the five MIS 5 sub-stages. This approach further informs on whether there

were longer-term trends in artifact styles that speak more to macroevolutionary processes or not, thus mitigating this limitation within the constraints of the available data.

Admittedly, these assemblages differ from the coastal, near-coastal, and other interior cave sites reported by Mackay *et al.* (2014) and Pazan *et al.* (2020), which have abundant chronometric dates. Along the coast and other interior areas, there are plentiful deposits of varying ages that were used to compare assemblages from different MIS stages and substages to assess coalescence and fragmentation. However, in the deep interior, that is, the Kalahari and adjoining regions, fewer sites have been chronometrically dated. To address this limitation, the study has sampled all the sites with available published chronometric MIS 5 dates in the region to ensure comprehensive coverage of the available data. The studied sites were chosen because they represent under-researched arid and semi-arid regions. The comparative approach used in the study provides valuable insights into the extent of cultural transmission in regions further north within the Kalahari and its neighboring areas, contributing to the existing literature on the dynamics of the MSA during MIS 5.

The studied sites encompass a diverse array of rock shelters and open-air locations situated in the arid and semi-arid regions of the Kalahari and its surroundings. This study acknowledges inherent limitations, including the comparison of sites in the semi-arid peripheral zones, such as GHN, KP6, FLB, and EFK, with those found in the more arid heartland of the Kalahari, notably #Gi and WPS. Comparing sites in different environmental zones, such as semi-arid peripheral areas and arid heartland regions, can pose limitations and raise questions about whether environmental factors

may have played a role in shaping technological choices. Another acknowledged limitation is the comparison of cave sites with open-air sites, deviating from the norm employed by previous works (Mackay *et al.*, 2014 and Pazan *et al.*, 2020), which predominantly sampled sites characterized by a greater prevalence of caves. Cave sites often offer better preservation conditions compared to open-air sites. Additionally, there are differences in site functionality, with rock shelters often serving as living spaces, while open-air sites might have been used for various purposes, including temporary campsites or specialized activity areas. All these factors can potentially influence the overall interpretations of the study's results. However, to alleviate these limitations, the study also leverages them as an opportunity to test and provide insights into whether lithic technological choices in the Kalahari and its environs were influenced by site setting, function, and environmental conditions.

It is also imperative to recognize that along the coastline, cave sites abound in contrast to the Kalahari and its adjacent regions, where cave sites are relatively scarce and open-air sites are prevalent. Thus, despite the marked differences in geographical and physiographic settings, these rockshelters and open-air sites dating to MIS 5 within the Kalahari and its environs serve as a valuable foundation for comparative analysis. They furnish crucial insights into the potential influences of site location, past environmental conditions, and physiographic settings on mobile foraging strategies. Additionally, they shed light on the relationship between technological decision-making and the adaptability of early modern humans to dry conditions.

In the context of MIS 5 archaeology, the study and comparison of lithic assemblages in the Kalahari and nearby regions contribute to our understanding of the characteristics and unique behaviors of MSA MIS 5 humans in southern Africa. While extensive MIS 5 archaeology research has been conducted along the coast and near-coastal regions of South Africa, there has been relatively less work in the interior, especially in the deep interior, such as the Kalahari and its adjacent areas. The majority of MIS 5 archaeology data comes from the coastal regions of South Africa, where well-preserved and well-dated sites with long cultural sequences are abundant (Wilkins *et al.*, 2021). These sites, including Blombos Cave, Border Cave, Cape St. Blaze, Diepkloof Rockshelter, Hoedjiespunt 1, Klasies River main site, Klipfonteinrand 1, Pinnacle Point site complex, Putslaagte 8, Sibudu Cave, and Ysterfontein 1, have been prime targets for in-depth research (see Brenner and Wurz, 2019; Douze *et al.*, 2015; Mackay *et al.*, 2014).

While some works do exist on interior MIS 5 sites, such as Apollo 11, Bushman Rockshelter, Melikane Rockshelter, Mwulu Cave, and Rose Cottage (see de la Peña *et al.*, 2018; Mackay *et al.*, 2014; Pazan *et al.*, 2020; Porraz *et al.*, 2018), research in the Kalahari and its environs remains notably limited and constitutes a minor part of the existing MIS 5 literature (see Brenner, 2019; Wilkins *et al.*, 2021). Therefore, the rationale for this study is to bridge this existing research gap. These sites in the Kalahari and adjoining regions hold significant potential to enhance our understanding of MIS 5 archaeology in the southern African deep interior.

## **1.2 Thesis organization**

This thesis comprises eight chapters. Chapter One introduces the background models hypothesized for social transmission, the study aim, and its rationale. Chapter Two provides essential contextual background information on the MSA of southern Africa. Chapter Three reviews the existing literature for the sites under study and the MIS 5 archaeology in the Kalahari and nearby regions. The subsequent four chapters contain the core of the study's original work: Chapter Four outlines the methods used to analyze and compare GHN with the other MIS 5 lithic assemblages, and Chapter Five presents the results from GHN technological analysis. Chapter Six presents the results of the technological analysis of the comparative sites. Chapter Seven presents the results of the statistical comparison between GHN and the comparative sites. Lastly, Chapter Eight synthesizes and discusses the results.

## **CHAPTER TWO: THE MIDDLE STONE AGE OF SOUTHERN AFRICA: AN OVERVIEW**

The MSA (~300-20 ka) is an important period in African prehistory, as it is a key time and place for investigating the origins of complex behaviors in Africa (Bader *et al.*, 2022; Blackwood and Wilkins, 2022; d’Errico, 2003; McBrearty and Brooks, 2000; Sahle *et al.*, 2019; Wadley, 2015; Willoughby, 2006). In southern Africa, the MSA documents the emergence and proliferation of innovative behaviors and practices that are considered to be defining characteristics of modern humans, such as art, symbolic engravings, burial practices, the production of bone implements, hafting technology, heat treatment, and advanced cognition seen with the introduction of Levallois technology (Bader *et al.*, 2022; Blackwood and Wilkins, 2022; d’Errico *et al.*, 2005; d’Errico and Backwell, 2016; Muller *et al.*, 2017; Schmidt *et al.*, 2013; Wadley, 2010, 2015). Several works concur that most of these technological and behavioral innovations developed and flourished during MIS 5 (Henshilwood *et al.*, 2011; Porraz *et al.*, 2021; Wadley, 2015; Wilkins *et al.*, 2021; Wurz, 2013). This chapter provides contextual background on the MSA of southern Africa, highlighting where the studied sites may fit within the broader MSA context. An exhaustive review of the MSA in Africa is beyond the scope of this thesis.

### **2.1 MSA in southern Africa from a lithic technology perspective**

The MSA is often associated with the emergence of our species, *Homo sapiens*. This period is also broadly defined by the appearance of a range of distinct technological behaviors. Notable lithic technological aspects of the MSA encompass the production of blades, flakes, and convergent pieces from prepared cores, along with their utilization as stone weapon tips (Goodwin and van Riet Lowe, 1929; McBrearty and Brooks, 2000; Sahle and Wilkins, 2024; Wadley, 2015). Much

of our knowledge about the southern African MSA derives from South Africa, which has received relatively high research attention in recent decades, particularly due to advancements in dating techniques such as OSL, which provides age estimates of archaeological strata beyond the limits of radiocarbon dating (Sahle and Wilkins, 2024). Thus, this overview primarily focuses on South Africa, although relevant examples from other southern African countries are also included.

In South Africa, our understanding of the MSA has been notably influenced by a geographical bias (Sahle and Wilkins, 2024; Wilkins *et al.*, 2021). Over the past few decades, extensive research efforts have primarily focused on MSA sites located along the coastline and its vicinity, although substantial research also exists in other regions (Sahle and Wilkins, 2024; Wilkins *et al.*, 2021). Sahle and Wilkins (2024) identify that the primary reason for this bias is the prevalence of rockshelters with well-preserved and datable layers in the mountain ranges along the coastal areas, while such sites are scarce in most other regions. This bias has led to a heightened focus on the importance of coastal environments in the evolution of *Homo sapiens* (Sahle and Wilkins, 2024).

Since the 1920s, researchers have classified the southern African MSA into technocomplexes, also referred to as industrial complexes, using absolute dating methods and based on the variability of lithic assemblages throughout the sequence (Dusseldorp *et al.*, 2013; Goodwin and van Riet Lowe, 1929; Lombard *et al.*, 2012, 2022). A technocomplex is a set of industries characterized by lithic artifact assemblages that share many common characteristics and attributes (Lombard *et al.*, 2012). The southern African MSA is categorized into eight technocomplexes that have regional variants and associated MIS, namely early MSA, Klasies River, Mossel Bay, pre-still Bay, Still Bay, Howiesons Poort (HP), post-HP, and final MSA (see Table 1). This overview focuses more on the

technocomplexes associated with MIS 5, although taking into consideration that named stone tool industries (“NASTIES”; Shea 2014) are an imperfect classification system, as reiterated by Wilkins (2020b). This thesis refrains from extensively using the industrial complex nomenclature due to the challenges posed by the inconsistencies and the changing terminological framework in characterizing the variations among the lithic artifact assemblages defining MIS 5 at different sites, as discussed by several scholars (e.g., Douze *et al.*, 2015; Wilkins, 2020b).

The term “early MSA” is an informal industrial complex used in sub-Saharan MSA to identify the period that dates between ~300 ka and 130 ka, corresponding to MIS 6-8 (Lombard *et al.*, 2012, 2022; Wurz, 2020; Sahle and Wilkins, 2024). South Africa’s early MSA record lacks significant transitional patterns from the preceding Acheulean period and the existence of early *Homo sapiens* fossils, which are well-documented in other regions of Africa (Sahle and Wilkins, 2024). Early MSA sites in South Africa are scarce, with the majority of the pertinent assemblages lacking precise absolute dating (Sahle and Wilkins, 2024). Early MSA sites also lack detailed descriptions, contributing to a lack of consensus regarding the antiquity and characteristics of their assemblages (Sahle and Wilkins, 2024). Nevertheless, the hallmark of this phase is the increased use of prepared core technologies, including both Levallois and discoidal methods, to make blanks that are fashioned into various tools, such as points, although the frequency of formal tools remains low. (Lombard *et al.*, 2012, 2022; Sahle and Wilkins, 2024). Key early MSA localities in South Africa include Border Cave, Bundu, Florisbad (FLB), Kathu Pan 1, Pinnacle Point, and Wonderwerk Cave (see Chazan *et al.*, 2020; Grün *et al.*, 1996; Kibberd, 2006; Marean *et al.*, 2007; Porat *et al.*, 2010; Sahle and Wilkins, 2024; Wadley, 2015; Wilkins *et al.*, 2012; Wurz, 2020).

The end of the early MSA in southern Africa closely aligns with the onset of MIS 5. During MIS 5, multiple sites in South Africa were inhabited, providing larger sample sizes of artifacts with more precise chronometric dates, which enhanced our comprehension of the emerging technological and behavioral patterns in this period (Sahle and Wilkins, 2024). Over the last fifty years, various technocomplexes and nomenclatures have been used to describe MIS 5 technological and behavioral patterns in southern Africa (see Douze *et al.*, 2015; Lombard *et al.*, 2012, 2022; Singer and Wymer, 1982; Wurz, 2002, 2013). Most of the MIS 5 assemblages are generally classified into two technocomplexes: the Klasies River technocomplex (also known as MSA I or MSA 2a), dated between ~130 and 105 ka, and the Mossel Bay technocomplex (~105 to 77 ka), also called MSA II or MSA 2b (Lombard *et al.*, 2012). Additionally, assemblages corresponding to MIS 4-5 are classified as Still Bay (~77 to 70 ka), while those predating the emergence of the Still Bay technocomplex are commonly referred to as pre-Still Bay (~96 and 72 ka) (Douze *et al.*, 2015; Lombard *et al.*, 2012, 2022).

The Klasies River technocomplex is named after the coastal site complex of Klasies River, which boasts one of the longest MIS 5 occupations, spanning the period from ~115 to 80 ka (Brenner and Wurz, 2019; Wurz, 2002). This technocomplex is generally characterized by the prevalent use of recurrent Levallois methods, with a focus on blade and convergent flake production (Wurz, 2000, 2002, 2013). Some of the end products of the Klasies River technocomplex are argued to share similarities with the Howiesons Poort (HP) technocomplex, including blades with curved profiles, retouched convergent pieces with prominent bulbs of percussion, and platforms exhibiting evidence of rubbing and dorsal scar patterns indicative of the removal of small flakes (Wurz, 2000, 2002, 2013). Important sites associated with the Klasies River technocomplex include Klasies

River main site, Pinnacle Point, and Ysterfontein 1 (Avery *et al.*, 2008; Jerardino and Marean, 2010; Wurz, 2002, 2012, 2013).

Another technocomplex corresponding to MIS 5 is Mossel Bay, which emerged in the MSA record of southern Africa shortly after the Klasies River technocomplex. The Mossel Bay technocomplex is generally characterized by the recurrent unipolar Levallois method to produce convergent pieces and blades with bulbs of percussion and impact points, indicating the use of hard hammer percussion. Formal tools within this technocomplex are relatively infrequent (Lombard *et al.*, 2012, 2022; Wurz, 2002, 2013). Key localities associated with the Mossel Bay technocomplex include Blombos Cave, Diepkloof Rockshelter, Klasies River main, and Pinnacle Point in South Africa, as well as Melikane Rockshelter in Lesotho (Jacobs, 2010; Lombard *et al.*, 2012; Pazan *et al.*, 2020; Sahle and Wilkins, 2024; Stewart *et al.*, 2012; Wadley, 2015; Wurz, 2021). The GHN assemblage (~105 ka) studied in this thesis corresponds with the transition from the Klasies River to the Mossel Bay technocomplex in terms of chronometric dates, highlighting some of the uncertainties associated with organizing lithic assemblages in southern Africa. Additionally, the Erfkroon (EFK; ~99 ka) assemblage, studied for comparative purposes, aligns with the Mossel Bay in terms of radiometric dates.

The pre-Still Bay and Still Bay technocomplexes mark the transition from MIS 5 to the onset of MIS 4. The term “pre-Still Bay” is used to describe assemblages that predate the Still Bay culture. Although pre-Still Bay has received less research attention, it is generally characterized by a flake-based instead of a blade industry, with the dominant formal tools being denticulates and unifacial points (Wadley, 2015). Important pre-Still Bay localities include Blombos Cave, Rose Cottage,

and Sibudu Cave (Henshilwood 2012; Soriano *et al.*, 2015; Villa and Lenoir 2006; Way and Hiscock 2021). The #Gi (~77 ka) and White Paintings Rockshelter (WPS; ~94 ka) assemblages fall within the Mossel Bay, pre-Still Bay, and Still Bay phases in terms of radiometric dates.

Technological trends noted in the pre-Still Bay phase persisted and heightened in the Still Bay, marked by the emergence of iconic bifacial lanceolate pointed lithic artifacts with varying morphologies, ranging from narrow to wide-oval, featuring pointed or double-pointed tips (Lombard *et al.*, 2012, 2022; Wadley, 2015; Wurz, 2013). Furthermore, most Still Bay lithic artifact assemblages are primarily composed of bifacial points, with relatively scarce cores and blades (Sahle and Wilkins, 2024). During this period, there was an apparent spike in the utilization of fine-grained materials, with some of them heat-treated to improve knapping qualities. While Still Bay is generally dated between ~77 and 70 ka (Lombard *et al.*, 2012, 2022), arguments have been made suggesting a much older age for the Diepkloof site (Tribolo *et al.*, 2013). Both pressure flaking and soft hammer methods were employed in producing Still Bay lithic artifacts (Wurz, 2013). The use of Still Bay points remains a subject of debate, with various suggestions ranging from their use as knives to projectile weapons (spear tips) (Lombard, 2006a; Shea, 2009; Wadley, 2007), while others argue that they functioned solely as hand-held spears, given their shape characteristics and fractures resemble Paleo-Indian points (Villa *et al.*, 2009; Villa and Soriano, 2010).

The distinctive features of the Still Bay technocomplex have raised the possibility that it may be associated with unique cultural groups that maintained interconnectedness, engaged in population interactions, and facilitated cultural transmission across southern Africa (Mackay *et al.*, 2014).

Similarities in tool forms across a span of over 1000 km within Still Bay imply a high degree of accuracy in transmission, which is more likely to reflect the replication of processes and learning from individuals over extended periods of knowledge exchange (Mackay *et al.*, 2014; Sahle and Wilkins, 2024). However, the extensive geographical range, with localities stretching from the northeastern to southern Cape coastal areas of South Africa, including sites such as Blombos Cave, Diepkloof Rockshelter, Hollow Rockshelter, Sibudu Cave, Umhlatuzana Rockshelter in South Africa, and Apollo II in Namibia, along with considerable variation in point morphology across these sites, has led others to suggest the potential for convergence and has cast doubt on the accuracy of cultural transmission and connectivity during the Still Bay (see Archer *et al.*, 2016; Henshilwood, 2012; Högberg and Lombard, 2016; Högberg and Larsson, 2011; Soriano *et al.*, 2015; Villa *et al.*, 2009; Wadley, 2007; Sahle and Wilkins, 2024).

The Still Bay culture transitions into the Howiesons Poort (HP), which is one of the most extensively documented and researched technocomplexes found in various sites across southern Africa (Wurz, 2013). Regardless of the extensive research on the HP, there is no consensus regarding its timing, with several researchers arguing that the HP is a short-lived technocomplex dated to the period ~66-58 ka (see Jacobs *et al.*, 2008; Jacobs and Roberts, 2017), although it might have persisted until about 50 ka at Diepkloof Rockshelter (see Tribolo *et al.*, 2013). On the other hand, Feathers (2015) suggests an HP age range of ~80 to 63 ka and another set of dates from the Varsche Rivier site, arguing for younger ages and suggesting that the HP technocomplex existed between ~45 and 41 ka (Steele *et al.*, 2016). The Kathu Pan 6 (KP6) assemblage, studied for comparative purposes, dates to ~74 ka, which is earlier than any of the timeframes considered

plausible for the HP by Jacobs *et al.* (2008) and Jacobs and Roberts (2017). However, technologically, it is argued to be consistent with HP (see Beaumont, 1990; Lukich *et al.*, 2019).

Despite the debates regarding the timing of the HP technocomplex, its key features have remained consistent (Wurz, 2013). The HP is characterized as a blade-based industry associated with distinctive formal tools, such as large backed pieces, burins, retouched points, notched pieces, and *pièces esquillées* (de la Peña, 2020; Deacon and Deacon, 1999; Deacon, 1995; Lombard, 2011; Porraz *et al.*, 2008; Wurz 1999). In most HP sites, blades are produced using a recurrent Levallois method and soft hammer percussion (Porraz *et al.*, 2008; Wurz, 2013). Similar to the Still Bay culture, the homogeneity of HP flaking systems and implement types across regions in southern Africa is argued to suggest widespread population interaction during glacial periods (see Mackay *et al.*, 2014). Notable HP sites include Boomplaas Cave, Border Cave, Diepkloof Rockshelter, Die Kelders, Klasies River main, Montague Cave, Nelson Bay Cave, Pinnacle Point, Rose Cottage Cave, Sibudu Cave, Umhlatuzana Rockshelter in South Africa, Melikane Rockshelter in Lesotho, and Apollo 11 Cave in Namibia (see de la Peña, 2020; de la Peña *et al.*, 2022; de la Peña and Wadley, 2014; Soriano *et al.*, 2007; Sahle and Wilkins, 2024; Stewart *et al.*, 2012; Villa *et al.*, 2010; Wurz, 2013).

The end of the MSA in southern Africa encompasses the Sibudu and final MSA technocomplexes. The Sibudu, named after the Sibudu Cave type site, is also referred to as post-HP or MSA III/3 (Lombard *et al.*, 2012). Sibudu is dated from ~58 to 45 ka, while the final MSA phase is dated to a period between ~40 and 20 ka, corresponding to MIS 3 (Lombard *et al.*, 2012). The long

archaeological sequence of Sibudu Cave provides valuable knowledge on the behavioral dynamics of the late MSA.

The end of the MSA is marked by significant technological and behavioral diversity, suggesting limited socio-cultural ties, possibly attributable to fragmentation and decreased intergroup interactions (Mackay *et al.*, 2014; Sahle and Wilkins, 2024). Various factors, such as demographic changes, shifts in resource availability, and alterations in mobility strategies, have been proposed to explain this substantial variability (Dusseldorp, 2014; Mackay *et al.*, 2014; Sahle and Wilkins, 2024). The lithic assemblages exhibit the use of different core reduction methods, including bipolar, discoid, and Levallois techniques. Key sites associated with the termination of the MSA include Border Cave, Diepkloof Rockshelter, Klasies River main, Klein Kliphuis, Rose Cottage, and Sibudu Cave in South Africa, as well as Melikane and Sehonghong in Lesotho (Porraz *et al.*, 2013; Villa *et al.*, 2010, 2012; Wadley, 2015; Wurz, 2021). Similar to its beginnings, the termination of the MSA in southern Africa exhibited considerable temporal and spatial variability, spanning tens of thousands of years (Sahle and Wilkins, 2024).

Despite the widespread use of technocomplexes to describe MSA sequences, relying on NASTIES and assemblage-level similarities is not the most effective way to assess intergroup connectedness in the past (Shea, 2014; Wilkins, 2020b). Many old inferences on connectedness lack theoretical frameworks and comparisons of the ecological contexts between different assemblages of interest, often relying solely on similarities in the final products (Shea, 2014; Wilkins, 2020b). For instance, 3-dimensional geometric morphometric studies have revealed significant variation between Still Bay points in the northeast and southwest of South Africa, casting doubt on the notion of the Still

Bay period indicating shared tradition and connectedness across many regions of southern Africa (see Archer *et al.*, 2016). Therefore, it is preferable to develop and employ methods supported by Middle-Range theories to study and infer the relationship between lithic technological systems, cultural transmission, and the past environment rather than refining a culture-historical framework (Pargeter *et al.*, 2019; Porter, 2019; Ranhorn, 2017; Ranhorn *et al.*, 2020; Shea, 2014; Tostevin, 2012; Wilkins, 2020b). This thesis adopts middle-range models, such as the behavioral approach to cultural transmission, to infer shared traditions rather than relying on a cultural-historical approach.

Table 1: Summary of the MSA technocomplexes in southern Africa (table combined using data from Lombard et al., 2012, 2022; Wadley 2015; Wurz 2013, 2021).

Period	Technocomplex	Age	Associated MIS	Regional variants	Key Localities	Characteristics
MSA ~300-20 ka	Early MSA	~300-130 ka	MIS 6-8	----	Border Cave, Bundu, Florisbad, Kathu Pan 1, Pinnacle Point, Wonderwerk Cave.	Levallois and discoidal flake technology; volumetric cores used to produced blades.
	Klasies River	~130-105 ka	MIS 5	MSA I at Klasies, MSA 2a generally.	Klasies River main, Pinnacle Point, Ysterfontein, Florisbad.	Production of convergent flakes and recurrent Levallois blades; knapped products that are elongated and fairly thin; tiny platforms with diffuse bulbs; pieces with denticulation.
	Mossel Bay	~105-77 ka	MIS 5	MSA II at Klasies River, MSA2b generally.	Klasies River main; Melikane Rockshelter, Pinnacle Point, White paintings Rockshelter, Rhino Cave, ≠Gi.	Recurrent unipolar Levallois convergent pieces and blade production; fomal tools infrequent; products have faceted platforms and straight profiles.
	Pre-Still Bay	~96-72 ka	MIS 4-5	----	Blombos Cave, Diepkloof Rockshelter, Rose Cottage, Sibudu Cave.	Flake based technology. End products include denticulates and unifacial points. Bone artifacts are also familiar.
	Still Bay	~77- 70 ka	MIS 4-5	----	Blombos Cave, Diepkloof, Hollow Rockshelter, Peers Cave Sibudu Cave, Umhlatuzana Rockshelter.	Thin bifacially worked foliate point; semi-circular or wide-angled pointed butts.
	Howiesons Poort	~66-58 ka	MIS 3-4	---	Boomplaas Cave, Border Cave, Diepkloof Rockshelter, Klasies River main, Klein Kliphuis, Klipdrift, Melikane Rockshelter, Ntloana Tšoana, Pinnacle Point, Rose Cottage Cave, Sibudu, Umhlatuzana Rockshelter.	Blade technology: small, backed tools (segments, scrapers, trapezes, backed blades).
	Sibudu	~58-45 ka	MIS 3	late MSA/post-HP or MSA III at Klasies; MSA 3 generally.	Border Cave, Diepkloof Rockshelter, Klasies River main, Klein Kliphuis, Melikane, Ntloana Tšoana, Rose Cottage Cave, Sehonghong, Sibudu Cave.	Levallois points; most retouch is oriented towards manufacturing unifacial points while bifacially retouched points are infrequent.
	Final MSA	~40-20 ka	MIS 3	MSA IV at Klasies River, MSA 4 in general.	Klein Kliphuis, Rose Cottage Cave, Sehonghong, Sibudu Cave, Umhlatuzana Rockshelter.	Bipolar method is visible; bifacial implements, bifacially retouched points, hollow-based points, and geometric backed pieces.

## **2.2 Innovative behavior in the MSA of southern Africa**

The earlier MSA of southern Africa is characterized by the lack of distinct spatial and chronological patterns in hominin behavior; by contrast, clearer patterns and numerous examples of novel behaviors start to appear sporadically in the later MSA after ~200 ka, particularly during MIS 5 (Sahle and Wilkins, 2024; Wadley, 2015; Wurz, 2013). These innovative behaviors are evident in the form of deliberate inscriptions on objects (such as ochre slabs), the use of ostrich eggshell (OES) container technology, ornamentation, burial practices, hafting, and heat treatment of raw materials (Bader *et al.*, 2022; Blackwood and Wilkins, 2022; McBrearty and Brooks, 2000; Sahle and Wilkins, 2024).

This proliferation of novel behaviors starting in MIS 5 has garnered significant research attention, particularly after the turn of the century. The advent of alternative dating techniques (e.g., OSL) has enabled the interpretation of evidence for early innovative technologies and behaviors from several southern and northern South African cave and coastal sites that boast excellent preservation (see Charrié-Duhaut *et al.*, 2013; d’Errico *et al.*, 2012; Henshilwood *et al.*, 2002, 2009; Porraz *et al.*, 2021, Sahle and Wilkins, 2024). The widespread occurrence of evidence for some innovative behaviors has led to the proposal that these were perhaps shared by groups that were connected during MIS 4 (Mackay *et al.*, 2014).

The deliberate marking of objects is recognized as a distinctive behavior associated with the later MSA. This behavior is exemplified through slabs and pieces of ochre with remarkable geometric engravings observed during MIS 5 at Blombos Cave and Klasies River main (d’Errico *et al.*, 2012; Henshilwood *et al.*, 2002, 2009). These incisions were deliberately produced using a pointed stone,

signifying intentional design (Henshilwood and d’Errico, 2011). Worked ochre is also found in southern Africa’s MSA record, including MIS 6 layers at Pinnacle Point Cave 13B and Wonderkrater (Backwell *et al.*, 2014; Marean *et al.*, 2007). McBrearty and Brooks (2000: 528) additionally report the recovery of grindstones with traces of ochre from the MSA horizon (~77 ka) at #Gi in Botswana. Ochre processing, including the use of an abalone shell mixing tool, has been observed at Blombos Cave (see Henshilwood *et al.*, 2011). Archaeologists often label these intentional engravings and ochre processing as “art,” and frequently attribute symbolic meaning to them (McBrearty and Brooks, 2000; Wadley, 2015). Ethnographically, processed ochre is employed in various activities, including body adornment, sun protection, insect repellence, and as a binding reagent in substance adhesives, indicating intricate behavioral patterns (Sahle and Wilkins, 2024).

The utilization of ornamental objects represents another innovative aspect observed during the MSA in southern Africa. Ornamentation is evident in the form of perforated seashell beads discovered in the Still Bay levels of Blombos and Sibudu Caves (d’Errico *et al.*, 2005, 2008; Henshilwood *et al.*, 2004; Vanhaeren *et al.*, 2013; Wadley, 2015). Some of these beads are argued to show traces of deliberate heat treatment (d’Errico *et al.*, 2015). Perforated seashell beads serve as both ornamental items and as demonstrations of specific competencies, like the capacity to drill and bind knots for fastening the beads (Henshilwood, 2012; Wadley, 2015).

MSA novel behaviors also encompass the utilization of OES container technology. The earliest documented evidence of OES container technology is found at Diepkloof Rockshelter, dating back to ~105 ka (Parkington *et al.*, 2005). Furthermore, a substantial collection of geometrically incised

OES is observed within the Diepkloof Rockshelter HP sequence (Parkington *et al.*, 2005). In the Kalahari Basin, deliberate collection of OES and non-utilitarian items, such as calcite crystals, is evident at ~105 ka (Wilkins *et al.*, 2021). These behaviors are posited to reflect the innovativeness of modern humans, thriving in the deep interior (Wilkins *et al.*, 2021).

New hunting and subsistence technologies also emerged during the MSA (Marean *et al.*, 2007; Villa *et al.*, 2009). These technologies encompass advanced hafting methods utilizing resins and compound adhesives, often incorporating ochre. Such practices are observed at various sites, including Diepkloof Rockshelter, Rose Cottage, Sibudu Cave, and Umhlatuzana Rockshelter (Charrié-Duhaut *et al.*, 2013; Gibson *et al.*, 2004; Lombard, 2006b; Wadley *et al.*, 2009). Hafting technology is also documented in the Kalahari region, specifically at #Gi, as proposed by Brooks *et al.* (1990). This technology is significant as it contributes to the diversification of hunting techniques during the MSA (Rots *et al.*, 2017).

Additionally, the heat treatment of rocks to enhance knapping quality also emerges in the MSA record of southern Africa. The application of heat treatment to raw materials, such as silcrete, is considered one of the early fire-based innovations in southern Africa (Brown *et al.*, 2009; Schmidt and Högberg, 2018). The heat treatment of raw materials has been observed at sites such as Diepkloof Rockshelter (Schmidt *et al.*, 2013; Porraz *et al.*, 2021) and Klipdrift Shelter (Delagnes *et al.*, 2016). Notably, this practice seems to be absent in the southern Kalahari Basin due to the unavailability of silcrete in the local environment (Schmidt *et al.*, 2017).

A plethora of bone artifacts emerged in southern Africa during the MSA, including bone points, awls, spatulas, retouchers, wedges, arrowhead scrapers, and notched rib fragments (Wadley, 2015). This proliferation is predominantly documented at sites such as Border Cave, Blombos Cave, Klasies River, and Sibudu Cave (Backwell *et al.*, 2008; d’Errico *et al.*, 2012; d’Errico and Henshilwood, 2007; Henshilwood, 2012; Henshilwood and Sealy, 1997; Wurz, 2013). Unfortunately, there is an absence of evidence for worked bone within the MSA deposits in the Kalahari, with the earliest bone points observed only in Later Stone Age (LSA) contexts at WPS (Robbins *et al.*, 2012).

Lastly, burial practices represent another innovative behavior during the MSA in southern Africa, although evidence of such practices is limited. The discovery of a potential four-month-old infant burial accompanied by a perforated conus shell within the layers corresponding to MIS 5 at Border Cave is considered the oldest known example of modern human burial in southern Africa (d’Errico and Backwell, 2016). However, this particular interment has not received the same level of scholarly attention as other North African burials from sites like Taramsa and Nazlet-Khater in Egypt, and East African burials, such as Panga ya Saidi in Kenya (Crevecoeur, 2012; d’Errico and Backwell, 2016; Martín-Torres *et al.*, 2021; Vermeersch *et al.*, 1998).

### **2.3 The southern African MSA from an evolutionary biological and cognitive perspective**

There is no agreement on the taxonomic status of hominins associated with the earliest known occurrences of the MSA on the continent. In South Africa, the Late Pleistocene hominin fossil record remains sparse (Sahle and Wilkins, 2024). A partial cranium that retains substantial portions

of the face and frontal bone was recovered from FLB MSA layers dated by Electron Spin Resonance (ESR) to ~260 ka (Bräuer, 2008; Grün *et al.*, 1996; Kuman *et al.*, 1999). Originally ascribed to the *Homo helmei* species, which is now largely abandoned, this specimen has been variously characterized as early *Homo sapiens*, late *Homo heidelbergensis*, or *Homo rhodesiensis*, or it has been deemed too fragmentary to be assigned to a species (see Sahle and Wilkins, 2024). Additionally, a tooth excavated at Sterkfontein and associated with early MSA tools was assigned to archaic *Homo sapiens* (Reynolds *et al.*, 2007). *Homo sapiens* fossil remnants have also been found at various sites, including Klasies River main, Border Cave, Ysterfontein 1, Diepkloof Rockshelter, Die Kelders, and Sibudu Cave (Beaudet *et al.*, 2022; Grine *et al.*, 2017 a and b; Sahle and Wilkins, 2024; Will *et al.*, 2019; Verna *et al.*, 2013).

The novel and technological behaviors that emerged during the later MSA have been inferred to imply that its population possessed cognitive traits akin to modern humans (Lombard and Haidle, 2012; McBrearty and Brooks, 2000; Wadley, 2015). For instance, the ability to innovate through multitasking is considered indicative of complex cognition (Wadley, 2015). By the same token, the introduction of Levallois technology during the MSA indicates advanced cognition among early modern humans (Muller *et al.*, 2017; Schlanger, 1996). The technologies of MSA weapons are also used as proxies for comprehending human cognition (Lombard and Gärdenfors, 2021), and these cognitive traits are argued to signify enhanced brain functionality (Wynn *et al.*, 2009). By studying the artifacts associated with specific technologies, we can gain insights into the mental processes and behaviors of the individuals who utilized them.

## CHAPTER THREE: MIS 5 LITHIC TECHNOLOGY IN SOUTHERN AFRICA

The previous chapter provided an overview of the MSA in southern Africa and placed the current research within the broader MSA context. In this chapter, the focus narrows down to reviewing the existing literature pertaining to MIS 5 lithic technology in southern Africa. Secondly, the chapter examines previous research conducted on the sites in and around the Kalahari from which the lithic samples for this study were obtained. Lastly, the chapter reviews literature on the paleoenvironment of the Kalahari and its environs during MIS 5.

MIS 5 lithic technology is generally characterized by increased variability in flaking systems and the predominant use of locally available raw materials (Mackay *et al.*, 2014). Extensive research has been conducted along the coast and near-coastal areas at sites containing MIS 5 lithic assemblages (Wilkins *et al.*, 2021). Notable sites include Blombos Cave, Border Cave, Cape St. Blaze, Diepkloof Rockshelter, Hoedjiespunt 1, Klasies River main site, Pinnacle Point site complex, Putslaagte 8, Sibudu Cave, and Ysterfontein 1 (Mackay *et al.*, 2014).

At Blombos Cave, the lithic assemblage from the M3 phase (~105–90 ka) is identified by its abundance of local raw materials (Douze *et al.*, 2015). The flaking system primarily focuses on producing flakes, triangular blanks, and a limited number of blades (Douze *et al.*, 2015). The assemblage contains a few retouched pieces, including notches and scrapers. Knapped lithics predominantly exhibit the use of freehand percussion, and core reduction methods employed include orthogonal, inclined, centripetal, parallel unipolar, and unidirectional convergent techniques (Douze *et al.*, 2015). Similarly, at Diepkloof Rockshelter, the assemblage from the MIS

5 period (~107–100 ka), referred to as “MSA Mike,” is also defined by the production of primarily flakes, convergent blanks with a limited number of blades (Porraz *et al.*, 2013; Tribolo *et al.*, 2013). Various reduction methods, including unidirectional and centripetal reduction, were employed at Diepkloof Rockshelter. The use of local raw materials is also evident at Diepkloof, with freehand, hard hammer percussion used as a knapping technique. Formal tools at Diepkloof include scrapers, notches, denticulates, and bifacial pieces. Additionally, *pièces esquillées* are present, which are absent at other sites such as Blombos Cave (Porraz *et al.*, 2013).

The Hoedjiespunt 1 MIS 5 assemblage, dated ~130 to 119 ka, is characterized by its use of locally available materials to predominantly produce flakes with a limited number of blades, mirroring observations at Blombos Cave and Diepkloof Rockshelter. The lithic assemblage includes various core types, such as inclined, parallel, and platform cores (Will *et al.*, 2013). A distinctive feature at Hoedjiespunt 1 is the presence of a bipolar core reduction strategy, which is absent at Blombos Cave and Diepkloof Rockshelter (Douze *et al.*; 2015; Will *et al.*, 2013). Denticulates are the primary formal tool type found at this site, while the frequency of points is low, akin to other MIS 5 sites like Ysterfontein 1.

The analysis of the Ysterfontein 1 MIS 5 lithic artifacts, dated from ~119 to 113 ka (Niespolo *et al.*, 2021), describes the assemblage as oriented towards flake production rather than blades (Wurz, 2012). The retouched piece component includes scrapers, notches, and denticulates, while points are rare (Wurz, 2012). Platform cores are frequent, although two-volume cores are part of the assemblage (Douze *et al.*, 2015; Wurz, 2012). These two-volume cores correlate to the inclined or

parallel reduction techniques observed at Blombos Cave (Douze *et al.*, 2015; Wurz, 2012). Additionally, unidirectional, bidirectional, and centripetal reduction methods are present. The primary knapping techniques involve hard hammer percussion. The lithic artifacts are made from local raw materials (Wurz, 2012).

Klasies River is one of the South African sites with the longest recorded sequences, where deposit thickness exceeds 10 meters (Douze *et al.*, 2015). Its MIS 5c-d (~130 to 105 ka; see Lombard *et al.*, 2012) layers are notable for the production of flakes, convergent pieces, and blades utilizing local quartzite, quartz, and sandstone (Brenner and Wurz, 2019). Bladelets are part of the Klasies River *chaîne opératoire*. The reduction methods employed at the site are the unidirectional parallel system on platform and parallel cores. Retouched tools are infrequent, with notches and denticulate pieces dominating the assemblage (Brenner and Wurz, 2019).

The MIS 5 lithic artifact assemblages from Pinnacle Point 13B are characterized by the dominant use of locally available raw materials, with less than 10% being exotic (Thompson and Marean, 2008; Thompson *et al.*, 2010). The MIS 5 assemblages at the site are divided into four areas: two from MIS 5c (East and West, dated ~94 and 99 ka, respectively), one from MIS 5d (East, ~110 ka), and the last one from MIS 5e (area LC-MSA, ~125 ka). Lithic reduction in MIS 5c (East area), MIS 5d, and MIS 5e is mainly focused on blade production, with blades outnumbering points. In the MIS 5c West area, points slightly outnumber blades. This observation is reinforced by the greater abundance of point cores compared to blade cores (see Thompson and Marean, 2008; Thompson *et al.*, 2010). The pointed pieces' cores found at Pinnacle Point 13B are probably

analogous to the parallel, unidirectional convergent ones identified at Blombos Cave (see Douze *et al.*, 2015). Pinnacle Point 5–6 MIS 5 (~96 and ~81 ka) assemblage is oriented toward a lithic reduction that primarily involves Levallois methods to produce convergent flakes and blades using local raw materials (Brown, 2011; Wilkins *et al.*, 2017). Notched denticulates are the common formal tool type at this site (Wilkins *et al.*, 2017).

Cape St. Blaize is another site that exhibits an MIS 5 lithic assemblage. The flaking systems at this site are oriented toward the production of flakes, convergent blanks, and blades made from locally available raw materials (Thompson and Marean, 2008). Retouched pieces include notches, denticulates, points, and backed pieces. In a similar context, the use of local raw materials during MIS 5 is also observed at Sibudu Cave. The reduction methods employed at Sibudu Cave encompass laminar unidirectional with a lateral crest on parallel cores. Analogous to Hoedjiespunt 1, bipolar reduction is also evident (Schmid *et al.*, 2019; Schmid, 2019). Blades are produced using hard and soft hammer internal direct percussion. Formal tools in the assemblage include unifacial pointed forms, scrapers, serrated pieces, and denticulates (Rots *et al.*, 2017; Schmid *et al.*, 2019; Schmid, 2019).

The Putslaagte 8 MIS 5 component (~75 ka) also exhibits a similar pattern of using locally available raw materials (Mackay *et al.*, 2015). Reduction methods at the site involve bipolar and Levallois techniques for the production of convergent blanks and blades. The primary percussion technique employed is hard hammer direct percussion (Mackay *et al.*, 2015). Similar to Ysterfontein 1 and Hoedjiespunt 1, the frequency of points is low at Putslaagte 8, with retouched

pieces primarily consisting of denticulates and *pièces esquillées*. While distinguishing *pièces esquillées* from bipolar cores may pose challenges, Mackay *et al.* (2015) successfully differentiated them by noting that the former were typically fashioned on flakes, lacked edge-to-edge scars, and exhibited greater weight compared to the latter. The Border Cave MIS 5 lithic artifact assemblage, dated between ~80 and 122 ka, is also characterized by locally available raw materials (Beaumont, 1978). Reduction primarily focuses on the production of flakes and blades. Retouched pieces in this assemblage include backed pieces, scrapers, burins, bifacial, and unifacial points (Beaumont, 1978). Lastly, the Klipfonteinrand 1 assemblage is also characterized by the predominant use of locally available raw materials at ~85 ka. The reduction techniques are aimed at producing flakes, with a significant proportion comprising convergent pieces. Prepared cores are common, and the retouched pieces are primarily denticulates and notched pieces (O’Driscoll and Mackay, 2023; see Figure 2 for geographical locations of the sites described in this chapter).

