Exploring Variability in Settlement Pattern in the Eastern Sahara During the Early Holocene: SHE Diversity Analysis and Legacy Assemblages

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A thesis submitted in fulfilment of the requirements for the degree of Master of Arts in Anthropology, the University of Auckland, 2022.

Abstract

Many current approaches to modelling settlement pattern for early Holocene sites in the Eastern Sahara continue to rely on identifying different site types and ‘cultural’ groups. A significant portion of these site types were defined by the Combined Prehistoric Expedition (CPE), which linked changes in settlement pattern to changes in the environment (e.g., wet and dry periods) and cultural changes identified through differences in assemblage composition (e.g., El Nabta or El Adam). Due to the nature of the archaeological record in the desert, these divisions are primarily defined by differences in the number and proportions of different tools at each site through techno-typological analysis. However, these divisions have not been tested for their significance.

Legacy collections and legacy assemblages provide an opportunity to re-examine the data that supports commonly held assumptions in archaeology. Using samples from legacy collections also requires a sufficient understanding of their context and what proportion of the original site they represent. This thesis focuses on testing whether differences in the diversity of lithic assemblages drawn from the CPE legacy collections support established identifications of site types through time and across space when the sample size is considered. SHE diversity analysis is presented as a method for identifying where diversity within an assemblage differs from an expected trend created through increasing sample size. The results suggest that sample size significantly contributes to the differences between assemblages analysed in this study with the history of curation, and observer differences also impacting some variation. Overall, this suggests that the techno-typological analysis of lithic artefacts lacks the specificity required to demonstrate differences in site types that are needed to discuss changes in settlement pattern in the Eastern Sahara.

Key Words: SHE diversity analysis, Lithics, Settlement Pattern, Legacy data, Nabta Playa, Bir Kiseiba, Early Holocene.

Acknowledgements

There are a number of people who contributed to the completion of this thesis that I would like to extend my deepest gratitude. First and foremost, to my supervisor Dr Rebecca Phillipps, thank you for your encouragement, assistance, and support throughout the process of researching and writing this thesis. I would like to extend my sincerest gratitude for your time reading multiple drafts of these chapters and for your irreplaceable advice. Your guidance has made me a better writer and academic. Thank you also for granting me access to the British Museum data I used in this thesis.

I would like to recognise the invaluable assistance of my supervisor Professor Simon Holdaway. Thank you for reading the final draft of these chapters and for the vital advice and feedback you provided me.

I am deeply grateful to my sister Uma Tuffnell for the many hours of discussion around structure and arguments. Thank you for your support, ideas, and critical comments and for providing opinions on multiple drafts along the way.

I would like to thank Liam Johns and Kendall Harris for their time and effort in proofreading this thesis.

I would also like to thank my teammates from sailing and friends from all walks of life for your understanding, support, and encouragement, especially Luca Muir and Annie Huang for your online company during long writing sessions, and a sympathetic ear when the work was hard. Finally, I wish to acknowledge my family, especially my parents for their unwavering support, and financial assistance, without which I would not have been unable to pursue this path.

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Abbreviations

AHP African Humid Period

BP Before Present (present = 1950)

CPE Combined Prehistoric Expedition

ITCZ Inter-Tropic Convergence Zone

SMU Southern Methodist University

UOA University of Auckland

Chapter One: Introduction

The archaeological record of the Eastern Sahara during the early Holocene documents a period of dramatic climate change, providing a valuable opportunity to explore how past humans adapted their behaviour in the face of an unpredictable climate (Mutri et al., 2020). The environmental change provided the conditions that allowed humans to occupy arid areas, that were previously inaccessible to humans for extended habitation. Studies indicate that groups of hunter-gatherers moved through the desert during this time, capitalising on areas with favourable environmental circumstances created by the African Humid Period (AHP), which resulted in the *greenification* of the Eastern Sahara (e.g., Claussen et al., 2017; Kröpelin et al., 2008; Kuper & Kröpelin, 2006; Wright, 2017). The slightly wetter and more humid conditions also supported a diverse range of plants and animals and allowed for a wider range of resources to be exploited (Kuper & Kröpelin, 2006; Nicoll, 2001, 2004). Some studies have produced chronologies and generalist models that describe the sequential human occupation of the Eastern Sahara during the early Holocene (see Koopman et al., 2016; Wendorf & Schild, 1980, 2001). However, there are also several studies from multiple disciplines including archaeology which note the unpredictability and shifting nature of the environment during the early Holocene along with the way human occupation of the desert was punctuated with rainy and arid periods (e.g., Claussen et al., 2017; Nicoll, 2018; Wright, 2017). Very few discussions of settlement pattern seriously consider or incorporate the potential impact of local and regional variation into their models (Nicoll, 2018). There is also limited critical discussion of the actual archaeological evidence used to support many of the theories put forward to explain how and why humans continued to live in the desert. Many of these approaches fail to critically consider the nature of the archaeological record, the impact that archaeological practice has on the composition of assemblages, and what these assemblages actually represent in terms of past human activity.