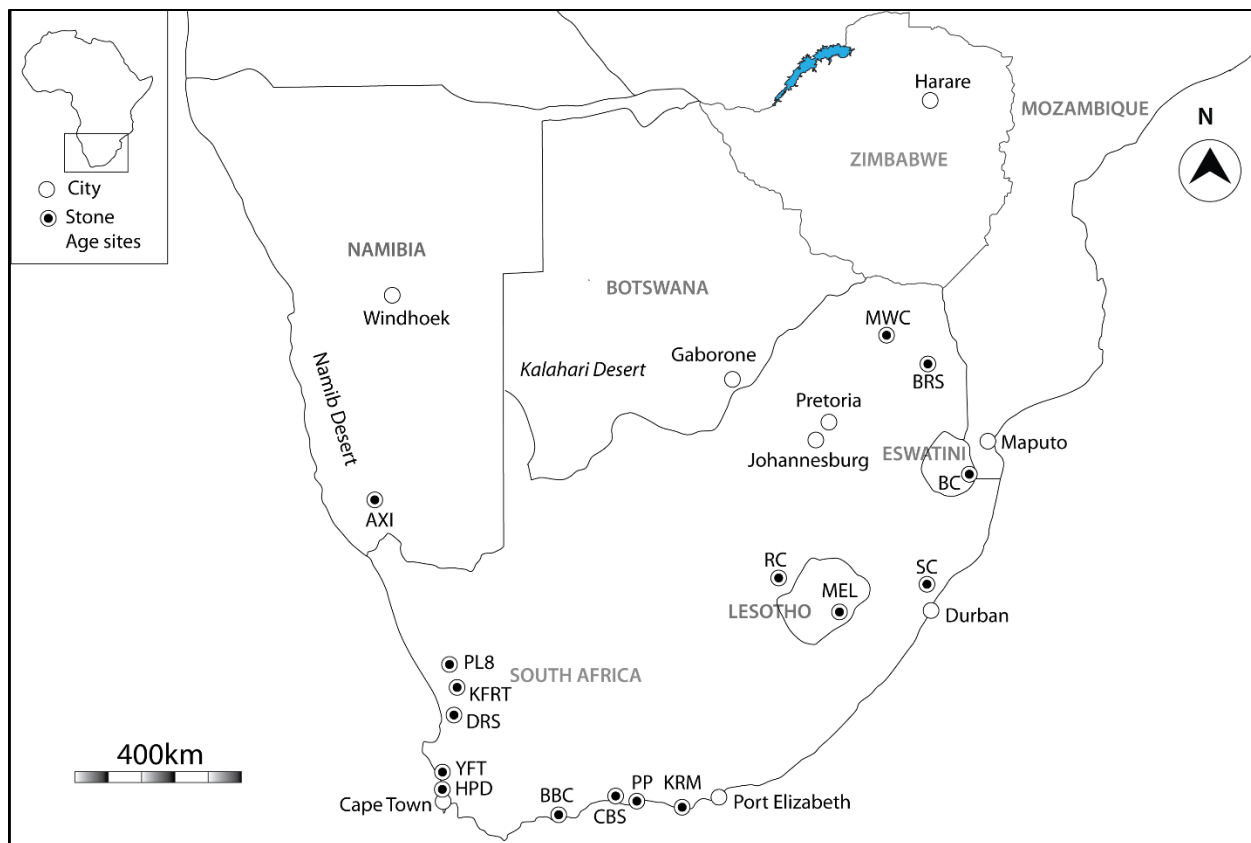


Figure 2: Locations of the coastal and inland MIS 5 sites in southern Africa. AXI=Apollo 11, BBC=Blombos Cave, BC=Border Cave, BRS=Bushman Rockshelter, CBS=Cape St. Blaize, DRS=Diepkloof Rockshelter, HDP=Hoedjiespunt 1, KRM=Klasies River main, KFR1=Klipfonteinrand 1, MEL=Melikane Rockshelter, MWC=Mwulu Cave, PP= Pinnacle Point 13B &5-6, PL8= Putslaagte 8, RC=Rose Cottage, SC=Sibudu Cave, YFT=Ysterfontein 1.

The above summary highlights the extensive research on MIS 5 lithic technology, particularly in coastal and near-coastal areas. These regions are abundant in well-preserved rockshelter sites with long cultural sequences, making them optimal for detailed research (Wilkins *et al.*, 2021). Despite the extensive research on lithic technology in coastal and near-coastal areas, significant work has also been carried out in interior regions, particularly at Apollo 11, Bushman Rockshelter, Melikane Rockshelter, Mwulu Cave, and Rose Cottage (see Figure 2; de la Peña *et al.*, 2018; Pazan *et al.*, 2020; Porraz *et al.*, 2018; Soriano *et al.*, 2007; Wadley and Harper, 1989; Vogelsang *et al.*, 2010).

The aforementioned sites have significantly contributed to our understanding of lithic technological and behavioral patterns during MIS 5 in the interior regions. For instance, while Melikane, Bushman, and Mwulu all primarily produced blades, there are notable variations in the production methods and attributes of blades among these sites (de la Peña *et al.*, 2018; Pazan *et al.*, 2020; Porraz *et al.*, 2018). Blades found at Melikane tend to have triangular morphology and exhibit curved profiles (see Pazan *et al.*, 2020), while blades at Bushman are trapezoidal and have flat profiles (see Porraz *et al.*, 2018). At Bushman, the described reduction methods include unidirectional Levallois and semi-prismatic laminar techniques (Porraz *et al.*, 2018), while at Melikane, parallel and bipolar flaking systems were used. In terms of formal tools, Melikane stands as an exception among most MIS 5 sites, exhibiting a comparatively elevated percentage of formal tools. Side scrapers are common at Melikane, whereas at Mwulu, side scrapers, denticulates, and notches are the three primary tool types seen (Pazan *et al.*, 2020). At Rose Cottage, denticulates outnumber bifacial or unifacial points (Wadley and Harper, 1989). While data on MIS 5 lithic technology at Apollo 11 remains tentative, it is notable that denticulates are frequently found, and points do not constitute a substantial portion of the assemblage (Vogelsang *et al.*, 2010).

Despite substantial work in coastal and interior regions of southern Africa, there is limited research specifically focusing on MIS 5 in the deep interior, particularly in the Kalahari and its environs. The archaeology of MIS 5 lithic technologies in and around the Kalahari has received relatively little attention from researchers. Few studies detail the MIS 5 lithic technologies in the deep interior, including FLB (Brenner, 2019; Kuman 1989; Kuman *et al.*, 1999) and #Gi (Kuman, 1989). These studies are reviewed in the subsequent sections.

The synthesis above demonstrates the variability in MIS 5 lithic technologies across southern Africa. As highlighted earlier in the introductory chapter, previous work has inferred this heterogeneity to signify reduced intergroup connectedness and population fragmentation during this interglacial phase, contrasting with glacial MIS 4 and MIS 2, which were characterized by coalescence (Mackay *et al.*, 2014; Pazan *et al.*, 2020). However, while acknowledging these important works, this study assesses the presence and extent of cultural transmission during MIS 5 in the Kalahari and its environs, which were not included in their sample. This contribution adds to the existing data on MSA MIS 5 dynamics.

### **3.1 MIS 5 archaeological sites in the Kalahari and its environs.**

#### **3.1.1 Ga-Mohana Hill North Rockshelter (GHN)**

There are a few MIS 5 archaeological deposits in and near the Kalahari Basin, including those at GHN. GHN was first systematically excavated by Wilkins and team in 2016 (Wilkins *et al.*, 2020, 2021). Although Thackeray and Thackeray (1980) conducted small test excavations in the largest of the Ga-Mohana Hill shelters, no detailed report is available on this prior work (Wilkins *et al.*, 2020). The excavations at GHN exposed a 170-cm stratified archaeological deposit containing a substantial quantity of lithic artifacts, faunal remains, OES fragments, botanical remains, and non-utilitarian items, including calcite crystals (see Wilkins *et al.*, 2020, 2021). Four stratigraphic aggregates were identified. These are termed “surface sediments and dung (Surface), dark brown gravelly silt (DBGS), orange ashy silt (OAS), and dark brown silt and roofspall (DBSR)”; see Wilkins *et al.*, 2020, 2021). The GHN assemblages are chronometrically dated by single-grain

OSL to DBGS ( $14.8 \pm 0.8$  ka), OAS ( $30.9 \pm 1.8$  ka), and DBSR ( $105.3 \pm 3.7$  ka) (see Wilkins *et al.*, 2021: 249).

The primary focus of this thesis is the lithic assemblage from the DBSR, dated to ~105 ka. The DBSR is described as an “ashy matrix-supported deposit with roofspall and gypsum inclusions” (see Wilkins *et al.*, 2020: 345). Most of the roofspall remnants are darkened, with portions of charcoal scattered throughout the strata (Wilkins *et al.*, 2020). Situated in the eastern area of the excavation, the DBSR is the lowermost aggregate in the GHN sequence, reaching a thickness of up to 80 cm. Density of artifacts in the DBSR is notably higher compared to the upper aggregates (OAS and DBGS) (Wilkins *et al.*, 2020, 2021). Lithic artifacts constitute a substantial percentage (52%) of the DBSR plotted finds, followed by faunal remains (40%), OES fragments (4%), and other finds, such as botanical remains (4%) (Wilkins *et al.*, 2020).

Recent work at GHN (Wilkins *et al.*, 2021) has revealed a rich record of early human behavior in the deep interior. For example, as highlighted in the previous chapter, the presence of OES and non-utilitarian objects (calcite crystals) at ~105 is argued to indicate innovative technologies and symbolic behaviors, suggesting that behavioral novelties were not confined to the coast and nearby areas (Wilkins *et al.*, 2021).

### **3.1.2 Kathu Pan 6 (KP6)**

The KP6 open-air site has been studied extensively by archaeologists since the 1970s. Initial excavations at KP6 were conducted by Peter Beaumont in the 1970s and 1980s, revealing a 4.5-meter sequence covering the period from the Mid Pleistocene to the present day (Beaumont, 1990; Lukich *et al.*, 2019). In his report, Beaumont (1990) documented various archaeological remains, including lithic artifacts, fragments of locally unavailable red ochre, faunal remains, and OES fragments. He described the lithic technologies of the MSA and identified elements associated with the HP industry. Beaumont (1990) HP layers were dated by OSL to ~79 ka (Feathers, 2015; Lukich *et al.*, 2019).

Renewed excavations at KP6 by Chazan and his team since 2015 have exposed 12 beds in KP6's stratigraphic sequence, spanning from Fauresmith, MSA, and Wilton components (Black *et al.*, 2023; Lukich *et al.*, 2019). Deposits from bed 9 yield an age of ~74 ka and are the focus of this study. The presence of an HP component at KP6 was again reported by Lukich *et al.* (2019), evident in blade production using unidirectional exploitation. The blades exhibit technological characteristics consistent with Soriano *et al.*'s (2007) classification of blades from the HP levels at Rose Cottage Cave, including the presence of oval triangular and punctiform platforms, often exhibiting lipping (Lukich *et al.*, 2019).

### **3.1.3 Erfkroon (EFK)**

The EFK open-air site documents the history of human occupation spanning the MSA to the LSA (Bousman *et al.*, 2023). The site was excavated by several researchers, including Berger, Churchill,

Bousman, and Brink (Bousman *et al.*, 2023). The work at EFK has resulted in Master's degree projects, including those by Trower (2010), Thornton-Barnett (2013), Palmison (2014), and Morris (2019) focusing on paleo landscape reconstruction, LSA Robberg paleoethnobotanical studies, and paleontological studies, respectively (Bousman *et al.*, 2023). Additional geochronological and geological studies at EFK include those of Tooth *et al.* (2013) and Lyons *et al.* (2014).

Investigations at EFK resulted in the identification of several locales, termed A to L containing archaeological and paleontological materials (Morris, 2019). The F area was divided into two sections: Upper F and Lower F (Morris, 2019). Within the EFK formation, six layers were identified from top to bottom: silty sand, upper gray, red sand, lower gray, upper sandy gravel, and lower sandy gravel (Bousman *et al.*, 2023). OSL samples collected from the Lower F, lower gray bed yielded a date of ~99 ka, and lithic artifacts from this area are the focus of this study (Bousman *et al.*, 2023). Unfortunately, no work has focused on the MSA lithic finds at EFK; thus, this research addresses this existing gap.

#### **3.1.4 Florisbad (FLB)**

The FLB open-air spring site is one of the relatively extensively studied sites, and archaeological research there has continued to date since its discovery in 1912 (see Brenner, 2019; Brink, 1988; Brink, 2005; Coetzee and Brink 2003; Grün *et al.*, 1996; Henderson 2001; Kuman and Clarke, 1986; Kuman, 1989; Kuman *et al.*, 1999). The site was excavated by Dreyer, Henderson, Kuman, and Clarke (see Henderson, 2001; Kuman and Clarke 1986; Kuman, 1989; Kuman *et al.*, 1999). Kuman and Clarke's excavations concentrated on the main excavation area, which exposed the

familiar in-situ, well-stratified MSA occupational horizon with an MIS 5 stratum, termed Unit F (~121 ka), which is the focus of this research (Kuman, 1989; Kuman and Clarke, 1986; Kuman *et al.*, 1999; Toffolo *et al.*, 2017). Unit F is described as a paleo-lake beach with fine white sands layered horizontally. The MSA horizon exposed archaeological deposits such as faunal remains and lithic artifacts.

The FLB MSA lithic material has been the focus of three doctoral theses, including Kuman (1989), Henderson (2001), and Brenner (2019). Kuman (1989) conducted a detailed study of the lithic material from the Kuman and Clarke excavation. She identified edge wear consistent with cutting on both formal and informal tools, observing an expedient MSA assemblage at ~121 ka. The MSA assemblage represents multiple brief visits focusing on medium-sized bovid hunting and butchery, as well as potential hippo scavenging. Henderson's (2001) work primarily focused on the spatial distribution of artifacts with no detailed description of the lithics. Brenner (2019) solely focused on the MIS 5 lithic technology, analyzing the assemblage from both Henderson's MSA excavations and Kuman and Clarke's Unit F MSA horizon. She compared the FLB MIS 5 lithic technology to that from coastal sites in South Africa and concluded that there were similarities in lithic reduction methods between FLB and Klasies River main site, signifying inter-regional connectivity. However, one limitation of Brenner's (2019) work is her consideration of similarities between FLB and Klasies River as indicative of social connectedness, without definitively ruling out the possibility of convergence. This approach is essential for ensuring that her results remain free from interpretive pitfalls stemming from equifinality. FLB provides a useful temporal comparison in this study because it offers critical information on whether the technological choices

and behaviors of early humans were determined by site function, environment, and geographical location.

### 3.1.5 ≠Gi

The ≠Gi pan is the first extensively studied and ultimately dated Stone Age site in Botswana (Nash *et al.* 2016). The site was excavated by Brooks and Yellen, and four stratigraphic units were observed: Units 1A and 2B (LSA) and Units 4 and 5 (MSA; Brooks and Yellen, 1977; Helgren and Brooks, 1983; Brooks *et al.*, 2006; Kuman, 1989). The Unit 4 light gray, sand, and silt clay layer was dated by thermoluminescence (TL) to ~77 ka (Brooks *et al.*, 2006; Brooks and Yellen, 1977; Helgren and Brooks, 1983; Nash *et al.*, 2016).

Analysis of MSA lithic finds from ≠Gi formed part of Kuman's (1989) doctoral thesis, in which stone artifacts (including 597 pointed pieces) were reported from the MSA units. Kuman's analysis revealed that the lithic pieces were mostly made from locally available raw materials, with some non-local materials also used, albeit in lower percentages (Kuman, 1989; Nash *et al.*, 2016). There has been significant debate about the use of ≠Gi points. Kuman (1989) argues that ≠Gi points were hafted, and their dominant function was cutting. Brooks *et al.* (2006) hypothesized that the ≠Gi MSA pointed pieces' base was modified and retouched for hafting. They further argue that some of these points exhibit multiple examples of what are known as diagnostic projectile impact damage, including burin-like fractures. Thus, ≠Gi points might have also been used as projectile weapons, likely to tip spear thrower darts, representing a potential early instance of such weapon use in southern Africa. Lombard and Churchill (2022) recently argued, based on the tip cross-

sectional area of the  $\neq$ Gi points, that they were used as thrusting spears during ambush hunting, possibly in conjunction with the use of lighter javelins. With its unique open-air setting, similar to other sites in and around Kalahari, the  $\neq$ Gi MSA assemblage is chosen for this comparative study.

### **3.1.6 White Paintings Rockshelter (WPS)**

WPS was excavated by Walker, Campbell, and Robbins, exposing a 7 meter deep stratigraphic sequence comprising 11 units representing the MSA and LSA periods (see Robbins *et al.*, 2000; Robbins *et al.*, 2023; Robbins and Murphy, 2011). An OSL age of  $\sim$ 94 ka was obtained in square 13 from Unit 10 at a depth of 605 cm (Ivester *et al.*, 2010; Nash *et al.*, 2016; Robbins *et al.*, 2000). The focal point of this research is the MSA deposit derived from Unit 10.

The lithic artifacts at WPS have been a focal point of Murphy's (1999) doctoral dissertation research, which specifically addressed the transition from the later MSA to the LSA. The study delved into raw material exchange and changes in lithic reduction techniques, ultimately concluding that there was technological continuity between the late MSA and the LSA. Further research on the MSA at WPS includes Donahue *et al.*'s (2004) microwear study of points recovered from deposits between  $\sim$ 66 and 94 ka (MIS 4 and 5). The findings revealed that 5 of these points were likely utilized as projectiles, primarily as spear points for hunting medium-sized mammals. Staurset and Coulson (2014) conducted a refitting analysis of WPS lithics, concluding that there was a significant horizontal and vertical artifact movement within the MSA stratigraphic sequence, raising questions about the accuracy of age estimates and the entire chronology.

Nevertheless, the ~94 ka lithic assemblage from WPS provides a robust sample suitable for this comparative study.

### **3.2 Paleoenvironment of the Kalahari Basin and its environs during MIS 5**

There is a scarcity of published data on the paleoenvironment in the Kalahari and its surrounding areas, especially during MIS 5. Consequently, this study faces the challenge of relying heavily on provisional data due to the lack of comprehensive research frameworks. However, the study reviews the limited available data. Insights from paleoenvironmental studies in the Kalahari are crucial for understanding how our species mitigated arid and semi-arid conditions. A thorough understanding of past environments is essential for assessing whether interactions were responses of hunter-gatherers to the macroenvironments of the Kalahari Basin and its surroundings.

Extending across vast expanses of southern Africa, the Kalahari Basin is predominantly characterized by arid and semi-arid landscapes, with occasional pockets of wet environments in the southern Kalahari and adjacent areas at the beginning of MIS 5 (Helgren and Brooks, 1983; Lukich and Ecker, 2022; Robbins *et al.*, 2000, 2016; Telfer and Thomas, 2007; Thomas *et al.*, 2022; Toffolo *et al.*, 2017; Wroth *et al.*, 2022; von der Meden *et al.*, 2022). Some researchers argue that the interglacial Kalahari is prone to short-term pulses of aridity caused by increased surface temperatures and the evaporation of surface water sources, potentially affecting human populations (Thomas *et al.*, 2022). This dichotomy of largely dry paleoenvironments with a few wet pockets contrasts with coastal and near-coastal regions, as well as other interior areas that exhibited wet environments during interglacial MIS 5 (Ambrose and Lorenz, 1990; Mackay *et al.*,

2014; Pazan *et al.*, 2020). Using the already published data, this thesis will explore how the arid and semi-arid conditions may have played a pivotal role in shaping past human behavior in the region.

Recent paleoenvironmental research on relict tufas at GHN indicates evidence of wet periods associated with human habitation at ~15 ka, ~31 ka, and ~105 ka (see von der Meden *et al.*, 2022). This data indicates that GHN was wet at ~105 ka, making the site one of the rare locations that reveal evidence of wet conditions in an otherwise arid environment, potentially sustaining human populations even during a dry macroclimate in the Kalahari and its environs. At KP6, paleoenvironmental research identified the presence of palygorskite-coated sands, indicating variations in water levels over five intervals from ~156 to 32 ka (see Lukich *et al.*, 2020; Lukich and Ecker, 2022). In particular, bed 9 indicates a dry environment at ~74 ka based on the buildup of aeolian sands and the lack of rich organic marshland deposits (see Lukich *et al.*, 2020; Lukich and Ecker, 2022; Wroth *et al.*, 2022).

In the adjacent region of the Kalahari Basin, at EFK, paleoenvironmental data indicate semi-arid conditions throughout the entire MSA (Bousman *et al.*, 2023; Morris, 2019). Specifically, occupations in the MIS 5 Lower F lower gray bed have been observed within the low-energy alluvial environment (Bousman *et al.*, 2023; Wroth *et al.*, 2022). A “low-energy” alluvial environment denotes subdued water flow, possibly indicative of slow-moving water, which could occur due to prevalent semi-arid conditions. Additionally, several paleoenvironmental studies suggest that FLB is a spring site characterized by alternating phases of lush lake vegetation and

more open grassland during the Middle to Late Pleistocene (Brink, 1988, 2016; Coetzee and Brink, 2003; Lewis *et al.*, 2011; Manegold and Brink, 2011; Toffolo *et al.*, 2017). The FLB spring possibly draws from deep aquifers and probably sustained hominin populations in the arid macroclimate of the Kalahari and its environs. Further palynological study of pollen samples from upland fynbos shrubs indicated the prevalence of cool environments during the MSA (Scott *et al.*, 2019).

Paleoenvironmental data for ≠Gi pan, provided by Helgren and Brooks (1983), who analyzed the hydrological setting of MSA unit occupancy, interpret Unit 4 of ≠Gi pan as primarily composed of anthropogenic valley-floor colluvial and alluvial sediments, indicative of semi-arid conditions even drier than the present day. The findings suggest that during MIS 5, ≠Gi pan experienced significant aridity. At WPS, paleoenvironmental data suggest that Units 1-10 consist mainly of aeolian deposits, indicating their formation during a period characterized by dry climatic conditions and active dune formation in the region (Robbins *et al.*, 2000). This implies that around 94 ka, the environment at WPS was characterized by arid conditions. Additionally, Robbins *et al.* (2016) further confirm the existence of dry conditions during MIS 5 in the Kalahari using evidence of submerged speleothems.

Evidence from areas within the Kalahari, discrete from the studied sites, provides valuable insights into the region's dry macroclimate and adaptations during MIS 5. In the Makgadikgadi Basin, Thomas *et al.* (2022) illustrate the use of the lacustrine basin during arid periods around 80 ka. The deliberate and meticulous transportation of raw materials for artifact production at

Makgadikgadi suggests intentional adaptability by hunter-gatherers to the arid environments in the lacustrine basin (Thomas *et al.*, 2022). At the Witpan site in the Kalahari, dune activity indicating an arid climate was observed between ~77 and 76 ka (Telfer and Thomas, 2007). At Lovedale, located 10 km upstream of EFK within the adjacent region of the Kalahari, Wroth *et al.* (2022) describe sediment deposition alongside human habitation and hunting scenes in the Modder River during a brief warm and dry interval within MIS 5 (around 77 ka). Wroth *et al.* (2022) underscore the significance of Modder River in sustaining human communities, especially in marginal areas. While data remains limited, the highlighted evidence from these Kalahari and adjacent region sites may suggest a pattern of persistently drier conditions during MIS 5 except at ~105 and 121 ka in these regions.

The above synthesis shows that arid and semi-arid conditions predominate across much of the Kalahari Basin, with wet environments present in select locales in the southern Kalahari and areas at the edge of the basin, indicating that the environment was not uniformly wet across the Kalahari and southern Africa during MIS 5. Despite the limited data, the extent to which the Kalahari environment may have influenced the behaviors of inhabitants at discrete MIS 5 sites will be addressed in the discussion chapter. This will provide a holistic framework for unraveling the intricate relationship between human responses and their environment in the region.

## CHAPTER FOUR: MATERIALS AND METHODS

### 4.1 Materials studied

#### 4.1.1 Ga-Mohana Hill North Rockshelter (GHN)

The GHN MIS 5 lithic material analyzed in this study derives from the lowermost aggregate at GHN, namely the DBSR stratum, with a  $105.3 \pm 3.7$  ka OSL age (Figure 3). The DBSR lithic artifacts analyzed are from 40 different lots. Lots are numbered, minimal excavation units of similar sediment, arbitrarily divided into 5-cm spits throughout the sequence if necessary (see Wilkins *et al.*, 2020). All lithic artifacts from the DBSR, totaling 625 plotted finds and 1090 found in the 10 mm sieve, were analyzed, resulting in a maximum total of 1715 lithic pieces (Table 2). The lithic material from GHN is presently stored temporarily in the Department of Archaeology at the University of Cape Town but is slated for permanent curation at the McGregor Museum in Kimberley, South Africa.

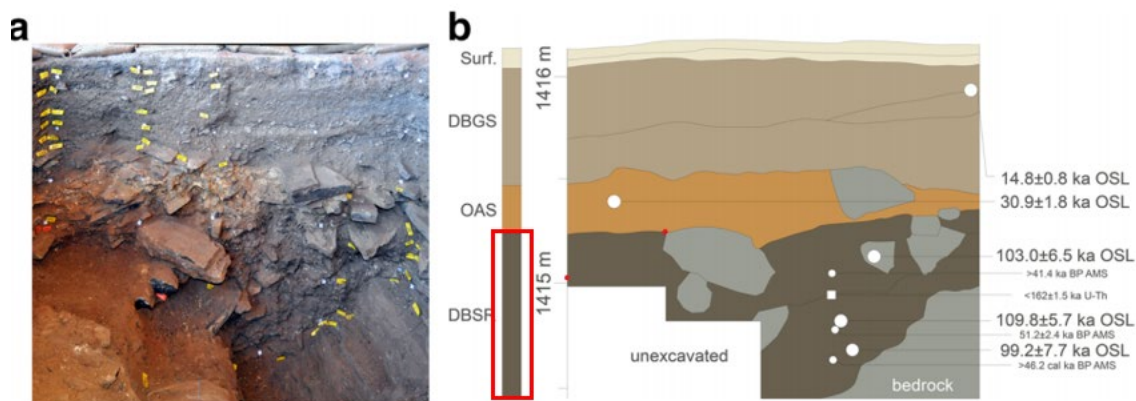


Figure 3: Stratigraphic profile showing the DBSR stratum (red box) at GHN (Wilkins *et al.*, 2020: 10).

### 4.1.2 Kathu Pan 6 (KP6)

The analyzed KP6 lithic material comes from Chazan and team's excavations (see Lukich *et al.*, 2019). The pertinent lithic artifacts derive from Bed 9, with an OSL date of  $74 \pm 5$  ka (Figure 4; Table 2). While the KP6 Bed 9 assemblage has been initially dated to MIS 5a, there is a possibility that it might be of a younger age. Ongoing research is in progress to refine these dates by gaining a better understanding of the age of the base of the deposit, coupled with intensive sampling of the profile for cryptotephra analysis (M. Chazan, *pers. comm*). Pending these chronological refinements, this research treats the assemblage within the previously suggested estimated age, specifically early MIS 5.

KP6 Bed 9 is subdivided into three squares: P8, Q8, and R8, and consists of seven stratigraphic subunits, referred to as spits 9 to 15. Due to practical constraints, this study exclusively focused on lithic artifacts from square R8, and all materials from spits 9 to 15 were analyzed. Square R8 was selected because it particularly yielded a substantial number of lithic specimens, totaling 743 pieces. Additionally, Lukich *et al.* (2019) sampled the same square for their chronological investigation. Professor Michael Chazan facilitated access to KP6 lithic material, currently curated at the McGregor Museum in Kimberly.

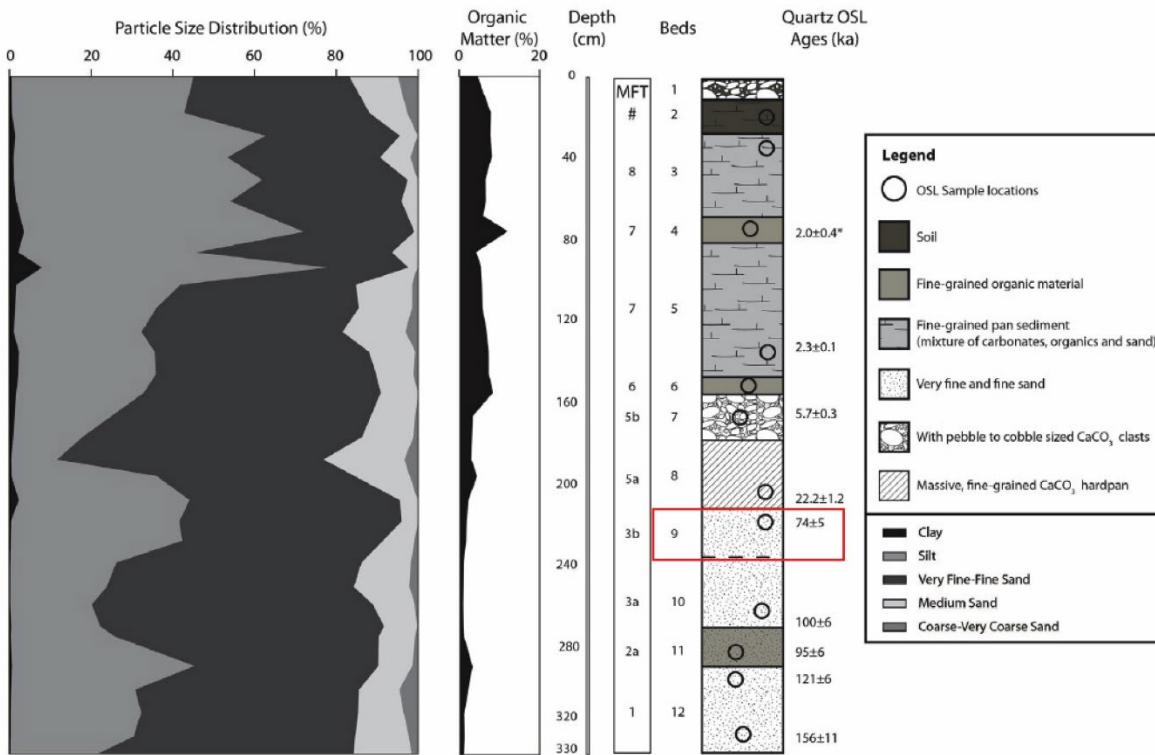


Figure 4: Stratigraphic profile showing Bed 9 (red box) at KP6 (Lukich *et al.*, 2020: 7).

### 4.1.3 Erfkroon (EFK)

The analyzed lithic material from EFK derives from Brink and Bousman excavations (see Bousman *et al.*, 2023; Morris, 2019). As detailed in the previous chapter, EFK's main terrace (termed Orangia) comprises six aggregates from top to bottom: silty sand, upper gray, red, lower gray, upper sandy gravel, and lower sandy gravel (Figure 5; Table 2). The EFK lithic pieces analyzed derive from Lower F, the lower gray bed, with an OSL date of  $99.4 \pm 6.6$  ka (Bousman *et al.*, 2023; Morris, 2019). All lithic artifacts recorded from the area Lower F, lower gray bed, were analyzed, resulting in a total sample of 202 lithic pieces. The EFK material was made available by Professor Britt Bousman and is curated at the Florisbad Quaternary Research Station in Bloemfontein.

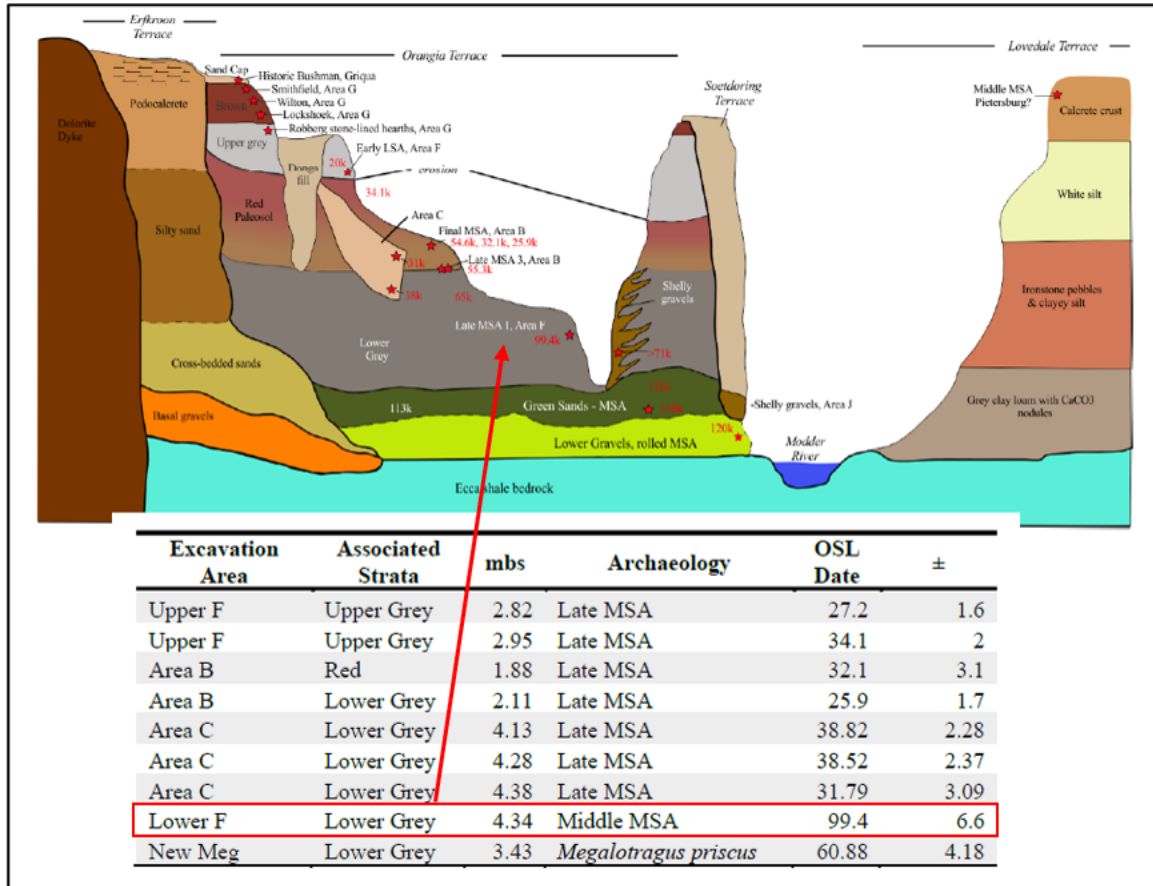


Figure 5: Stratigraphic profile showing Lower F, lower gray bed (indicated by red box and arrow) at EFK (Morris 2019: 53 and 74).

#### 4.1.4 Florisbad (FLB)

The analyzed lithic material from FLB comes from Kuman and Clarke’s (1986) excavations. The lithic artifacts derive from Unit F with an OSL date of  $121 \pm 6$  ka (Figure 6; Table 2). All boxes labeled Unit F were examined, constituting a sample of 874 lithic pieces. Although Henderson’s excavations at FLB yielded MSA material, this study specifically sampled material from Kuman and Clarke’s excavation due to its association with relatively secure MIS 5 dates. The FLB MIS 5 lithic sample was made available by the Florisbad Quaternary Research Station in Bloemfontein, where it is curated.

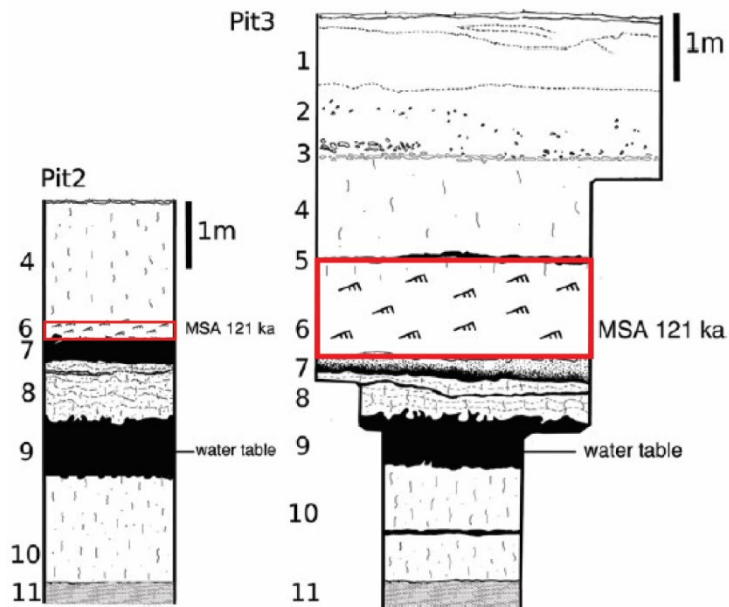


Figure 6: Stratigraphic profile showing Unit F (red box) at FLB (Toffolo et al., 2017: 416).

#### 4.1.5 ≠Gi

The ≠Gi lithic material is sourced from Brooks and Yellen excavations. The studied ≠Gi sample derives from the Unit 4 MSA horizon, dated by TL to  $77 \pm 11$  ka (Figure 7; Table 2). Unlike other sites included in this study, only points were studied from the ≠Gi lithic assemblage. This was necessitated by the mixed nature of the assemblage due to curatorial problems that have affected all artifact classes other than the pointed pieces (n= 455) that were stored separately and in better shape (A.S. Brooks, *pers. comm*). Access to the point assemblage was granted by the Botswana National Museum in Gaborone, where it is curated.

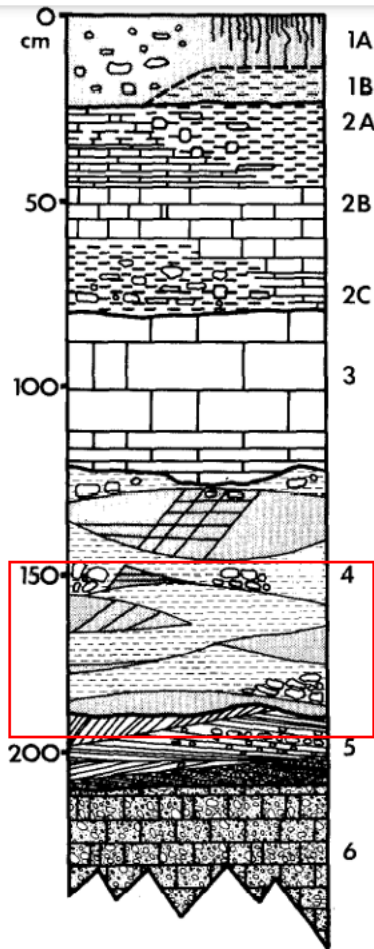


Figure 7: Stratigraphic profile showing Unit 4 (red box) at #Gi (Helgren and Brooks 1983: 185).

#### 4.1.6 White Paintings Rockshelter (WPS)

The lithic material at WPS derives from the excavations conducted by Robbins and Campbell (see Robbins *et al.*, 2000). The analyzed lithic artifacts are derived from MSA deposits in square 13, Unit 10, with an OSL age of  $94.3 \pm 9.4$  ka (see Ivester *et al.*, 2010; Nash *et al.*, 2016; Robbins *et al.*, 2000) (see Figure 8). A total of 416 lithic pieces were analyzed. Access to the WPS assemblage was provided by the Botswana National Museum in Gaborone, where it is curated.

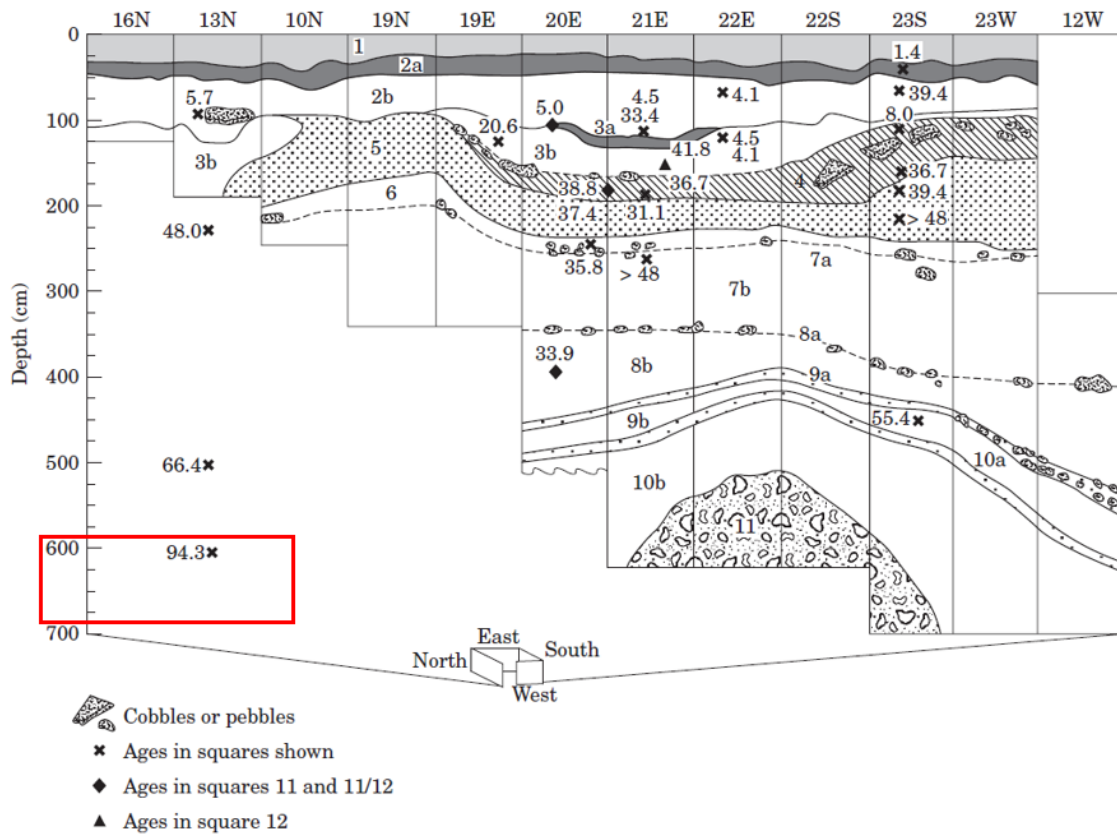


Figure 8: Stratigraphic profile showing the OSL age obtained at 605 cm from sediments in square 13, Unit 10 (red box) at WPS (Robbins et al., 2000: 1090).