Lithic artefacts are by far the most common artefact associated with early Holocene assemblages in the Eastern Sahara and can provide additional material evidence within discussions of settlement pattern (see Close, 1996, 1999, 2000; Davies et al., 2018; Holdaway, 2004; Holdaway et al., 2004; Holdaway & Davies, 2020). The approaches for developing models for hunter-gatherer settlement pattern are usually focused on observing the archaeological evidence for different site types in the past. This is often connected to discussions of how and where people moved, and what resources they were exploiting. In many instances, mobility is inferred from the distribution of lithic artifacts, differing densities and variation between locations (Holdaway & Davies, 2020). Close (2000) highlights that the commonly cited proxies for mobility are based around the potential to move rather than direct indications of human movement. These proxies are usually based on assumptions about how patterns within assemblages or the presence of specific features represent past human behaviour. The link between different aspects of human behaviour and specific patterns within the archaeological record is most often illustrated by ethnographic analogies (Holdaway & Davies, 2020). In theory, examining assemblage diversity could demonstrate settlement patterns by identifying base camps, foraging camps or extraction sites (Phillipps et al., 2022; Shott, 2010). However, the analogies and models based on ethnographic examples tend to represent comparatively short periods of time. These have a limited application to describe areas used for many hundreds or thousands of years in the past, represented by the lithic assemblages archaeologists examine. Alternative methods such as refit, or cortex and volume ratios better incorporate the complexities of the record. However, they also require specific assemblage conditions that are not always possible to acquire, especially from legacy collections (e.g., al-Nahar & Olszewski, 2016).

Due to the volume of artefacts collected and recorded over half a century of fieldwork, and the limited access to perform further fieldwork since 2011 (Di Lernia, 2021), much of the information related to many early Holocene sites are contained within legacy collections and past publications. However, using lithics as proxies to support models of settlement pattern requires specific assemblage conditions to be met. Therefore, data drawn from legacy collections need to be able to fulfil these conditions to be used as a proxy. Understanding the data requires understanding the sample. Studies of legacy data have demonstrated that important details about the context and condition of samples can be obtained by investigating past research (Ellis, 2008; Ellis et al., 2008; Wylie, 2016).

Despite the archaeological investigations which have been done, there is still significant debate around how the data produced from past and current fieldwork can be best used to answer questions about human behaviour and adaptations during the early Holocene. Publications often lament a lack of data or the need for new and better samples or quantitative tests to draw more concrete conclusions (see Mutri et al., 2020). However, it is also possible to re-examine the archaeological record itself, including past publications, to test and examine some of the commonly held assumptions about the early Holocene in the Eastern Sahara to see whether some of the issues, in fact, lie there.

The Nabta-Kiseiba area (Figure 1.1.) has been the focus of more than 30 years of ongoing archaeological research (see Close et al., 1984; Wendorf & Schild, 1980, 1998, 2001). These sites were excavated over several different field seasons, so understanding the condition of the assemblage requires the addition of an investigation of the publications and reports produced by the Combined Prehistoric Expedition (CPE) to infer their context. This includes unpacking the changes in approach, sampling strategies, and survey and excavations methods. The process highlighted changing priorities, approaches, and questions that have affected what was sampled throughout the overall project. The Wendorf Collection holds some of the excavated material from Nubia, Egypt and the Eastern Sahara excavated by the CPE between 1960 and 2000.

Early Holocene sites in the Eastern Sahara are often predominantly comprised of lithic artefacts. These artefacts provide evidence to support models of settlement pattern. Observations from studies of the climate and environment suggest that this area must have experienced a range of adaptive strategies throughout the early Holocene allowing people to thrive in an increasingly unpredictable environment. Current approaches to settlement pattern that use assemblage composition as a proxy for past human mobility or sedentism primarily rely on the number and frequency of different tool types as well as some discussion of raw materials and cores to identify different site types. However, archaeology often grapples with the ability to demonstrate clear links between theories of settlement patterns and what is represented by the archaeological record. Samples of the lithic assemblages used to identify site types employed by the CPE are contained within the British Museum and past publications. As a result, there is an opportunity to explore whether it is possible to differentiate site types from assemblage composition when accounting for fundamental assemblage characteristics such as sample size. This thesis aims to investigate whether differences in diversity, in addition to those that reflect assemblage size, can support the identification of changes in site types derived from lithic assemblages through time or space. Investigating whether these differences are statistically quantifiable and should be used as proxies to support models for settlement pattern in archaeology.

1.1 Thesis Structure

This thesis consists of seven chapters. Chapter Two reviews the current archaeological approaches to modelling early Holocene settlement pattern in the Eastern Sahara along with their issues and the archaeological proxies that are used to support them. It also outlines alternative approaches and the assemblage conditions required to implement them. It unpacks the current approaches to incorporate legacy material into archaeological research and examining the insights this can provide. Chapter Three describes the methods that will be used in this thesis including the specific method for the diversity analysis implemented within this study. Chapter Four explores the context of the early Holocene lithic material held in the Wendorf Collection. It also reviews the archaeological research undertaken by the Combined Prehistoric Expedition and how this has influenced assemblage condition and assemblage composition. The results of the interrogation of the past publications and the diversity analysis are presented in Chapter Five. Chapter Six discusses the implications of these results and Chapter Seven summarises the key arguments of this study.