As detailed in the introductory chapter, the dates for the studied samples span different substages within the period of interest, that is, MIS 5a to e (Table 2). The lack of sites dated to similar substages within the Kalahari and its environs has necessitated the inclusion of sites sampling different substages within MIS 5, rendering the study a stage-level treatment. Additionally, another limitation of the study involves comparing the GHN lithic assemblage with artifacts from museum collections that may have been affected by mixing in the museum. For instance, as previously mentioned, the assemblage from both the MSA and LSA units at the ≠Gi site was inadvertently mixed during the curation process, except for the pointed pieces that were stored separately and in better condition (A.S. Brooks, *pers. comm*). Conversely, museum collections from sites such as

KP6, FLB, EFK, and WPS remain intact and well curated. Although FLB and WPS materials originate from excavations conducted in the 1980s and 1990s, they have been meticulously curated. Furthermore, the KP6 and EFK materials used for comparison purposes consist of freshly excavated material from the 2000s that has also been well curated.

*Table 2: Summary of analyzed samples, including absolute dates, MIS 5 substages, and sample size.*

Site	Strata aggregate	Date	MIS 5 substage	Sample size
GHN	DBSR	~105 ka	MIS 5c-d	1715
KP6	Bed 9	~74 ka	MIS 5a	743
EFK	Lower F, lower gray bed	~99 ka	MIS 5c	202
FLB	Unit F	~121 ka	MIS 5e	874
≠ GI	Unit 4	~77 ka	MIS 5a	455
WPS	Unit 10	~94 ka	MIS 5c	416
<b>Total</b>	---	---	---	<b>4405</b>

## 4.2 Methods

### 4.2.1 Lithic analysis

For southern African MSA assemblages, there is no single, universally applied lithic analytical framework. Several researchers have developed analytical frameworks to study stone artifacts, including, but not limited to, Volman (1984), Singer and Wymer (1982), Thackeray and Kelly (1988), Wurz (2000), Conard *et al.* (2004), Villa *et al.* (2005), Soriano *et al.* (2007), and Wilkins *et al.* (2017). In this study, I employed a modified framework based on the lithic attribute recording

system developed by Wilkins *et al.* (2017), initially designed for the Pinnacle Point Site 5-6 assemblages. The modified framework also adopts aspects of analytical frameworks used by scholars such as Tostevin (2012) and Mackay *et al.* (2014) that signify social transmission.

A total of 64 different attributes were recorded on each lithic artifact that is  $\geq 10$  mm in any dimension. These encompassed typological, metric, and technological traits. A size cutoff of  $\geq 10$  mm was utilized because smaller artifacts can be more challenging to observe and manipulate during analysis. Stone artifacts  $\geq 10$  mm in size offer clearer details and are easier to handle, measure, and accurately document. The next section provides a description of the recorded attributes and the rationale behind their recording. A detailed narrative of the modified framework, including the lithic traits recorded and their definitions, is further available in Appendix 1. The open-source E5 software (<https://github.com/surf3s/E5>) was utilized to record these traits. This software is designed to reduce analysis time and data entry errors. The code for using these traits in E5 is also provided in Appendix 2. These codes were inserted into a CFG file while launching the program. Subsequently, the raw data from E5 were exported to a Microsoft Excel database for further analysis.

#### ***4.2.1.1 Typological traits***

All contextual information, including the find ID number, lot or layer number, square, unit, and bed, was recorded during the analysis. Subsequently, each lithic piece was assigned to a lithic typological class, such as flakes, blades, unretouched convergent pieces, retouched pieces, cores, shatter or debris, pebbles, and hammerstones or manuports. Additionally, the completeness of the

lithic piece and details on fragments (e.g., proximal, medial, distal, left or right lateral) were determined and recorded.

Several researchers in South Africa have used various terminologies in lithic studies. As such, it is crucial for this study to define the following typological terms to ensure clarity in their usage here (see Shea, 2008: Appendix). A flake is defined as any piece detached from a core, either during core preparation or blank production. The use of the word “flake” does not imply a particular morphology (see Inizan *et al.* 1999). Convergent pieces refer to all pointed blanks or any piece with lateral edges that converge into a point, forming a triangular blank shape, regardless of dimensional proportions (see Brenner, 2019). Blades are elongated blanks with a length more than double their width, with straight edges and arrises that run parallel both to each other and to the flake’s axis of fracture propagation (see Shea, 2020). Blade fragments have parallel edges and parallel or convergent dorsal scars, appearing as a broken section of a blade. Retouched pieces are lithic artifacts exhibiting a fairly continuous series of small retouches along an edge (see Wilkins *et al.*, 2017). Cores are defined as any piece that has at least one visible negative bulb of percussion and exhibits one or more blank removals. Shatter or debris are lithic pieces without a bulb with indistinct ventral and dorsal surfaces. It was selected for any uncertain pieces. For further definitions, refer to Appendix 1 and Wilkins *et al.* (2017: S1 File).

#### **4.2.1.2 Technological traits**

##### *Raw materials*

Technological attributes, such as raw material type, were recorded for all lithic pieces. Raw materials found within a 10 km radius of the site were identified as local, while those from sources more than 10 km away were categorized as non-local (Delpiano *et al.*, 2018; Will, 2021). Distinguishing between local and exotic raw materials was done in order to infer social interactions between regions and possible long-distance trade and exchange. This is widely researched and suggested in eastern African contexts (e.g., Brooks *et al.*, 2018).

The presence, amount, and type of raw material cortex on lithic pieces were recorded. The presence and extent of cortex cover are often used to make inferences about raw material distance and the mode of transported material (i.e., unmodified pebble vs. roughed-out nodule vs. blank or preform), which have implications for how unified or fragmented the production sequence was and for the phases of reduction (i.e., early through advanced) represented in a given assemblage. Substantial cortex levels are used to infer the initial reduction stages, while the absence of cortex is indicative of more advanced reduction phases (see Dibble, 1995; Marwick, 2008; Mauldin and Amick, 1989; Morrow, 1984). Additionally, highly cortical pieces are also used to infer whether knapping activities took place on site. The analysis also distinguishes between cobble cortex, which is river-rolled and identified by smooth surfaces and rounded edges, as well as by the presence of chatter marks, produced under high-energy settings such as rivers and streams, and outcrop cortex, identified by its rougher surface, slightly rounded to angular edges, and the lack of chatter marks, as a result of no exposure to highly energetic water transportation (see Oestmo *et al.*, 2014; Wilkins, 2017).

### *Banding orientation*

Experimental observations have shown that homogeneous banded ironstone is easier to knap and control flaking than heavily banded varieties (see Wilkins, 2017). Therefore, recording banded ironstone categories helps determine whether careful attention was paid to raw material selection. Banding orientation attributes of ironstone raw materials were recorded following Wilkins's (2017) framework, which includes homogeneous and banded types. The latter is further divided into (1) *through*, with flaking direction parallel to the noticeable bands and fractures that do not cut across the bands longitudinally; (2) *with*, where the fractures cut longitudinally across the bands, and the flaking direction is parallel to the noticeable bands; (3) *diagonal*, with observable bands oblique to the flaking axis; and (4) *against*, with flaking direction perpendicular to the noticeable bands (see Wilkins 2017).

### *Blade technical categories*

Identifying blade technical categories is crucial for this study because it helps infer whether blades were produced on site. Blade technical categories were recorded following Soriano *et al.*'s (2007) framework, which includes the initial stage, or A category, the main production phase (B category), and core maintenance blades (C category). The A stage is further sub-categorized into three phases: A1 represents blades featuring a crest with a few (one or two) prepared versants; A2 includes blades that are completely cortical; and A3 comprises blades with >50% cortex.

The B stage is sub-categorized into the following: (1) B1: non-cortical blades manufactured during the ultimate stage of the debitage, with bidirectional or unidirectional dorsal scar patterns; (2) B2: which are blades with cortex centered at the a distal edge; (3) B3: plunging blades with dorsal

scars, either bidirectional or unidirectional and only a portion of the platform; (4) B4: plunging blades retaining either unidirectional or bidirectional scars with a portion of the opposing cortical end; (5) B5: blades positioned directly beneath a crested blade with an asymmetrical or symmetrical section, while also retaining unidirectional or bidirectional scars; (6) B6: blades featuring a lateral edge preserving <50% cortex and exhibit unidirectional or bidirectional dorsal scar patterns; (7) B7: blades with a bidirectional or unidirectional scar and a cortical back; (8) B8: blades with distal and lateral edges preserving <50% cortex; (9) B9: blades exhibiting centripetal scar patterns; (10) B10: which are blades with a cortex on the distal edge and back; (11) B11: plunging blade types B4 and B6; (12) B12: plunging blades types B4 and B7; (13) B13: B3 and B6 plunging blades types, and lastly (14) B14: plunging blades types B3 and B7. The C category is subdivided into C1 and C2 representing core maintenance blades (see Soriano *et al.*, 2007: 685).

#### *Dorsal attributes*

Similarities in the dorsal convexity systems and the direction of core exploitation (profile shape and aris orientation) are used to infer the sharing of ideas among past human groups (Tostevin, 2012). Dorsal scar patterns, crucial in determining the direction of core exploitation and the main reduction systems used to produce blanks, were recorded. These patterns include unidirectional, bidirectional, centripetal, and radial or multidirectional patterns. In addition, the curvature and shape of the convexity of the blanks were documented during the analysis. The curvature of convexity is determined by the blank's profile shape, which can be flat, curved, or twisted. The shape of convexity is determined by the aris orientation on the dorsal surfaces, which can be parallel or convergent.

### *Technological measurements*

Complete lithic pieces were measured for metric data such as technological length, maximum width perpendicular to the technological length, and maximum thickness, including the bulb of percussion if visible. For incomplete blanks, maximum length, width, and thickness were measured. All dimensions were taken with a digital caliper. Metrics are crucial in determining the longitudinal (length-width ratio) and vertical (width-thickness ratio) convexities of blanks, which are also used to identify shared knowledge (Tostevin, 2012).

### *Platform attributes*

Platform attributes are crucial because they determine knapping techniques. In this study, knapping technique refers to the practical methods employed by prehistoric knappers to accomplish specific tasks. According to Inizan *et al.* (1999), these techniques include indirect percussion, direct percussion with a soft or hard hammer, and pressure-flaking. Lipped platforms suggest soft hammer percussion, while the absence of lipping, accompanied by distinct bulbs with noticeable Hertzian cones and rounded impact points, signifies the use of hard hammer percussion (Pelegrin, 1995, 2000). Similarities in platform maintenance attributes and knapping techniques are used to infer shared traditions (Tostevin, 2012). Platform attributes, including platform preparation, thickness, width, and external platform angle (EPA; measured using a goniometer), were recorded on all complete and proximal pieces. Platform preparation categories include facets with a visible negative bulb of percussion and residual facets without bulbs of percussion.

#### ***4.2.1.4 Retouched piece attributes***

Retouched piece attributes are crucial in this study because similarities in retouched toolkit morphology are used to infer shared traditions (Mackay *et al.*, 2014; Tostevin, 2012; Way *et al.*, 2022). Attributes such as retouched piece typology, retouch type, edge angle, and diameter of the largest notch were recorded for retouched pieces. Retouched piece typology includes scrapers, convergent pieces, backed tools, notched pieces, and denticulates. Retouch type categories include marginal edge shaping, minimally retouched, backing, and invasive edge shaping (long retouch scars that extend into the body of the formal tool). Retouched edge angles were measured using a goniometer.

#### ***4.2.1.5 Core traits***

Similarities in the exploitation and reduction of cores across the studied sites are utilized in this study to infer technological information exchange. As highlighted earlier, core reduction is a complex process that requires general strategies and decision-making based on specific actions in the reduction chain. Due to this complexity, core reduction is a learned skill involving the transfer of information from experienced knappers to apprentices (Mackay *et al.*, 2014; Tostevin, 2012).

With the above rationale, the following core traits were recorded, detailing how the cores were exploited and reduced. These traits include the direction of removals on the surface of a core, such as unidirectional, bidirectional, centripetal, or multidirectional exploitation, the number of core platforms (either single, opposed, or multiplatform), and the arrangement of removals on the core surface (parallel, centripetal, or orthogonal). Core exploitation methods, which can be preferential

or recurrent, were also documented. Preferential exploitation entails the extraction of one large flake from the production face before reparing the convex portions of the production face (Chazan 2020). The recurrent method involves extracting a sequence of flakes from a production face without the need for reparation in between (Chazan 2020). Within recurrent methods, three variants emerge, depending on the exploitation pattern. Unidirectional exploitation focuses on removing predetermined flakes from a single platform. Recurrent bidirectional exploitation refers to systems in which predetermined flakes are struck from platforms located on opposite sides. Centripetal exploitation include predetermined flake removals executed from the outer edges or circumference of the core (see Appendix 1 for further definitions).

Core orientation, indicating whether the longitudinal, broad face, or both surfaces were exploited during reduction, was also documented. The degree of core reduction, which can be either exhaustive or minimally reduced, was recorded. To assess the extent of reduction, these methods were employed. Firstly, the maximum length, width, and thickness of the cores were measured. Additionally, the distribution and arrangement of flake scars on the core were examined, as an exhausted core typically displays a high density of flake scars covering most or all available striking platforms. Signs of significant reduction, such as a flattened or irregular surface resulting from extensive flake removal, were noted. The presence of debris may further support the interpretation of core exhaustion.

The study also recorded the core blanks, categorized as pebble, cobble, or flake. The intended product, based on the removals of the discarded cores, which could be blades, flakes, or convergent

pieces, was documented. However, acknowledging that this interpretation is biased by the assumption that a core's final state reflects its entire use-life (i.e., the finished artifact fallacy; see Dibble *et al.*, 2017). The study also recorded data on whether the cores were managed by *débordant* removals or via centripetal flaking (see Appendix 1 for further details on the analytical framework).

#### **4.2.2 Behavioral approach to cultural transmission: Inter-site Comparisons**

Archaeologists in lithic studies have increasingly advocated approaches supported by middle-range theories, such as Tostevin's (2007, 2012, and 2019) behavioral approach to cultural transmission, to investigate behavioral patterns. Such approaches include social interactions in the past and call for a move beyond NASTIES and culture-historical approaches (e.g., Shea, 2014; Pargeter *et al.*, 2019; Ranhorn *et al.*, 2020; Wilkins, 2020b). For this reason, Tostevin's (2007, 2012, and 2019) behavioral approach to cultural transmission was utilized for data comparison in this study. This model integrates cultural transmission and dual inheritance models with the study of knappers' choices in the production of lithic artifacts. The approach was initially developed to assess patterns in the organization and production of lithic technologies that would indicate instances of knowledge transfer in Middle Pleistocene hominin populations. Tostevin's (2012) approach acknowledges how different cultural transmission processes create patterns in the material culture of foragers. Lithic technological variability reflects changes in the level of interaction among past human groups (Tostevin, 2012).

The behavioral approach to cultural transmission is also preferred in this study because it is based on experimental data. The outcomes of these experiments showed that knappers have control over several independent operational stages during the reduction process; thus, the identification of similar choices reflected in characteristics of lithic assemblages are used to infer unique behaviors, such as shared traditions. Employing Tostevin's (2012) approach to compare MIS 5 lithic data in the present study informs on the presence and extent of interaction between early human populations across the Kalahari and adjacent areas.

Tostevin (2007, 2012, and 2019) presents several criteria for assessing the suitability of different lithic assemblages for comparative analyses. Firstly, this entails ensuring that the assemblages represent two primary stages of manufacture: blank and retouched tool production. The second criterion to test acculturation in the behavioral approach to cultural transmission analysis is to ensure that assemblages are categorized into three hypothesized roles: firstly, the substrate, representing earlier assemblages believed to have existed before cultural assimilation; in this study, earlier assemblages include FLB (~121 ka) and GHN (~105 ka). Secondly, the acculturator representing assemblages that have been influenced by the substrate and potentially impacted the third group, which is the product, and lastly, the product referring to assemblages originating from the substrate and possibly influenced by the acculturator (see also Porter, 2019). In this study, assemblages such as EFK (~99 ka) and WPS (~94 ka) can be considered as acculturator assemblages, while #Gi (~77 ka) and KP6 (~74 ka) may represent potential product assemblages. However, Tostevin (2012), Ranhorn (2017), and Porter (2019) argue that certain steps can be omitted or modified to accommodate particular MSA datasets that one is working with.

In the behavioral approach to cultural transmission, the lithic attributes described in the first section of the methods chapter, which can indicate learned behaviors associated with the production of blanks and retouched toolkits, are classified into five “domains” of stone tool manufacture (Tostevin, 2012). As indicated in Chapter One, these domains include core modification, platform maintenance, the direction of core exploitation, dorsal convexity systems, and retouched toolkit morphology. They represent knapping behaviors, the inherent constraints in blank production, and the process of tool-making (Tostevin, 2012). The approach relies on the premise that similarities in stone tool production domains among diverse hominin populations may indicate an elevated level of socio-cultural learning and connection.

#### ***4.2.2.1 Domain 1: Core modification***

The first domain in which a knapper has many equivalent options to choose from when producing stone tools is the modification of the raw material (Tostevin, 2012). The core modification domain consists of attributes based on qualitative observations, including raw material selection, knapping technique (hard or soft hammer), core reduction methods (Levallois or non-Levallois), and core management to prevent the premature exhaustion of the core (either by *débordant* flakes or centripetal flaking). These descriptions of core modifications are used to understand general, identifiable similarities and changes across the sites.

#### ***4.2.2.2 Domain 2: Platform maintenance***

Platform maintenance involves the knapper’s decision on how far into the platform to strike, creating platform thickness, an exterior platform angle (EPA), and whether to alter the angle with

faceting beforehand. Attributes within this domain include platform preparation, width, thickness, and EPA. The study tested and controlled the impact of raw material type in producing platform attributes. The aim was to determine whether raw material quality influenced the knapper's choice to maintain platforms. The study addressed raw material control by comparing components of the assemblage that shared similar raw materials across sites. For example, EPA was compared to one artifact class (blades) in assemblages from sites with similar raw material types, such as GHN and KP6.

#### ***4.2.2.3 Domain 3: Direction of core exploitation***

The third behavioral domain that is used to test shared traditions is the direction of core exploitation. It refers to how predetermined flake removals were detached from the exploitation surface. These include unidirectional exploitation, involving the removal of predetermined flakes from a single platform; bidirectional exploitation, where predetermined flakes are struck from opposing platforms; centripetal exploitation, with predetermined flakes struck from around the periphery of the core; and orthogonal exploitation, towards intersections forming a right angle or aligned roughly perpendicular with one another on multiple production surfaces.

#### ***4.2.2.4 Domain 4: Dorsal convexity system***

This domain mainly focuses on how the dorsal convexities of a core are maintained during the reduction process. The dorsal convexity system domain comprises quantitative and qualitative variables, such as profile shape (curvature convexity), axis orientation (shape convexity), length-width ratio (longitudinal convexities), and width-thickness ratio (vertical convexity), considering

the limitation that differences in raw materials can lead to dimension variation. Additionally, the frequency of blades and convergent pieces is part of this domain to assess possible variations in their manufacture across the studied sites.

#### **4.2.2.5 Domain 5: Retouched toolkit morphology**

The comparison of retouched toolkits does not delineate production domains, as the formal tools fundamentally extend from the reduction process. Retouched pieces are selected for further modification and use, constituting an integral part of the overall production process. The lithic attributes in this domain include retouched piece typology, retouch type, and angle of retouch. Similar retouched toolkits have been argued to represent shared knowledge (Mackay *et al.*, 2014; Tostevin, 2012; Way *et al.*, 2022).

#### **4.2.3 Statistical analysis**

Pairwise comparisons were conducted between GHN and sites in and around the Kalahari. This comparison was carried out within each attribute of the five domains. The goal was to assess levels of similarity or dissimilarity across the five domains or stages of lithic artifact production to determine the existence and degree of shared or transmitted knowledge. The Paleontological Statistics (PAST; Hammer and Harper, 2008) software, version 4.14, was utilized for this analysis. The lithic attributes were subjected to a standard two-sample paired test (*t*-test) for quantitative variables, including length-width ratio, width-thickness ratio, platform width, thickness, EPA, and retouched angle. The probability (*p*-value), *t*-value, mean, degrees of freedom (*df*), and standard deviation (*s.d.*) values are reported for each category. The *t*-test was chosen for this study due to

its suitability for comparing means between two samples. Prior to the *t*-test, a normality test of the distribution was conducted.

Chi-square ( $\chi^2$ ) tests of association were conducted for categorical variables, including platform preparation, the direction of core exploitation, axis orientation, profile shape, retouched piece typology, retouch type, and counts of blades, convergent pieces, and formal tools. The chi-square value ( $\chi^2$ ) or Fisher's exact (for 2x2 tabular), degrees of freedom (*df*), and probability (*p*-value) are reported. The *p*-values for both the *t*-test and the chi-square ( $\chi^2$ ) test indicates the probability that the compared sites were formed by similar behaviors; a *p*-value of 0.05 is employed to denote significance. Lithic attributes from domain one (core modification) were not statistically analyzed due to the observational and interpretive nature that characterizes this domain. The chi-square ( $\chi^2$ ) test was preferred because it is mainly suitable for raw counts with no measurements. It is mainly used to determine the association between two categorical variables.

Additionally, the significance level of 0.05 was corrected using the Bonferroni method, ensuring that each individual test maintained a corrected significance threshold appropriate for controlling the overall errors. The Bonferroni method adjusts the significance level according to the number of comparisons made. It is particularly useful in *t*-tests and chi-square ( $\chi^2$ ) tests to control for the increased likelihood of Type I errors (false positives) resulting from multiple comparisons. This correction is typically applied when conducting multiple pairwise comparisons, as in this study. In essence, the Bonferroni correction reduces the likelihood of false discoveries, thus ensuring the validity and reliability of the results.

## CHAPTER FIVE: MIS 5 LITHIC TECHNOLOGY AT GA-MOHANA HILL NORTH ROCKSHELTER

### 5.1 Assemblage composition

The GHN DBSR lithic assemblage primarily represents a reduction focused on flake production, with few convergent pieces and blades. Flakes constitute the predominant portion of the assemblage (68.7%, n=1179). Convergent pieces account for 4.2% (n=73), while blades are relatively scarce at 2.2% (n=37). Retouched pieces, mainly scrapers and minimally retouched pieces, make up 5.7% (n=97) of the analyzed sample. Cores constitute 2% (n=35) of the total assemblage. Other lithic artifacts include debris or shatter (16.7%, n=286), pebbles altered by humans (0.3%, n=5), and hammerstones (0.2%, n=3; see Table 3; Figure 10). The presence of hammerstones and waste products, such as abundant debris or shatter with cortex, indicates that the knapping activity took place on site (see Inizan *et al.*, 1999). All lithic artifacts are in good physical condition.

The DBSR blades fit into the technical stages of reduction, determined based on their position on the debitage surfaces of a core (see Perlès, 1994; Soriano *et al.*, 2007). About 24.3% (n=9) are blades from the initial stages of reduction, specifically classified as A3 blades and characterized by >50% cortex cover. More than half (54.1%, n=20) of the blades represent the main production phase (B category), with an additional 21.6% (n=8) classified as core maintenance blades (C category; see Figure 9).

Table 3: GHN DBSR lithic assemblage composition.

Assemblage composition	n	% Frequencies
Complete flakes	246	14.3%
Flake fragments	933	54.4%
Blade/blade fragments	37	2.2%
Convergent pieces	73	4.2%
Retouched pieces	97	5.7%
Cores	35	2%
Hammerstones	3	0.2%
Debris/shatter	286	16.7%
Small nodules/pebbles	5	0.3%
<b>Total</b>	<b>1715</b>	<b>100%</b>

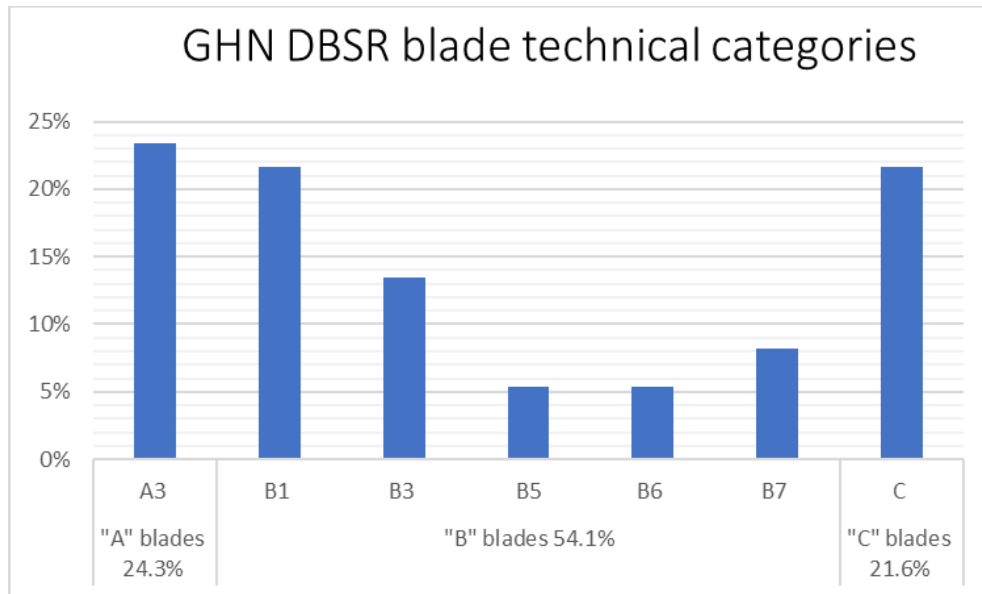


Figure 9: GHN DBSR blade technical categories and percentages.

In metric dimensions, interestingly, the length and width of retouched pieces are close to those of convergent pieces but much thicker than all unmodified blanks. Additionally, thickness shows the least amount of variation among the blank types (Table 4). Within raw material types, blades and retouched pieces made from chalcedonic black chert are relatively smaller than those made from other types of raw materials (see Figure 10 and 13). Mass is mostly comparable across the three blank types and retouched pieces.

*Table 4: Mean dimensions (mm) and mass (g) for GHN DBSR complete blanks and retouched pieces. Standard deviations in parentheses.*

<b>Lithic artifact class</b>	<b>n</b>	<b>Technological length</b>	<b>Technological width</b>	<b>Maximum thickness</b>	<b>Mass</b>
Flakes	246	27.0 (11.7)	22.8 (9.1)	6.5 (3.3)	8.1 (10.1)
Blades	10	42.2 (16.5)	17.2 (6.9)	6.9 (4.2)	7.7 (9.9)
Convergent Pieces	17	36.0 (17.7)	23.4 (9)	6.5 (3.2)	8.6 (10.5)
Retouched Pieces	36	32.8 (16.2)	24.4 (10.1)	7.8 (3.3)	8.0 (10.2)
<b>Total</b>	<b>309</b>				



Figure 10: GHN DBSR blanks showing dorsal, profile, ventral, and platform views, a to d=convergent pieces; (a) #2192 (banded ironstone), (b) #2198 (banded ironstone, with adherent matrix), (c) #4281 (tuff), (d) #1946 (banded ironstone), e to g=blades; (e) #13968 (banded ironstone), (f) #13967 (banded ironstone), (g) #4379 (chalcedonic black chert).

## 5.2 Raw material exploitation

The dominant raw materials in the DBSR assemblage include chalcedonic black chert (37.3%, n=639), banded ironstone (36.0%, n=618), and tuff (21.2%, n=364), as shown in Table 5. Fewer artifacts are made from quartz (2.4%, n=41), while other raw materials such as agate and volcanic rocks occur at much lower frequencies (3.1%, n=53), mostly in the form of hammerstones, pebbles, flake fragments, and shatter. All three main raw materials are represented in the core and blank assemblages, as detailed in Table 5.

Chalcedonic black chert refers to a non-clastic, cryptocrystalline rock that is black or dark gray and possesses a translucent texture (Wilkins, 2017). In terms of its structure, it generally exhibits homogeneity but can also present itself in banded or mottled forms with commendable knapping properties (Wilkins, 2017). Banded ironstone is defined as a sedimentary rock characterized by stratified bands containing shale along with haematite or iron-rich magnetite. In this region, the red variations are sometimes referred to as “jaspilite” or “jasper” (see Wilkins, 2017). Banded ironstone occurs in homogeneous and banded forms and exhibits translucence to opacity. It appears in various colors such as brown, red, gray-blue, orange, and purple, although in the GHN DBSR, it predominantly presents in shades of brown and red. Tuff, a type of rock formed from volcanic ash, is present at GHN in the form of a fine-grained outcrop with a conchoidal fracture. It appears in a dark gray-green color and contains small reflective iron inclusions (~0.5-1 mm in size) (Sumner and Bowring, 1996; Wilkins *et al.*, 2020).

Table 5: GHN DBSR assemblage composition by raw material type. Frequency of raw material types is calculated across the entire assemblage, and lithic class frequency within a specific raw material type is calculated within the total assemblage of that type.

<b>Raw materials</b>	<b>n</b>	<b>%</b>
<b>Chalcedonic black chert</b>	<b>639</b>	<b>37.3%</b>
Complete flakes	103	16.1%
Flake fragments	370	57.9%
Blade/blade fragments	23	3.6%
Convergent pieces	24	3.8%
Retouched pieces	45	7.0%
Cores	20	3.1%
Debris/shatter	54	8.5%
<b>Banded ironstone</b>	<b>618</b>	<b>36.0%</b>
Complete flakes	85	13.8%
Flake fragments	366	59.2%
Blade/blade fragments	10	1.6%
Convergent pieces	28	4.5%
Retouched pieces	40	6.5%
Cores	7	1.1%
Debris/shatter	82	13.3%
<b>Tuff</b>	<b>364</b>	<b>21.2%</b>
Complete flakes	58	15.9%
Flake fragments	157	43.1%
Blade/blade fragments	4	1.1%
Convergent pieces	20	5.5%
Retouched pieces	12	3.3%
Cores	7	1.9%
Debris/shatter	106	29.2%
<b>Quartz</b>	<b>41</b>	<b>2.4%</b>
Flake fragments	26	63.4%
Core	1	2.4%
Debris/shatter	14	34.2
<b>Other</b>	<b>53</b>	<b>3.1%</b>
Flake fragments	14	26.4%
Convergent pieces	1	1.9%
Hammerstones	3	5.7%
Pebble	5	9.4%
Debris/shatter	30	56.6%
<b>Total</b>	<b>1715</b>	<b>100.0%</b>

While all three main raw material types are fairly represented in the DBSR assemblage, there is a noticeable preference for chalcedonic black chert and banded ironstone when manufacturing retouched tools, constituting 7.0% (n=45) and 6.5% (n=40) of the total count, respectively (see Table 5). Fewer retouched pieces are made on tuff at 3.3% (n=12), and none are made from quartz or other raw material types. In addition, chalcedonic black chert is the most preferred material for blades (3.6%, n=23), followed by banded ironstone (1.6%, n=10) and tuff (1.1%, n=4). In contrast, the acquisition of complete flakes shows a similar distribution across the three major raw material types, suggesting that the first two were deliberately chosen mostly for blade and retouched tool production.

The greater preference for chalcedonic black chert and banded ironstone in blade production and retouched tool-making is attributed to their fine-grained and homogeneous nature. These qualities enable the production of tools with enhanced sharpness, durability, and strength in the edges, making them less prone to breakage and resulting in longer-lasting implements. This observation is supported by experiments and thin section analyses conducted by Wilkins (2017) at Kathu Pan, focusing on banded ironstone and chalcedonic black chert. Although no experiments specifically targeted tuff, this distinctive pattern underscores the influence of the mechanical characteristics of chalcedonic black chert and banded ironstone in the knappers' selection of blanks for further modification. The absence of retouched tools made from quartz and other raw materials may be attributed to their respective qualities and limited availability in the vicinity of GHN.

As highlighted in the methods chapter, previous research by Wilkins (2017) on Kalahari raw materials observed that flaking banded ironstone could follow different patterns: “*through*”, “*with*”, “*diagonal*”, or “*against*”. Banded ironstone exhibiting flaking patterns “*with*” dominates the DBSR assemblage, comprising 39% (n=41). In addition, flaking is easier and more controllable with homogeneous banded ironstone than with heavily banded varieties (Wilkins, 2017). The results of this study show that homogeneous banded ironstone (67.9%; n=420/618) dominates the banded ironstone raw material category more than the non-banded variety. Thus, at GHN, the selection of fine-grained raw materials that exhibit excellent knapping qualities and lack flaws underscores the careful attention paid by knappers during the process of material acquisition.

The raw material types exploited at GHN are located in close proximity to the site (Wilkins *et al.*, 2020). To reiterate, raw materials found within a 10 km radius of the site are commonly categorized as “local”, while those found farther than 10 km away are termed “non-local” (Delpiano *et al.*, 2018; Will, 2021). Based on the findings reported by Wilkins *et al.* (2020), significant layers of chalcedonic black chert are present within the dolomitic Gamohaana Formation, which encompasses the location of the shelter. Additional surveys further confirmed the presence of chalcedonic black chert atop Ga-Mohana Hill, although it occurs in seams and bands typically measuring less than 15 cm in thickness (see Figure 11). This characteristic may have influenced the size of chalcedonic black chert lithic artifacts, as mentioned earlier. Furthermore, the presence of chalcedonic black chert in bands within the dolomite formation could have posed challenges in extraction, leading to constraints in raw material procurement and fostering curation practices at GHN, despite its local availability. Additionally, this observation of raw material curation may offer an explanation for the relatively smaller size of chalcedonic black chert cores compared to

other raw materials, as will be comprehensively explained in the subsequent sections of this chapter.

Abundant outcrops of banded ironstone are found atop Ga-Mohana Hill, with numerous nodules also noted on the talus slope and within the valleys, as reported by Wilkins *et al.* (2020). Additional surveys conducted by the researcher revealed that the most preferred type of banded ironstone (the homogeneous), known for its good knapping qualities, is primarily situated atop Ga-Mohana Hill and is less likely to be found in the surrounding areas. This circumstance may have also contributed to raw material constraints despite their proximity. Tuff is identified in the form of thick blocks embedded in the dolomitic Ga-Mohana Formation, where the shelter is situated, as noted by Wilkins *et al.* (2020) and confirmed during surveys. Additionally, sizable quartz crystals and quartz seams were observed embedded in the dolomite formation at Ga-Mohana Hill (see Wilkins *et al.*, 2020).



*Figure 11: Geological occurrences of GHN raw materials. (a) and (b) chalcidonic black chert bands with a thickness of less than 15 cm, (c) a layer of tuff, and (d) the top summit of Gamohana Hill, where homogeneous banded ironstone is situated. Photo credit: Bharti Jangra.*

## 5.3 Lithic reduction

### 5.3.1 Knapping technique

Hammerstones (n=3) with clear percussion pitting were retrieved from the studied DBSR assemblage. There seems to be a preference for rounded volcanic rocks as hammerstones. This assumption is further supported by the test knapping I co-performed while in the field, which revealed the inherent difficulty of knapping or fracturing volcanic material. This insight helps explain the preference for volcanic material for hammerstones as opposed to its utilization in the production of lithic artifacts. Additional findings from our surveys suggest that the potential origin of these volcanic hammerstones is possibly from a volcanic formation located in the Kathu region, at least 45 km away.

DBSR lithic artifacts show the exclusive use of the hard hammer percussion technique across all raw material types. This is demonstrated by the presence of characteristics argued to indicate the use of hard hammer percussion, including prominent bulbs marked by noticeable Hertzian cones, circular cracks at the impact points, and an absence of lipping (see Pelegrin, 1995, 2000). Notably, a significant proportion (67.9%, n=416/613) of the complete flaked products and proximal pieces in the DBSR display noticeable bulbs of percussion along with ring cracks at the impact points. In contrast, a smaller portion (32.1%, n=197/613) exhibits cracks at the impact points without corresponding bulbs.

### 5.3.2 Core types

The DBSR core sub-assembly primarily includes recurrent Levallois cores (74.3%; n=26), with a smaller representation of platform cores (5.7%, n=2), as well as core fragments and indeterminates (20%, n=7; Figure 12). Within the recurrent method, the DBSR Levallois cores exhibit three primary variants determined by the pattern of exploitation. These variants include the recurrent unidirectional, which is the most prevalent (37.1%, n=13), followed by the recurrent bidirectional (28.6%, n=10), with very few recurrent centripetal cores (8.6%, n=3; see Table 6; Figure 12).

The types of Levallois cores found in the DBSR display predetermined removals that extend beyond the midpoint and run parallel to the plane of intersection. This observation aligns with expectations for Levallois cores (Boëda, 1986, 1995; Chazan, 2020). Levallois core preparation is primarily observed on both the upper and lower surfaces. The upper surfaces were prepared for planned blank removals, while the lower surfaces were prepared to serve as striking platforms. The presence of recurrent Levallois within the DBSR is further supported by the observation of Levallois blanks exhibiting large dorsal scars from previous predetermined removals, a characteristic consistent with the recurrent Levallois technique (see Boëda, 1986, 1995; Chazan, 2020).

Table 6: GHN DBSR core types.

Core type	Definition	n	%
Recurrent unidirectional	Unidirectional exploitation involves the removal of predetermined flakes from a single platform.	13	37.1%
Recurrent bidirectional	Bidirectional exploitation refers to systems where predetermined flakes are struck from two opposed platforms.	10	28.6%
Recurrent centripetal	In the centripetal method, predetermined flake removals are struck from around the periphery of the core.	3	8.6%
Platform	The volume of platform cores is defined by multiple surfaces with removals parallel to one another. Primary removals originate from a well-defined platform.	2	5.7%
Core fragments/indeterminate/other	Cores that did not fit any category and minimally exploited cores.	7	20.0%
<b>Total</b>	----	<b>35</b>	<b>100.0%</b>

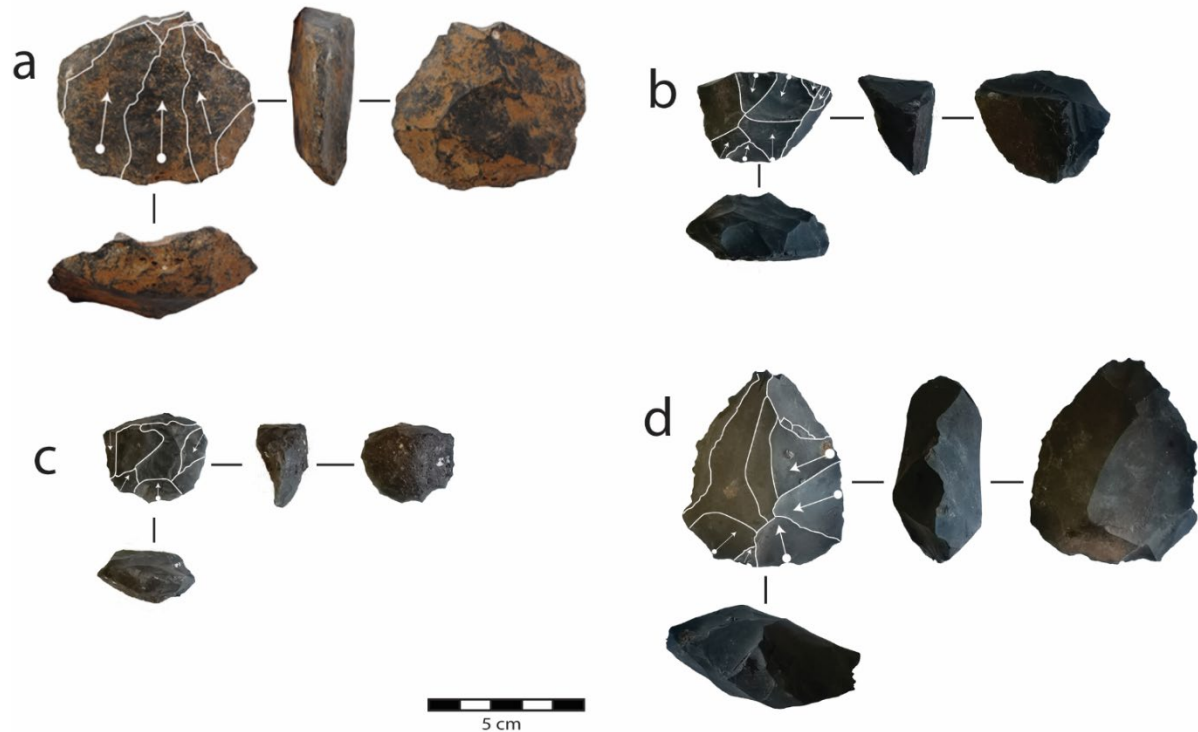


Figure 12: GHN DBSR prepared cores showing the platform, upper, lower, and lateral views (a) #4642; recurrent unidirectional (chalcedonic black chert), (b) #4236 platform core (chalcedonic black chert and (c) #4650; recurrent bidirectional (chalcedonic black chert), (d) #5065 recurrent centripetal (tuff).

The analysis of DBSR cores has revealed several significant observations. Notably, chalcedonic black chert (n=15) and homogenous banded ironstone cores (n=3) are smaller in dimensions, lighter in weight, and more extensively reduced than those from tuff (n=12) and banded ironstone with visible bands (n=4) (see Table 7). The exhaustion of chalcedonic black chert and homogeneous banded ironstone cores can be attributed to their preference for retouched toolmaking and blade production due to their favorable qualities in producing sharp and durable-edged tools, as previously noted. Core fragments and indeterminates, discarded after a single removal that extracts the majority of the upper surface of the core, are found across all raw material types but are most prevalent in tuff and banded ironstone with visible bands.

*Table 7: Mean dimensions (mm) and mass (g) for GHN DBSR cores. Standard deviations in parentheses.*

<b>Raw material</b>	<b>n</b>	<b>Length</b>	<b>Width</b>	<b>Thickness</b>	<b>Mass</b>
Chalcedonic black chert	20	35.7 (21.3)	27.3 (11.0)	19.0 (4.2)	32.5 (19.5)
Homogenous banded ironstone	3	38.7 (14.0)	21.7 (12.7)	19.5 (8.1)	36.0 (18.1)
Banded ironstone with visible bands	4	59.4 (4.0)	46.5 (13.4)	35.2 (17.7)	60.0 (62.7)
Tuff	7	58.1 (16.5)	46.0 (13.3)	22.3 (12.5)	44.2 (20.1)
Quartz	1	23.8 (0)	17.4 (0)	13.5 (0)	5.4 (0)
<b>Total</b>	<b>35</b>				

The noticeable disparity in core exhaustion across the three primary raw material types implies a strategic approach aimed at optimizing the usage of available resources. This observation further reinforces the notion of the challenges associated with material extraction, as previously mentioned, such as the thin embedding of chalcedonic black chert bands within dolomite, making extraction difficult. In addition, the preferred bands of homogeneous banded ironstone are

positioned at the summit of GHN, necessitating strategies for resource conservation. The limited availability of chalcedonic black chert and homogeneous banded ironstone, combined with their favorable qualities for producing sharp and durable tools, required this careful and efficient utilization strategy, as evident in the extensive reduction of their cores. By contrast, tuff cores are less extensively reduced due to the easy accessibility of the raw material.

### **5.3.3 Core reduction**

All stages of reduction are evident at GHN, as indicated by the presence of decortication flakes or early-stage flakes retaining over 50% cortex and non-cortical late-stage blanks. Blades from the initial stages of production (A blades), including those entirely cortical and some with >50% cortex, present in the DBSR assemblage, further confirm early-stage reduction. In total, within the DBSR, 35.1% (n=546) of the knapped products are classified into two categories: those with entirely cortical surfaces and those with >50% cortex, signifying early stages of reduction and that cores were primarily transported to the site as unknapped or minimally worked raw materials. The availability of raw materials in the proximity of the GHN site also supports the idea that cores were brought in unknapped due to the minimal transportation cost involved.

The presence of debris or shatter with cortex further substantiates that knapping took place at the rockshelter (see Kuhn, 1994). Cortex (ranging from 40% to 60%) was also identified on 37% (n=13) of the cores, with outcrop cortex being predominant (95%, n=490). Tuff cores retain more cortex than other raw materials (i.e., chalcedonic black chert, 28.7%; banded ironstone, 28.8%; tuff, 42.5%), and there are few pieces with cobble cortex present in the assemblage. To distinguish

cobble and outcrop cortex, I followed the guidelines established in previous research (see Wilkins, 2017), detailed in the methods chapter.

### ***5.3.3.1 Core exploitation***

Based on the scar patterns observed on the upper surfaces of recurrent Levallois cores in the DBSR, three primary exploitation modes were employed during lithic reduction: unidirectional (37.7%), bidirectional (28.6%), and centripetal (8.6%). These patterns are supported by a significant percentage of DBSR blanks that exhibit unidirectional and bidirectional dorsal scar patterns (86.7%, n=659), with lower frequencies of centripetal patterns (13.3%, n=101). Unidirectional, bidirectional, and centripetal exploitations were applied to all three main raw material types. Platform cores, in particular, exhibit primarily parallel reduction, as evidenced by the parallel orientation of scars on non-Levallois blanks.

The reduction sequence at GHN indicates that blades are rare and not the primary focus or targeted blanks of reduction. Blades were produced on site and removed during the first stages of reduction. The blade cores were transformed for flake removal in later stages reduction, likely to optimize the use of raw materials due to constraints as mentioned earlier. Final scars on cores show flake removals, yet blades from all phases of manufacture are also present. Blades from the initial phase, with either an entirely or  $\geq 50\%$  cortical surface, coexist in the assemblage with blades from the main production phase and core maintenance blades.

This observation is further reinforced by earlier discussions highlighting that the majority of blades are made from chalcedonic black chert found in thin blocks. This underscores the necessity of conserving chalcedonic black chert cores by converting them into flake reduction. Their conversion into flake cores also explains why they are exhausted when discarded and appear smaller in size compared to those from tuff and banded ironstone with visible bands. However, it is important to note that the study does not rule out the possibility of blades being manufactured off-site and then brought to GHN as preforms.

#### ***5.3.3.2 Striking platform preparation***

Prepared platforms suggesting the use of the Levallois method dominate the blank assemblage, comprising 50.2% (n=308), while plain platforms constitute 49.8% (n=305). Among the prepared platforms, the majority are faceted with a visible negative bulb of percussion (33.1%, n=203), while 17.1% (n=105) exhibit residual facets without bulbs of percussion. The striking platforms of the Levallois cores also exhibit a high investment in preparation near the platforms of negative flake scars. In addition to platform preparation, the analysis included measurements of platform dimensions, and the results indicate that, in general, flakes and convergent pieces have wide and thick platforms, while blades show narrow and thin ones (see Table 8). External platform angles (EPA) maintain similar mean values of 76° to 77° across flakes, convergent pieces, blades, and retouched pieces.

Table 8: GHN DBSR mean platform dimensions (mm). Standard deviation in parentheses. EPA = External Platform Angle, and 'n' includes complete pieces and proximal parts.

<b>Blanks</b>	<b>n</b>	<b>Platform width</b>	<b>Platform thickness</b>	<b>EPA</b>
Flakes	514	17.2 (38.6)	6.4 (17.6)	77° (5.7)
Blades	16	12.9 (4.4)	4.8 (2.3)	77° (5.2)
Convergent pieces	46	17.1 (8.2)	6.1 (2.8)	76° (5.2)
Retouched pieces	37	13.3 (10.1)	5.8 (3.3)	76° (5.8)
<b>Total</b>	<b>613</b>			

### 5.3.3.3 Core maintenance

*Débordant* flakes with no cortex were identified within the DBSR, constituting 8.9% of the assemblage. These flakes represent the maintenance of the lateral convexity of the cores. In addition, a few core maintenance blades are also evident within the DBSR blade sample. It is plausible that these blades were used to maintain cores during the initial and main phases of production.

### 5.3.3.4 Discarded cores

Both cores and knapped products were discarded at the GHN site. The discarded cores primarily exhibit flake removals and vary in size. As mentioned earlier, chalcedonic black chert and homogeneous cores are discarded in a more heavily reduced state compared to other raw material types, which were not discarded in an exhausted condition. Some cores categorized as “core fragments and indeterminate” display only one to a few removals, indicating that they were discarded during the earlier stages of reduction.

## 5.4 Retouched pieces

A few DBSR blanks were modified into retouched pieces, constituting 5.7% (n=97) of the assemblage. Both blades and flakes served as blanks for retouched pieces, with the majority (73.2%; n=71) produced from flake blanks rather than blade blanks (5.3%; n=4). The represented categories include very few retouched convergent pieces, scrapers, minimally retouched pieces, and miscellaneous pieces (see Table 9; Figure 13). The type of retouch is primarily limited to marginal edge shaping (94.8%, n=92), notches or denticulates (4.1%, n=4.1), and invasive edge shaping (1.03%, n=1; see Figure 13).

Table 9: Frequency of retouched piece types in the GHN DBSR assemblage.

<b>Retouched pieces</b>	<b>Definition</b>	<b>n</b>	<b>%</b>
Retouched convergent pieces	Converging edges shaped into a pointed form.	2	2.1%
Minimally retouched pieces	Limited retouch visible on edges.	62	63.9%
Notched/denticulated pieces	Can be formed by one single notch (Clactonian) or by several retouches (see Inizan <i>et al.</i> , 1999).	4	4.1%
Side scrapers	Continuous retouch along a portion of one lateral.	12	12.4%
End scrapers	Continuous retouch that includes distal end.	9	9.3%
Double scrapers	Continuous retouch along two edges.	2	2.1%
Miscellaneous and broken fragments	Fragment of a retouched piece that cannot be assigned to the categories above.	6	6.1%
<b>Total</b>	---	<b>97</b>	<b>100%</b>

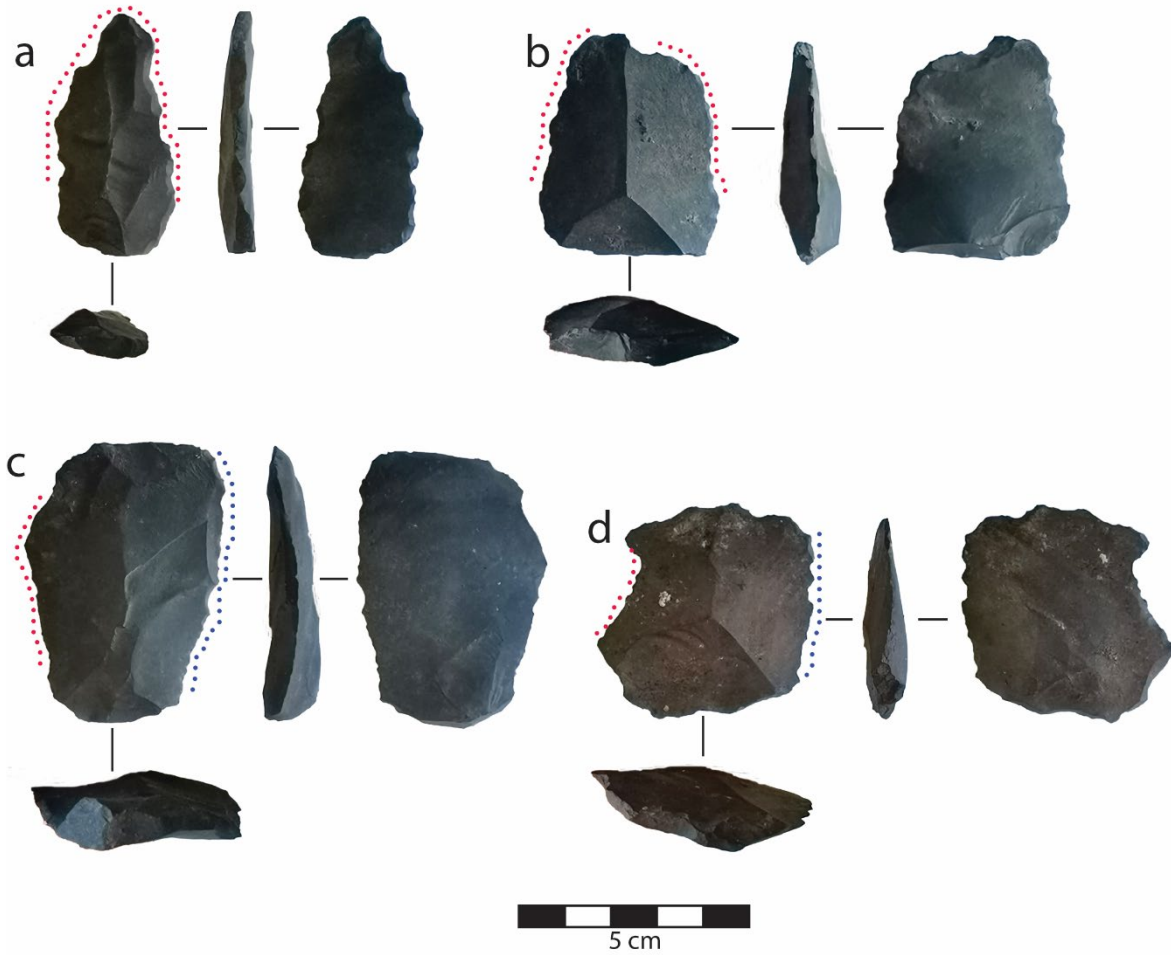


Figure 13: GHN DBSR formal tools showing upper, lateral, lower, and platform view (a) #4783, retouched convergent piece (chalcedonic black chert), (b) #4478, double scraper (tuff), (c) #3670, side scraper (tuff) and (d) #1920, side scraper (banded ironstone). Note: Red dots indicate retouch and blue dots, edge damage.

## CHAPTER SIX: MIS 5 LITHIC TECHNOLOGY OF COMPARATIVE SITES

For comparative purposes with the GHN MIS 5 assemblage, this study analyzed five MIS 5 lithic assemblages in the Kalahari and its environs: KP6, EFK, FLB, ≠Gi, and WPS. This chapter describes the lithic technologies employed at these sites, laying the foundation for comparisons in the subsequent chapter. The general background and MIS 5-related data on these sites has been presented in Chapter Three. Comprehensive lithic technological data has been published for FLB (Brenner, 2019; Kuman, 1989; Kuman *et al.*, 1999). The pertinent lithic assemblages from KP6, ≠Gi, and WPS have similarly been described as MIS 5 assemblages but without detailed consideration of reduction strategies (Beaumont, 1990; Brooks *et al.*, 2006; Donahue *et al.*, 2006; Kuman, 1989; Lukich *et al.*, 2019; Robbins *et al.*, 2000; Lombard and Churchill, 2022). The EFK MIS 5 lithic assemblage has not yet undergone detailed technological analysis (Bousman *et al.*, 2023).

In all cases, it was necessary for me to conduct primary research on the lithic assemblages to collect data for each relevant trait in my comparative analysis. Analyzing the assemblages myself had the added benefit of ensuring consistency in trait identifications and characterizations. The results of my lithic analyses contribute to and complement existing reports on lithic technology at each of these sites.

## 6.1 Kathu Pan 6 (KP6)

### 6.1.1 KP6 Bed 9 lithic assemblage composition

KP6 open-air is the closest site to GHN, situated 45 km southwest of it. The lithic assemblage from KP6 Bed 9 (~74 ka) was classified by previous researchers as an HP industry based on its predominance of blades with few flakes and convergent pieces (see Beaumont, 1990; Lukich *et al.*, 2019). Blades constitute 29.9% (n=221) of the Bed 9 assemblage. Flakes account for 20.6% (n=154), while convergent pieces are relatively scarce at 1.3% (n=10). Within the analyzed assemblage, retouched pieces make up 1.7% (n=13) of the collection, including minimally retouched items and two bifacially retouched pieces that are double-pointed and narrow-oval-shaped. These characteristics are consistent with descriptions of Still Bay-type points by several researchers (e.g., Archer *et al.*, 2016; Lombard, 2006a; Wadley, 2007; Wurz, 2013). Cores represent 1.5% (n=11) of the total assemblage analyzed. Other lithic artifact types, such as debris or shatter, account for 40.4% (n=300), and small pebbles make up 4.6% (n=34; see Table 10; Figures 14 and 15). Bed 9 lithic artifacts show comparable dimensions, with flakes being shorter and wider compared to other blanks (see Table 11).

Table 10: KP6 Bed 9 lithic assemblage composition.

<b>Assemblage composition</b>	<b>n</b>	<b>%</b>
Complete flakes	50	6.7%
Flake fragments	104	13.9%
Blade/blade fragments	221	29.9%
Convergent pieces	10	1.3%
Retouched pieces	13	1.7%
Cores	11	1.5%
Debris/shatter	300	40.4%
Small pebbles	34	4.6%
<b>Total</b>	<b>743</b>	<b>100.0%</b>

Table 11: Mean dimensions (mm) and mass (g) for KP6 Bed 9 complete blanks and retouched pieces. Standard deviations in parentheses.

Blanks	n	Technological length	Technological width	Maximum thickness	Mass
Flakes	50	24.4 (11.5)	22.6 (9.0)	4.8 (2.5)	4.9 (4.3)
Blades	55	33.7 (12.5)	15.7 (4.8)	5.1 (2.0)	2.9 (3.6)
Convergent pieces	2	33.3 (15.5)	16.5 (3.2)	4.8 (1.3)	3.4 (3.1)
Retouched pieces	2	31.2 (11.6)	20.5 (6.9)	5.8 (3.6)	4.5 (3.7)

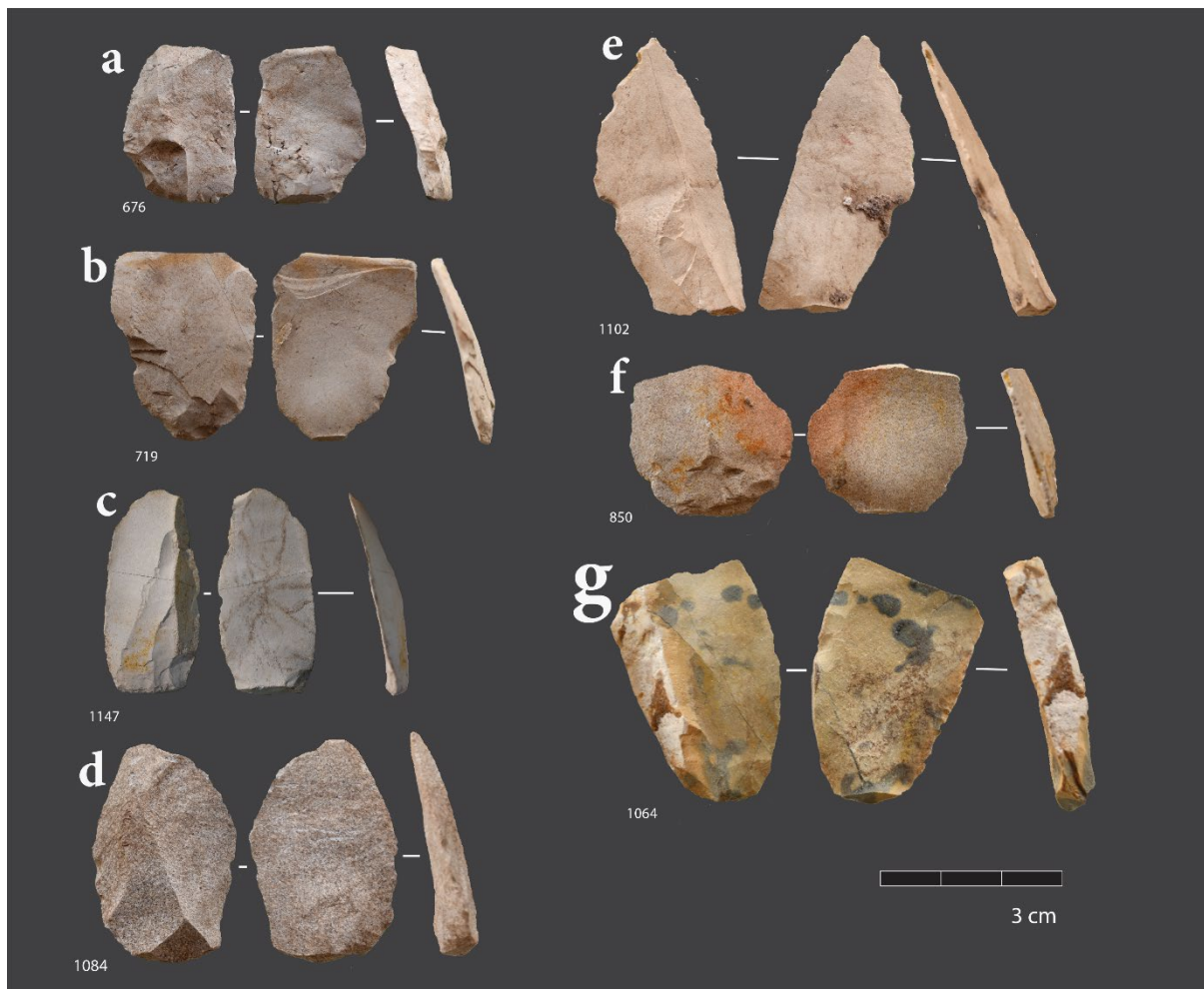


Figure 14: KP6 Bed 9 lithic artifacts; (a) #676 complete flake, (b) #719 snapped flake with step-terminating bending fracture on the ventral face and lipped platform (banded ironstone), (c) #1147 complete blade (banded ironstone), (d) #1084 complete flake (quartzite), (e) #1102 minimally retouched convergent piece with lipped platform, (f) #850 flake fragment with lipped platform (quartzite) and (g) #1064 flake fragment with lipped platform (banded ironstone).

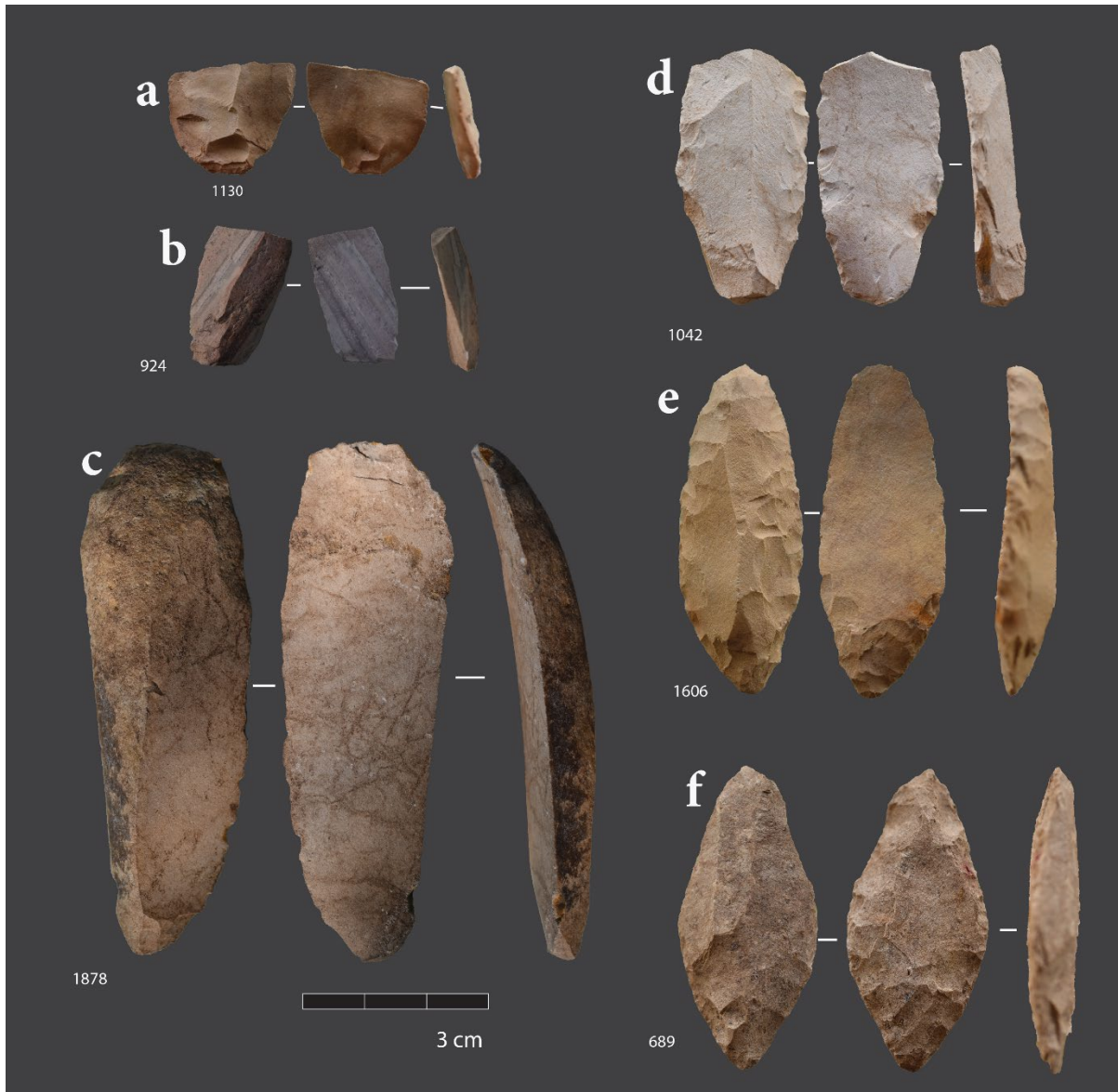


Figure 15: KP6 Bed 9 lithic artifacts; (a) #1130 flake fragment (banded ironstone), (b) #924 blade fragment (banded ironstone), (c) #1878 and (d) #1042 complete blades with lipped platforms (banded ironstone), (e) #1606 and (f) #689 retouched pieces (banded ironstone).

KP6 Bed 9 blades fit into the blade classification described by Soriano *et al.* (2007). A relatively small number are blades from the initial stages of production, specifically A2 (6.8%, n=15) and A3 blades (5.4%, n=12). The majority (82.8%, n=183) can be classified into the main production

phase (B category), while 5.0% (n=11) are categorized as core maintenance blades (C category) (see Figure 16).

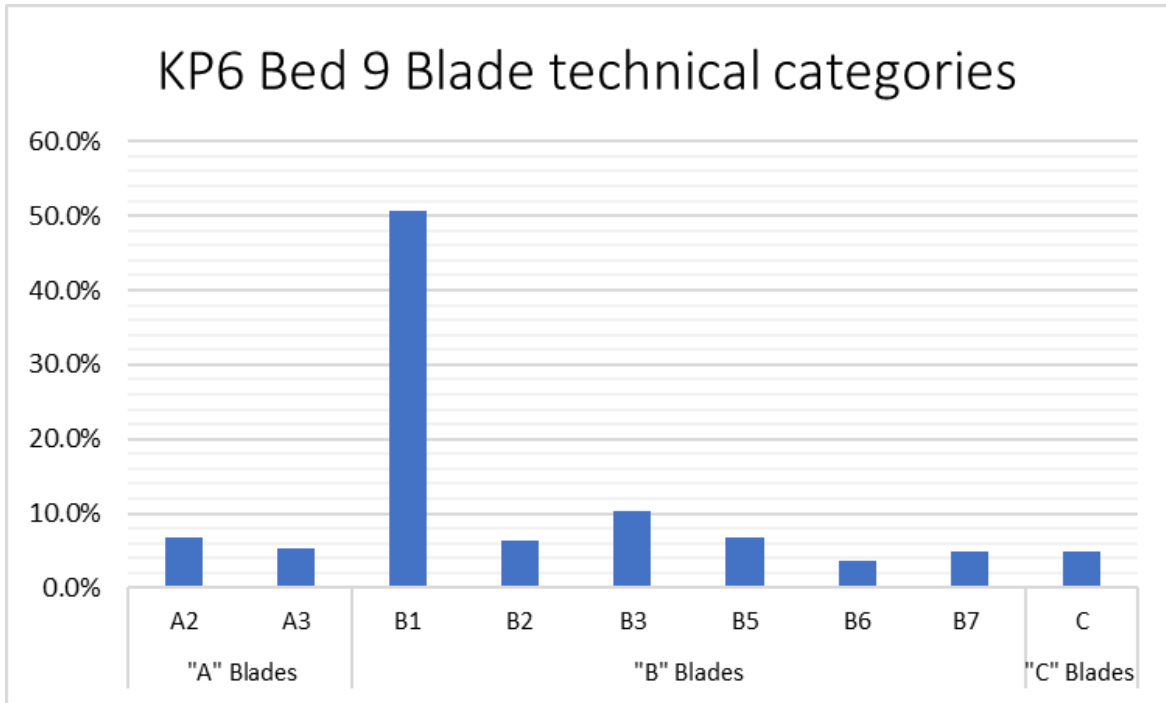


Figure 16: KP6 Bed 9 blade technical categories.

### 6.1.2 KP6 Raw material exploitation

The lithic assemblage from Bed 9 is primarily composed of banded ironstone, accounting for 79.9% (n=594) of the assemblage. Banded ironstone exhibits various types, including homogeneous and non-homogeneous varieties, and displays a range of colors from red or brown to light and dark gray (see Figures 14 and 15). More detailed information on the different types of banded ironstone can be found in Wilkins (2017: 177). Chalcedonic black chert is the second most prevalent raw material, representing 13.5% (n=100), followed by quartz at 3.5% (n=26) and quartzite at 2.4% (n=18). Other raw materials, such as quartz crystal and rose quartz, occur at much lower frequencies, comprising only 0.7% (n=5) and primarily appearing as fragments and shatter.

While banded ironstone is the most preferred raw material overall, Table 12 further highlights its dominance in blade production, constituting 34.5% (n=205), followed by chalcedonic black chert at 18.0% (n=18). The frequency of blades made from quartzite drops to 11.1% (n=2) while no blades are produced from quartz or other raw materials. The preference for banded ironstone and chalcedonic black chert in blade production and retouched toolmaking at KP6 can be attributed to their qualities that enable the production of tools with sharp and durable edges, as noted in the previous chapter.

The raw material types utilized at KP6 are readily available within a 10 km radius (see Wilkins, 2017). High-quality, flawless, and homogeneous banded ironstone have been observed abundantly and are easily accessible in the surrounding landscape of the Kathu Pan sites. Banded ironstone outcrops are also present at the Kathu Townlands archaeological site, located 6.6 km away from KP6. Furthermore, surveys conducted in the area have revealed an abundance of high-quality banded ironstone at the summits of two adjoining hills situated in the eastern region of Kathu Townlands (Wilkins, 2017). Chalcedonic black chert was identified as seams embedded within banded ironstone on top of Wonderwerk Cave and Kuruman Hills, located 7 km from KP6 (see Wilkins, 2017). Additional surveys, in which I participated, confirmed the presence of chalcedonic black chert embedded in dolomite on top of Wonderwerk (see Figure 17). The challenges posed by the extraction of chalcedonic black chert, embedded within banded ironstone and dolomite, may explain why it is found less frequently than banded ironstone at KP6. The main Gamagara River (~10 km from KP6), is argued to have likely served as one of the sources of quartz and quartzite raw materials (see Wilkins, 2017).

Table 12: KP6 Bed 9 assemblage composition by raw material type. Frequency of raw material types is calculated across the entire assemblage, and lithic class frequency within a specific raw material type is calculated within the total assemblage of that type.

<b>Raw Material</b>	<b>n</b>	<b>%</b>
<b>Banded Ironstone</b>	<b>594</b>	<b>79.9%</b>
Complete flakes	43	7.2%
Flake fragments	58	9.8%
Blade/blade fragments	205	34.5%
Convergent pieces	9	1.5%
Retouched pieces	9	1.5%
Cores	10	1.7%
Debris/shatter	253	42.6%
Small pebbles	7	1.2%
<b>Chalcedonic Black Chert</b>	<b>100</b>	<b>13.5%</b>
Complete flakes	4	4.0%
Flake fragments	30	30.0%
Blade/ blade fragments	18	18.0%
Convergent pieces	1	1.0%
Retouched pieces	3	3.0%
Cores	1	1.0%
Debris/shatter	28	28.0%
Small pebbles	15	15.0%
<b>Quartz</b>	<b>26</b>	<b>3.5%</b>
Complete flakes	1	3.8%
Flake fragments	4	15.4%
Retouched pieces	1	3.8%
Debris/shatter	8	30.8%
Small pebbles	12	46.2%
<b>Quartzite</b>	<b>18</b>	<b>2.4%</b>
Complete flakes	2	11.1%
Flake fragments	6	33.3%
Blade/blade fragments	2	11.1%
Debris/shatter	8	44.4%
<b>Other</b>	<b>5</b>	<b>0.7%</b>
Flake fragments	2	40.0%
Debris/shatter	3	60.0%
<b>Total</b>	<b>743</b>	<b>100.0%</b>



*Figure 17: Chalcedonic black chert embedded in dolomite atop Wonderwerk Cave.*

### **6.1.3 Lithic reduction**

#### ***6.1.3.1 Knapping technique***

Bed 9 knapped lithic artifacts exclusively demonstrate the use of soft hammer percussion. This is indicated by the presence of plain, tiny, thin oval-shaped platforms, often accompanied by lipping, with or without prominent bulbs of percussion (see Figures 14 and 15 for examples of lipped platforms at KP6). These characteristics are observed in 82.1% (n=160/195) of complete blanks and those with proximal parts. While this study could not definitively determine which soft hammer materials were used at KP6, most prehistoric soft hammerstone techniques utilized softer

materials such as friable sandstone, desiccated limestone, or organic substances like antlers, bone, and wood (see Callahan, 1979).

### ***6.1.3.2 Core reduction***

The Bed 9 core sub-assembly includes primarily blade cores (54.5%, n=6), flake cores (27.3%, n=3), and undetermined core fragments (18.2%, n=2). No prepared cores were identified. The abundance of blade cores at KP6 supports a lithic reduction predominantly focused on blade production. While the abandoned KP6 cores provide limited information about reduction stages, the knapped products indicate the presence of all stages, as shown by blades from the initial reduction stage (A blades, either cortical or with  $\geq 50\%$  cortex), main production stage (B blades), and core maintenance stage (C blades). Additionally, decortication flakes are present.

Blades with  $\geq 50\%$  cortex make up 11.3% (n=27) of the total blade count, while flakes with  $\geq 50\%$  constitute 22.7% (n=35) of the total flake count. The relatively lower occurrence of cortical blades, in contrast to flakes, shows that certain blade cores are initially prepared by removing flakes during reduction. The presence of blanks with  $\geq 50\%$  cortex suggests that raw materials were brought to the site as minimally worked nodules, with on-site knapping evident from the presence of knapping debris.

Blade production primarily occurred on blade cores using parallel unidirectional and unidirectional convergent reduction methods. Most blades were produced with parallel unidirectional reduction,

as shown by 69.2% (n=135) displaying parallel and unidirectional dorsal scar patterns. A smaller proportion (30.8%, n=60) shows evidence of unidirectional convergent reduction. Flake cores exhibit a similar reduction pattern. Further evidence from dorsal scar patterns on flakes and convergent pieces showed both parallel unidirectional (60.4%, n=93) and unidirectional convergent (39.6%, n=61) reduction. In addition, the primary target was producing blanks with flat profiles (77%), while curved (17.9%) and twisted blanks (5.1%) are less common. Cores were maintained by removing core maintenance blades and flakes.

### 6.1.3.3 Striking platform characteristics and dimensions

Bed 9 knapped lithic platforms are plain. Platform attributes identified by Soriano *et al.* (2007) are also present in Bed 9 lithic artifacts. Bed 9 blanks show lipped, oval, narrow, and thin platforms, further supported by their platform thickness measurements below 4 mm (see Table 13). These attributes were also observed earlier by Lukich *et al.* (2019). The external platform angles (EPA) show relatively similar mean values ranging from 76° to 78° across flakes, blades, convergent, and retouched pieces.

Table 13: KP6 Bed 9 mean platform dimensions (mm). Standard deviation in parentheses. EPA = External Platform Angle, and 'n' includes complete pieces and proximal parts.

Blanks	n	Platform width	Platform thickness	EPA
Flakes	159	10.8 (4.7)	3.8 (1.9)	78° (4.6)
Blades	56	9.0 (4.1)	3.6 (2.0)	77° (11.3)
Convergent pieces	5	9.3 (2.9)	3.3 (2.1)	77° (8.9)
Retouched pieces	5	9.2 (2.1)	3.4 (0.9)	76° (5.9)

#### **6.1.3.4 Discarded cores**

Cores and implements were both discarded on site, including blade and flake cores. The prevalence of discarded cores on banded ironstone (90.9%) explains its dominance in the blank assemblage. These cores show significant reduction, are relatively lightweight (average mass of 33.7 g), and measure, on average, 43.9 mm in length, 36.7 mm in width, and 17.4 mm in thickness, indicating extensive reduction processes before disposal. The discarded Bed 9 cores display scars from both blade and flake removals.

#### **6.1.4 Retouched pieces**

The Bed 9 lithic assemblage contains a limited number of retouched artifacts, constituting 1.7% (n=13) of the total assemblage count. These mainly consist of minimally retouched pieces (92.3%) with marginal edge shaping retouch. Additionally, two double-pointed, oval-shaped pieces are present (see Figure 15 above, images e and f). These points exhibit bifacial invasive retouch. The two oval-shaped retouched pieces are consistent with descriptions of Still Bay-type points, as mentioned earlier.

### **6.2 Erfkroon (EFK)**

#### **6.2.1 EFK Lower F, lower gray lithic assemblage composition**

EFK open-air is the second-closest site to GHN studied for comparative purposes. It is located 330 km southeast of GHN within the adjacent region of the Kalahari Basin. Lower gray bed (~99 ka) lithic assemblage represent a reduction focused on flake production (55.5%; n=112), with few convergent pieces (5.4%; n=11) and blades (3.0%; n=6). The few blades include one blade with a

natural surface and cortex >50%, four non-cortical blades with unidirectional and bidirectional scars, and a single blade that might have been produced during core maintenance.

Retouched pieces, primarily minimally retouched artifacts, make up 2.0% (n=4) of the analyzed assemblage. Other lithic artifacts include debris or shatter, accounting for 32.1% (n=65), and small pebbles at 2.0% (n=4; Table 14; Figures 18 and 19). Notably, there are no cores present in the EFK lower gray assemblage. EFK flakes and convergent pieces exhibit comparable dimensions. However, blades and retouched pieces tend to be relatively long and narrow compared to other pieces, as shown by their mean length and width (see Table 15).

*Table 14: EFK Lower F assemblage composition.*

<b>Assemblage composition</b>	<b>n</b>	<b>%</b>
Complete flakes	47	23.3%
Flake fragments	65	32.2%
Blade/ blade fragments	6	3.0%
Convergent pieces	11	5.4%
Retouched pieces	4	2.0%
Debris/shatter	65	32.1%
Small pebbles	4	2.0%
<b>Total</b>	<b>202</b>	<b>100.0%</b>

*Table 15: Mean dimensions (mm) and mass (g) for EFK Lower F complete blanks and retouched pieces. Standard deviations in parentheses.*

<b>Blanks</b>	<b>n</b>	<b>Technological length</b>	<b>Technological width</b>	<b>Maximum thickness</b>
Flakes	47	42.6 (14.2)	28.5 (8.6)	9.5 (3.2)
Blades	4	53.5 (13.4)	23.4 (2.7)	10.2 (4.4)
Convergent pieces	10	43.3 (15.1)	26.5 (8.7)	8.1 (3.7)
Retouched pieces	3	57.5 (17.2)	23.9 (1.0)	11.1 (3.1)

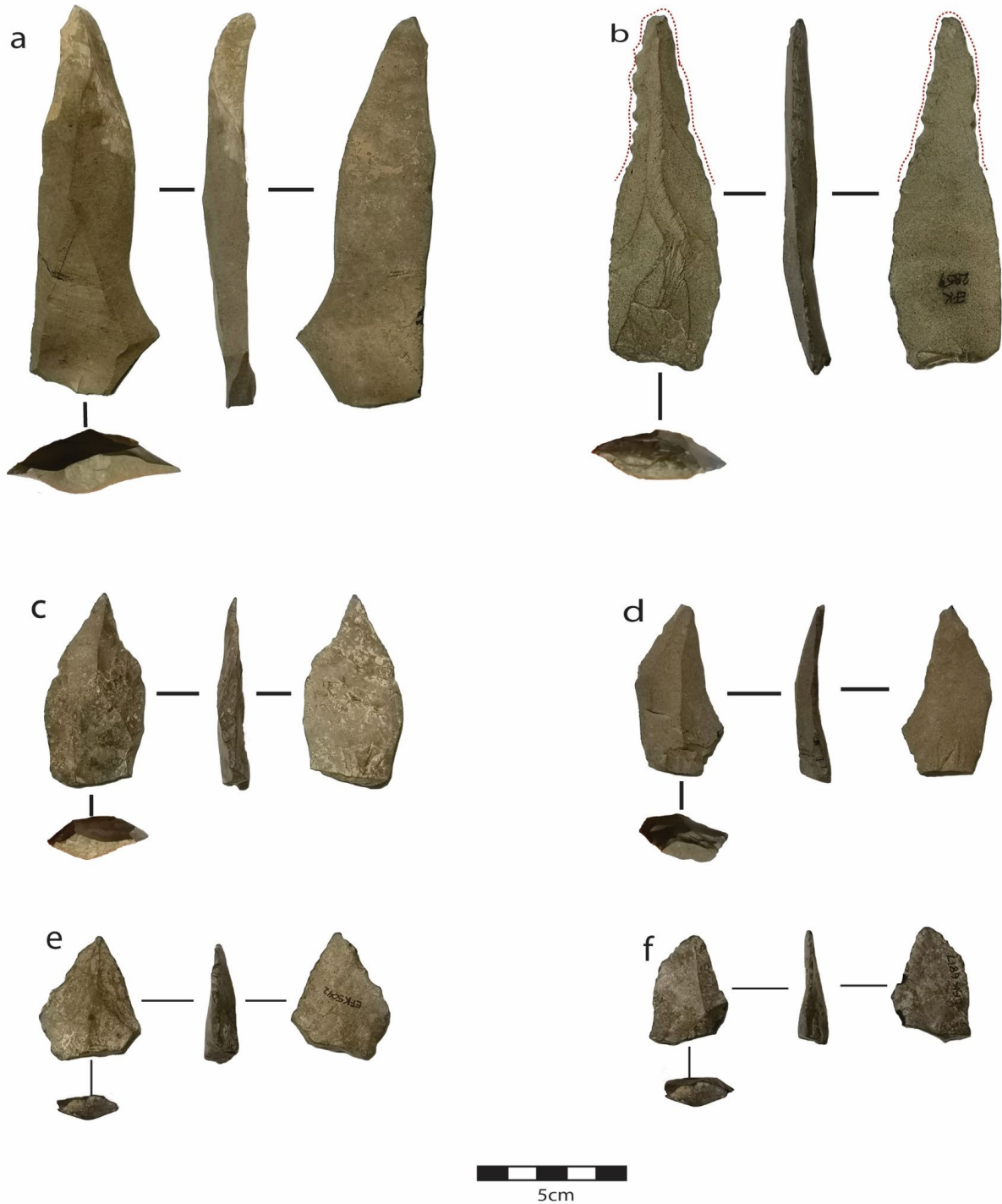


Figure 18: EFK Lower F hornfels lithic artifacts; convergent pieces = (a) #EFK 2018, (c) #EFK 7228, (d) #EFK 2211, (e) #EFK 5042 and (f) #EFK6817. Retouched convergent piece = (b) #EFK 2859. Red dots indicate the location of the retouch.