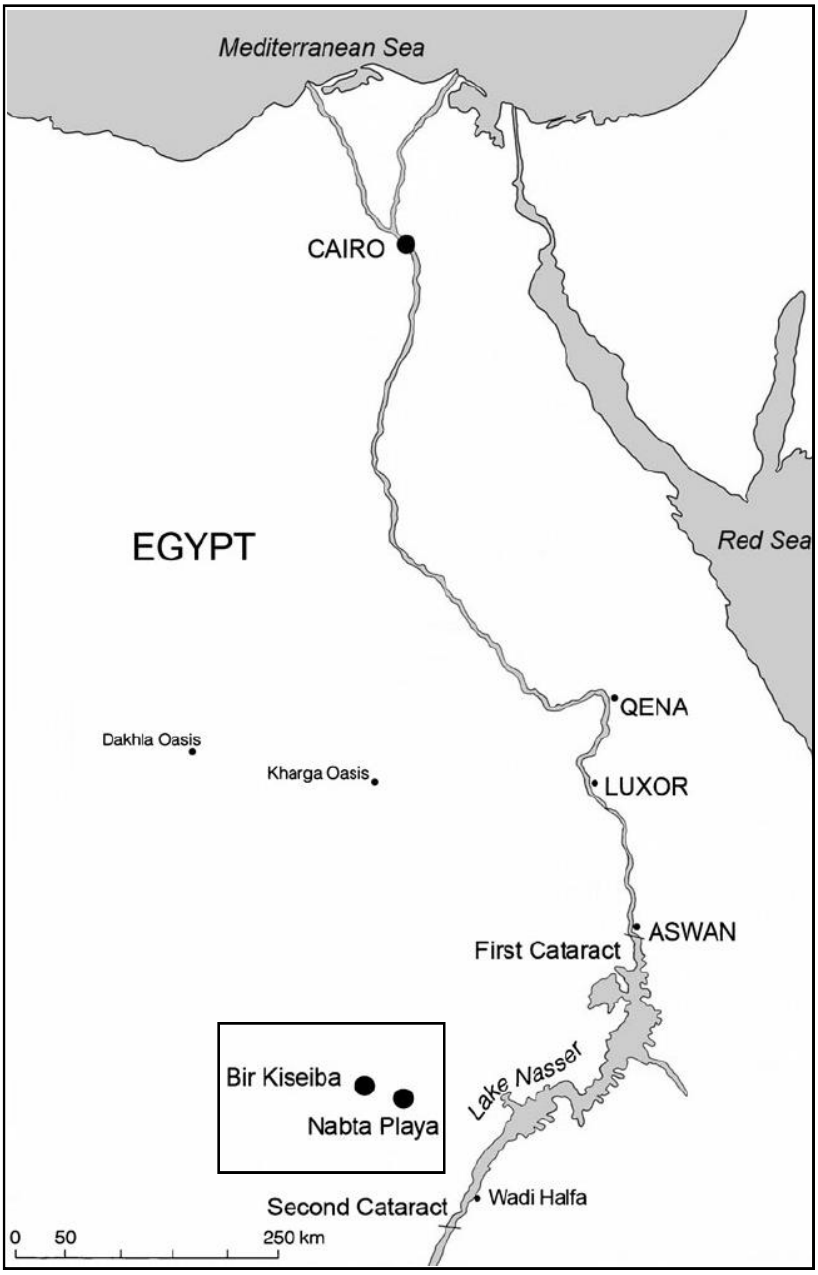


Figure 1.1. Map of Egypt indicating the location of Nabta Playa and Bir Kiseiba (Jórdeczka et al., 2013)

Chapter Two: Literature Review

The early Holocene period in the Eastern Sahara has interested scholars of Egyptian prehistory since the beginning of the twentieth century. Habitation of the Eastern Sahara during the early Holocene occurred during a period of dramatic climate change, making it a valuable time period for archaeologists to explore when examining the ways past humans adapted their behaviour in the face of unpredictable climate conditions and increased aridity (Mutri et al., 2020). Most of the approaches for reconstructing settlement pattern for this period draw on models or evidence produced the by Combined Prehistoric Expedition (CPE), particularly the work performed in Natba Playa and Bir Kiseiba (Usai, 2005). These studies have produced chronologies and generalised models that describe the sequential human occupation of the Eastern Sahara during the early Holocene based on site types (e.g., Marshall & Hildebrand, 2002; Usai, 2005; Wendorf & Schild, 2001). However, very few critically consider or incorporate the potential impact of local and regional variation into their models (e.g., McDonald, 2009). Furthermore, current settlement models are not sufficiently demonstrated by archaeological evidence (see Close, 2000).

Studies suggest that hunter-gatherer groups moved through the desert, capitalising on areas with favourable environmental circumstances created by the African Humid Period (AHP) (e.g., Drake et al., 2011; Kröpelin et al., 2008; Kuper & Kröpelin, 2006). The slightly wetter and more humid conditions supported a diverse range of plants and animals and allowed for a wider array of resources to be exploited (McDonald, 2009). More recent reconstructions of the environment also suggest these conditions could vary significantly on a local scale (e.g.,Claussen et al., 2017). This indicates it may be useful to reconsider the evidence of variability between site types in the Eastern Sahara during this period, either through time or across space.

Lithic assemblages can provide additional material evidence within discussions of settlement pattern (see Close, 1996, 1999, 2000; Davies et al., 2018; Holdaway, 2004; Holdaway et al., 2004; Holdaway & Davies, 2020). Lithic material is one of the most abundant artefacts at early Holocene sites. It is also material that is usually well recorded in CPE publications particularly in relation to techno-typological analysis and to some extent, raw materials. Furthermore, the long traditional interest in tool types meant that this material is also well represented within sample assemblages that are stored within legacy collections. As a result, there is an opportunity to explore the archaeological evidence used to distinguish early Holocene sites by examining variability in their lithic assemblages.

The following sections (Sections 2.1 and 2.2) outline the current interpretation of the environment and climate present in the Eastern Sahara during the early Holocene and the general interpretation of where and how humans lived in the desert. Section 2.3 will explore the models for settlement pattern employed to explain and describe specific settlement strategies, identifying their shortcomings and examining the archaeological evidence used to support them. Section 2.5 will identify recognised archaeological proxies for human movement, methods for identifying human movement using lithic assemblages, and the assemblage conditions required to implement these methods. Section 2.5 will discuss past and current approaches to identifying variation within and between lithic assemblages, particularly in North Africa, focusing on aspects of assemblage composition particularly in relation to the work performed by the CPE. Section 2.6 discusses the problem with modelling settlement pattern using site types based on variation in lithic assemblages and an alternative approach that allows for the incorporation of an awareness of assemblage properties that affect sample resolution such as assemblage size. Section 2.7 then summarises current approaches when incorporating legacy material into new studies along with the issues and limitations to be aware of. Finally, Section 2.8 summarise what this means for this study and how the identified issues have been resolved.