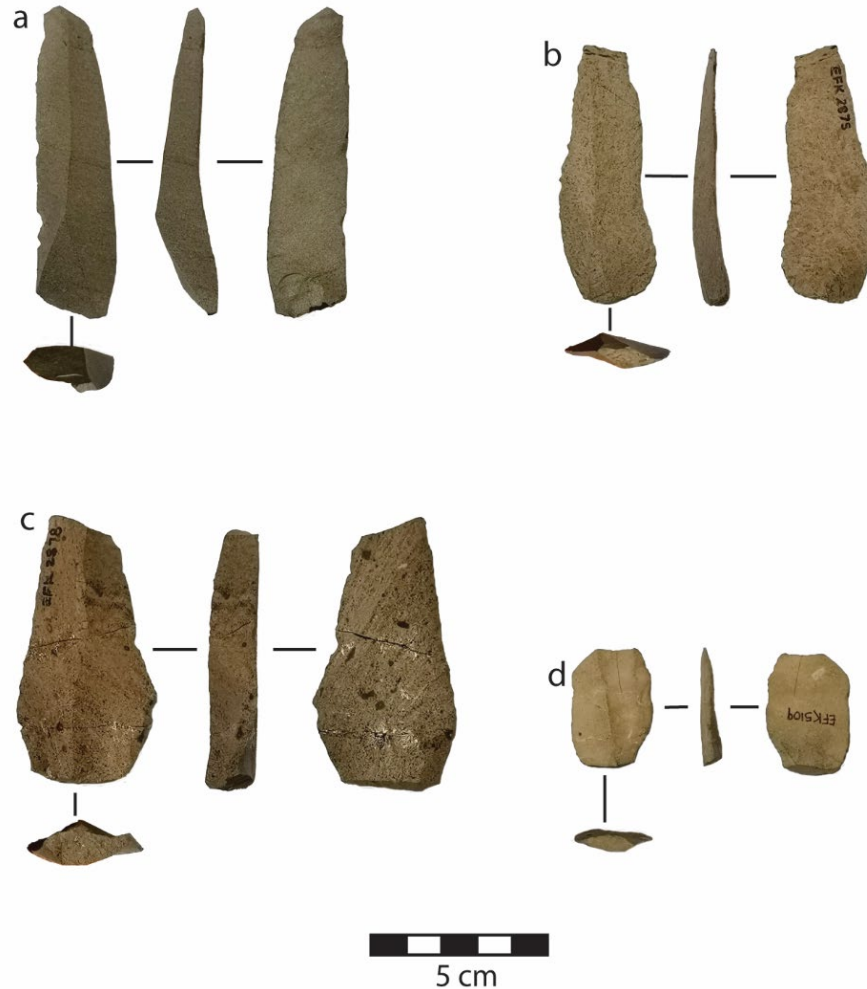


Figure 19: EFK Lower F hornfels lithic artifacts; complete blades= (a) #EFK 5042 and (b) #EFK 2875. Complete flakes=(c) #EFK 2878 and (d) #EFK 5109.

## 6.2.2 Raw material exploitation

All the lithic pieces analyzed from the Lower F, lower gray bed are made on hornfels, which occur in a range of colors varying from light to dark gray. Hornfels raw material is abundant near the EFK site. Hornfels outcrops were identified to the east of the dolerite hill situated between Damvlei and Lovedale; however, the conchoidal fracture quality of these hornfels is reported to be subpar, making them unsuitable for knapping (see Wroth *et al.*, 2022). Nevertheless, Wroth *et al.* (2022)

further mention the presence of hornfels cobbles with favorable knapping qualities in the Modder River, where the EFK site is situated on the river's overbank.

### **6.2.3 Lithic reduction**

#### ***6.2.3.1 Knapping technique***

Lithic artifacts from the EFK lower gray bed exhibit noticeable bulbs of percussion along with ring cracks at the impact points on 68.4% (n=91) of complete blanks and those with proximal parts. These findings collectively support the use of hard hammer, direct percussion at EFK despite the absence of hammerstones in the assemblage.

#### ***6.2.3.2 Core reduction***

There are no cores within the EFK Lower F, lower gray bed analyzed assemblage; however, the knapped products offer several indications of the core reduction process at the site. Despite the absence of cores, a significant portion (33.2%) of the knapped products have >50% cortex, suggesting the early stages of reduction. This observation also implies that raw materials were brought to the site in an unprepared or minimally worked state. As mentioned earlier, hornfels is readily available in the vicinity of the site, which minimizes the weight or transportation costs associated with acquiring suitable raw materials. The presence of knapping debris, comprising 32.1% of the entire assemblage, along with cortical blanks (33.2%) and late-stage non-cortical blanks (66.8%), indicates on-site knapping, suggesting that the cores were likely exhausted or depleted.

### **6.2.3.3 Core exploitation**

While cores are absent, the presence of Levallois flakes within the assemblage attests to the use of the method. The dorsal scar patterns observed on EFK Lower F, lower gray blanks show three exploitation modes: mainly unidirectional (75.8%), and bidirectional (16.1%), with centripetal exploitation being less common (8.1%). Aris orientation reveals parallel and convergent dorsal scars. The lithic reduction process at EFK is primarily aimed at producing flakes with flat profiles (63.5%) as opposed to curved (25.7%) or twisted profiles (10.8%). *Débordant* flakes are also present within the EFK assemblage, possibly used for maintaining the lateral convexities of the cores.

### **6.2.3.4 Striking platform preparation and dimensions**

Despite the absence of cores, prepared platforms dominate the EFK lithic artifact assemblage, attesting to the use of the Levallois method. Faceted platforms account for 61.7% (n=82) of complete lithic artifacts and those with proximal parts. Of those faceted, the majority (51.1%, n=48) have a visible negative bulb of percussion, while the remaining 48.9% (n=46) show residual facets without bulbs of percussion. A few pieces also show evidence of trimmed platforms. Additionally, flakes, convergent, and retouched pieces have wide and thick platforms, whereas blades exhibit narrow and thin platforms (Table 16). The external platform angles (EPA) have similar mean values of 75° and 78° across flakes, convergent pieces, blades, and retouched pieces.

Table 16: EFK Lower F mean platform dimensions (mm). Standard deviation in parentheses. EPA = External Platform Angle, and 'n' includes complete pieces and proximal parts.

<b>Blanks</b>	<b>n</b>	<b>Platform width</b>	<b>Platform thickness</b>	<b>EPA</b>
Flakes	102	17.4 (8.4)	6.9 (3.0)	78° (6.1)
Blades	5	13.7 (6.0)	5.5 (1.5)	78° (6.1)
Convergent pieces	6	26.7 (8.2)	8.3 (0.6)	78° (8.6)
Retouched pieces	4	22.8 (6.0)	9.5 (4.4)	75° (6.4)

### 6.2.4 Retouched pieces

The EFK Lower F, lower gray assemblage has a relatively low percentage of retouched pieces, accounting for only 2.0% (n=4) of the analyzed collection. Within this small subset of retouched pieces, there is one retouched convergent blade and three minimally retouched pieces. The retouch type is marginal edge shaping.

## 6.3 Florisbad (FLB)

### 6.3.1 FLB Unit F assemblage composition

FLB open-air is the third-closest site to GHN studied for comparative purposes. It is located 341 km southeast of GHN within the adjacent region of the Kalahari Basin. The FLB Unit F (~121 ka) lithic assemblage primarily consists of flakes, making up a total of 60.8% (n=531) of the analyzed collection. Convergent pieces are the second most frequent blank type, comprising 9.0% (n=79) of the overall assemblage (Figure 20). Blades and bladelets are less frequent, representing 6.8% (n=59; Figure 21). Retouched artifacts, mainly minimally retouched pieces and scrapers, constitute 4.0% (n=35). Cores constitute 1.5% (n=13). Other lithic artifacts present include debris or shatter

(16.6%, n=145), hammerstone (0.1%, n=1), cobbles (1.0%, n=9), and small pebbles (0.2%, n=2; see Table 17).

While blade frequency is low in the Unit F assemblage, these blades conform to Soriano *et al.*'s (2007) technical categories. Approximately a quarter (25.4%, n=15) fall into the initial production stage A, representing fully cortical blades or those with >50% cortex. The majority (71.2%, n=42) fit within the main production phase B. Only 2 (3.4%) blades are classified as core maintenance blades (C category).

The dimensions of Unit F lithic artifacts indicate that flakes have the smallest measurements in terms of length and thickness. In contrast, blades, convergent pieces, and retouched pieces exhibit greater lengths and thickness. These findings suggest that the FLB Unit F lithic assemblage reflects a technology oriented towards the production of relatively large lithic specimens. Refer to Table 18 for specific measurements.

Table 17: FLB Unit F assemblage composition.

<b>Assemblage Composition</b>	<b>n</b>	<b>%</b>
Complete flakes	109	12.5%
Flake fragments	422	48.3%
Blade/ blade fragments and bladelets	59	6.8%
Convergent pieces	79	9.0%
Retouched pieces	35	4.0%
Cores	13	1.5%
Cobbles	9	1.0%
Hammerstone	1	0.1%
Debris/shatter	145	16.6%
Small nodules/pebbles	2	0.2%
<b>Total</b>	<b>874</b>	<b>100.0%</b>

Table 18: Mean dimensions (mm) and mass (g) for FLB Unit F complete blanks and retouched pieces. Standard deviations in parentheses.

<b>Blanks</b>	<b>n</b>	<b>Technological length</b>	<b>Technological width</b>	<b>Maximum thickness</b>
Flakes	109	36.1 (17.9)	25.8 (12.0)	6.4 (4.2)
Blades	30	54.4 (19.9)	16.5 (6.0)	7.4 (3.2)
Convergent pieces	65	50.3 (18.6)	25.7 (11.8)	6.7 (3.4)
Retouched pieces	11	52.7 (10.4)	24.8 (13.7)	7.3 (2.3)

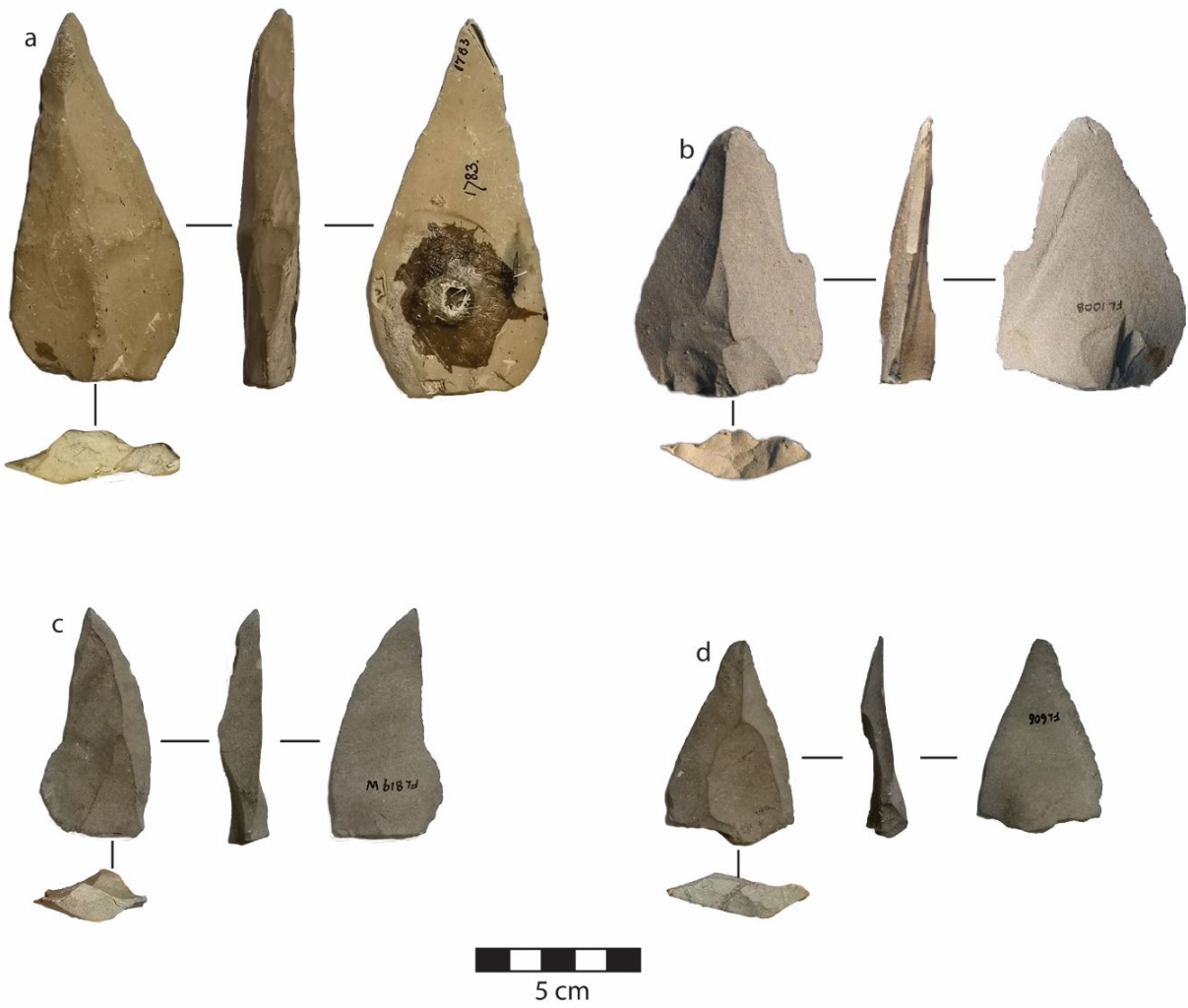


Figure 20: FLB Unit F hornfels convergent pieces; (a) #1783, (b) #1008, (c) #819, (d) #606



Figure 21: FLB Unit F hornfels blades; (a) #142, (b) #1924, (c) #474, (d) #445, and (e) #1046

### 6.3.2 Raw material exploitation

The dominant raw material found in Unit F is hornfels, accounting for 99.6% (n=870) of the assemblage. Hornfels is available in various colors, ranging from light to dark gray. Within Unit F, some hornfels lithic artifacts exhibit a patina characterized by a light gray color, typical of raw materials found in springs where oxidation is accompanied by hydration. Furthermore, certain

pieces are friable due to inadequate preservation. These phenomena were previously observed by Kuman (1989) and Brenner (2019).

Only a small number of artifacts in the assemblage are made from materials other than hornfels. Specifically, there are 2 (0.2%) small pebbles made of quartz and 2 (0.2%) flake fragments made of quartzite. Kuman (1989) described the raw material in her sample as predominantly hornfels, including two dolerite stone balls. Henderson (2001) exclusively reports on hornfels lithic artifacts, while Brenner (2019) similarly identifies hornfels as the primary raw material, with only a few artifacts made from quartzite, shale, dolerite, quartz, and sandstone. The dominant raw material, hornfels, is abundant in the immediate vicinity of the FLB site, and Kuman (1989) suggests that it may have been extracted from the layered outcrops or the scattered debris surrounding FLB.

### **6.3.3 Lithic reduction**

#### ***6.3.3.1 Knapping technique***

One hammerstone and three cobbles with clearly visible percussion pitting were recovered from the Unit F analyzed assemblage. Moreover, within the analyzed collection, 86.6% (n=350) of the knapped lithic artifacts, comprising complete and proximal pieces, exhibit ring cracks at impact points, prominent bulbs with visible Hertzian cones, and an absence of lipping. These characteristics indicate the use of a hard hammer, direct percussion. In the samples examined by Kuman (1989) and Henderson (2001), they noted the presence of one hammerstone each but did not make specific inferences regarding percussion techniques. However, Brenner (2019) described

the presence of hammerstones and inferred the use of the hard hammer, direct percussion technique.

### 6.3.3.2 Core types

The Unit F assemblage analyzed in this study comprises 13 cores. Previous studies, such as Kuman (1989), identified 10 cores from the MSA horizon layer, while Henderson (2001) identified 63 cores. Further research conducted by Brenner (2019) revealed the presence of 75 cores from both Unit F and Henderson’s MSA excavation. For this study, only lithic artifacts from Kuman and Clarke’s Unit F excavations were sampled, explaining the relatively low number of cores analyzed. Additionally, differences in the typo-technological classifications used in this study compared to Kuman’s (1989) may have resulted in variations in the core samples.

The 13 analyzed cores are categorized as follows: 5 (38.5%) recurrent Levallois cores, 4 (30.7%) prismatic blade cores, 3 (23.1%) cores-on-flakes, and 1 (7.7%) indeterminate core fragment (see Table 19). The recurrent Levallois cores and the prismatic blade cores are in an exhaustive state. Cores-on-flakes refer to flakes that exhibit evidence of further use or reduction as core blanks.

*Table 19: FLB MSA Horizon core types.*

<b>Core type</b>	<b>n</b>	<b>%</b>
Recurrent unidirectional Levallois	3	23.1%
Recurrent bidirectional Levallois	1	7.7%
Recurrent centripetal Levallois	1	7.7%
Prismatic blade cores	4	30.7%
Core-on-flakes	3	23.1%
Core fragment	1	7.7%
<b>Total</b>	<b>13</b>	<b>100%</b>

### ***6.3.3.3 Core reduction***

The presence of decortication blanks with >50% cortex (1.8%, n=16) and non-cortical pieces suggests that both early and late reduction stages are evident at FLB. Cortex was also identified on three cores, with the outcrop cortex predominant. This implies that knapping took place at the site, and cores might have been brought primarily unknapped or minimally worked due to minimal transportation costs, given the local availability of hornfels. Moreover, the presence of flaking debris or shatter (16.6%, n=145) further supports on-site knapping.

### ***6.3.3.4 Striking platform preparation and dimensions***

Prepared platforms, indicating the Levallois technique at FLB, are visible within the blank assemblage, with 55.4% (n=224) exhibiting facets. Among these, the majority also show a visible negative bulb of percussion (63.4%, n=142/224), while 36.6% (n=82/224) display residual facets without bulbs of percussion. The striking platforms of the Unit F Levallois cores also exhibit significant preparation near the platforms of negative flake scars. In terms of platform measurements, external platform angle (EPA) exhibits relatively consistent values across all blank types and retouched pieces, with mean values ranging from 77° to 79°. Platform thickness shows the least variation, with means ranging from 4.8 to 5.7 mm. Platform width displays significant variation, with convergent and retouched pieces featuring wider platforms (mean, 22.5 and 20.7 mm, respectively) compared to flakes and blades, which have mean widths of 16.0 and 12.0 mm, respectively.

### 6.3.3.5 Core exploitation, and maintenance

Flakes and convergent pieces at FLB were primarily produced from recurrent Levallois cores. Within this technique, three variants are observed based on the pattern of core exploitation: frequently unidirectional, less commonly bidirectional, and centripetal exploitation. This is supported by Levallois flakes and convergent pieces, predominantly exhibiting unidirectional dorsal scar patterns (87.2%, n=327), with only 12.3% (n=46) showing bidirectional patterns and 0.5% (n=2) displaying centripetal dorsal scar patterns. Aris orientation shows both parallel (55.0%) and convergent (45.0%) dorsal scar patterns. *Débordant* flakes were employed to maintain the dorsal convexities of Levallois cores.

On the other hand, blades were primarily produced from prismatic blade cores using parallel unidirectional reduction. This is also confirmed by the presence of hinge terminations on the distal part (60.3%) of the blades, along with parallel dorsal scar patterns coming from one direction. Moreover, blades resulting from this reduction method display distinct flat profiles, particularly in the distal part, a characteristic shared by most FLB blades. These features were also observed by Brenner (2019). In general, Unit F blanks predominantly exhibit flat profiles (62.9%), with fewer displaying curved (31.4%) and twisted ones (5.7%). The few core maintenance blades (3.4%) in the analyzed assemblage were likely used for maintaining blade cores.

A small number of flakes (23.1%, n=3) from Unit F exhibit secondary reduction on their ventral faces and were employed to produce bladelets using the burination technique. Bladelets at FLB display hinge terminations as well as curved and flat profiles, confirming the use of this method.

Initially identified by Brenner (2019) at FLB, the application of burination to core-on-flakes was interpreted as a form of recycling. This could be seen as a way to maximize the use of good-quality raw materials despite proximity.

#### **6.3.4 Retouched pieces**

Low frequencies of retouched pieces are observed at FLB, accounting for 4.0% (n=35) of the total assemblage composition. Both blades and flakes serve as blanks for these retouched pieces. The represented categories include retouched convergent pieces (8.6%), minimally retouched pieces (51.4%), notched pieces (5.7%), side scrapers (17.2%), end scrapers (11.4%), and double scrapers (5.7%).

#### **6.4 ≠Gi**

≠Gi, an open-air site located 900 km northwest of GHN, within the Kalahari Basin, is the fourth site studied for comparative purposes. As outlined in the methods chapter, unlike the other sites in this study, only pointed artifacts from the ≠Gi, Unit 4 MSA horizon (~77 ka) were subject to analysis. This focus was necessitated by the mixed nature of the assemblage resulting from curatorial problems or improper storage, impacting all artifact classes except for the separately stored and better-curated pointed pieces (A.S. Brooks, *pers. comm*). Therefore, this section will exclusively discuss the technological characteristics of the ≠Gi pointed pieces.

#### **6.4.1 Assemblage composition**

The ≠Gi pointed pieces were classified into retouched (70.3%, n=320) and unretouched (29.7%, n=135) convergent pieces. These were made on various raw materials, including chalcedony (76.9%, n=350), quartzite (6.8%, n=31), silcrete (5.5%, n=25), quartz (4.8%, n=22), chert (4.6%, n=21), and chalcedonic black chert (1.3%, n=6). The ≠Gi convergent pieces are notably smaller compared to typical MSA points, as previously observed by Brooks *et al.* (2006) and Lombard and Churchill (2022). The mean technological length for retouched convergent pieces is 37.9 mm, while it is 36.3 mm for unretouched ones. The technological width measures 28.4 mm for retouched convergent pieces and 27.2 mm for unretouched ones. The mean thickness for both retouched and unretouched convergent pieces is 9.8 mm and 10.1 mm, respectively, further supporting the observation that ≠Gi MSA convergent pieces tend to be relatively smaller than typical MSA points. The smaller dimensions of ≠Gi convergent pieces are argued to be consistent with the use of the discoidal method (see Brooks *et al.*, 2006).

#### **6.4.2 Striking platforms characteristics**

The majority (70.3%) of ≠Gi convergent pieces exhibit striking platforms and bulbs of percussion, often positioned at the corner as opposed to the center of the proximal portion (see Figure 22). This characteristic was also observed by Brooks *et al.* (2006), who inferred the use of the discoidal method of manufacture instead of the Levallois technique. Both plain (44.8%) and prepared (55.2%) platforms are evident. However, platforms for retouched pieces are primarily modified with retouch, resulting in thinner (mean 6.2 mm) and narrower platforms (mean 13.3 mm)

compared to unretouched ones, with a mean platform width and thickness of 15.9 mm and 6.8 mm, respectively.

### **6.4.3 Exploitation mode**

To support the observation of the use of the discoidal method, the results of this study's analysis of  $\neq$ Gi convergent pieces indicate that their dorsal scar patterns seldom extend beyond the center of the lithic pieces, which is one of the characteristics of the discoid defined by Chazan (2020). The dorsal scar patterns observed on  $\neq$ Gi convergent pieces demonstrate three main exploitation modes: unidirectional, bidirectional, and centripetal. Additionally, axis orientation shows that these convergent pieces exhibit more convergent (68.9%) dorsal scar patterns than parallel ones (39.1%). The reduction system employed for  $\neq$ Gi convergent pieces is primarily focused on the production of pieces with flat profiles (63.6%), while curved profiles (28.6%) and twisted profiles (5.7%) are less common.

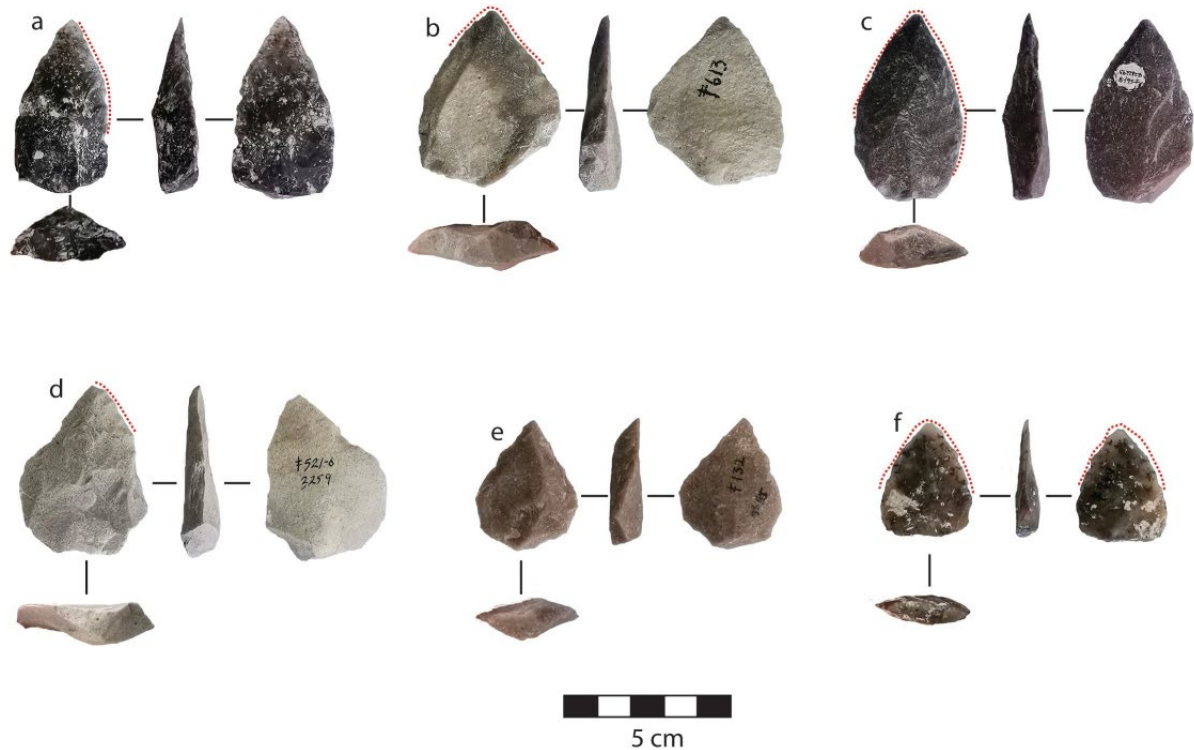


Figure 22: ≠Gi convergent pieces; (a-d) unifacial retouched pieces (a #253=chalcedonic black chert, b #163=silcrete, c #2293=quartzite, d #3259=silcrete), (e) unretouched piece (#132=quartzite) and (f) bifacial retouched piece (#740=chalcedonic black chert). Pieces c, d and f have platforms situated in the corner of the proximal part. Red dots indicate retouch.

#### 6.4.4 Retouched pieces

The retouched piece category of ≠Gi convergent pieces is predominantly comprised of unifacial pieces (63.8%, n=204), followed by partly bifacial pieces (12.5%, n=40) and bifacial pieces (23.7%, n=76). The most common type of retouch is marginal edge shaping (97.8%, n=313), while invasive retouch is less common (2.2%, n=7).

## 6.5 White Paintings Rockshelter (WPS)

### 6.5.1 WPS Unit 10 lithic assemblage composition

WPS Rockshelter, situated 1300 km northwest of GHN within the Kalahari Basin, is the fifth site studied for comparative purposes. The WPS Unit 10 (~94 ka) lithic assemblage represents a reduction primarily focused on flake production, with some convergent pieces and blades. Flakes constitute the vast majority of the assemblage (56.5%, n=235). Convergent pieces account for 17.5% (n=73), while blades are relatively scarce at 1.7% (n=7; Table 20). Although the frequency of blades is low, one blade with >50% cortex from the initial stage was observed. Five blades are non-cortical with unidirectional and bidirectional scars, and only one blade can be attributed to core maintenance.

Retouched pieces, including minimally retouched pieces, retouched points, and scrapers, make up 3.4% (n=14) of the analyzed sample. Cores represent 1.0% (n=4) of the total analyzed assemblage. Debris or shatter accounts for 19.7% (n=82), and one hammerstone is present, constituting 0.2% of the assemblage (Figure 23). In terms of metric dimensions, flakes, convergent pieces, and retouched pieces, display comparable measurements while blades are longer and narrower (Table 21).

Table 20: WPS assemblage composition.

<b>Assemblage Composition</b>	<b>n</b>	<b>%</b>
Complete flakes	50	12.0%
Flake fragments	185	44.5%
Blade/blade fragments	7	1.7%
Convergent pieces	73	17.5%
Retouched pieces	14	3.4%
Cores	4	1.0%
Hammerstone	1	0.2%
Debris/shatter	82	19.7%
<b>Total</b>	<b>416</b>	<b>100.0%</b>

Table 21: Mean dimensions (mm) and mass (g) for WPS complete blanks and retouched pieces. Standard deviations in parentheses.

<b>Blanks</b>	<b>n</b>	<b>Technological length</b>	<b>Technological width</b>	<b>Maximum thickness</b>
Complete flakes	50	31.1 (10.9)	25.8 (10.3)	6.0 (3.1)
Blades	4	38.9 (11.7)	17.1 (4.7)	6.1 (2.0)
Convergent pieces	30	33.7 (5.9)	24.5 (6.7)	6.8 (2.0)
Retouched pieces	8	33.2 (2.5)	24.7 (2.5)	7.1 (0.4)



Figure 23: WPS lithic artifacts; (a) #w121 side scraper (chalcedony), (b) #w21 convergent piece (quartzite), (c) #22 retouched convergent piece (chalcedony), (d) #w33 convergent piece (chalcedony), (e) #w54 convergent piece (chalcedonic black chert) and (f) convergent piece (chalcedony). Red dots indicate retouch.

### 6.5.2 Raw material exploitation

The WPS Unit 10 lithic assemblage predominantly comprises various raw materials, with chalcedony representing 25.7% (n=107), followed by silcrete (27.2%, n=113), chalcedonic black chert (20.0%, n=83), chert (13.0%, n=54), and quartz (11.5%, n=48). There are a few artifacts made from other raw materials such as quartzite and jasper (2.6%, n=11). All these raw materials are present in the blank assemblage, but only chalcedonic black chert, quartz, and chert are represented in the core sub-assemblage (Table 22).

Except for quartz and quartzite, other materials such as silcrete, chalcedony, chert, and jasper are not found in the immediate vicinity of the WPS site. For instance, silcrete is considered exotic to WPS but is found within the Botswana expanse of the Kalahari at locations such as Lake Ngami and the Boteti River in the southeast of Tsodilo. It is also observed at MSA sites, such as Kudiakamp (see Nash *et al.*, 2016; Robbins *et al.*, 2000). Despite being considered exotic to WPS, silcrete is still found within the Kalahari Basin. The exact sources of other raw materials are unknown, but they are confirmed to be within the Kalahari Basin (see Nash *et al.*, 2016; Robbins *et al.*, 2000). Further, in-depth research on the sources of raw materials at WPS is required.

Table 22: WPS assemblage composition by raw material type.

<b>Raw Materials</b>	<b>n</b>	<b>%</b>
<b>Chalcedony</b>	<b>107</b>	<b>25.7%</b>
Complete flakes	14	13.1%
Flake fragments	41	38.3%
Blade/blade fragments	2	1.9%
Convergent pieces	29	27.1%
Retouched pieces	10	9.3%
Debris/shatter	11	10.3%
<b>Chalcedonic black chert</b>	<b>83</b>	<b>20.0%</b>
Complete flakes	7	8.4%
Flake fragments	40	48.2%
Convergent pieces	10	12.1%
Blade/blade fragments	1	1.2%
Cores	1	1.2%
Retouched pieces	4	4.8%
Debris/shatter	20	24.1%
<b>Silcrete</b>	<b>113</b>	<b>27.2%</b>
Complete flakes	19	16.8%
Flake fragments	51	45.1%
Blade/blade fragments	2	1.8%
Convergent pieces	15	13.3%
Hammerstone	1	0.9%
Debris/shatter	25	22.1%
<b>Chert</b>	<b>54</b>	<b>13.0%</b>
Complete flakes	7	13.0%
Flake fragments	25	46.3%
Blade/blade fragments	1	1.9%
Convergent pieces	6	11.1%
Cores	2	3.7%
Debris/shatter	13	24.1%
<b>Quartz</b>	<b>48</b>	<b>11.5%</b>
Complete flakes	3	6.3%
Flake fragments	24	50.0%
Convergent pieces	10	20.8%
Cores	1	2.1%
Debris/shatter	10	20.8%
<b>Other (quartzite and jasper)</b>	<b>11</b>	<b>2.6%</b>
Flake fragments	4	36.4%
Convergent pieces	3	27.3%
Blade/blade fragment	1	9.1%
Debris/shatter	3	27.3%
<b>Total</b>	<b>416</b>	<b>100.0%</b>

### **6.5.3 Lithic reduction**

#### ***6.5.3.1 Knapping technique***

Only one hammerstone with clear percussion pitting was found in the WPS Unit 10 assemblage. Furthermore, 77.5% (n=86) of complete knapped lithics and proximal parts display prominent bulbs, rounded impact points, and an absence of lipping for all types of raw materials. Therefore, the predominant percussion technique employed is hard hammer, direct percussion.

#### ***6.5.3.2 Core reduction***

All stages of reduction are present at WPS based on the presence of lithic artifacts with >50% cortex (6.4%) and non-cortical knapped lithic artifacts (93.6%). However, the relatively low percentage of cortical blanks suggests that the raw materials used at WPS may have been partially worked before being brought to the site due to transport cost considerations, given that the predominance of raw materials used is not in the immediate vicinity (>10 km) but still found within the Kalahari Basin. Materials transported over long distances need to be prepared to be smaller and lighter compared to those readily available nearby (see Kuhn, 1994). In addition, debris and shatter, accounting for 19.7% (n=82) of the analyzed assemblage, provide evidence for on-site knapping.

### 6.5.3.3 Striking platform preparation and dimensions

Prepared platforms dominate the Unit 10 blank assemblage, constituting 56.9% (n=66) of platforms with facets. Among them, the majority (53.0%, n=35) are faceted and display a visible negative bulb of percussion, while 47.0% (n=31) exhibit residual facets without bulbs of percussion. In addition, two Levallois cores, demonstrating significant preparation, are present. In terms of platform measurements, flakes, convergent, and retouched pieces have wide and thick platforms, while blades exhibit narrow and thin ones. External platform angles (EPA) show similar mean values across all blanks and retouched pieces (Table 23).

Table 23: WPS mean platform dimensions (mm). Standard deviation in parentheses. EPA = External Platform Angle, and 'n' includes complete pieces and proximal parts.

Blanks	n	Platform width	Platform thickness	EPA
Flakes	72	13.3 (6.8)	5.6 (2.8)	79° (4.1)
Blades	6	10.5 (1.8)	4.3 (1.2)	77° (3.8)
Convergent pieces	30	14.8 (6.5)	6.2 (2.5)	77° (4.4)
Retouched pieces	8	15.2 (8.9)	8.1 (2.1)	79° (2.1)

### 6.5.3.4 Core exploitation

Only four cores were recovered from the analyzed assemblage at WPS, comprising two Levallois cores, one blade core, and one indeterminate core fragment. The Levallois cores and the blade core are in an exhausted state, possibly reflecting a strategy to maximize the use of raw materials found at a distance from WPS. In addition, the consideration that most raw materials used at WPS are exotic may explain the relatively low frequency of cores, suggesting that most cores were likely depleted as a means of maximizing raw material use. The two Levallois cores exhibit recurrent

unidirectional and bidirectional exploitation modes, with a significant proportion of the end products displaying unidirectional (65.5%) and bidirectional (35.5%) dorsal scar patterns.

The non-Levallois blade core shows parallel, unidirectional reduction. Aris orientation on shows parallel (63.2%) and convergent (36.8%) scar patterns. The reduction process primarily focused on producing flat profiles (67.3%), with lesser frequencies of curved (25.7%) and twisted (7.0%) profiles. The presence of *débordant* flakes indicates maintenance of the lateral convexity of the Levallois cores.

#### 6.5.4 Retouched pieces

Retouched pieces are infrequent, comprising only 3.4% (n=14) of the assemblage. This category includes retouched convergent pieces, side scrapers, and minimally retouched pieces (Table 24). The retouching technique is predominantly invasive and marginal edge shaping.

*Table 24: Frequency of retouched piece types in the WPS assemblage.*

<b>Retouched pieces</b>	<b>n</b>	<b>%</b>
Retouched convergent pieces	4	28.6%
Minimally retouched pieces	5	35.7%
Side scrapers	3	21.4%
Miscellaneous and broken fragments	2	14.3%
<b>Total</b>	<b>14</b>	<b>100.0%</b>

## **CHAPTER SEVEN: BEHAVIORAL APPROACH TO CULTURAL TRANSMISSION: INTER-SITE COMPARISONS**

To investigate the potential social transmission of cultural information among various early human groups inhabiting discrete MIS 5 sites in the Kalahari and its environs, an inter-assemblage comparison is crucial. This chapter presents detailed results of the inter-assemblage comparison between GHN and sites in and around the Kalahari selected for comparative purposes, including KP6, EFK, FLB, ≠Gi, and WPS. The chapter builds upon the data presented in Chapters Five and Six, focusing on lithic technological behaviors and patterns observed at the aforementioned sites.

To reiterate, the comparative approach used in this study follows Tostevin's (2012) behavioral approach to cultural transmission. This method involves statistical comparisons across five stages of lithic artifact production, referred to as "domains". These domains include core modification, platform maintenance, direction of core exploitation, dorsal convexity system, and retouched toolkit morphology, as detailed in the methods chapter.

In addition to qualitatively describing similarities and differences among the studied assemblages, the comparative approach assesses the nature and strength of similarities within each domain, as determined by pairwise two-sample (*t*-test) and chi-square ( $\chi^2$ ) tests. The data from the statistical comparisons, detailing homogeneity and heterogeneity within the domains, are used in the next chapter to infer the presence and extent of technological information exchange across these regions. Similarities in domains across sites suggest that hunter-gatherers were using similar techniques in stone tool manufacture, indicating some form of information exchange. Conversely, the lack of similarities indicates the use of different techniques and lithic reduction methods hence

possible fragmentation. The subsequent sections provide the results of the pairwise statistical comparison within each domain of stone tool production. A summarized version of the comparative analysis results is displayed in Figure 24, and detailed results with chi-square ( $\chi^2$ ), and  $p$ -values are further provided in Table 25 at the end of this chapter.

## **7.1 Domain 1: Core modification**

### **7.1.1 Raw material exploitation**

Statistical analysis was not applied to the lithic attributes in domain one due to its interpretive and observational nature. The core modification domain encompasses attributes derived from qualitative observations, such as raw material exploitation. Inter-site comparisons revealed a predominant use of locally available resources (within a  $\leq 10$  km radius) across the studied sites except for WPS. Source attributions for these sites are mainly drawn from published data and from additional surveys in which I participated. Most of these attributions lack geochemical provenance, except for data from Nash *et al.* (2016) on #Gi and WPS silcrete, representing one of the limitations of raw material source comparisons.