2.1 Environmental Context

Most studies of early Holocene Egyptian prehistory focus on the Western Desert (see figure 2.1). This area, located within the Eastern Sahara, is one of the most arid environments in the modern world, spanning 681,000km^2 between the Libyan Desert and the Nile Valley. Bubenzer and Bolten (2007) note that the area is historically devoid of any permanent settlements except in a few areas alongside the chain of oases containing ground-fed springs (also see Kuper & Kröpelin, 2006). The oases like Siwa, Dakhleh, Farafra, Kharga, and Bahariya provide year-round access to ground fed water sources vital for human activity to thrive. It is, therefore, no surprise that these areas are consistently identified as focal points for human presence in the hyper-arid environment throughout all human history, especially as points of refuge during overland travel. The well-documented importance of oases for trade, travel, resource exploitation and conflict in ancient, historical and modern Egypt underpin many of the assumptions about their importance and use in prehistory (Bubenzer & Riemer, 2007; Butzer, 2005; Riemer, 2003, 2013; Sutton, 1977). However, the early Holocene is known to coincide with a period of significant climate change that is thought to provide the circumstances for the occupation of arid regions.

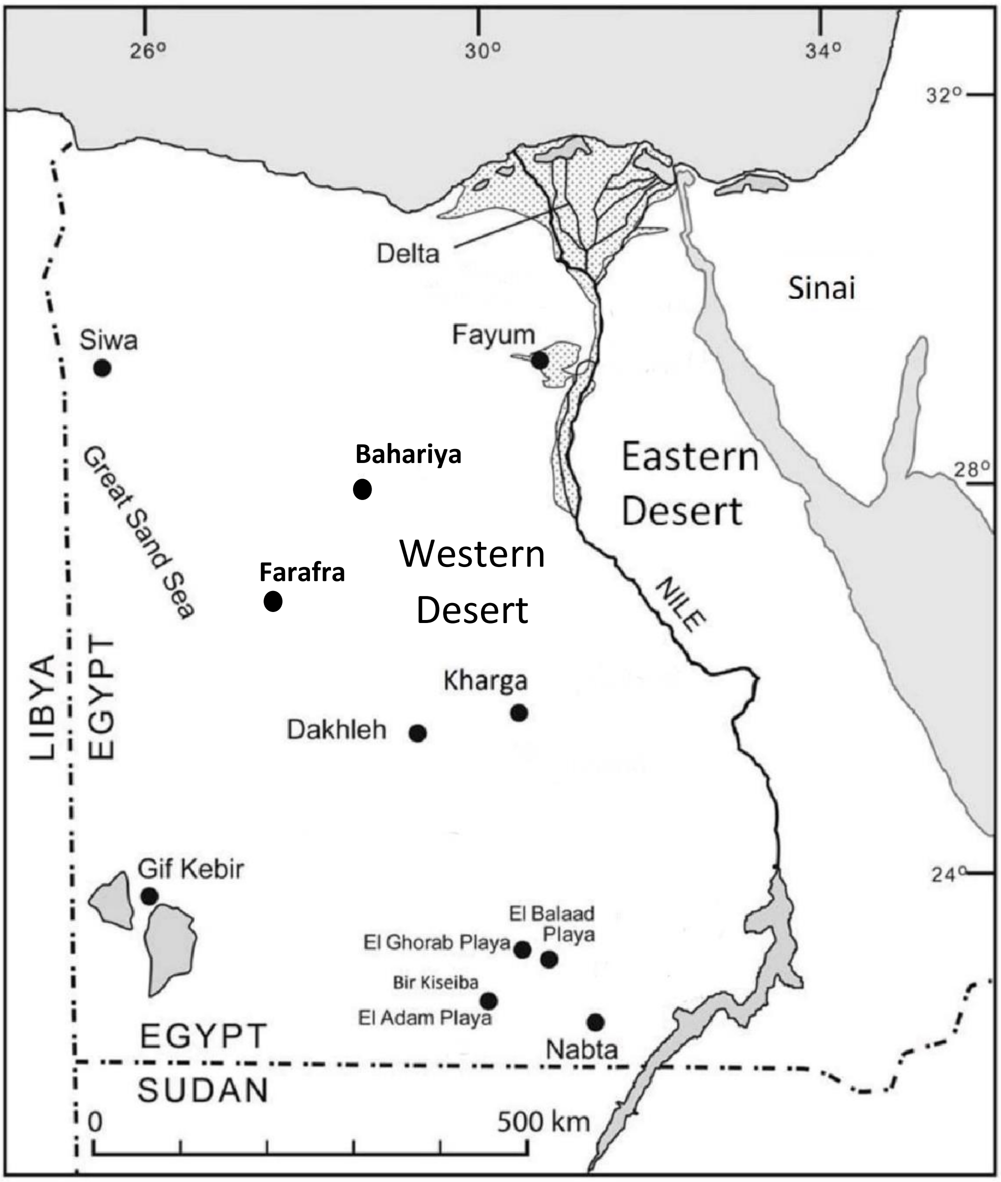


Figure 2.1. Map of the Western Desert and locations of significant interest to the early Holocene (following Phillipps 2012: Figure 2.1).

As a result, a significant portion of the archaeological research on the Eastern Sahara has focused on reconstructing aspects of the climate and environment present during the early Holocene. This period (between ~10,000 – 7,000 BP) coincides with the advent of wetter conditions across the deserts of Northeast Africa (Haynes Jr, 2001). Earlier studies focused on distinct regions and time periods, attempting to explain general environmental change and develop chronologies for periods of rain or aridity to assist in descriptions of human settlement pattern (e.g., Close et al., 1984; Haynes, 1985; Haynes Jr et al., 1989; Kropelin, 1987; Kuper, 1989; Neumann, 1989; Pachur et al., 1990; Wendorf & Schild, 1980; Wendorf et al., 1976). A significant portion of this work was connected to the archaeological surveys of the desert and oases initially performed by the CPE. However, a review of the publications and evidence by

Nicoll (2001, 2004) observed that the published interpretations of palaeoecological archives and radiocarbon dates from Egypt and Sudan prior to 1990s were broadly consistent even though they drew their conclusions from different and sometimes inconsistent datasets.

Numerous broad models for the environmental conditions present across North Africa have been developed by archaeologists and climate scientists since the 1990s and the impacts and timeline for key events are discussed extensively (e.g., Claussen et al., 2017; Holmes & Hoelzmann, 2017; Kröpelin et al., 2008; Kuper & Kröpelin, 2006; Wright, 2017). As more data becomes available, there is an increasing awareness of the complexity of many of the processes involved. Kröpelin and associates (2008) note that although the area is still arid, southern parts of the Eastern Sahara experienced rainfall due to the northward shift of the Inter-tropic Convergence Zone (ITCZ). They also observed that the environment was wetter and warmer than it is today due to global environmental processes. The shift provided the conditions for the African Humid Period (AHP), which supported a more diverse range of flora and fauna across areas where water was collected and drained (sometimes known as the *Green Sahara*). These conditions are thought to have lasted for the length of the early Holocene (see Claussen et al., 2017). The area between the Nile and Central Sahara experienced improved environmental conditions providing unique opportunities for human occupation along water basins in areas further into the desert (Wright, 2017).

Archaeologists studying the Eastern Sahara have expressed particular interest in understanding the timing of wet and arid phases. Smith (2001) argued that a precise chronology for understanding arid periods in a narrower timeframe (<1000 years), is crucial to understanding resource availability and specific human adaptive responses to hydroclimatic stress. As more evidence is assessed, it has become clear that the climate of the Eastern Sahara during the early Holocene was incredibly volatile and subject to significant shifts between periods of rain and drought (Nicoll, 2004). Riemer (2006, p. 560) argues that a precise chronology can be obtained from radiocarbon analysis performed at sites with known examples of abrupt climate change visible in the environmental or climatic archives alongside the occupational history. However, Kröpelin et al. (2008, p. 768), observed that there are no strong markers for alternations between wet and dry episodes identified in local environments occurring concurrently across the whole of North-East Africa related to broader climate change. Furthermore, Nicoll (2018) emphasises that recent reassessments of the environment across the whole of the Eastern Sahara showed how conditions varied greatly between localities with droughts commonly occurring even during the wettest phases of the AHP, reinforcing the need to observe human adaptations at a local rather than regional scale. For example, Phillipps et al. (2016) observed that variation demonstrated there could be dramatic differences between years dependent upon annual rainfall just in one area during the early to mid-Holocene (also see Holdaway & Wendrich, 2017; Koopman et al., 2016; Marston et al., 2017).

While more recent studies indicate that the climate was increasingly unpredictable in the long term, the archaeological evidence suggests that humans utilised wetter conditions during periods of stability (e.g., McDonald, 2009; Mutri et al., 2020; Wendorf & Schild, 2001). The arid regions experienced greater local variability in the quantity, location, and timing of rainfall. Therefore, variability in local conditions is also an important factor to consider when discussing human adaptation to climate change regardless of the broader trends. Generally, there is a consensus that the Eastern Sahara had been devoid of humans for a long time prior to the early Holocene, with the early Holocene experiencing a brief repopulation during the AHP before this waned during the mid-Holocene (Kröpelin et al., 2008). As a result, the change in climate is considered paramount to the occupation of the arid areas in the eastern Sahara. The increased precipitation is thought to support a more diverse range of human activities within the Eastern Sahara, particularly in the south where there was an increase in the number of locations that could be suitable for semi-permanent habitation along the shores of playa lakes (Bubenzer & Riemer, 2007; Butzer, 2005), as well as providing alternative routes to cross northeast Africa (Drake et al., 2011). When discussing the models for re-populating the desert areas, Kuper and Kröplen (2006), suggest that opportunistic human groups followed the rain into the desert utilising resources where they were available to settle in favourable areas while the climate allowed. These areas were abandoned when the area became too arid during the mid-Holocene and no longer supported this range of biodiversity (see Kuper & Kröpelin, 2006; McDonald, 2009; Mutri et al., 2020; Wendorf & Schild, 2001).

Archaeological studies have therefore suggested that the AHP had a significant impact on the way people occupied the eastern Sahara, particularly in locations further from permanent water sources. There is archaeological evidence for sustained occupation throughout the AHP from around 11,000 years ago (Holdaway & Phillipps 2017). The archaeological evidence is widespread throughout the desert, which is unique to this period. Most known sites are in the vicinity of permanent or semi-permanent water sources, particular lake shores and oases, and much of the archaeological research has focused on these areas (Bubenzer & Riemer, 2007). However, Wendorf & Schild (2001) observed there were also sites further into the desert that consisted of a small and thin scattering of artefacts of surface material. Wendorf & Schild interpreted these as brief camps occupied by a few individuals, assuming them to be evidence of groups of hunter-gatherers utilising favourable environments and establishing camps periodically throughout the year to exploit resources. Due to interest in the way prehistoric humans inhabited the desert and adapted to fluctuating climate conditions, a significant proportion of the scholarship has been dedicated to developing models for settlement pattern to describe this activity. Many of these models are based on theories related to the way hunter-gatherers move and exploit environments.