At GHN, the predominant raw materials, including banded ironstone, chalcedonic black chert, and tuff, are all accessible within a 10 km radius (Wilkins *et al.*, 2020). Similarly, at KP6, banded ironstone and chalcedonic black chert are found within a 10 km radius (Wilkins, 2017). EFK and FLB primarily utilize locally sourced hornfels in their assemblages. At #Gi, Brooks *et al.* (2006) report the presence of chert, jasper, chalcedony, quartz, and quartzite in nearby outcrops, while Nash *et al.* (2016) highlight that silcrete was obtained from quarries near Lake Ngami and the

Boteti River in the Kalahari. For WPS, most of the raw materials, such as chert, jasper, chalcedony, quartz, quartzite, and silcrete, are not found within a 10 km radius of the WPS site, as indicated by Robbins *et al.* (2000). However, research by Nash *et al.* (2016) demonstrates that these materials are available within the Kalahari Basin. Thomas *et al.* (2022) highlight the presence of silcrete at numerous sites across the Botswana expanse of the Kalahari, signifying the transportation of raw materials in the Kalahari basin.

The inter-assemblage comparison has revealed a consistent pattern of exploiting fine-grained, high-quality raw materials that enable the production of tools with sharp and durable edges across all sites. GHN and KP6 exhibited a preference for excellent-quality banded ironstone and chalcedonic black chert, suitable for retouched toolmaking and blade production, as elucidated in Chapters Five and Six. Hornfels, characterized by similar qualities, was utilized at EFK and FLB (see Brenner, 2019; Kuman 1989; Kuman *et al.*, 1999; Wroth *et al.*, 2022). Furthermore, the high-quality nature of raw materials, such as chalcedony, silcrete, quartz, and quartzite used at #Gi and WPS, has been confirmed by earlier researchers (see Nash *et al.*, 2016; Thomas *et al.*, 2022; Robbins *et al.*, 2000).

In addition, the tendency to maximize and conserve raw materials, even when found nearby, is observed across most studied sites. As detailed in Chapter Five, GHN shows a deliberate effort to conserve high-quality homogeneous banded ironstone and chalcedonic black chert due to extraction costs. This is evident in the heavily reduced cores and blade cores, later transformed into flake cores in the reduction sequence. FLB also demonstrates raw material conservation by

using flakes as cores, as indicated by the presence of cores-on-flakes, a practice suggested for recycling (Brenner, 2019) possibly aimed at maximizing resource use. At WPS, raw materials were conserved due to their absence in the immediate vicinity of the site. At KP6, cores are in an exhaustive state, and EFK's assemblage lacked any cores, possibly indicating depletion. However, attributing this conclusively to raw material constraints is challenging at this stage. The #Gi assemblage comprises only convergent pieces, making it difficult to argue for any conservation of raw materials.

### **7.1.2 Knapping technique**

The comparative analysis results indicate that, in most MIS 5 assemblages studied, a hard hammer direct percussion technique was employed, except at the KP6 site. The application of this technique at GHN, EFK, FLB, #Gi, and WPS is inferred from knapped lithic artifacts displaying noticeable bulbs, impact points, and the absence of lipping. Additionally, GHN, FLB, and WPS show hammerstones with percussion pitting in their assemblages, confirming the use of hard hammer percussion. However, an exception is observed at KP6, where the use of soft hammer percussion is evident. This is substantiated by knapped lithics exhibiting tiny oval lipped striking platforms.

### **7.1.3 Core preparation**

Inter-assemblage comparisons indicate that all stages of reduction are present at GHN, KP6, EFK, FLB, and WPS. Raw materials were brought in unprepared or partially worked, with evidence of on-site knapping demonstrated by the presence of debris or shatter, along with knapped lithics retaining >50% cortex in all the aforementioned assemblages. Cores were prepared at these sites,

as evidenced by the presence of decortication blanks. However, determining this in the case of ≠Gi is challenging, as the analyzed assemblage consists solely of convergent pieces.

#### **7.1.4 Core reduction strategy**

The preferred core reduction strategies are quite similar across all sites. GHN, EFK, FLB, and WPS primarily employ the Levallois method, with other non-Levallois techniques also observed. Within the Levallois methods, recurrent is the dominant strategy at GHN, EFK, and FLB, with unidirectional exploitation being the most common, followed by bidirectional and centripetal, though less frequently. At WPS, only recurrent unidirectional and bidirectional Levallois methods are evident, with no sign of centripetal methods.

Non-Levallois methods are also present at GHN, as evidenced by platform cores reduced using parallel unidirectional reduction. At FLB, parallel unidirectional reduction occurs in blade production, and burination on core-on-flakes is evident in bladelet production. WPS has one blade core exhibiting parallel unidirectional reduction. For KP6, there is no evidence of the Levallois method, as platforms of knapped products are mainly plain, and blade production occurs on cores reduced using parallel unidirectional and unidirectional convergent methods. At ≠Gi the discoidal technology may have been used over the Levallois method.

### **7.1.5 Core maintenance**

Similar core maintenance strategies exist across most studied sites, except for KP6. At GHN, EFK, FLB, and WPS, *débordant* flakes are primarily used to maintain the lateral convexities of the cores, although core-maintenance blades are also observed. However, at KP6, there is no evidence of the Levallois method, and *débordant* flakes are absent. Instead, blade cores are maintained using core maintenance blades and flakes. Determining core maintenance strategies at ≠Gi is challenging as the assemblage consists exclusively of convergent pieces.

## **7.2 Domain 2: Platform maintenance**

The platform maintenance domain consists of attributes based on quantitative observations, namely platform preparation, width, thickness, and exterior platform angle (EPA). These attributes were compared using a pairwise chi-square ( $\chi^2$ ) test of association for platform maintenance and a two-sample paired (*t*-test) for platform width, thickness, and EPA.

### **7.2.1 Striking platform preparation**

Pairwise chi-square ( $\chi^2$ ) tests between GHN and the studied sites in and around the Kalahari indicate no significant difference in platform preparation across all sites, except for KP6. Striking platforms at GHN, EFK, FLB, and WPS show a high investment in preparation through faceting. Prepared platforms dominate the GHN DBSR (50.2%), EFK Lower F, lower gray (61.7%), FLB Unit F (55.4%), and WPS Unit 10 (56.9%) assemblages. ≠Gi striking platforms exhibit indications of preparation and modification, with striking platforms and bulbs of percussion oriented towards

the corner as opposed to the center of the proximal portion. Nevertheless, a statistical comparison for platform preparation reveals no significant difference between GHN and ≠Gi (see Table 25 for  $\chi^2$  and  $p$ -values). Exceptions in platform frequencies are noted at KP6, where 97.8% are plain, oval-shaped, and lipped, representing a distinctive style that sets KP6 apart from other examined MIS 5 assemblages. A pairwise chi-square ( $\chi^2$ ) test between GHN and KP6 platform frequencies indicates a significant difference between the two samples (see Table 25 for  $p$ -values).

### **7.2.2 Platform thickness**

A two-sample paired test ( $t$ -test) was employed to examine differences in mean platform thickness between GHN and other studied sites. The results show that, excluding KP6, there are no significant differences in platform thickness across the analyzed sites. The platforms of blanks at GHN, EFK, FLB, ≠Gi, and WPS are comparatively thicker than those at KP6, ranging from a mean of 5.4 to 7.1 mm. Additional two-sample paired tests between GHN and the aforementioned sites reveal no significant variation in platform thickness. KP6 is a notable exception, exhibiting very thin platforms (mean=3.6 mm). When comparing GHN with KP6, a significant difference in platform thickness between the two sites was observed (see Table 25 for  $p$ -values).

### **7.2.3 Platform width**

GHN, EFK, FLB, and WPS exhibit moderately wide platforms, with means ranging from 13.2 to 18.2 mm, in contrast to those from KP6 and ≠Gi. Results from the two-sample paired  $t$ -test indicate that the platform width means are not significantly different between GHN and comparative sites such as EFK, FLB, and WPS. However, the ≠Gi site features blanks with narrow platforms

(mean=13.0 mm), while KP6 platforms are narrower (mean=9.8 mm). The two-sample paired tests comparing GHN with ≠Gi and KP6 show a statistical difference in platform width means.

#### **7.2.4 External platform angle (EPA)**

The mean exterior platform angle (EPA) values for all types of blanks across the studied sites are comparable, except for KP6. GHN, EFK, FLB, ≠Gi, and WPS exhibit very similar acute EPAs, ranging from 76.9° to 77.9°. The two-sample paired *t*-test indicates that the EPA is not significantly different between the aforementioned sites. In contrast, KP6 blanks have a larger acute EPA, with a mean of 78.5°, and the two-sample paired *t*-test reveals a significant difference in EPA between GHN and KP6.

### **7.3 Domain 3: Direction of core exploitation**

The directionality of core exploitation during lithic reduction appears relatively consistent across most of the studied MIS 5 sites, with no significant variation. The primary methods of core exploitation used to produce blanks at GHN are unidirectional, bidirectional, and less commonly centripetal. At FLB, unidirectional exploitation is dominant, while bidirectional and centripetal methods are less common. These patterns are supported by a significant percentage of knapped pieces that exhibit similar exploitation patterns. At KP6, unidirectional exploitation is frequent, and bidirectional is less common. A chi-square ( $\chi^2$ ) test of association between GHN, KP6, and FLB indicates no significant differences. Due to a low sample size for cores (n=4), chi-square ( $\chi^2$ ) comparisons for the direction of exploitation at WPS were not conducted. However, the four WPS cores exhibit both unidirectional and bidirectional exploitation. EFK and ≠Gi do not include

cores; hence, no chi-square ( $\chi^2$ ) comparisons were made for these sites. Nevertheless, knapped pieces at EFK and  $\neq$ Gi exhibit unidirectional, bidirectional, and centripetal exploitation modes.

## **7.4 Domain 4: Dorsal convexity system**

The dorsal convexity domain encompasses attributes derived from quantitative observations, including longitudinal convexity (length-width ratio), vertical convexity (width-thickness ratio), shape convexity (axis orientation), and curvature convexity (profile shape). Blade and unretouched convergent piece frequencies were incorporated into this domain to explore potential variations in their production across the sites. The lithic attributes from domain four were subjected to a two-sample paired (*t*-test) for longitudinal and vertical convexities, and a pairwise chi-square ( $\chi^2$ ) test of association for shape and curvature convexities, as well as blade and unretouched convergent piece frequencies (see Table 25).

### **7.4.1 Technological length-width ratio**

There is no statistically significant variation in longitudinal convexities (length-width ratios) across most studied MIS 5 sites, except for  $\neq$ Gi. The longitudinal convexities exhibit comparable mean values for all blank types and across all sites, ranging from a ratio of 1.3 to 1.5 mm. The two-sample paired (*t*-test) comparison of GHN with KP6, EFK, FLB, and WPS revealed no significant differences (see Table 25). However, a significant difference is observed at  $\neq$ Gi, where retouched convergent pieces or points are markedly smaller than typical MSA points from other studied MIS 5 sites.

### **7.4.2 Technological width-thickness ratio**

Vertical convexities exhibit comparable mean values for GHN, EFK, and WPS, ranging from a ratio of 3.2 to 3.3 mm. A two-sample paired test (*t*-test) indicates no significant difference in technological width-thickness ratios between these sites. However, FLB, ≠Gi, and KP6 exhibit greater variation within the studied samples, with ratios ranging from 3.7 to 4.0 mm. Comparisons between GHN and comparative sites such as FLB, ≠Gi, and KP6 confirm a significant difference in the vertical convexities of these samples (see Table 29).

### **7.4.3 Aris orientation**

Chi-square ( $\chi^2$ ) test of association, reveal that there is no significant difference in convexity shape (aris orientation) across all the studied sites. All the studied MIS 5 assemblages exhibit both parallel and convergent dorsal scar patterns (see Table 25 for  $\chi^2$  and *p*-values).

### **7.4.4 Profile shape**

The curvature of convexity (the profile shape of blanks) can be described qualitatively in three ways: flat, curved, and twisted. Across most studied sites, there are no significant variations in profile shapes, with the exception of KP6. In the GHN, EFK, FLB, ≠Gi, and WPS assemblages, flat profiles are the most common, averaging from 56.2% to 67.3%, compared to curved and twisted profiles. However, at KP6, there is a surge in flat profiles, accounting for 77.0% of the blanks observed. When comparing profile shapes between GHN and the studied sites EFK, FLB, ≠Gi, and WPS using a chi-square ( $\chi^2$ ) test of association, the results indicate that there is no

significant difference. Conversely, the chi-square ( $\chi^2$ ) test between GHN and KP6 indicates a significant difference in the profile shapes of blanks (see Table 25).

#### **7.4.5 Blade frequency**

This section compares the frequency of blades to assess possible variation in their manufacture across the studied sites. The frequency of blade-to-flake products is relatively consistent across all sites, with exceptions observed at FLB and KP6. GHN, EFK, and WPS exhibit very low blade-to-flake frequencies, ranging from 3.0% to 5.0%, while FLB shows a slightly higher blade frequency of 10.0%, along with the presence of bladelets. KP6 stands out with the highest blade frequency at 58.9% and has been classified as an HP assemblage by previous researchers (Beaumont 1990; Lukich *et al.*, 2019) due to the abundance of blades. When comparing blade frequencies between GHN, EFK, and WPS using a chi-square test ( $\chi^2$ ) of association, the results indicate no significant difference. In contrast, the chi-square ( $\chi^2$ ) test between GHN, KP6, and FLB shows a significant difference in blade frequency. The  $\neq$ Gi assemblage was not included in the blade frequency comparison because the sample only included convergent pieces (see Table 25).

#### **7.4.6 Unretouched convergent piece frequency**

Domain four further compares the changes in the production of unretouched convergent pieces relative to other blanks, such as blades, across the MIS 5 sites. Using a chi-square ( $\chi^2$ ) test of association for comparison, the findings reveal that there is no significant difference in the frequency of unretouched convergent piece-to-blade products between GHN, EFK, and FLB. The study notes moderate frequencies of unretouched convergent pieces at these sites, ranging from

57.2% to 66.4%. On the other hand, WPS showed a significant surge (91.3%) in unretouched convergent pieces relative to blades. Conversely, KP6 has a very low frequency (10.0%) of unretouched convergent pieces relative to blades. When comparing GHN with KP6 and WPS, the results indicate a significant difference in the frequency of unretouched convergent pieces. The ≠Gi assemblage was not included in the convergent piece-to-blade frequency comparison as the sample only included convergent pieces (see Table 25).

## **7.5 Domain 5: Retouched toolkit morphology**

### **7.5.1 Retouched piece frequency**

The retouched toolkit is an extension of the choices made during blank production. It consists of tools selected for further modification by toolmakers during the production process. The frequency of retouched pieces in relation to blanks is relatively consistent across most of the MIS 5 sites studied, with one exception being KP6. At GHN, EFK, FLB, and WPS, a small percentage of blanks were later modified into formal tools, making up 4.0% to 6.0% of the calculated frequency of blank-to-retouched pieces. A chi-square ( $\chi^2$ ) test of association comparing the above-mentioned sites indicates that there is no significant difference in formal tool frequency between these sites. A significant decrease in retouched pieces is observed at KP6, evidenced by a lower frequency of blank-to-retouched pieces, which stands at 3.3%. A significant difference was observed when comparing GHN with KP6 retouched tool frequency. The frequency of retouched pieces in relation to blanks was not compared for ≠Gi because the assemblage only includes convergent pieces.

### **7.5.2 Retouched piece typology**

The retouched tools found across all sites are primarily represented by scrapers, minimally retouched pieces, and convergent pieces. However, notches and denticulate tools occasionally appear, at GHN and FLB, but in low numbers. Scrapers are the predominant formal tool type across most sites, except for KP6 and WPS. Results from the chi-square ( $\chi^2$ ) test of association show no significant variation in retouched piece typology between GHN and FLB. At KP6, there are no scrapers, and at WPS, convergent pieces are more prevalent than scrapers. Thus, when comparing GHN with KP6 and WPS using the chi-square ( $\chi^2$ ) test, a significant difference was found. Retouched pieces from EFK were not subjected to statistical analysis due to the low sample size (n=4). The ≠Gi assemblage was not included in the retouched piece typology comparison because the sample only contained convergent pieces (see Table 25).

### **7.5.3 Retouch type**

The retouch type is primarily limited to marginal and invasive edge shaping across all sites, with notch denticulate present only at GHN and FLB. The chi-square ( $\chi^2$ ) test of association shows no significant difference in retouch type across most sites, except for ≠Gi. However, the comparison between GHN and ≠Gi indicates a significant difference in retouch type, with ≠Gi retouched convergent pieces showing mostly bifacial modifications. Retouched pieces from EFK were not statistically analyzed due to the low sample size (n=4).

#### **7.5.4 Retouch angle**

Across all the MIS 5 sites studied, there is no variation in the retouch angles. The retouch angles are stepped on acute angles, with mean values ranging from 64.9° to 66.5°. The results of a two-sample paired test comparing GHN with KP6, EFK, FLB, ≠Gi, and WPS indicate that there is no significant difference in retouch angles among these sites.

Table 25: Detailed inter-site comparison results of GHN and nearby studied sites in and around the Kalahari Basin. For the chi-square ( $\chi^2$ ) test, the chi-square ( $\chi^2$ ) value or Fishers exact (for 2x2 cross-tabulation), degrees of freedom (df), and probability (p) values are reported. For the two-sample paired test (t-test), the mean, standard deviation (s.d.), t-test, degree of freedom (df), and probability (p) values are reported. A p-value of 0.05 is used to denote significance. Additionally, the significance level of 0.05 was corrected using the Bonferroni method, ensuring that each individual test maintained a corrected significance threshold appropriate for controlling the overall errors. Variations in lithic attributes contribute to a calculated overall difference, which is utilized to assess and ascertain the distinctions in lithic technological behaviors between GHN and its environs. Boxes highlighted in yellow indicate lithic attributes where a significant difference was identified.

Lithic reduction by domain	Ga-Mohana (GHN) DBSR, ~ 105 ka	Kathu Pan 6 (KP6) Bed 9, ~ 74 ka	Erfkroon (EFK) Lower F, ~ 99 ka	Florisbad (FLB) Unit F, ~ 121 ka	≠Gi Unit 4, ~ 77 ka	White paintings site (WPS) Unit 10, ~ 94 ka
Distance from GHN	--	45 km	330 km	341 km	900 km	1300 km
<b>Domain 1: Core Modification</b>						
Raw material exploitation local vs non-local	100% Local	100% Local	100% Local	100% Local	100% Local	80% found in distances >10 km but within the Kalahari Basin
Knapping technique (Hammer type)	Hard hammer percussion	Soft hammer percussion	Hard hammer percussion	Hard hammer percussion	Hard hammer percussion	Hard hammer percussion
Core preparation	Decortication flakes	Decortication flakes	Decortication flakes	Decortication flakes	Sample analyzed include convergent pieces only	Decortication flakes
Core reduction strategy	Levallois and Non-Levallois	Non-Levallois	Levallois	Levallois and Non-Levallois	Discooidal	Levallois and Non-Levallois
Core maintenance	Débordant flakes	Core maintenance blades and flakes	Débordant flakes	Débordant flakes	Sample analyzed include convergent pieces only	Débordant flakes
Number of differences/ 4 steps	0/5=0	2/5=0.4	0/5=0	0/5=0	1/3=0.3	0/5=0
<b>Domain 2: Platform Maintenance</b>						
Platform preparation	n=613 Faceted with bulb=33.1% Residual facet without bulb= 17.1% Not prepared = 49.8%	n=225 Faceted with bulb=0% Residual facet without bulb=2.2% Not prepared =97.8% $\chi^2=14.974$ <b>p=0.001</b> df=2	n=133 Faceted with bulb=35.0% Residual facet without bulb=26.7% Not prepared =38.3% $\chi^2=5.087$ <b>p=0.079</b> df=2	n=404 Faceted with bulb=35.1% Residual facet without bulb=20.3% Not prepared =44.6% $\chi^2=3.007$ <b>p=0.222</b> df=2	n=279 Faceted with bulb=35.1% Residual facet without bulb=20.1% Not prepared =44.8% $\chi^2=2.125$ <b>p=0.346</b> df=2	n=116 Faceted with bulb=30.7% Residual facet without bulb=26.2% Not prepared =43.1% $\chi^2=5.245$ <b>p=0.073</b> df=2
Platform thickness	n=614 Mean =5.8 S.d.=3.0	n=199 Mean=3.6 S.d.=2.0 t=2.817 <b>p=0.005</b> df=811	n=75 Mean=7.1 S.d.=3.0 t=0.992 <b>p=0.322</b> df=687	n=409 Mean=5.2 S.d.=3.0 t=1.137 <b>p=0.256</b> df=1021	n=281 Mean=6.6 S.d.=3.1 t=1.049 <b>p=0.294</b> df=893	n=112 Mean=5.4 S.d.=2.6 t=0.384 <b>p=0.701</b> df=724
Platform width	n=559 Mean=15.5 S.d.=6.1	n=184 Mean=9.8 S.d.=4.8	n=74 Mean=18.2 S.d.=8.6	n=383 Mean=16.0 S.d.=9.6	n=278 Mean=13.0 S.d.=8.6	n=109 Mean=13.2 S.d.=6.6

		t=2.947 p=0.003 df=741	t=0.866 p=0.387 df=631	t=0.334 p=0.739 df=940	t=2.204 p=0.028 df=835	t=0.913 p=0.361 df=666
External platform angle (EPA)	n=614 Mean =77.4° S.d.=5.6	n=199 Mean =78.5° S.d.=4.6 t=2.407 p=0.006 df=811	n=75 Mean =77.9° S.d.=6.3 t=0.729 p=0.466 df=687	n=409 Mean =77.9° S.d.=6.0 t=1.259 p=0.208 df=1021	n=281 Mean =76.9° S.d.=3.9 t=1.419 p=0.156 df=893	n=112 Mean =77.9° S.d.=4.3 t=0.938 p=0.349 df=724
Number of differences/ 3 steps		4/4=1.0	0/4=0	0/4=0	1/4=0.2	0/4=0
<b>Domain 3: Direction of Core Exploitation</b>						
Direction of core exploitation	n=35 Unidirectional=53.1% Bidirectional=40.6% Centripetal =9.3%	n=11 Unidirectional=85.7% Bidirectional=14.3% Centripetal=0% $\chi^2=5.024$ p=0.081 d.f=2	n=38 Unidirectional =75.8% Bidirectional =16.1% Centripetal=8.1%  No cores (direction determined by dorsal scar patterns)	n=13 Unidirectional=88.4% Bidirectional=11.1% Centripetal=0.5% $\chi^2=1.339$ p=0.512 d.f=2	n=61 Unidirectional =35.8% Bidirectional =34.6% Centripetal=29.6%  No cores (direction determined by dorsal scar patterns)	n=4 Unidirectional=65.5% Bidirectional=35.5% Centripetal=0% Sample size too low for statistical comparison
Number of differences/ 1 Step	0/1=0	1/1=1	---	0/1=0	---	---
<b>Domain 4: Dorsal Convexity System</b>						
Technological length-width ratio	n=338 Mean=1.3 S.d.=0.8	n=83 Mean=1.3 S.d.=0.8 t=1.409 p=0.159 df=419	n=59 Mean=1.4 S.d.=0.8 t=2.087 p=0.058 df=395	n=209 Mean=1.4 S.d.=0.6 t=2.833 p=0.056 df=545	n=258 Mean=1.2 S.d.=0.5 t=0.388 p=0.008 df=594	n=86 Mean=1.4 S.d.=0.7 t=1.152 p=0.250 df=422
Technological width-thickness ratio	n=656 Mean=3.3 S.d.=1.3	n=203 Mean=4.0 S.d.=1.4 t=6.291 p<0.001 df=857	n=74 Mean=3.2 S.d.=1.2 t=0.675 p=0.499 df=728	n=401 Mean=3.7 S.d.=1.6 t=3.747 p<0.001 df=253	n=299 Mean=3.6 S.d.=0.8 t=2.952 p=0.003 df=953	n=125 Mean=3.3 S.d.=1.3 t=0.228 p=0.821 df=529
Aris orientation	n=212 Parallel=56.6% Convergent=43.4%	n=46 Parallel= 65.2% Convergent= 34.8% p=0.310 Fishers Exact=0.034 df=1	n=38 Parallel=52.6% Convergent=47.4% p=0.335 Fishers Exact=0.379 df=1	n=140 Parallel=55.0% Convergent=45.0% p=0.880 Fishers Exact=0.913 df=1	n=61 Parallel=68.9% Convergent=31.1% p=0.068 Fishers Exact=0.078 df=1	n=38 Parallel=63.2% Convergent=36.8% p=0.399 Fishers Exact=0.478 df=1
Profile shape	n=619 Curved=35.9%	n=196 Curved=17.9%	n=74 Curved=25.7%	n=407 Curved=31.4%	n=294 Curved=28.6%	n=113 Curved=25.7%

	Flat=56.2% Twisted=7.9%	Flat=77.0% Twisted=5.1% $\chi^2=27.476$ $p<0.001$ df=2	Flat=63.5% Twisted=10.8% $\chi^2=3.263$ $p=0.196$ df=2	Flat=62.9% Twisted=5.7% $\chi^2=5.059$ $p=0.079$ df=2	Flat=63.6% Twisted=7.8% $\chi^2=5.021$ $p=0.081$ df=2	Flat=67.3% Twisted=7.0% $\chi^2=4.995$ $p=0.082$ df=2
Blade frequency  *Frequency/counts of blades to flakes	n=1216 Blades=3.0% Flakes=97.0%	n=375 Blades=58.9% Flakes=41.1% $p<0.001$ Fishers Exact=<0.001 df=1	n=118 Blades=5.1% Flakes=94.9% $p=0.231$ Fishers Exact=0.26608 df=1	n=590 Blades=10.0% Flakes=90.0% $p<0.001$ Fishers Exact=<0.001 df=1	Sample do not include blades	n=242 Blades=2.9% Flakes=97.1% $p=0.900$ Fishers Exact=1 df=1
Unretouched convergent piece frequency  *Frequency/counts of convergent pieces to blades	n=110 Unretouched Convergent pieces=66.4% Blades=33.6%	n=385 Unretouched Convergent pieces=10.0% Blades=90.0% $p<0.001$ Fishers Exact=<0.001 df=1	n=17 Unretouched Convergent pieces=64.7% Blades=35.3% $p=0.893$ Fishers Exact=1.00 df=1	n=138 Unretouched Convergent pieces=57.2% Blades=42.8% $p=0.143$ Fishers Exact=0.151 df=1	Sample include convergent pieces only	n=80 Unretouched Convergent pieces=91.3% Blades=8.7% $p<0.001$ Fishers Exact=<0.001 df=1
Number of differences/ 6 steps		4/6=0.7	0/6=0	2/6=0.3	2/4=0.5	1/6=0.1
<b>Domain 5: Retouched toolkit morphology</b>						
Retouched piece frequency  *Frequency/counts of retouched pieces to blanks	n=1386 Retouched pieces=6.0% Blanks=93.0%	n=398 Retouched pieces=3.3% Blanks=96.7% $p=0.006$ Fishers Exact=0.006 df=1	n=133 Retouched pieces=4.0% Blanks=96.0% $p=0.078$ Fishers Exact=0.098 df=1	n=704 Retouched pieces=5.0% Blanks=95.0% $p=0.072$ Fishers Exact=0.086 df=1	Sample include convergent pieces only	n=329 Retouched pieces=4.3% Blanks=95.7% $p=0.069$ Fishers Exact=0.080 df=1
Retouched piece typology	n=97 Retouched convergent piece/ points=2.1% Minimally retouched=63.9% Notched pieces=4.1% Side scrapers=12.4% End scrapers=9.3% Double scrapers=2.1% Miscellaneous and Broken fragments=6.2%	n=13 Retouched convergent piece/ points=7.7% Minimally retouched=92.3% Notched pieces=0% Side scrapers=0% End scrapers=0% Double scrapers=0% Miscellaneous and Broken fragments=0% $\chi^2=17.129$ $p=0.013$ df=6	n=4 Retouched convergent piece/ points=20.0% Minimally retouched=75.0% Notched pieces=0% Side scrapers=5% End scrapers=0% Double scrapers=0% Miscellaneous and Broken fragments=0% Sample size too low for statistical comparison	n=35 Retouched convergent piece/ points=8.6% Minimally retouched=40.0% Notched pieces=5.7% Side scrapers=17.2% End scrapers=11.4% Double scrapers=5.7% Miscellaneous and Broken fragments=11.4% $\chi^2=8.196$ $p=0.224$ df=6	Sample include convergent pieces only	n=14 Retouched convergent piece/ points=28.6% Minimally retouched=35.7% Notched pieces=0% Side scrapers=21.4% End scrapers=0% Double scrapers=0% Miscellaneous and Broken fragments=14.3% $\chi^2=21.539$ $p=0.001$ df=6
Retouch type	n=97 Invasive Edge Shaping= 1.0% Marginal Edge Shaping= 94.8% Notch Denticulate= 4.1%	n=13 Invasive Edge Shaping=7.7% Marginal Edge Shaping=92.3% Notch Denticulate=0%	n=4 Invasive Edge Shaping=0% Marginal Edge Shaping=100% Notch Denticulate=0%	n=35 Invasive Edge Shaping=2.9% Marginal Edge Shaping=91.4% Notch Denticulate=5.7%	n=320 Invasive Edge Shaping=2.2% Marginal Edge Shaping=97.8% Notch Denticulate=0%	n=14 Invasive Edge Shaping=7.1% Marginal Edge Shaping=92.9% Notch Denticulate=0%

	Backing=0%	Backing=0% $\chi^2=3.348$ $p=0.188$ df=2	Backing=0% Sample size too low for statistical comparison	Backing=0% $\chi^2=0.741$ $p=0.690$ df=2	Backing=0% $\chi^2=13.782$ $p=0.001$ df=2	Backing=0% $\chi^2=3.119$ $p=0.210$ df=2
Retouch angle	n=97 Mean=66.5° S.d.=5.7	n=13 Mean=66.0° S.d.= t=0.295 $p=0.761$ df=103	n=4 Mean=66.5° S.d.=4.7 t=0.001 $p=0.998$ df=99	n=35 Mean=64.9° S.d.=6.1 t=1.244 $p=0.216$ df=130	n=320 Mean=65.9° S.d.=5.4 t=0.891 $p=0.374$ df=415	n=14 Mean=65.9° S.d.=3.5 t=0.362 $p=0.718$ df=109
Number of differences/ 3 steps		2/4=0.5	0/2=0	0/4=0	1/2=0.5	1/4=0.2
Total difference GHN vs KP6/19 steps		13/20=0.65				
Total difference GHN vs EFK/16 steps			0/17=0			
Total difference GHN vs FLB/19 steps				2/20=0.10		
Total difference GHN vs #GI/13 steps					5/13=0.38	
Total difference GHN vs WPS/18 steps						2/19=0.11

	GHN	KP6	EFK	FLB	≠GI	WPS
<b>Local raw materials</b>	■	■	■	■	■	●
<b>Knapping technique</b>						
Hard hammer percussion	■	●	■	■	■	■
Soft hammer percussion	●	■	●	●	●	●
<b>Core reduction strategy</b>						
Recurrent unidirectional Levallois	■	●	■	■	◆	■
Recurrent bidirectional Levallois	■	●	■	■	◆	■
Recurrent centripetal Levallois	■	●	■	■	◆	●
Parallel unidirectional	■	■	◆	■	◆	■
Unidirectional convergent	●	■	◆	●	◆	●
Burination technique	●	●	●	■	●	●
Discoidal	●	●	●	●	■	●
<b>Core maintenance</b>						
<i>Débordants</i>	■	●	■	■	◆	■
<b>Prepared platforms</b>	■	●	■	■	■	■
<b>Types of blanks</b>						
Blades > 20%	●	■	●	●	◆	●
Convergent pieces	■	■	■	■	■	■
Flakes	■	■	■	■	◆	■
<b>Implement types</b>						
Scrapers	■	●	■	■	◆	■
Convergent pieces	■	■	■	■	■	■
Notch denticulates	■	●	●	■	◆	●

■=Present    ●=Absent    ◆=Unknown

Figure 24: A schematic representation of the similarities and differences across typotechnological and raw material attributes among the studied assemblages.

## 7.6 Total differences

The differences obtained from the chi-square ( $\chi^2$ ) test of association and the two-sample paired *t*-test are summarized in Table 25. In summary, the comparison between GHN and KP6 reveals 13 differences out of the 20 steps or stages in lithic artifact production considered here. To reiterate, these differences are noted in knapping techniques, with GHN favoring hard hammer percussion and KP6 preferring soft hammer percussion. Core maintenance practices also differ, with *débordant* removals being dominant at GHN, while KP6 relies on core maintenance blades and flakes.

Platform maintenance practices exhibit variations in preparation, where GHN platforms are heavily prepared contrasting with the plain platforms at KP6. Differences are also noted in thickness and width, with GHN featuring thicker and wider platforms, while KP6 showcases thinner and narrower ones. Dorsal convexity systems show variations in technological width-thickness ratios, and profile shapes differ, with KP6 tending to have flatter profiles. Blade frequency varies significantly, as KP6 is characterized by a blade-based reduction approach, whereas blade production is less prominent at GHN. Within the domain of retouched toolkits, the two assemblages also differ in terms of retouched piece frequency, with KP6 having a lower frequency compared to GHN. Additionally, the typology of retouched pieces varies, with GHN featuring retouched convergent pieces, scrapers, a few notches, and denticulates, while KP6 predominantly includes minimally retouched pieces, with only two retouched convergent pieces.

Table 25 also indicates that GHN is very similar to EFK. In summary, no differences are observed in any of the 17 steps or attributes identified by Tostevin (2012) as the most significant for understanding cultural transmission. Similarities are evident across all stages, starting with core modification. Both sites utilized local high-quality raw materials and employed a hard hammer percussion technique, as well as prepared cores through decortication. The primary reduction method at both sites is the Levallois technique, and *débordant* flakes were mainly used for core maintenance. Within the platform maintenance domain, both assemblages are characterized mainly by faceted platforms, and platform measurements were found to be relatively consistent. Both GHN and EFK feature wide and thick platforms.

While the analyzed EFK assemblage does not contain cores, the knapped lithics from EFK exhibit evidence of unidirectional, bidirectional, and centripetal exploitation similar to that of GHN. Dorsal convexity systems at both sites share similar dimensions and aris orientation, displaying both parallel and convergent scars on blanks. Reduction primarily focused on producing flakes, with relatively low frequencies of convergent pieces and blades. Blanks at both sites exhibit flat profiles with fewer curved and twisted ones. Additionally, both sites show evidence of low frequencies of retouched pieces, with the main retouch types being marginal edge shaping and invasive retouch.

GHN exhibits many similarities with both FLB and WPS. The comparison reveals 2 differences out of the 20 steps for FLB and 2 differences out of the 19 steps compared for WPS. High-quality local raw materials are utilized at the three sites. The prevalent technique employed at the three

sites is the hard hammer technique. Cores are also prepared through decortication, and raw materials were brought to the site in an unknapped or minimally worked state. The Levallois technique is present at the three sites, along with the parallel unidirectional technique. However, the burination method is uniquely used at FLB and is not visible at GHN and WPS sites. *Débordant* removals are primarily employed to maintain the cores.

Platforms are mainly faceted at GHN, FLB and WPS sites. At GHN and FLB, the exploitation direction is predominantly unidirectional, though bidirectional, and centripetal approaches are also present. At WPS, only unidirectional and bidirectional approaches are observed. Dorsal convexity systems exhibited similarities in technological length-width ratio, but a notable difference was observed at FLB in terms of technological width and thickness ratio, indicating that FLB blanks were wider and thicker than those at GHN and WPS.

Aris orientation shows both parallel and convergent dorsal scars, and the blanks at GHN, FLB and WPS tends to be flatter rather than curved and twisted. Reduction primarily focused on producing flakes, blades, and convergent pieces. Notably, FLB exhibited a higher frequency of blades, and bladelets were also part of the assemblage. At WPS, the frequency of convergent pieces is slightly higher than at GHN and FLB. Retouched pieces are less frequent (6.0% and below). The morphology of the retouched toolkit is relatively consistent at GHN and FLB, featuring retouched convergent pieces, scrapers, a few notches, and denticulates. A difference is observed at WPS, where the frequency of retouched convergent pieces is relatively higher, and no denticulates are

present, although scrapers are observed. The predominant retouch methods are marginal edge shaping and invasive retouch.

Lastly, although the analysis of  $\neq Gi$  was exclusively conducted on convergent pieces, GHN exhibits both similarities and differences with  $\neq Gi$ . A total of 5 differences out of the 13 steps compared were observed. Similar attributes include the utilization of local high-quality raw materials, the use of the hard hammer technique, common platform preparation, and the presence of thick platforms with similar external platform angles (EPA). Aris orientation shows similar patterns with both parallel and convergent scar patterns.

However, notable differences were also observed.  $\neq Gi$  employed the discoidal method, which is absent at GHN. Convergent pieces from  $\neq Gi$  have narrower platforms in terms of platform width.  $\neq Gi$  convergent pieces are smaller than those at GHN and typical MSA points. Additionally, at  $\neq Gi$ , retouched convergent pieces are both unifacially and bifacially retouched, a feature absent in GHN points. The subsequent chapter provides a detailed discussion of these results and their implications in assessing the presence and extent of information exchange and interactions across the Kalahari Basin and adjoining regions during MIS 5.

## CHAPTER EIGHT: DISCUSSION AND CONCLUSIONS

The transmission of cultural ideas is extensively recognized as a crucial component that contributes to the survival and prosperity of our species (Ambrose and Lorenz, 1990; Mackay *et al.*, 2014; Pazan *et al.*, 2020; Ranhorn, 2017; Tostevin, 2012). A central inquiry of this thesis has revolved around the presence and extent of interaction among early hunter-gatherer communities within the Kalahari and its environs during MIS 5. This has been explored by studying lithic artifact assemblage traits and the associated technological behaviors, encompassing the most relevant aspects of lithic artifact production for understanding the social transmission of cultural information based on middle-range theory. This was performed with the understanding that lithic production is a critical skill involving various reduction methods and that new ways of lithic production need to be transmitted from skilled personnel to apprentices; hence, certain aspects are more dependent on social transmission than others (Mackay *et al.*, 2014; Tostevin, 2012). Therefore, similarities in these particular domains of manufacture are likely to reflect transmitted knowledge.

As outlined in the introductory chapter, the Kalahari and adjacent regions are characterized by limited sites and fewer radiometric dates, which differ from the coastal and near-coastal context studied by Mackay *et al.* (2014) and the other interior regions investigated by Pazan *et al.* (2020), where abundant deposits of different ages are present. While Chapter One has acknowledged these limitations, the current study has produced interesting results, and these limitations might not diminish the value of the findings. This is especially true in the context of understanding the extent of interactions in the understudied, semi-arid, and arid microclimatic regions of the Kalahari and its environs.

In pursuit of addressing the overarching research question about the presence and extent of interactions in the Kalahari and adjacent regions, this thesis analyzed lithic artifacts from GHN MIS 5 levels. The lithic data from GHN were subsequently compared with contemporaneous MIS 5 sites, notably KP6, EFK, FLB, #Gi, and WPS. Comparative data reveal a high degree of coherence and similarity in lithic technological behaviors across most of the sites studied in this thesis. These include the predominant use of local raw materials and the modification of cores through similar lithic reduction methods. The methods encompass the dominant use of recurrent Levallois, hard hammer percussion technique, and core maintenance by *débordant* removals. Other similarities include the manufacturing of similar products such as flakes, convergent pieces and blades, mostly with comparable blank shapes and sizes. Most of the blanks have faceted platforms and comparable platform dimensions. A low frequency of retouched tools, mainly scrapers and convergent pieces, is also observed.

I begin by discussing the results obtained from the GHN lithic analysis in Chapter Five. I then synthesize and discuss the findings derived from the comparative assemblages in Chapters Six and Seven. This discussion addresses the primary research question concerning connections among human groups within the Kalahari and adjacent regions during MIS 5. It evaluates the extent of socio-cultural ties in and around the Kalahari, considering whether these connections could represent strategic responses and adaptations to the prevailing arid and semi-arid environment.

## **8.1 GHN lithic technological behaviors and site function**

In this section, I synthesize the results of the GHN DBSR lithic analysis, which is the main studied site, and discuss their implications for understanding lithic technological behaviors at the site during MIS 5.

The results of the technological analysis at GHN reveal a lithic reduction strategy oriented toward the production of flakes, with few convergent pieces and blades during MIS 5. On site knapping was conducted using a hard hammer direct percussion. Lithic artifacts were produced from locally available raw materials, predominantly brought to the site in their unknapped or minimally worked nodule forms rather than as knapped nodules or blanks due to minimal transportation costs.

The selection of materials for transport back to the site appears to have prioritized those with a homogeneous structure and without flaws. For instance, a preference for chalcedonic black chert and homogeneous banded ironstone, noted for its excellent properties (see Wilkins, 2017), was evident over banded ironstone with noticeable bands. This preference signifies a meticulous approach in the selection of raw materials, reflecting a thoughtful assessment of the attributes, knapping properties, and durable capabilities of the resources.