2.3 Settlement Pattern Models

Early Holocene human activity in the Eastern Sahara is often discussed in relation to settlement patterns or settlement systems. Studies of settlement patterns examine how people moved and established themselves within an environment by examining site and artifact distribution, interregional dynamics in economic strategies and environmental impacts on subsistence choices (David et al., 2008). Due to the nature of the archaeological evidence for human presence in the Eastern Sahara, many of the approaches to settlement pattern have focused on establishing broad trends and general histories (e.g., Kuper & Kröplen 2006; Koopman et al. 2016; Nicoll 2001; 2004). This allows researchers to look across a whole region without needing to look at individual sites. While these models have their place when looking to establish trends, the timescales they represent limit their application. They do not contain sufficient detail or scope to examine regional or local variability in settlement patterns. In other cases, in an attempt to narrow the scale, researchers have employed a seasonality-based model which focuses on describing variation across an annual timeframe(e.g., Usai, 2005; Vermeersch, 2001; Vermeersch, 2002; Wendorf & Schild, 2001). While these models usually make a stronger attempt to incorporate the available archaeological evidence, more recent studies have identified issues with the connection between the evidence used and the claims being made (see Usai 2005; Holdaway & Wendrich 2017).

Many of the models draw their evidence from the prehistoric cultural-chronological framework built largely on the archaeological material and information collected by the CPE (e.g., Close & Wendorf, 1987; Close et al., 1984; Wendorf, 1968; Wendorf & Chielewski, 1965; Wendorf & Schild, 1980, 1998, 2001; Wendorf et al., 1976). These are employed to differentiate different cultural groups based on techno-typological analysis of lithic and ceramic assemblages and provide evidence for different site types and successive 'cultures' (e.g., El Nabta Type or Khartoum Variant). This evidence is used to link environmental change to cultural change and related to settlement pattern through concepts related to subsistence practices, sedentism and the movement of material. The CPE focused on identifying groups of tool types (or 'tool kits') within stratified deposits that could divide early Holocene sites chronostratigraphically, that are then applied to early Holocene sites across the desert to demonstrate aspects of settlement pattern, particularly timelines for sites and connections across space (see Usai, 2005). These approaches tend to focus on settlement permanence, settlement size, and the presence of certain archaeological features to indicate elements of sedentism. Connections between sites and areas are identified from a shared material culture. More recent studies also often incorporate several other types of archaeological data to further support the division of sites into different types when discussing settlement pattern in this area (see McDonald, 1998, 2009; Mutri et al., 2020). These include examining paleoenvironmental and climate data, radiocarbon chronologies, structures such as houses, hearths and grinding stones, the faunal assemblages, source materials, and historical ethnographical analogies.

Archaeological studies of settlement pattern in the Eastern Sahara employ theoretical models and analogies based on specific subsistence systems (e.g., hunter-gatherers or pastoralists) to answer questions about how and why people chose certain ways to live in the past which cannot be drawn empirically from the material record alone (e.g., Marshall & Hildebrand, 2002; McDonald, 2009; Wendorf & Schild, 2001).They include discussions of how humans came to populate certain areas, how and why they chose to remain in a single area or moved around a lot (e.g., sedentary or mobile) and how and why they moved between areas in the environment over a specified timeframe (e.g., seasonally or annually). This is termed settlement-subsistence analysis. However, these models continue to predominantly rely on the identification of site types as the main archaeological evidence for differences in settlement approaches.

For example, Marshall and Hilderbrand (2002) argued that intensification of the use of resources is structurally linked to a need for predictable day-to-day access and scheduled consumption. They suggest that understanding this connection allows for the opportunity to model a broader range of contexts where the predictability of access to specific resources is central to the discussion, implying that it is possible to predict both settlement pattern and subsistence choices based on assumptions about resource availability. This argument is reiterated in Marshall (2006) where it is argued that faunal assemblages provide the most robust evidence for when a site was occupied. The model uses changes in sedentism as one of its proximate factors to describe settlement pattern. Sedentism is identified as arising where key resources are abundant and concentrated. For the early Holocene sites in the Eastern Sahara, the environmental chronology and site types that are loosely based on location, the presence of storage facilities and shared ceramic types are cited as the evidence for a delayed-return strategy for hunting and gathering (Marshall & Hilderbrand 2002). The increased aridity and environmental unpredictability of food resources is cited as the driver behind increased mobility and the adoption of pastoralism later in the period. However, when applied, due to the nature of the archaeological evidence, this model condenses several thousand years of human prehistory into a description of humans moving between the desert and the Nile due to specific subsistence practices like pastoralism. Models based on pastoralism are unlikely as the evidence for cattle pastoralism during the early Holocene is lacking (Di Lernia et al., 2013; Holdaway & Phillipps, 2017; Linseele et al., 2014). The identification of changes in hunter-gatherer technology and social organisation are drawn from the cultural-chronological framework that is used as further evidence to differentiate site types. The theory used to support the motives behind changing settlement pattern is drawn from ethnoarchaeological studies that focus on the motives for domestication in hunter-gatherer groups.

Typically, studies from the Eastern Sahara use environment, subsistence or features based hypotheses to test the validity of their model for settlement pattern. An environment-based hypothesis assumes specific human adaptations occur in response to environmental changes, such as the loss of water resources that cause a group to move (e.g. Wendorf & Schild 2001). A features hypothesis assumes that features present at an archaeological site indicate whether inhabitants at that site were mobile, sedentary, or somewhere in between. The non-portability of the features has led to their inclusion as secondary indicators of sedentism (Boyd, 2006). A subsistence hypothesis assumes that specific subsistence strategies are fundamentally linked with a predetermined settlement strategy, and therefore, the designation of a group's subsistence practices can be used to determine the way archaeological material is interpreted. All three of these examples continue to use site types to assist in differentiating approaches.

It is generally accepted that humans inhabiting the Eastern Sahara during the early Holocene were hunter-gatherers. Many approaches to hunter-gatherer settlement pattern studies attribute many of their foundational theories to Binford (1980, 1984). While Marshall and Hilderbrand (2002) do not cite Binford directly, they do acknowledge that their model confers with the archaeological literature that does (e.g.,Halstead & O'Shea, 1989; Kelly, 1995). Binford (1980) employed ethnographic analogies drawn from modern-day indigenous populations to build a model for hunter-gatherer settlement strategies that divided mobility strategies into two distinct groups (residential and logistical) to distinguish foragers from collectors. This model was widely applied as a binary model to the archaeological record, however, Binford (1980, pp. 18-19) in fact emphasised that logistical and residential variability only represent 'organisational alternatives' that could be employed in varying ways within an annual settlement pattern, and not intended for use in an archaeological setting. Nevertheless, these distinctions are often treated as discrete, distinguishable phenomena that can be identified in the archaeological record (see Kelly, 1992; Perreault & Brantingham, 2011).

Hunter-gatherer settlement patterns reduce studies of 'archaeology of place' to the relationship between the places where people live and the things that people ate (David et al., 2008, p. 30). Because most theories for why hunter-gatherers chose certain strategies are behavioural, studying settlement patterns in archaeology often requires the identification of discrete resources that people responded to through time (see Kelly 1995). Holdaway and Davies (2020) observe that this causes hunter-gatherer settlement patterns to depend on the identification of basecamps and extraction sites which oversimplifies the archaeological record (also see Preston & Kador, 2018). This leads to unsatisfactory interpretations and discrepancies between the archaeological evidence and the proposed settlement pattern. It also suggests that the complexities of the archaeological record and archaeological assemblages or samples require acknowledgement to be able to critically discuss what they represent. Nevertheless, site types continue to provide a means to conceptualise different adaptive approaches within settlement models that should hypothetically be demonstratable provided that the archaeological record from the site has preserved evidence overwhelmingly from one activity over others.

Examination of these models and hypotheses demonstrates the complexity of developing and testing settlement models. All three hypotheses discussed above experience discrepancies when presented contrary archaeological evidence. This leaves little room to discuss potential variation, making it challenging to effectively use archaeological material to support or negate either supposition. More recent studies (e.g., Close, 2000; McDonald, 2009; Phillipps & Holdaway, 2016) have critiqued the way the analogy-based models have been applied to North Africa and offered alternative approaches to examining variability in settlement patterns. For example, McDonald (2009) argued that incorporating Kelly's (1992) 'push' hypothesis that assumes foragers can be forced to settle due to general subsistence stress allowed for a study of 'degrees of sedentism' based on evidence from within the archaeological record. By avoiding a binary model (e.g., mobile or sedentary), McDonald was able to incorporate additional data such as the evidence of manufacturing activities as a secondary proxy for sedentism, allowing for greater variability in interpretations between sites. These recent studies draw on developments in theoretical approaches gaining traction outside of North Africa to provide a fresh interpretation of the available archaeological evidence.

McDonald (2009) demonstrates it is possible to gather an indication of variation in settlement strategies across a landscape and through time when numerous aspects of the archaeological record are incorporated as proxies. While this approach solves some of the anthropological issues created by binary models, there continue to be theoretical and methodological challenges to understanding settlement pattern due to the nature of the archaeological record.

Hunter-gatherer settlement patterns assume past humans are mobile and significant effort has been applied to reconstructing movement in the past, to be able to identify archaeological markers for past movement within archaeological assemblages. However, most models of movement are primarily focused on patterns of mobility or mobility strategies, and how this affects the formation of assemblages or the organisation of technology (see Close, 2000; Holdaway & Davies, 2020; Kuhn, 2020). As a result, these models fail to completely appreciate the complex processes which create assemblages, particularly in relation to assemblages that represent several thousand years of human activity. In order to be able to interpret the evidence for variability in hunter-gatherers' settlement pattern between different archaeological sites, studies would need to critically examine the factors that contribute to the construction of these assemblages, such as sample size and strategies employed to sample the assemblage, the cultural and natural processes that may have impacted the state of the assemblage, the length of time represent, and the length of time that has passed since the material was first deposited.

The way people moved and interacted with their environment is highly variable and can be influence by a plethora of factors, so the original context of where models are developed is an important consideration in contemporary approaches to modelling settlement pattern. (Edwards, 1989; Larsson et al., 2002; Wengrow et al., 2014). The current interpretations for settlement pattern in discussion of sites across the Eastern Sahara draw a portion of their evidence from differentiating site types and connections between sites from chronostratigraphic and techno-typological groups derived from lithic assemblages. Other aspects of settlement pattern are assumed from subsistence strategies, environmental conditions, site/assemblage size and the evidence for permanent features or structures. However, these interpretations are overly simplistic and struggle to account for data that falls outside of several preconceived expectations of what is a 'typical' example of a hunter-gatherer site. The lithic material that is used as one of the proxies to support settlement models for early Holocene sites recorded by the CPE can provide an opportunity to test the concept of different site types at Nabta Playa and Bir Kiseiba.