Moreover, the DBSR assemblage is characterized by a prevalence of Levallois cores and detached pieces, exhibiting faceted platforms that serve as unequivocal indications of the method's utilization. The most frequently employed Levallois reduction methods at the site encompass

recurrent unidirectional, bidirectional, and centripetal exploitations. In addition to the Levallois approach, alternative techniques were utilized for blank production, notably parallel reduction on a limited number of platform cores.

At GHN, blade cores were transformed into flake cores during the later stages of the reduction process. This inference is drawn from the absence of blade cores, while blades from all phases of production (initial, main production, and core maintenance) are present within the assemblage. This pattern is not exclusive to GHN; similar observations have been documented at other Stone Age sites, such as the nearby Kathu Pan 1 (see Wilkins and Chazan, 2012). These findings may indicate a deliberate effort to conserve raw materials, despite the ready availability of high-quality resources in the local vicinity.

One explanation for the conservation of raw materials, even when they are nearby, is based on the fact that chalcedonic black chert, the most preferred raw material constituting the largest proportion in the DBSR, is found in thin bands (<15 mm) near the top of the hill. This limited distribution poses challenges for effective raw material acquisition, potentially necessitating conservation and curation efforts despite raw materials' local availability. The distribution pattern also influenced the size of lithic artifacts, as blades made from chalcedonic black chert are shorter than those from banded ironstone and tuff. In addition, another highly favored and utilized raw material with excellent qualities, homogeneous banded ironstone, is primarily located atop Gamohana Hill. This location could have also led to material acquisition constraints and prompted

conservation efforts, emphasizing the efficient utilization of resources despite their nearby availability.

In terms of site function, GHN served as a location where diverse activities were conducted. A notable proportion of ungulate faunal remains with preserved cut marks and percussion marks on various specimens were observed within the DBSR (see Wilkins *et al.*, 2020). Given that knapping took place on site, it is plausible to argue that tools were manufactured and used right at the site. Although this study did not conduct a dedicated functional analysis of the retouched pieces, it is likely that these tools were employed for a variety of tasks and everyday activities. Therefore, detailed functional analysis is needed for future study. Figure 25 depicts an in-situ hammerstone discovered adjacent to a fragmented ungulate bone with percussion marks, further indicating the presence of a versatile toolkit designed to address a wide array of needs, including possibly fragmented bone or marrow extraction.



*Figure 25: An in-situ hammerstone recovered adjacent to a fragmented ungulate bone with percussion marks.*

## 8.2 Regional comparison and implications towards social transmission across the Kalahari and its environs during MIS 5

In this section, I discuss the results of the inter-assembly comparison using the behavioral approach to cultural transmission method. Firstly, I synthesize the implications of comparing GHN, EFK, FLB, and WPS, sites that have exhibited the most similar lithic technological behaviors. Later in the subsequent section, I explore the implications of the comparative study involving KP6 and #Gi, which have demonstrated the most differences with GHN.

The lithic technology in the GHN DBSR exhibits striking similarities to that of EFK Lower F, lower gray, with EFK being the closest site to GHN (~330 km southeast), apart from KP6. Moreover, the GHN DBSR assemblage shows comparable similarity to FLB Unit F (total difference of 2 out of 20 steps) and WPS Unit 10 (total difference of 2 out of 19 steps). FLB and WPS are located ~341 km southeast and ~1300 km northwest of GHN, respectively. This indicates significant homogeneity across extensive distances within the Kalahari Basin and its adjacent regions.

To emphasize, homogeneity among the GHN, EFK, FLB, and WPS MIS 5 assemblages entails selecting good quality raw materials found in the vicinity of the sites and within the Kalahari Basin. Raw materials in the WPS assemblage are not considered local ( $\leq 10$  km radius) but are found within the Kalahari Basin (see Nash *et al.*, 2016; Thomas *et al.*, 2022). Moreover, a consistent pattern of coherence is evident, particularly in core modification across these sites. For instance, cores were transported to these sites unknapped or partially worked, and all stages of the reduction

process are present. In addition, evidence of on-site knapping is observed across the aforementioned sites. The reduction methods observed primarily include the recurrent Levallois method. Non-Levallois methods, such as parallel reduction, exist at GHN, FLB, and WPS. On the other hand, the burination method on core-on-flakes evident at FLB, used for producing bladelets, is a distinguishing factor that sets the site apart from others. Using flakes as cores at FLB is interpreted as a form of recycling (Brenner, 2019), and I would further interpret this recycling possibly as a means to maximize raw material use, given the need for a variety of tools during shorter visits to FLB. As reiterated in the previous section, conservation and maximal raw material utilization are also evident at GHN due to procurement constraints despite the local availability of the raw material.

Cores are consistently prepared via decortication across the GHN, EFK, FLB, and WPS sites during MIS 5. The exploitation of cores follows prevalent strategies, with unidirectional and bidirectional exploitation being the most common, while centripetal exploitation is less frequent. *Débordant* flakes are the primary means of core maintenance across these sites. The use of hard hammer percussion is uniformly observed. Striking platforms are prepared in a similar fashion, with faceted platforms being predominant. This uniformity signifies an analogous way of producing lithic artifacts across the GHN, EFK, FLB, and WPS sites during MIS 5.

Lithic reduction at GHN, EFK, FLB, and WPS sites is primarily focused on the production of flakes, a few convergent pieces, and blades. Notably, the presence of bladelets at FLB distinguishes the site from others. The presence of bladelets at FLB can be attributed to the high

demand for tools at the site, which was occupied during brief visits (Brenner 2019; Kuman *et al.*, 1999). There is consistency in the shape and size of the blanks produced across these sites. The predominant focus of lithic reduction at these locations lies in the production of large, long, and wide blanks characterized by flat and less curved profiles. Furthermore, the morphology of the retouched toolkit exhibits a significant level of homogeneity across GHN, EFK, FLB, and WPS. Retouched pieces are comparatively less frequent across these sites. Flakes and blades serve as primary blanks for retouched pieces at the three sites. The implement types include mainly scrapers and retouched convergent pieces, primarily retouched using marginal edge shaping, while invasive edge shaping remains relatively low.

Despite variations in physiographic settings among these sites, numerous similarities in their lithic technology are evident. For instance, GHN and WPS are rockshelters that accommodate diverse activities, including tool production and sheltering sites occupied for varying lengths of time, and EFK and FLB are as open-air sites occupied during brief visits, but a similar reduction chain is observed. These similarities suggest that site location and setting did not play a decisive role in the technological decisions and behaviors of early humans in the Kalahari and its environs.

The data presented above, indicating a greater degree of homogeneity in lithic technology among GHN, FLB, EFK, and WPS sites, may reflect a substantial level of technological information exchange and connections among human groups over long distances during MIS 5. The observed pattern of homogeneity suggests that distance correlates with the level of similarities among these sites. For instance, GHN demonstrates a high level of similarity in various technical steps to EFK,

the closest site located ~331 km away. The subsequent site closely resembling GHN is FLB, situated at ~341 km away, retaining distinctions only along blade/bladelet frequency and vertical convexities (width-thickness ratio) of blanks out of the 20 steps compared with a frequency of 0.10 (Table 25). WPS, positioned 1300 km away, retains distinctions along the unretouched and retouched convergent piece frequencies out of the 19 steps, compared with an overall frequency of 0.11. Notably, WPS displays the use of raw materials not found in the vicinity of the site, although they are present within the Kalahari Basin. This pattern indicates that communities in close geographical proximity demonstrate heightened levels of interactions and information exchanges, with a corresponding increase in differences noted as the distance between sites extends.

The evidence presented in this thesis best supports a scenario where similarities between these assemblages are due to cultural transmission. I suggest that cultural transmission is a likely explanation in this case because there is homogeneity in the five domains or aspects of stone tool production, which are often passed on through social transmission as stipulated in the behavioral approach to cultural transmission by Tostevin (2007, 2012, and 2019). To reiterate, these similarities include cores being modified similarly across the sites, use of similar reduction methods in stone tool manufacture such as the recurrent Levallois method, the use of hard hammer percussion techniques, and cores being maintained in a similar manner in the first domain. The second domain also shows a high level of similarity, with common platform faceting alongside comparable measurable datasets, such as platform angles, width, and thickness. In the third and fourth domains of core modification, there are also high levels of similarity, with the direction of exploitation mainly being unidirectional and bidirectional, and the dorsal convexity system

showing minimal statistical differences. The last domain, which pertains to retouched toolkits, also demonstrates comparable implement types as well as the type of retouch. Thus, this chain of similarities likely indicates connectivity across the Kalahari and its nearby regions.

While I believe the evidence presented in this thesis best supports cultural transmission, the possibility remains that convergent evolution might have played a role. As highlighted in Chapter One, studies testing social transmission should always account for the potential of independent innovation. Additionally, one of the challenges when studying cultural transmission is dealing with convergence; however, ruling out convergence is as difficult as proving it. Despite these challenges, lithic artifacts will remain to be invaluable for tracking early human interactions on different scales due to their exceptional durability and consistent spatiotemporal patterns (Will and Mackay, 2020).

In addition, the assemblages at the core of this thesis are widely spread across MIS 5. Therefore, the temporal scale of cultural transmission witnessed in this study shows interactions between groups that are spatially distanced over a long period throughout the entire MIS 5. The cultural transmission observed in the Kalahari and its environs involves a set of processes occurring at the macroevolutionary scale, which encompasses large-scale and long-term knowledge exchange processes occurring over generations across populations. This implies longer-term population retention of key methods, styles, and traditions. Therefore, I posit that FLB (~121 ka) and GHN (~105 ka) are earlier assemblages that existed prior to transmission, and technological styles and methods at these two sites were passed on to other groups later in the MIS 5 stages, such as EFK

(~99 ka) and WPS (~94 ka), which I would refer to as acculturators or products. As highlighted in the methods chapter, acculturators and product assemblages are influenced by the substrate assemblages.

The study further suggests that the connectivity among GHN, EFK, FLB, and WPS may have been a response and adaptation to the drier macroclimatic conditions that prevailed in the Kalahari Basin and its adjacent regions during MIS 5. Interconnectedness serves as both a survival strategy and a coping mechanism in unfavorable environments. Semi-arid and arid conditions likely led to relative resource scarcity and unpredictability, compelling early humans to depend on one another and form connections during times of stress to ensure their survival.

To substantiate the suggestion that arid Kalahari conditions may explain this connectivity, the study reviewed published paleoenvironmental data obtained from sites in the Kalahari and its environs. The data indicates that the region experienced arid and semi-arid macroclimatic conditions during both MIS 4 and MIS 5 (Helgren and Brooks, 1983; Lukich and Ecker, 2022; Robbins *et al.*, 2016; Wroth *et al.*, 2022). In addition, the interglacial Kalahari is prone to short-term pulses of aridity caused by increased surface temperatures and the evaporation of surface water sources, and the mobilization of dunes is the most obvious manifestation of this (see Thoms *et al.*, 2022). Thus, perhaps human populations at sites considered in this analysis were affected by those pulses. Therefore, there may have been a sustained necessity for interconnectedness within these regions, serving as a coping mechanism from MIS 5 to MIS 4.

To further support the aforementioned proposed notion, this section provides a recapitulation of the paleoenvironmental data reviewed in Chapter Three for MIS 5 and compares it to MIS 4 to assess any changes in the environments of the Kalahari and adjacent areas. In the Kalahari Basin, Robbins *et al.* (2016) suggest that submerged speleothems provide evidence that interglacial periods (e.g., MIS 5) in some instances experienced intense drought conditions when contrasted with glacial periods (e.g., MIS 2 and MIS 4), as well as interstadial periods (e.g., MIS 3). Moreover, the deposits at ~94 ka at WPS primarily consist of aeolian deposits, indicating formation during a period marked by dry climatic conditions and active dune formation in the region (Robbins *et al.*, 2000). At #Gi, Helgren and Brooks (1983) conducted a paleoenvironmental study of the hydrology, interpreting deposits at ~77 ka as representing semi-arid conditions. Furthermore, at KP6, Bed 9 MIS 5 and MIS 4 deposits exhibit a notable buildup of aeolian sands and lack of marsh deposits, suggesting a dry environment during both MIS 4 and early MIS 5 (Lukich *et al.*, 2020; Lukich and Ecker, 2022; Wroth *et al.*, 2022).

In the adjacent regions of the Kalahari, exemplified at EFK, the recovery and subsequent dating of faunal remains attributed to *Megalotragus priscus* and *Equus capensis* indicate a pronounced drought episode that occurred during MIS 4 (between ~62.5 and ~60.9 ka; Wroth *et al.*, 2022; Bousman *et al.*, 2023). This drought reached an extent significant enough to result in widespread herbivore starvation within the Modder River basin, as detailed by Wroth *et al.* (2022). Similarly, during MIS 5 (~99 ka), remains of *Equus capensis* were observed, particularly within the lower gray bed associated with “low-energy alluvial” deposits. This bed lacks extensive oxidization typically associated with wet environments, indicating the persistence of semi-arid conditions during MIS 5 (Wroth *et al.*, 2022; Bousman *et al.*, 2023).

Moreover, evidence from regions within the Kalahari distinct from the studied sites provides valuable insights into the Kalahari dry macroclimate and adaptations during MIS 4 and MIS 5. In the Kalahari, at Witpan site, between ~77 and ~76 ka, dune activity suggesting an arid climate was observed (Telfer and Thomas, 2007). In the Makgadikgadi Basin, Thomas *et al.* (2022) demonstrate the deliberate use of the lacustrine basin during arid periods spanning from ~80 to ~72 ka. At Makgadikgadi, the deliberate and meticulous transportation of raw materials for artifact production is suggested as evidence of intentional adaptability by hunter-gatherers to the arid environments in the lacustrine basin (Thomas *et al.*, 2022).

At a site called Lovedale, situated 10 km upstream of EFK within the adjoining region of the Kalahari, Wroth *et al.* (2022) describe sediment deposition coupled with human habitation and hunting scenes in the Modder River during a brief warm and dry interval within MIS 5 (~77 ka) and MIS 4 (~69 ka). Wroth *et al.* (2022) emphasize the significance of Modder River marsh environments in sustaining human communities, especially in marginal areas. While data remains limited, the highlighted evidence from these Kalahari and adjacent region sites may support a pattern of persistent drier conditions from MIS 4 to MIS 5 in these regions, potentially underscoring the need for sustained interconnectedness as a survival strategy.

### **8.3 Coalescence in the Kalahari and adjoining regions**

The described pattern pertinent to the topic under discussion diverges from observations made in other parts of southern Africa, particularly those along the coast, near-coastal, and other inland areas. Previous research, notably the work of Mackay *et al.* (2014), has focused on the dichotomy

between interglacial and glacial periods in coastal and near-coastal regions. These argued that glacial periods, such as MIS 4, necessitated coalescence, while interglacial periods, like MIS 5, characterized by more favorable, wetter, and warmer climatic conditions, prompted fragmentation. Inland sites, exemplified by Melikane Rockshelter (Pazan *et al.*, 2020), have also pointed to social fragmentation during MIS 5. However, in the Kalahari, I observe less fragmentation, and even a continuation of interconnectedness between the Kalahari and its neighboring regions, during the MIS 5 interglacial.

My results demonstrate that the dynamics in the Kalahari and its adjacent regions differed from those observed in other parts of southern Africa during MIS 5 interglacial. While MIS 5 interglacial conditions led to fragmentation in other regions, the Kalahari and its neighboring regions did not follow the same pattern. Thus, the social transmission of cultural information remained crucial in the Kalahari, as evidenced by the lithic technology. This suggests that in marginal environments like the Kalahari and its environs, the nature and extent of interactions during MIS 5 were comparable to those observed during glacial environments.

The opportunities available in coastal locations, coupled with abundant food resources, might have offered significant prospects for inhabitants in the southern Africa during MIS 5 to lead isolated lives with less reliance on each other (see Ambrose and Lorenz, 1990; Mackay *et al.*, 2014; Marean, 2016; Parkington, 2010). Although paleoenvironmental data is limited for most interior sites, Melikane is an exception. Melikane site has evidence of a predictable environment during MIS 5, characterized by the prevalence of C3 grasses, indicating a humid and cool climate with

the presence of woody plants transitioning to grasses, akin to the coastal environment (Pazan *et al.*, 2020). However, the Kalahari and its environs present a distinct set of environments compared to the coast and Lesotho highlands. Resources are in general more scarce and unpredictable in this region, potentially necessitating human adaptation for survival and fostering increased interactions.

The wet conditions at GHN and FLB may indicate that the southern Kalahari and its environs had isolated paleoenvironmental data, suggesting the presence of wet conditions at the beginning of MIS 5. Persistent aridity trends begin to be evident around 99 ka onwards in the Kalahari Basin and its environs. However, Robbins *et al.* (2000) argue that some areas of the Kalahari experienced drought throughout MIS 5, highlighting the caveats related to the limitations of the sparse paleoenvironmental data available for the Kalahari, especially when inferring climate dynamics within MIS 5 and across this vast region.

On the other hand, if the rest of the Kalahari was arid during the entire MIS 5, as argued by Robbins *et al.* (2000), then this would lead one to assume that the wetter conditions at GHN and FLB could have been potential water sources, serving hominin populations and faunal communities throughout the relatively arid and semi-arid Kalahari Basin and adjacent areas. Regular access to water is a vital need for humans, and heightened water stress amplifies the likelihood of falling short in fulfilling daily needs essential for the overall well-being of humans (Grey and Sadoff, 2007; Schoville *et al.*, 2021). Therefore, one can assume that GHN and FLB might have been

visited as water sources by inhabitants from other areas within the Kalahari and adjoining regions, facilitating information exchange and interconnectedness.

The FLB spring is argued to have attracted numerous herds of animals from the nearby grasslands to drink water (Hutson, 2018; Kuman and Clarke, 1986; Lukich and Ecker, 2022). I assume, therefore, that this may have also been the case at GHN, where there is evidence of water availability. Thus, the environment around GHN and FLB may have supported vegetation and resources, potentially making them key areas with scarce vegetation available. This scarcity of resources, including ungulates and mammals for hunting, may have caused them to congregate in certain pockets, like the wet regions found around GHN and FLB. This unpredictability of resources may have prompted communities to rely on each other, thereby fostering interactions. Hence, this may reflect the adaptability of human populations to the challenges posed by aridity, utilizing wetland environments to navigate climatic stress. Environmental conditions may have played a role in shaping the adaptive behaviors of the inhabitants of the Kalahari and adjacent regions. Such ability to adapt to challenging environments is a hallmark of modern humans, encompassing practices such as the sharing of ideas, toolmaking techniques, and the understanding of resource locations (Ambrose and Lorenz, 1990; Thomas *et al.*, 2022).

The present study aligns with certain aspects of Mackay *et al.*'s (2014) findings, particularly their hypothesis that unfavorable environments can foster interconnectedness and the utilization of locally available materials during MIS 5. However, it diverges from Mackay *et al.*'s (2014: 21) research, in which they observed: “little coherence in flaking systems within climate regions

during MIS 5, and material selection often appears highly localized, both of which imply a localized sphere of interaction.” By contrast, this study reveals a high degree of homogeneity in lithic technology across groups separated by a distance of over 1300 km, suggesting a heightened level of interaction and potential connections among the inhabitants of MIS 5 sites across the Kalahari and its neighboring regions. This highlights how disparate regions may respond differently depending on their environmental conditions.

The observed consistencies within MIS 5 assemblages in the Kalahari Basin and its environs may also indicate continuity and stability in lithic technological traditions through time, over various periods: from MIS 5c (~94 ka, WPS; ~99 ka, EFK), MIS 5d (~105 ka, GHN), to MIS 5e (~121 ka, FLB). Despite intermittent wetter conditions occurring around 105 and 121 ka, lithic technology in the Kalahari and its environs may have remained consistent and stable. This may imply that the persistent application of similar reduction strategies and the use of certain tool types by ancient human populations in this region might not have undergone significant changes during these periods and at these two sites of environmental variation (GHN and FLB), potentially influenced by persistent arid and semi-arid macroclimatic constraints. Similarly, previous research, as exemplified by the work of Douze *et al.* (2015), has also noted a similar case of stability in the MSA MIS 5 on the coastal sites of South Africa.

In addition, through the application of the behavioral approach to cultural transmission, the current study exemplifies the utilization of methods based on middle-range theory in understanding knowledge transmission during the MSA. As highlighted earlier, Tostevin's (2012) behavioral

approach, utilized in this study, incorporated middle-range experimental data on known knapping mechanisms to isolate traits that are likely transmitted, possibly through careful copying of each domain or stage of lithic reduction. Thus, while many studies have concentrated on formulating middle-range theories, this thesis pioneers a new avenue of study which focuses on applying middle-range-based methods to comprehend how cultural transmission can be investigated within Stone Age assemblages, with a specific focus on the MSA in southern Africa, particularly its deep interior.

#### **8.4 Kathu Pan 6 (KP6): A point of difference**

The KP6 site, located 45 km southwest of GHN, exhibits notable disparities in lithic technology compared to GHN, EFK, FLB, and WPS. The results of the statistical analysis indicate a total variance of 13 differences out of 20 steps compared, with a frequency of 0.65.

While the utilization of local raw materials, such as banded ironstone and chalcedonic black chert, similar to those at GHN, was favored at KP6, distinctions in lithic technological behaviors from the rest of the examined sites were identified. For instance, while hard hammer percussion was the preference at GHN, EFK, FLB, and WPS, soft hammer percussion took precedence at KP6. Cores at KP6 were managed using core maintenance blades and flakes, as opposed to the *débordant* removals that were dominant at other sites. Furthermore, lithic reduction primarily entails non-Levallois techniques at KP6, particularly the parallel unidirectional method on blade cores, contrasting with the dominant Levallois approach observed at the other sites. The lithic reduction strategy at KP6 revolves around blade production, deviating from the norm of flakes with few

blades and convergent pieces. This leads to a higher frequency of long and narrow blanks with flat profiles in the assemblage.

Distinctly, the assemblage at KP6 is dominated by plain, tiny, thin, oval, and lipped platforms, diverging from the prevalence of faceted ones at other sites. Additionally, there is a notable difference in the morphology of the retouched tool kits at KP6 compared to GHN, EFK, FLB, and WPS. While scrapers and retouched convergent pieces are present in the formal tool assemblage at the aforementioned sites, KP6 primarily showcases very few minimally retouched pieces and two bifacial points.

Considering these disparities, I propose that KP6 stands apart from other studied sites within the Kalahari and its adjacent regions. I posit that this distinctiveness may be linked to issues concerning dating accuracy, although further research is needed to substantiate this argument. This suggestion is framed against KP6's typological and technological alignment with HP, as similarly noted by prior researchers such as Beaumont (1990) and Lukich *et al.* (2019). HP assemblages are characterized by substantial blade production (see Wadley, 2015, Wurz, 2002), a characteristic evident in the KP6 Bed 9 assemblage.

Chapter Two accentuates the debates surrounding the emergence, duration, and culmination of the HP technocomplex, noting the dedicated efforts of scholars such as Jacobs *et al.* (2008), Feathers (2015), Tribolo *et al.* (2013), and Jacobs and Roberts (2017) in dating HP contexts across South Africa. To reiterate, various dates have been proposed for the HP, ranging from ~66-58 ka (Jacobs

*et al.*, 2008; Jacobs and Roberts, 2017) to potentially persisting up to ~50 ka at sites such as Diepkloof (Tribolo *et al.*, 2013). From my perspective, it seems plausible that the KP6 Bed 9 assemblage, used for comparative analysis, may be of a more recent origin than ~74 ka. This potential age disparity may mean that the KP6 assemblage is not concurrent with MIS 5 and could explain the notable distinctions observed between KP6 and the remaining studied sites, which otherwise exhibit a degree of uniformity.

This perspective aligns with observations by Lukich *et al.* (2019), who identified a dating disparity in KP6's HP layers (Bed 9) when comparing ages obtained from K-feldspar and quartz. Lukich *et al.* (2019) reported that quartz dating suggests a range of ~100 to 74 ka for the KP6 HP period, while feldspar ages align more closely with the timeline proposed by Jacobs and Roberts (2017), spanning from ~66 to 58 ka. Given this background, my study concurs with Lukich *et al.*'s (2019) advocacy for further investigation using alternative dating methods to refine the chronology of KP6's lower beds. I also support the need to reconcile divergent dates obtained from quartz and K-feldspar dating, as proposed by Lukich *et al.* (2019). As mentioned earlier, ongoing research is aimed at gaining a better understanding of the deposit's base age, coupled with intensive sampling for cryptotephra analysis (M. Chazan, *pers. comm.*). Therefore, the resolution of this matter awaits the availability of new data. Thus, the results of this study underscore the significance of quantitative and middle-range-based comparisons in identifying differences within lithic assemblages. These distinctions could potentially result from disparities in dating accuracy, as noted by Lukich *et al.* (2019).

## 8.5 Limitations of ≠Gi analysis

The comparative results between GHN and ≠Gi pose challenges in terms of interpretation. This difficulty arises due to the analysis being limited to convergent pieces at ≠Gi, owing to curation constraints that have affected all artifact classes other than the pointed pieces stored separately and in better condition (A.S. Brooks, *pers. comm*). However, when comparing the ≠Gi convergent pieces with those of GHN, the data indicate a total difference of 5 out of 13 steps, with a frequency of 0.38 (Table 25). Among the noted similarities that link ≠Gi with the other studied sites are the use of local raw materials, the application of the direct hard hammer percussion technique, platform preparation (although plain platforms also dominate), similar dorsal scar patterns, and comparable profile shapes of these convergent pieces.

The notable distinctions that set ≠Gi apart from the other examined sites include the use of the discoidal method instead of Levallois techniques for tool manufacturing. Moreover, ≠Gi's points are predominantly small, occasionally exhibiting bifacial retouching and frequently showing bulbs and striking platforms situated at the corners of the proximal parts as opposed to the center, a contrast to what is observed at GHN, EFK, FLB, and WPS. As mentioned earlier, these observations regarding ≠Gi convergent pieces have also been previously highlighted by researchers such as Brooks *et al.* (2006) and Lombard and Churchill (2022).

Despite the highlighted similarities and differences, advocating for connectivity and interactions between ≠Gi and other neighboring communities within the Kalahari and adjoining regions remains complex. Nevertheless, it is plausible that the production of points at ≠Gi could align with

its function as a hunting site, as suggested by previous studies asserting that ≠Gi pointed tools were employed for hunting purposes (Brooks *et al.*, 2006; Lombard and Churchill, 2022). This contrasts with GHN, where there is no evidence of tool use as projectile weapons. The insights gained from the analysis of ≠Gi's pointed tools could be integrated into future research endeavors.

Overall, although the thesis deviated from the cultural-historical approach, this work may contribute valuable data to the existing knowledge on industrial technocomplexes. Technologically, the GHN, EFK, FLB, and WPS assemblages analyzed in this thesis may align with the characteristics of the Mossel Bay (~105-77 ka) technocomplex. This complex is characterized by the use of recurrent Levallois techniques to produce blanks with prominent bulbs of percussion, straight profiles, faceted platforms, and with formal tools infrequently present. However, Mossel Bay primarily focuses on the production of convergent pieces and blades, while the above-mentioned sites predominantly exhibit flake-based reduction, with blades and convergent blanks occurring in low numbers. Additionally, in terms of absolute dates, the FLB (~121 ka) assemblage does not align with Mossel Bay, presenting challenges in classifying assemblages into industrial technocomplexes. The KP6 assemblage technologically fits within the HP in terms of blade production. However, the age estimate for KP6 Bed 9 (~74 ka) does not align closely with plausible dates for the HP. The ≠Gi site is challenging to classify into any technocomplex because the assemblage solely comprises pointed pieces. Due to these challenges in classifying lithic assemblages into complexes, this study employs a middle-range-supported approach to understand past human behavior.

## 8.6 Future directions

Beyond these significant findings and the highlighted limitations of the study, the data presented in this thesis offer valuable insights that can serve as guiding principles for future research. Firstly, there is a pressing need for further efforts to identify sequences and establish comprehensive dating frameworks for MIS 4 and MIS 5 occurrences, especially within the Kalahari and its adjacent regions. Such efforts will facilitate intra-site diachronic comparisons, which are currently absent from the studied sites. In many of the Kalahari and adjacent regions sites, we do not observe occupations that span MIS 4. For instance, FLB does not exhibit any evidence of occupations associated with MIS 4. However, does this necessarily indicate that these areas were uninhabited during that period? This, therefore, underscores the necessity for additional archaeological and geochronological fieldwork to further address this question. Additionally, improvements in dating would also enable more nuanced comparisons within the context of MIS 5 substages. In this thesis, the study specifically compares MIS 5 assemblages from substages a to e, which is one of the limitations of the study as highlighted in Chapter One. Thus, refining the accuracy of chronometric dating during the MIS 5 period would facilitate a more precise differentiation and comparison between distinct MIS 5 substages. This, in turn, would bolster the discourse surrounding interactions within the Kalahari and adjoining regions during the MIS 5 phase.

Secondly, due to the lack of solid paleoenvironmental data, the current study has inferred or suggested that the connectivity among populations in and around the Kalahari Basin may have been influenced by the arid and semi-arid macroclimatic environment that persisted in the Kalahari. Thus, there is a critical need to advance research focused on paleoenvironmental data within the Kalahari Basin. Such advancement is pivotal to strengthen the claim of intricate

relationships between past hunter-gatherer societies and the environments they once inhabited, shedding more light on the adaptive strategies employed in response to surrounding areas. While certain studies, including von der Meden *et al.* (2022), Lukich and Ecker (2022), Helgren and Brooks (1983), Kuman *et al.* (1999), and Robbins *et al.* (2016), have offered insights into the MIS 5 paleoenvironments of the Kalahari and its adjacent regions for this study, a comprehensive research gap remains in this domain. Notably, this thesis occasionally encountered the need to heavily rely on tentative data related to past environments due to the absence of a more comprehensive research framework.

Thirdly, future work should also involve conducting experiments to test the behavioral approach to cultural transmission using southern African raw materials from the Kalahari. Tostevin's (2012) work was initially designed for flint, prompting the question of whether empirical traces of cultural transmission can be detected on southern African raw material. To accomplish this, knappers will create stone tools using raw materials from the Kalahari under two controlled conditions of cultural transmission: imitation and replication. Additionally, experiments will include knappers making stone tools without any knowledge transmission. Subsequently, the lithic assemblages will be measured and analyzed to determine if raw materials can influence the application of methods developed to test for cultural transmission using flint artifacts.

In addition, future research endeavors should prioritize conducting robust use-wear analysis of the formal tools observed within the studied sites. This imperative task is essential for shedding light on the tool functions across the Kalahari and its environs. Such analysis will not only deepen our

understanding of these tools but also pave the way for comparative studies that elucidate similarities and differences in tool functions across these groups. Thus, undertaking robust functional analysis represents another step toward unraveling the complexities of cultural transmission and enriching our knowledge of early human behavior.

Lastly, conducting a larger-scale analysis that includes MIS 5 lithic assemblages across various regions of southern Africa is imperative for a more holistic assessment of coalescence and fragmentation beyond regional boundaries. The currently available data concerning MIS 5 lithic technology across southern Africa has predominantly been presented within culture-historical frameworks and the NASTIES classification. However, as emphasized by several researchers such as Mackay *et al.* (2014), Pargeter *et al.* (2019), Ranhorn *et al.* (2020), Shea (2014), and Wilkins (2020b), the bulk presentation of site sequences based on culture-historic industries and NASTIES categories poses challenges in facilitating effective comparison of MIS 5 sites across the entire southern African region. Moreover, this approach complicates the assessment of social transmission patterns.

Therefore, for future research endeavors, I recommend applying Tostevin's (2012) behavioral approach to cultural transmission in different regions, as attempted in this thesis and in the works of Porter (2019) and Ranhorn (2017). This approach would substantially contribute to a more nuanced understanding of social transmission. This method facilitate a refined evaluation of technological information exchange, providing insights that extend beyond mere regional contexts.

## 8.7 Conclusions

The aim of this thesis was to evaluate the presence and extent of socio-cultural transmission and techno-cultural connections among hunter-gatherers in and around the Kalahari Basin. The focus of the study was to assess traits of information exchange by examining lithic artifact assemblages. Additionally, the study also assesses whether this interconnectedness may be linked to the response toward the harsh environments present in the Kalahari and its adjoining regions. To achieve this, the thesis utilized the stratified site GHN, which contains MIS 5-aged lithic assemblages derived from a stratum referred to as DBSR and dated to ~105 ka. Through a comparative analysis of the GHN assemblage with other MIS 5 lithic artifact deposits within the Kalahari and the adjoining regions, the research revealed similarities in lithic artifact assemblages and technological behaviors. These similarities serve as evidence to support the hypothesis that there was less fragmentation and greater interconnectedness within the Kalahari and its adjoining regions.

The results presented in this thesis reveal a clear pattern in lithic technological behaviors during the MIS 5 period across the majority of the studied sites. This thesis uncovers a level of coherence and similarity in various aspects of these behaviors. These aspects include the predominant use of recurrent Levallois methods, hard hammer percussion technique, core maintenance primarily by *débordant* flakes, and production of similar knapped artifacts mostly dominated by flakes with few blades and convergent pieces. These blanks have comparably similar shapes and sizes, mostly with faceted platforms. Formal tools are infrequent and mainly consist of scrapers and retouched convergent pieces. The choice of raw materials shows the use of those located in the vicinity of the sites. This remarkable uniformity in the assemblages suggests a form of connectivity and

techno-cultural ties among the human groups that inhabited the Kalahari Basin and its environs during MIS 5.

The interconnectivity may reflect a response to the drier climatic conditions within the Kalahari and its adjoining regions compared to the coastal areas. The arid macroclimate in this region may have prompted the formation of socio-cultural ties that facilitated access to scarce and potentially unpredictable resources. Building on previous work that has examined patterns of coalescence and fragmentation through the Pleistocene, this study found compelling evidence for coalescence across the Kalahari and its adjoining regions during MIS 5. This differs from other works that have highlighted fragmentation in other regions of southern Africa during MIS 5. As a result, it appears that more extensive socio-cultural ties and networks existed among the MIS 5 groups within the Kalahari and the adjoining regions than hitherto appreciated. This finding underscores the significance of intergroup connections during this period, shedding new light on the possible survival dynamics of these ancient communities in arid and semi-arid landscapes.

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## SUPPLEMENTARY INFORMATION

### **Appendix 1: Analytical framework and definitions.**

#### **Adopted and modified from Wilkins *et al.* (2017)**

This appendix presents the lithic traits and their definitions recorded during the analysis of GAGHN, FLB, EFK, KP6 in South Africa, #Gi, and WPS lithic artifact assemblages. The list includes traits, definitions, references, and the conditions for their coding. The analytical framework used in this study was adapted from Wilkins *et al.* (2017) but was modified to suit the research questions concerning coalescence and fragmentation in and around the Kalahari Basin. This modified framework incorporates elements from different analytical approaches proposed by scholars like Tostevin (2012), which are relevant to understanding the social transmission of cultural information.

Lithic traits were recorded using the open-source E5 data entry program developed by Shannon McPherron and Harold Dibble, which can be accessed at (<https://github.com/surf3s/E5>). E5 represents the latest version, succeeding E4, which is why it was chosen for this study. Its use expedited data entry and minimized errors. Detailed instructions for integrating these traits into E5 can be found in Appendix 2. According to Wilkins *et al.* (2017), one can simply copy and paste the coded traits into the CFG file when launching E4/E5. Alternatively, the text can be pasted into Notepad, saved as a .TXT file, and then renamed with the .CFG extension, which E4/E5 can open. These CFG codes are customizable to match the assemblage's characteristics and address specific research questions (Wilkins *et al.* 2017).

Trait	Code	Condition	Menu	Definition	Reference for additional details
Plotted Find Number	Plotted Find Number	-	Enter Plotted Find Number	Unique identification number assigned to the piece.	-
Lot	Lot	-	Enter lot number	Provenience data.	-
Strata	Strat Agg		DBSR/ Bed 9/ Lower F/ Unit F/Unit 4/Unit 10	Strata that belong to MIS 5 across the studied sites in and around the Kalahari.	-
Researcher	Researcher	-	Select the Researcher:	Name of researcher analyzing the lithic artifacts.	-
Raw Material	Raw Material		Menu will depend on local raw material availability	Visual examination was used to for raw material identification.	-
Lithic Class Artifact	Lithic Artifact Class		Complete flake	Any piece detached from a core, either during core preparation or blank production. A complete flake has a bulb, platform, distal end, clear dorsal and ventral surfaces, and no significant breaks. The use of the word “flake” does not imply a particular morphology.	Inizan <i>et al.</i> (1999); Wilkins <i>et al.</i> (2017)
			Flake fragment	Incomplete or broken flake exhibiting distinct dorsal and ventral surfaces. The bulb of percussion and platform may or may not be present.	
			Blade/ blade fragment	A blade or blade fragment possesses a blank length that is twice the width (this measurement must be estimated for fragments). Expect parallel or nearly parallel dorsal scars, along with anticipated lateral edges.	
			Bladelets/ bladelet fragment	The length is twice the width, and the width is <10 mm. Anticipate parallel or nearly parallel dorsal scars and lateral edges.	
			Convergent piece	Blank’s lateral edges converging into a point.	
			Shatter	Lithic artifact lacking a bulb, and with indistinguishable dorsal and ventral surfaces. This category was selected for all pieces in doubt/question.	

Trait	Code	Condition	Menu	Definition	Reference for additional details
			Retouched piece	Any piece exhibiting retouch, which involves a relatively continuous series of small removals along the edge.	
			Core	Any piece with one or more blank removals, with at least one noticeable negative bulb of percussion.	
			Hammerstone/ Manuport/ Grindstone	A piece that has not undergone knapping. In the context of a hammerstone, it pertains to a lithic artifact that has not been knapped and may show noticeable percussion pitting marks.	
Retouched Piece Blank	Retouched Piece Blank	Condition1=Lithic Artifact Class Retouched Piece	Flake	A retouched piece was probably produced from a flake blank.	Wilkins <i>et al.</i> (2017)
			Blade	A retouched piece was probably produced from a blade blank.	
			Shatter/ Indeterminate	A retouched tool was likely produced from shatter or other types of knapping debris, making it challenging to categorize as either a “Flake” or a “Blade.” When uncertain, opt for “Shatter or indeterminate.”	
Completeness	Completeness	Condition1=Lithic Artifact Class NOT Comp Flake Shatter Core Hammer Manuport Grindstone	Complete	The artifact is complete. Minor snaps or damage are also acceptable.	Wilkins <i>et al.</i> (2017)
			Proximal	Lithic artifact piece has the entire bulb and platform but lacks the distal end.	
			Distal	Distal part of the lithic artifact piece, with no platform or bulb of percussion.	
			Medial	Medial part of the lithic artifact piece, with no platform or bulb of percussion or distal part.	
			Fragment	Fragment - it is not possible to confidently determine which part of the flake it represents.	
			Left lateral	Retains the left part of the platform and bulb; the flake or blade is split along the flaking axis.	
			Right lateral	Retains the right part of the platform and bulb; the flake or blade is split along the flaking axis.	
			Prox Left Lat	Proximal left lateral.	

Trait	Code	Condition	Menu	Definition	Reference for additional details
			Prox Right Lat	Proximal right lateral.	
			Distal Left Lat	Distal left lateral.	
			Distal Right Lat	Distal right lateral.	
			Mesial Left Lat	Medial left lateral.	
			Mesial Right Lat	Medial right lateral.	
Core Hammerstone or Hammerstone Completeness	Core Hammer Completeness	Condition1=Lithic Artifact Class Core Hammerstone Manuport Grindstone	Complete	Complete core or hammerstone or grindstone or manuport.	Wilkins <i>et al.</i> (2017)
			Split Fragment	Split or Fragment. A part of a core or hammerstone or grindstone or manuport that seem to have split or broke.	
Evidence for Bipolar Percussion	Evidence Bipolar Percussion	Condition1=Lithic Artifact Class Comp Flake Core Hammer Manuport Grindstone OR Condition2=Completeness Complete Left Lateral Right Lateral Split Hammer Cobble	Yes	The artifact displays two distinct opposing bulbs on the ventral surface or two opposing negative bulbs within a single dorsal or flake scar.	Wilkins <i>et al.</i> (2017)
			No	The artifact shows no signs of being the result of bipolar percussion.	
			Indeterminate	The classification of the artifact is challenging, possibly leaning towards being bipolar.	
Blade Technical Category	Technical Category	Condition1=Lithic Artifact Class Blade, Blade Frag	Enter the blade technical category (i.e., B1, B2, B3, etc....)	The definitions of types are sourced from Soriano <i>et al.</i> (2007) and Villa <i>et al.</i> (2005).	Soriano <i>et al.</i> (2007); Villa <i>et al.</i> (2005); Wilkins <i>et al.</i> (2017)
Cortex Area	Cortex Area		0%	Enter the estimated cortex area of dorsal surface, or the entire surface of shatter core and hammer manuport grindstone.	Brown 2011; Marwick (2008); Mauldin and Amick (1989); Wilkins <i>et al.</i> (2017)
			1-20%		
			21-40%		
			41-60%		
			61-80%		
			81-99%		
Platform Cortex	Platform Cortex	Condition1=Lithic Artifact Class Comp Flake OR Condition2=Completeness Complete Proximal Left Lateral Right Lateral Prox Left Lat Prox Right Lat	Yes Complete	Entirely cortical platform.	Wilkins <i>et al.</i> (2017)
			Yes Partial	Partially cortical platform.	
			No	No cortex on the platform.	
Cortex Chatter Marks	Cortex Chatter Marks	Condition1=Cortex Area NOT 0% OR	Yes	Chatter marks	Wilkins <i>et al.</i> (2017)

Trait	Code	Condition	Menu	Definition	Reference for additional details
		Condition2=Platform Cortex Yes Complete Yes Partial	No	There are no chatter marks evident.	
			Indeterminate	The cortex has marks, but it is challenging to ascertain whether there are distinct chatter marks. When uncertain, opt for an indeterminate classification.	
Cortex Roundness	Cortex Roundness	Condition1=Cortex Area NOT 0% OR Condition2=Platform Cortex Yes Complete Yes Partial	Angular	Applies solely to the cortical surface and any visible edges, excluding consideration of the overall core's shape.	Wilkins <i>et al.</i> (2017)
			Subangular		
			Subrounded		
			Rounded		
			Indeterminate	There is no edge (the cortical part of the piece is flat) or it is challenging to categorize.	
Cortex Location	Cortex Location	Condition1=Cortex Area NOT 0% AND Condition2=LithicArtifactClass NOT Shatter Core Hammer Manuport Grindstone	See "Completeness" categories above.	Specify the location where the majority of cortex is found on the dorsal surface. Refer to the categories under "Completeness" above.	Wilkins <i>et al.</i> (2017)
Cortex Type	Cortex Type	Condition1=Cortex Area NOT 0% OR Condition2=Platform Cortex Yes Complete Yes Partial	Cobble	Rounded water-worn cortex.	Wilkins <i>et al.</i> (2017)
			Outcrop	Irregular, rough cortex.	
			Indeterminate	It is not possible to determine whether it is cobble or outcrop cortex.	
Evidence of Post depositional Burning	Evidence Post Dep Burning		None	There is no indication of post-depositional burning.	Wilkins <i>et al.</i> (2017)
			Pot Lid Scar	The lithic artifact exhibits negative scars from pot lids.	
			Piece Is Potlid	The lithic artifact is a pot lid.	
			Crazing	The artifact displays a network of fine cracks.	
			Color Change	The artifact exhibits alterations in color attributed to burning.	
			Combination of Features	The artifact displays a combination of two or more of the previously mentioned features associated with burning.	

Trait	Code	Condition	Menu	Definition	Reference for additional details
Dorsal Scar Count	Dorsal Scar Count	Condition1=Lithic Artifact Class NOT Shatter Core Hammer Manuport Grindstone AND Condition2=Cortex Area NOT 100%	-	The count of dorsal flake scars that exceeds 6 mm in maximum length.	Wilkins <i>et al.</i> (2017)
Dorsal Direction/Dorsal pattern	Dorsal Direction	Condition1=Lithic Artifact Class NOT Shatter Core Hammer Manuport Grindstone AND Condition2=Retouched Piece Blank NOT Shatter Indeterminate AND Condition3=Cortex Area NOT 100% AND Condition4=Dorsal Scar Count NOT 0 1	Radial	Three or more scars originating from at least three distinct directions.	Wilkins <i>et al.</i> (2017)
			Subradial	Two or more scars from distinct, non-opposing directions.	
			Bidirectional	Two or more scars from two opposing directions.	
			Unidirectional	Two or more scars originating from a single direction.	
			Bi Or Uni	Two or more scars from parallel directions, with ambiguity regarding whether they are bidirectional or unidirectional.	
			Indeterminate	Challenging to categorize.	
Aris Orientation	Aris Orientation	Condition1=Dorsal Direction Bidirectional Unidirectional Bi Or Uni AND Condition2=Cortex Area NOT 100% AND Condition3=Dorsal Scar Count NOT 0 1 2	Parallel	Arrises are parallel or sub-parallel.	Wilkins <i>et al.</i> (2017)
			Convergent	Arrises are converging.	
			Indeterminate	Challenging to categorize.	
Profile Shape	Profile Shape	Condition1=Lithic Artifact Class Comp Flake OR Condition2=Completeness Complete Proximal Left Lateral Right Lateral Prox Left Lateral Prox Right Lat	Flat	The ventral face, from the end of the bulb to the distal end, is flat and makes full or nearly full contact with a flat surface.	Tostevin (2012); Wilkins <i>et al.</i> (2017)
			Curved	The ventral face is curved, forming an arch and not making contact with a flat surface.	
			Twisted	The ventral surface curls, and frequently, the distal end is oblique in relation to the proximal end.	

Trait	Code	Condition	Menu	Definition	Reference for additional details
			Indeterminate	It is not possible to ascertain whether the profile is flat, curved, or twisted.	
Mass	Mass		-	Weight in grams.	Wilkins <i>et al.</i> (2017)
Maximum Length	Max Length		-	Maximum length.	Wilkins <i>et al.</i> (2017)
Maximum Width	Max Width		-	Maximum width perpendicular to maximum length.	Wilkins <i>et al.</i> (2017)
Technological Length	Tech Length	Condition1=Lithic Artifact Class Comp Flake OR Condition2=Completeness Complete Left Lateral Right Lateral	-	The length dimension from percussion point (or center of platform if not visible) to the distal end of the blank along flaking axis. In cores, the length is measured along axis of last flake/blade removal on surface with the most flake scars.	Debénath and Dibble, (1994:19), method 3; Wilkins <i>et al.</i> (2017)
Maximum Technological Width	Max Tech Width	Condition1=Lithic Artifact Class Comp Flake OR Condition2=Completeness Complete Proximal Mesial	-	Maximum technological width perpendicular to the technological length.	Debénath and Dibble (1994:19), method 3; Wilkins <i>et al.</i> (2017)
Maximum Thickness	Max Thickness		-	Maximum thickness inclusive of the bulb of percussion.	Wilkins <i>et al.</i> (2017)
Mid-point Thickness	Mid Thickness	Condition1=Lithic Artifact Class Comp Flake OR Condition2=Completeness Complete Left Lateral Right Lateral	-	Thickness at midpoint of technological length.	Wilkins <i>et al.</i> (2017)
Platform Width	Platform Width	Condition1=Lithic Artifact Class Comp Flake OR Condition2=Completeness Complete Proximal	-	The distance between two points where the striking platform intersects the ventral surface.	Debénath and Dibble (1994:19), method 3; Wilkins <i>et al.</i> (2017)

Trait	Code	Condition	Menu	Definition	Reference for additional details
Platform Thickness	Platform Thickness	Condition1=Lithic Artifact Class Comp Flake OR Condition2=Completeness Complete Proximal Left Lateral Right Lateral Prox Left Lat Prox Right Lat	-	The distance from the point of percussion to the opposite point on the dorsal edge of the striking platform, encompassing the dorsal surface of the flake.	Debénath and Dibble (1994:19); Wilkins <i>et al.</i> (2017)
Exterior Platform Angle	Exterior Plat Angle	Condition1=Lithic Artifact Class Comp Flake OR Condition2=Completeness Complete Proximal Left Lateral Right Lateral Prox Left Lat Prox Right Lat	-	Measure the angle of the platform and dorsal surface at the platform midpoint, aligning the goniometer arm parallel to the flake profile.	Dibble (1997); Wilkins <i>et al.</i> (2017)
Flake Termination	Flake Termination	Condition1=Lithic Artifact Class Comp Flake OR Condition2=Completeness Complete Distal Left Lat Distal Right Lat	Feather	Sharp, acute angle.	Andrefsky (2005:21); Wilkins <i>et al.</i> (2017)
			Partial Hinge Or Step	Partial hinge/step. Termination is s-shaped in profile. In profile, termination is hinged or stepped on the ventral side and is feathered on the dorsal side.	
			Hinge	Curved upward towards the dorsal surface.	
			Step	Abrupt right angle break.	
			Hinge or Step	Challenging to categorize if it is either hinge or step.	
			Overshoot	Retains the remnant edge of the core or the opposing platform, whether plunging or not.	
			Indeterminate	Termination is challenging to categorize, or the artifact exhibits retouching at the distal end.	
Platform Preparation	Platform Prep	Condition1=Lithic Artifact Class Comp Flake OR Condition2=Completeness	Not Prepared	Plain platform, bearing only a single scar.	Soriano <i>et al.</i> (2007); Wilkins <i>et al.</i> (2017)
			Faceted With Bulb	Faceted. It has more than one scar, and negative bulbs of percussion are evident within at least one of them.	

Trait	Code	Condition	Menu	Definition	Reference for additional details
		Complete Proximal Left Lateral Right Lateral Prox Left Lat Prox Right Lat AND Condition3=Plat form Cortex NOT Yes Complete	Residual Facet Without Bulb	Residual facets. It has more than one scar, and negative bulbs of percussion are not discernible.	
			Indeterminate	Challenging to categorize, may be due to crushing or very small thin size.	
Number of Platform Scars	Number Platform Scars	Condition1=Lit hic Artifact Class Comp Flake OR Condition2= Completeness Complete Proximal Left Lateral Right Lateral Prox Left Lat Prox Right Lat AND Condition3=Plat form Prep NOT Prepared Indeterminate	Enter number of platform scars (greater than 1mm)	The number of platform scars.	Wilkins <i>et al.</i> (2017)
Banding Orientation	Banding Orientation	Condition1=Ra w Material Quartzite AND Condition2=Lit hic Artifact Class Comp Flake OR Condition3= Completeness Complete Proximal Distal Left Lateral Right Lateral Prox Left Lat Prox Right Lat Distal Left Lat Distal Right Lat Mesial Left Lat Mesial Right Lat	No Banding Visible	No visible banding.	Wilkins (2013, 2017)
			With	Bands will be observable on both dorsal and ventral surfaces, running parallel to the flaking axis.	
			Through	The bands are primarily observable on the inner side and run parallel to the flaking axis.	
			Oblique	Diagonal bands are evident on both the dorsal and ventral surfaces in relation to the flaking axis.	
			Against	Bands are observable on the dorsal and lateral surfaces, oriented perpendicular to the flaking axis.	
			Indeterminate	Challenging to categorize.	
Retouch Type	Retouch Type	Condition1=Lit hic Artifact Class	Notch Denticulate	Can be formed by one single notch (Clactonian) or by several retouches.	Wilkins <i>et al.</i> (2017)

Trait	Code	Condition	Menu	Definition	Reference for additional details
		Retouched Piece	Backing	Blunted edge(s) are characterized by a very steep retouch, perpendicular to the plane of the piece.	
			Burination	Likely uncommon but must possess a negative bulb and be situated along a lateral edge.	
			Invasive Edge Shaping	Invasive edge shaping involves long flake scars that extend into the body of the piece.	
			Marginal Edge Shaping	Marginal edge shaping involves short flake scars that do not extend into the body of the piece.	
			<i>Pieces Esquillees</i>	Wedge-shaped piece with several small, stepped scars emanating from two opposing chisel-like edges.	
Retouch Angle	Edge Retouch Angle	Condition1=Retouch Type Notch Denticulate Backing Invasive Edge Shaping Marginal Edge Shaping	Enter angle of retouch.	Measure the angle of the retouched edge from the center of the longest continuous retouch series or from inside the largest notch.	Wilkins <i>et al.</i> (2017)
Diameter of Largest Notch	Diameter Of Largest Notch	Condition1=Retouch Type Notch Denticulate	Enter the Diameter of the Largest Notch (mm):	Diameter of largest notch on a retouched piece.	Wilkins <i>et al.</i> (2017)
Retouched Piece Typology	Retouched Piece Typology	Condition1=Lithic Artifact Class Retouched Piece	Backed Piece	Backed piece.	Wilkins <i>et al.</i> (2017)
			Notched Piece	Notches must display multiple flake scars, either notch or denticulate.	
			Retouched convergent piece/Point	Retouched edges converging to form a point.	
			Side Scraper	Continuous retouch along a portion of one lateral edge.	
			End Scraper	Continuous retouching includes distal portion.	
			Double Scraper	Continuous retouch along two edges that do not converge or converge into a very thick or irregular point (not meeting the criteria for classification as a point).	
			Scraper With Three Or More Edges	Scraper with three or more retouched edges.	

Trait	Code	Condition	Menu	Definition	Reference for additional details
			<i>Pieces Esquillees</i>	Wedge-shaped piece with several small, stepped scars emanating from two opposing chisel-like edges.	
			Minimally Retouched	Limited retouch visible on edges.	
			Indeterminate	Challenging to categorize.	
			Other	Does not fall into the above category, but a typological designation is feasible.	
Other Retouched Piece Typology	Other Retouched Piece Typology	Condition 1=Retouched Piece Typology Other	Please enter other retouched piece typology	Option to write in other typology if "other" is selected.	-
Direction of removals on the surface of a core	Direction of removals	Condition 1=Lithic artifact class Core	Unidirectional	Refers to a core with removals coming from one direction.	Tostevin (2012)
			Bidirectional	A core with removals coming from two directions, usually opposed directions.	
			Multidirectional	Multidirectional cores have removals coming from more than two different directions.	
			Indeterminate/Other	Challenging to categorize.	
Number of Removal on core surface	Number of Removal surface	Condition 1=Lithic artifact class Core	Unifacial	A core flaked on one side or face only. The removals must originate from the same edge of the core.	Shea (2013, 2020)
			Bifacial	A core flaked on opposing sides or faces. Flakes are alternately taken from either side.	
			Multifacial	A core subjected to flaking on three or more distinct sides or faces.	
			Indeterminate/Other	Challenging to categorize.	
Number of Platforms on a core	Number of platforms	Condition 1=Lithic artifact class Core	Single Platform	This is when a series of flake scars primarily originate from a single platform or a single continuous worked edge.	Shea (2013, 2020); Brenner (2019)
			Opposed	These cores have two distinct (opposing) worked edges roughly parallel to each other. The flakes removed from these edges may be present on the same or different sides of the core.	
			Multiplatform	Three or more primary platforms from which flakes were struck in a consistent direction.	

Trait	Code	Condition	Menu	Definition	Reference for additional details
			Indeterminate/Other	Challenging to categorize.	
Removal arrangements on a core surface	Removal arrangement	Condition 1=Lithic artifact class Core	Parallel	Cores with parallel or sub-parallel scars, where flake scars from a platform originate or stem from either the same direction or opposed directions.	Shea (2013, 2020); Brenner (2019)
			Centripetal/Radial	Cores with removals directed from the periphery toward the center of one surface or toward the centers of two opposing surfaces.	
			Orthogonal	Cores with removals that tend to converge towards an intersection, forming a right angle or aligning roughly perpendicular to one another.	
			Indeterminate/Other	Challenging to categorize.	
Percussion Technique	Percussion Technique	Condition 1=Lithic artifact class complete flakes and proximal parts	Direct hard hammer	The lack of lipping on blanks, along with pronounced bulbs featuring visible Hertzian cones and circular cracked impact points.	Pelegrin (1995, 2000).
			Direct soft hammer	Blanks show evidence of lipped platforms.	
			Other	Refers to any percussion technique observed apart from direct hard and soft hammer, for example bipolar, indirect percussion etc.	
Degree of reduction	Degree Of Reduction	Condition 1=Lithic artifact class Core	Exhausted core	A core from which numerous flakes have been removed during the knapping process, rendering it unusable for any other purpose, possibly due to its size.	Brenner (2019)
			Minimal Core	Minimal cores exhibit only a few flake removals.	
			Core fragment	Core fragments are broken and cannot be determined in terms of their original category.	
			Indeterminate/Other	Challenging to categorize.	
Core exploitation method	Levallois category: Exploitation Method	Condition 1=Lithic artifact class Core	Recurrent Unidirectional	Unidirectional exploitation involves the removal of predetermined flakes from a single platform.	Chazan (2020); Boëda (1986, 1995)
			Recurrent Bidirectional	Bidirectional exploitation refers to systems where predetermined flakes are struck from two opposed platforms.	

Trait	Code	Condition	Menu	Definition	Reference for additional details
			Recurrent Centripetal	In the centripetal method, predetermined flake removals are struck from around the periphery of the core.	
			Unidirectional convergent	Flakes are removed from a single platform. Nevertheless, the direction of these flake removals converges toward the midpoint, creating conditions favorable for extracting a central flake and ultimately forming a triangular shape.	
			Preferential	Preferential exploitation entails extracting a single, substantial flake from the production face before re-preparing the convex portions of the production face.	
			Indeterminate/ Other	Challenging to categorize.	
	Exploitation Method	Condition 1=Lithic artifact class Core	Blade/let cores/ Prismatic	Core prepared for blade removal. The core features a cylindrical shape resulting from the systematic extraction of blades. A flat surface is formed at its upper part to establish platforms for flake removal, and it typically tapers toward the bottom.	Tostevin (2012)
		Condition 1=Lithic artifact class Core	Platform	The volume of platform cores is defined by multiple surfaces with removals parallel to one another. Primary removals originate from a well-defined platform.	
			Discoidal	The discoidal method seeks to generate multiple flakes through centripetal, repeated, and typically bifacial removals.	Chazan (2020)
Core blank	Core blank	Condition 1=Lithic artifact class Core	Cobble	Pebbles are defined as being smaller than 5 cm, while anything larger is classified as a cobble.	Brenner (2019)
			Pebble		
			Flake	Core-on-flake. A flake was re-used as a core blank.	
			Indeterminate/ Other	Challenging to categorize.	
Core Sphericity Blank	Core Blank Sphericity	Condition1=Lithic Artifact Class Core	Spherical Or Cubic	The estimated shape of the core blank is a spherical or cubical nodule that would have had a low surface area to volume ratio.	Wilkins <i>et al.</i> (2017)

Trait	Code	Condition	Menu	Definition	Reference for additional details
			Not Spherical Flat	The estimated shape of the core blank is a flat tabular nodule that would have had a high surface area to volume ratio.	
			Flake	Likely a flake blank, inferred from the visible or partially visible bulbar surface.	
			Indeterminate	Challenging to categorize.	
Intended Product	Intended Product	Condition 1=Lithic Artifact Class Core	Blade/Bladelet	The removals of flake scars resemble those of a blade or bladelet (where the length is twice the width).	Wilkins <i>et al.</i> (2017)
			Flake	The intended products are neither blades nor points.	
			Point	The ridges of the flake scar converge where a relatively large triangular product was removed.	
			Indeterminate	Challenging to categorize.	
Core: Orientation	Core Orientation	Condition 1=Lithic artifact class Core	Longitudinal	The narrower and more extended surface of a core is primarily utilized for the majority of removals.	Tostevin (2012)
			Broad face	The broader or wider surface of the core, typically possessing a large area, is utilized for most of the removals.	
			indeterminate	Challenging to categorize.	
Core management	Core management	Condition 1=Lithic artifact class core	<i>Débordant</i> Removals	Core edge flakes primarily utilized to maintain the lateral convexities of the cores.	Tostevin (2012)
			Circumferential removals/Central flaking	Flakes are removed from the periphery or outer edge of a core as part of core maintenance. These removals may converge at the core's center.	
			Core maintenance blades	This approach involves extracting multiple blades from a surface positioned adjacent to the original surface, as a method of preserving the lateral convexities of a core.	
			Indeterminate	Challenging to categorize.	
Other Core typologies Conard Unified core type	Conard Unified Type	Condition 1=Lithic artifact class core	Inclined	Two opposing surfaces display removals angled in relation to the intersecting plane, with these removals taking place on broader surfaces and converging toward the center.	Conard <i>et al.</i> (2004)

Trait	Code	Condition	Menu	Definition	Reference for additional details
			Parallel	Removals are parallel or nearly parallel to the intersecting plane. These removals occur on wide surfaces and can converge towards the center, the near distal end, or run parallel to each other.	
			Indeterminate	Challenging to categorize.	
Site specific typology	Site Specific Core Typology	Condition 1=Lithic artifact class core	Enter site core typology	This section is for the cores that cannot fit in other core typologies mentioned above that have already been defined.	Yellen <i>et al.</i> (2005)
Completeness of Backed Pieces	Completeness Of Backed Piece	Condition1=RetouchedPiece Typology Backed Piece	Complete	Complete backed pieces.	-
			Fragment	A fragment of a backed artifact.	
Backed Piece Typology	Backed Piece Typology	Condition1=RetouchedPiece Typology Backed Piece	Segment	A curved edge with backing, which can be fully or partially backed.	Inizan <i>et al.</i> (1999); Porraz <i>et al.</i> (2013); Villa <i>et al.</i> (2010); Way <i>et al.</i> 2022; Wilkins <i>et al.</i> (2017)
			Triangle	Two edges with backing converge into point.	
			Trapeze	Completely backed to form a trapeze shape that is a geometric form characterized by a quadrilateral with two parallel sides and two non-parallel sides.	
			Truncation Single	A single truncation occurs when the distal or proximal portion of a blade is “truncated,” leaving the back unretouched. The piece is considered partially backed.	
			Truncation Double	Double truncation occurs when both the distal and proximal portions of a blade are truncated, leaving the back unretouched. The piece is considered partially backed.	
			Truncation Indeterminant	The piece is fractured, making it challenging to determine whether it exhibits double or single truncation.	
			Minimally Backed	Minimally backed with a low level of retouch.	
			Indeterminate	Challenging to categorize.	
			Other	The artifact represents another form of backed piece not included in the menu.	

Trait	Code	Condition	Menu	Definition	Reference for additional details
Other Backed Piece Typology	Other Backed Piece ID	Condition1=Backed Piece Typology Other	Identify the other backed piece typology:	Backed pieces that do not fall into the previously mentioned category.	-
Backing Distribution	Backing Distribution	Condition1=Retouched Piece Typology Backed Piece	Completely Backed	Fully backed. Retouch covers the entire lateral edge of the blade.	Wilkins <i>et al.</i> (2017)
			Partially Backed	The lateral edge is backed only to a partial extent.	
Other Notes	Other Notes		Enter Other Notes	-	-

## Appendix 2: Code for CFG file to use with E5

[E5] (<https://github.com/surf3s/E5>)

FILENAME=DBSR/ BED 9/ LOWER F/ UNIT F/UNIT 4/UNIT 10 Lithic Analysis 2021-23.mdb

DELAYTIME=1

TABLE=DBSR/ BED 9/ LOWER F/ UNIT F/UNIT 4/UNIT 10 Lithic Analysis 2021-23

RE-EDIT=Yes

BACKCOLOR=13619151

DATABASE=C:\Users\Precious\Desktop\ e5\ e5\11 May 2021 PM.json

[PLOTTEDFINDNUMBER]

TYPE=TEXT

PROMPT=Enter Plotted Find Number:

LENGTH=6

UNIQUE=True

[STRATAGG]

TYPE=MENU

PROMPT=select Strat Agg (if applicable)

MENU=DBSR

LENGTH=20

CARRY=True

[LOT/LAYER]

TYPE=NUMERIC

PROMPT=Enter the Lot/layer Number:

LENGTH=6

CARRY=True

[RESEARCHER]

TYPE=MENU

PROMPT=Select the Researcher:

MENU=PreciousMaenzanise

LENGTH=30

CARRY=True

[RAWMATERIAL]

TYPE=MENU

PROMPT=Select the Raw Material:

MENU=ChalcedonicBlackChert,Tuff,BandedIronStone,Quartz,Quartzite,Hornfels,  
chalcedony,Other

LENGTH=25

CARRY=True

[OTHERRAWMATERIALID]

TYPE=TEXT

PROMPT=Identify or Describe the Raw Material:

LENGTH=50

CONDITION1=RawMaterial Other

[LITHICARTIFACTCLASS]

TYPE=MENU

PROMPT=Select the Lithic Artifact Class:

MENU=CompFlake,FlakeFrag,BladeBladeFrag,Shatter,RetouchedPiece,Core,HammerManuport  
Grindstone

LENGTH=25

[UNRETOUCHEDPOINT]

TYPE=MENU

PROMPT=Is this piece a Point or Point Fragment?:

MENU=No,Yes,Indeterminate

LENGTH=15

CONDITION1=LithicArtifactClass CompFlake,FlakeFrag,BladeBladeFrag

[RETOUCHEDPIECEBLANK]

TYPE=MENU

PROMPT=Enter the probable Blank for the Retouched Piece:

MENU=Flake,Blade,ShatterIndeterminate

LENGTH=20

CONDITION1=LithicArtifactClass RetouchedPiece

[COMPLETENESS]

TYPE=MENU

PROMPT=Enter the Portion of the Artifact that is Present. For Retouched Pieces Record the Blank:

MENU=Complete,Proximal,Fragment,Distal,Medial,LeftLateral,RightLateral,ProxLeftLat,Prox  
RightLat,DistalLeftLat,DistalRightLat,MedialLeftLat,MedialRightLat

LENGTH=25

CONDITION1=LithicArtifactClass NOT CompFlake,Shatter,Core,HammerManuportGrindstone

[COREHAMMERCOMPLETENESS]

TYPE=MENU

PROMPT=Select completeness of Core or HammerManuportGrindstone:

MENU=Complete,SplitFragment

LENGTH=20

CONDITION1=LithicArtifactClass Core,HammerManuportGrindstone

[EVIDENCEBIPOLARPERCUSSION]

TYPE=MENU

PROMPT=Is there Evidence for Bipolar (Hammer/Anvil) Percussion?:  
MENU=No,Yes,Indeterminate,  
LENGTH=15  
CONDITION1=LithicArtifactClass CompFlake,Core,HammerManuportGrindstone OR  
CONDITION2=Completeness Complete,LeftLateral,RightLateral

[TECHNICALCATEGORY]  
TYPE=TEXT  
PROMPT=Enter the Sub-Agg Specific Technical Category:  
LENGTH=25  
CONDITION1=LithicArtifactClass BladeBladeFrag

[CORTEXAREA]  
TYPE=MENU  
PROMPT=Enter the Estimated Cortex Area of DORSAL surface, or the entire surface of Shatter  
Core and HammerManuportGrindstone:  
MENU=0%,1-20%,21-40%,41-60%,61-80%,81-99%,100%,Indeterminate  
LENGTH=13

[PLATFORMCORTEX]  
TYPE=MENU  
PROMPT=Is there Platform Cortex?:  
MENU=No,YesComplete,YesPartial,Indeterminate,  
LENGTH=20  
CONDITION1=LithicArtifactClass CompFlake OR  
CONDITION2=Completeness  
Complete,Proximal,LeftLateral,RightLateral,ProxLeftLat,ProxRightLat

[CORTEXCHATTERMARKS]  
TYPE=MENU  
PROMPT=Select whether there are Chatter Marks present, or not:  
MENU=No,Yes,Indeterminate  
LENGTH=20  
CONDITION1=CortexArea NOT 0% OR  
CONDITION2=PlatformCortex YesComplete,YesPartial

[CORTEXROUNDNESS]  
TYPE=MENU  
PROMPT=Select the Roundness of the Cortex Edges:  
MENU=Angular,SubangularSubrounded,Rounded,Indeterminate  
LENGTH=20  
CONDITION1=CortexArea NOT 0% OR  
CONDITION2=PlatformCortex YesComplete,YesPartial

[CORTEXLOCATION]  
TYPE=MENU

PROMPT=Select where the Majority of Cortex is Located:  
MENU=WholeDorsal,Proximal,Distal,Medial,LeftLateral,RightLateral,ProxLeftLat,ProxRightLat,DistalLeftLat,DistalRightLat,MedialLeftLat,MedialRightLat,Indeterminate  
LENGTH=20  
CONDITION1=CortexArea NOT 0% AND  
CONDITION2=LithicArtifactClass NOT Shatter,Core,HammerManuportGrindstone

[CORTEXTYPE]  
TYPE=MENU  
PROMPT=Select the probable Cortex Type:  
MENU=Cobble,Outcrop,Ind.  
LENGTH=25  
CONDITION1=CortexArea NOT 0% OR  
CONDITION2=PlatformCortex YesComplete,YesPartial

[EVIDENCEPOSTDEPBURNING]  
TYPE=MENU  
PROMPT=Select what kind of Evidence for Post-Depositional Burning is Present, if any:  
MENU=None,PotLidScar,PieceISPotlid,Crazing,ColorChange,CombinationOfFeatures  
LENGTH=21

[DORSALSCARCOUNT]  
TYPE=NUMERIC  
PROMPT=Enter the Number of Dorsal Scars Greater than 6mm:  
LENGTH=5  
CONDITION1=LithicArtifactClass NOT Shatter,Core,HammerManuportGrindstone AND  
CONDITION2=CortexArea NOT 100%

[DORSALDIRECTION]  
TYPE=MENU  
PROMPT=Enter the Dorsal Scar Directionality:  
MENU=Radial,Subradial,Bidirectional,Unidirectional,BiOrUni,Indeterminate  
LENGTH=25  
CONDITION1=LithicArtifactClass NOT Shatter,Core,HammerManuportGrindstone AND  
CONDITION2=RetouchedPieceBlank NOT ShatterIndeterminate AND  
CONDITION3=CortexArea NOT 100% AND  
CONDITION4=DorsalScarCount NOT 0,1

[ARISORIENTATION]  
TYPE=MENU  
PROMPT=Enter the Aris (Scar Ridge) Orientation:  
MENU=Parallel,Convergent,Indeterminate,  
LENGTH=13  
CONDITION1=DorsalDirection Bidirectional,Unidirectional,BiOrUni AND  
CONDITION2=CortexArea NOT 100% AND  
CONDITION3=DorsalScarCount NOT 0,1,2

[PROFILESHAPE]  
TYPE=MENU  
PROMPT=Enter the Profile Shape:  
MENU=Flat,Curved,Twisted,Indeterminate,  
LENGTH=13  
CONDITION1=LithicArtifactClass CompFlake OR  
CONDITION2=Completeness  
Complete,Proximal,LeftLateral,RightLateral,ProxLeftLat,ProxRightLat

[MASS]  
TYPE=NUMERIC  
PROMPT=Enter the Mass (g):  
LENGTH=10

[MAXLENGTH]  
TYPE=INSTRUMENT  
PROMPT=Enter the Maximum Length (mm):  
LENGTH=10

[MAXWIDTH]  
TYPE=INSTRUMENT  
PROMPT=Enter the Maximum Width (mm):  
LENGTH=10

[TECHLENGTH]  
TYPE=INSTRUMENT  
PROMPT=Enter the Technological Length (mm):  
LENGTH=10  
CONDITION1=LithicArtifactClass CompFlake OR  
CONDITION2=Completeness Complete,LeftLateral,RightLateral

[MAXTECHWIDTH]  
TYPE=INSTRUMENT  
PROMPT=Enter the Max Technological Width (mm):  
LENGTH=10  
CONDITION1=LithicArtifactClass CompFlake OR  
CONDITION2=Completeness Complete,Proximal,Medial

[MAXTHICKNESS]  
TYPE=INSTRUMENT  
PROMPT=Enter the Max Thickness (mm):  
LENGTH=10

[MIDTHICKNESS]  
TYPE=INSTRUMENT  
PROMPT=Enter the Thickness at the Midpoint (mm):

LENGTH=10  
CONDITION1=LithicArtifactClass CompFlake OR  
CONDITION2=Completeness Complete,LeftLateral,RightLateral

[PLATFORMWIDTH]  
TYPE=INSTRUMENT  
PROMPT=Enter Width of the Platform (mm):  
LENGTH=10  
CONDITION1=LithicArtifactClass CompFlake OR  
CONDITION2=Completeness Complete,Proximal

[PLATFORMTHICKNESS]  
TYPE=INSTRUMENT  
PROMPT=Enter Thickness of the Platform (mm):  
LENGTH=10  
CONDITION1=LithicArtifactClass CompFlake OR  
CONDITION2=Completeness  
Complete,Proximal,LeftLateral,RightLateral,ProxLeftLat,ProxRightLat

[EXTERIORPLATANGLE]  
TYPE=NUMERIC  
PROMPT=Enter Exterior Platform Angle (degrees):  
LENGTH=10  
CONDITION1=LithicArtifactClass CompFlake OR  
CONDITION2=Completeness  
Complete,Proximal,LeftLateral,RightLateral,ProxLeftLat,ProxRightLat

[FLAKETERMINATION]  
TYPE=MENU  
PROMPT=Select the Termination Type:  
MENU=Feather,Hinge,Step,HingeOrStep,PartialHingeOrStep,Overshoot,Indeterminate  
LENGTH=25  
CONDITION1=LithicArtifactClass CompFlake OR  
CONDITION2=Completeness Complete,Distal,DistalLeftLat,DistalRightLat

[PLATFORMPREP]  
TYPE=MENU  
PROMPT=Select the Platform Preparation:  
MENU=NotPrepared,FacetedWithBulb,ResidualFacetWithoutBulb,Indeterminate  
LENGTH=35  
CONDITION1=LithicArtifactClass CompFlake OR  
CONDITION2=Completeness  
Complete,Proximal,LeftLateral,RightLateral,ProxLeftLat,ProxRightLat AND  
CONDITION3=PlatFormCortex NOT YesComplete

[NUMBERPLATFORMSCARS]

TYPE=TEXT

PROMPT=Enter the Number of Platform Scars (greater than 1 mm):

LENGTH=4

CONDITION1=LithicArtifactClass CompFlake OR

CONDITION2=Completeness

Complete,Proximal,LeftLateral,RightLateral,ProxLeftLat,ProxRightLat AND

CONDITION3=PlatformPrep NOT NotPrepared,Indeterminate

[PLATFORMMORPHOLOGY]

TYPE=MENU

PROMPT=Select the Platformmorphology:

MENU=Punctiform,narrow linear,curved,Oval or narrow triangular,Quadrangular or wide trapezoidal,Indeterminate

LENGTH=25

CONDITION1=LithicArtifactClass BladeBladeFrag

CONDITION2=Completeness

Complete,Proximal,LeftLateral,RightLateral,ProxLeftLat,ProxRightLat

[BULBMORPHOLOGY]

TYPE=MENU

PROMPT=Select the Bulbmorphology:

MENU=Lipped without a bulb,Prominent bulb with or without lipping,Indeterminate

LENGTH=25

CONDITION1=LithicArtifactClass BladeBladeFrag

CONDITION2=Completeness

Complete,Proximal,LeftLateral,RightLateral,ProxLeftLat,ProxRightLat

[BANDINGORIENTATION]

TYPE=MENU

PROMPT=How is the Axis of Percussion Oriented with respect to Visible Banding, if present?

MENU=NoBandingVisible,With,Through,Oblique,Against,Indeterminate

LENGTH=16

CONDITION1=RawMaterial BandedIronStone,Quartzite AND

CONDITION2=LithicArtifactClass CompFlake OR

CONDITION3=Completeness

Complete,Proximal,Distal,LeftLateral,RightLateral,ProxLeftLat,ProxRightLat,DistalLeftLat,DistalRightLat,MedialLeftLat,MedialRightLat

[RETOUCHTYPE]

TYPE=MENU

PROMPT=Select the Type of Retouch:

MENU=NotchDenticulate,Backing,Burination,InvasiveEdgeShaping,MarginalEdgeShaping,PiecesEsquillees

LENGTH=25

CONDITION1=LithicArtifactClass RetouchedPiece

[RETOUCHEDGEANGLE]

TYPE=NUMERIC

PROMPT=Enter the Angle of the Retouched Edge. Measure center of longest series of continuous retouch or from inside the largest notch.:

LENGTH=5

CONDITION1=RetouchType

NotchDenticulate,Backing,InvasiveEdgeShaping,MarginalEdgeShaping

[DIAMETEROFLARGESTNOTCH]

TYPE=INSTRUMENT

PROMPT=Enter the Diameter of the Largest Notch (mm):

LENGTH=5

CONDITION1=RetouchType NotchDenticulate

[RETOUCHEDPIECETYOLOGY]

TYPE=MENU

PROMPT=Select the Retouched Piece Typology:

MENU=BackedPiece,NotchedPiece,RetouchedPoint,SideScraper,EndScraper,DoubleScraper,ScraperWithThreeOrMoreEdges,PiecesEsquillees,MinimallyRetouched,Indeterminate,Other

LENGTH=30

CONDITION1=LithicArtifactClass RetouchedPiece

[OTHERRETOUCHEDPIECETYOLOGY]

TYPE=TEXT

PROMPT=Type in Retouched Piece Typology:

LENGTH=50

CONDITION1=RetouchedPieceTypology Other

[DIRECTIONOFREMOVALS]

TYPE=MENU

PROMPT=Select the Core Type: According to Direction of Removals

MENU=Unidirectional,Bidirectional,Multidirectional,Indeterminate/Other

LENGTH=50

CONDITION1=LithicArtifactClass Core

[NUMBEROFREMOVALSURFACE]

TYPE=MENU

PROMPT=Select the Core Type: According to Number of Removal Surface

MENU=Unifacial,Bifacial,Multifacial,Indeterminate/Other

LENGTH=50

CONDITION1=LithicArtifactClass Core

[NUMBEROFPLATFORMS]

TYPE=MENU

PROMPT=Select the Core Type: According to Number of Platforms

MENU=SinglePlatform,Opposed,MultiPlatform,Indeterminate/Other  
LENGTH=50  
CONDITION1=LithicArtifactClass Core

[REMOVALARRANGEMENT]

TYPE=MENU  
PROMPT=Select the Core Type: According to Removal Arrangement  
MENU=Parallel,Centripetal/Radial,Orthogonal,Indeterminate/Other  
LENGTH=50  
CONDITION1=LithicArtifactClass Core

[PERCUSSIONTECHNIQUE]

TYPE=MENU  
PROMPT=Select the Percussion Technique  
MENU=Direct hard hammer,Direct soft hammer,Indeterminate/Other  
LENGTH=50  
CONDITION1=LithicArtifactClass CompleteFlake,Flakefragment,Blade/blade fragments  
CONDITION2=Completeness Complete,Proximal,

[DEGREEOFREDUCTION]

TYPE=MENU  
PROMPT=Select the Degree of Reduction  
MENU=ExhaustedCore,MinimalCore,CoreFragment,Indeterminate/Other  
LENGTH=50  
CONDITION1=LithicArtifactClass Core

[EXPLOITATIONMETHOD: LEVALLOISCATEGORY]

TYPE=MENU  
PROMPT=Select the Exploitation method Levallois Category  
MENU=Recurrent,RecurrentUnidirectional,RecurrentBidirectional,RecurrentCentripetal,UnidirectionalConvergent,Preferential,Indeterminate/Other  
LENGTH=50  
CONDITION1=LithicArtifactClass Core

[OTHEREXPLOITATIONMETHODS]

TYPE=MENU  
PROMPT=Select the Other Exploitation Methods  
MENU=Blade/letCores/Prismatic,Discoidal,Indeterminate/Other  
LENGTH=50  
CONDITION1=LithicArtifactClass Core

[COREBLANK]

TYPE=MENU  
PROMPT=Select the Core Blank  
MENU=Cobble,Pebble,Flake,Indeterminate  
LENGTH=20

CONDITION1=LithicArtifactClass Core

[COREBLANKSPHERICITY]

TYPE=MENU

PROMPT=Select the Estimated Core Blank Sphericity:

MENU=NotSphericalFlat,SphericalOrCubic,Flake,Indeterminate

LENGTH=20

CONDITION1=LithicArtifactClass Core

[INTENDEDPRODUCT]

TYPE=MENU

PROMPT=Select the Intended Product

MENU=Blade/bladelet,Flake,Point,indeterminate

LENGTH=20

CONDITION1=LithicArtifactClass Core

[COREORIENTATION]

TYPE=MENU

PROMPT=Select the Core orientation

MENU=Longitudinal,Broad-face,Discoidal,Other

LENGTH=20

CONDITION1=LithicArtifactClass Core

[COREMANAGEMENT]

TYPE=MENU

PROMPT=Select the Core management

MENU=DebordantRemovals,CircumferentialRemovals,SideBladeRemovals,Other

LENGTH=50

CONDITION1=LithicArtifactClass Core

[OTHERCORETYPOLOGIES: CONARDUNIFIEDCORETYPE]

TYPE=MENU

PROMPT=Select Other typologies: Conard Unified Core Type

MENU=Inclined,Parallel,Platform,Other

LENGTH=20

CONDITION1=LithicArtifactClass Core

[SITESPECIFICCORETYPOLOGY]

TYPE=TEXT

PROMPT=Enter Site Specific Core Typology

LENGTH=50

CONDITION1=LithicArtifactClass Core

[COMPLETENESSOFBACKEDPIECE]

TYPE=MENU

PROMPT=Enter the completeness of the backed piece:

MENU=Complete,Fragment  
LENGTH=25  
CONDITION1=RetouchedPieceTypology BackedPiece

[BACKEDPIECETYOLOGY]  
TYPE=MENU  
PROMPT=Select the backed piece typology:  
MENU=Segment,Triangle,Trapeze,TruncationSingle,TruncationDouble,TrunctionInd,Minimally  
Backed,Indeterminate,Other  
LENGTH=25  
CONDITION1=RetouchedPieceTypology BackedPiece

[OTHERBACKEDPIECEID]  
TYPE=TEXT  
PROMPT=Identify the other backed piece typology:  
LENGTH=50  
CONDITION1=BackedPieceTypology Other

[BACKINGDISTRIBUTION]  
TYPE=MENU  
PROMPT=Enter how the backing retouch is distributed:  
MENU=CompletelyBacked,PartiallyBacked  
LENGTH=30  
CONDITION1=RetouchedPieceTypology BackedPiece

[OTHERNOTES]  
TYPE=TEXT  
PROMPT=Enter Other Notes:  
LENGTH=50