2.4 Identifying Past Human movement from Lithic Artefacts

Models for hunter-gatherer settlement pattern are also often concerned with identifying evidence for human movement in the past, especially as mobility is considered a consistent factor in human life in prehistory (Close, 1996). Studies of settlement pattern and hunter-gatherers in early-Holocene Egypt, have used lithics in order to make inferences about movement in Egyptian prehistory (e.g., Close, 1999; Usai, 2005; Wendorf & Schild, 2001).

However, there are very few methods that actually identify direct evidence for human movement in the past from artefacts. Close (2000, p. 50) notes that the act of moving is ephemeral and does not always leave any material trace in the archaeological record. It continues to be very difficult to study movement in archaeology (Kelly 1992; Close 2000). In general, portable material culture provides some of the strongest evidence for human movement, because in most instances it is all that is currently archaeologically detectable (Holdaway & Wendrich, 2017). Early Holocene archaeological sites identified within the Eastern Sahara are primarily comprised of lithic artefacts (Bubenzer & Bolten, 2013; Bubenzer & Riemer, 2007; Riemer, 2003; 2006; Wendorf & Schild, 1980, 2001). Almost all the sites identified by the CPE with the exception of a few heavily cited exceptional examples (e.g., E-75-6 at Nabta Playa), are heavily deflated surface scatters with only the most durable artifacts remaining (see Wendorf & Schild 1980; 2001). The patterns of mobility used in settlement models in the Eastern Sahara inferred from these lithics assemblages tend to focus on sources of raw material and the identification of different site types based on differences in technology as discussed above. As Close (2000) observes, these represent a palimpsest of multiple individual movements which allow for the identification of the range of movement (e.g., annual, or long term), assuming that the models are correct. In most instances, the evidence used provides evidence for the connection between two points, however, it does not speak to the frequency of movement, or how people or artefacts moved.

While there are very few ways of reading actual movement from artefacts directly, lithics can provide hard evidence for past human movement when specific assemblage conditions are met as demonstrated by Close (1996) at Bir Safsaf. Here, all raw material had to be transported to the site as it is devoid of any rocky outcrops. The sites provided a unique opportunity to examine local movements and draw inferences about further movements. Close used general lithic analysis and raw material analysis as well as refitting to establish links within sites and between sites. The number of artefacts that could be associated with a core was calculated. Through this Close identified the movement of ‘premade’ material and the movement of raw material for ‘future use’ as well as the movement of artefacts made within the surveyed area. Close interpreted the presence of the combination of raw material and premade material to represent highly mobile task groups moving short distances across an area where they had prior knowledge. This is discussed further in Close (2000) where it is noted that refitting provides some of the best evidence for travel between two points, however, the circumstances which allowed for a comprehensive study of refits at Bir Safsaf are not often found at other archaeological sites.

Studies that focus on refitting can provide evidence for a wider variety of movements (e.g., between each piece of the artefact which can be refitted together). Refit studies also move away from viewing lithics as discrete end products and instead identify them as points along a continuum of morphological change which are affected by the environment and situational circumstances (Turq et al., 2013). However, as Close (2000) notes, refit studies are constrained within a site or a local landscape. Information gathered from a wider assemblage which includes flake fragments, cores, tools, raw material, and the associated archaeological context can demonstrate whether the artefact was worked at point A before being transported to point B. While refitting studies contain the ability to demonstrate some of the complexity of movement in the past, identifying how people moved through the landscape, the chronology of events, the number of people involved, and movement not related to artefact discard cannot be completely known. Refit studies also have several limitations. The identification of refits is highly specialised and time-consuming, and the locations of the artefacts require excellent provenience in order to create links between locations so they can only feasibly be applied under very specific conditions. Because the application of studies of refitting is so limited, researchers tend to focus on assemblage composition, assuming different site types will have different assemblages.

2.5 Assemblage Composition

Studying variability in the composition of artefact assemblages can help identify similarities and differences between sites and infer movement that can potentially contribute to understanding settlement pattern, however, it remains unclear what this identified variation represents in terms of past human behaviour (Holdaway & Stern, 2004). To be able to compare sites, the archaeological data from past studies must be in a comparable format (categorised using the same typologies). Holdaway and Stern (2004) identify that there are four key variables that have been discussed in relation to lithic assemblage composition in the past 50 or so years. These are flaking techniques (differences in production method), the artefact's use (use-wear), the shape of the object (morphology or style) and the raw material (quality and type). The initial approaches used to describe lithic assemblage composition in North Africa were based on typologies. These were used to identify different cultural-historical groups providing the foundation to form chronologies for successive settlement (e.g., Petrie, 1899). This approach was then adapted with the adoption of techno-typological approaches that were employed to identify different site types. However, in many instances, this change was not that dramatic, and much of the lithic analysis, particularly the analysis employed by the CPE continued to use modified typology and type lists in order to discuss assemblage composition (e.g., Close et al., 1984; Wendorf, 1968; Wendorf & Chielewski, 1965; Wendorf & Schild, 1980, 2001).

The most simplistic examples identify movement between areas based on typological similarities. It is assumed people must have moved and interacted with each other for the objects they produce to share similar forms and styles. However, similarities between lithic assemblages alone do not necessarily identify clear ‘cultural’ links between sites or evidence for direct movement between groups or sites (Usai, 2005). Regardless, similarities noted in both lithic and pottery assemblages in the Khartoum Variant cultural material and the Nabta/Kiseiba cultural material have been cited as evidence for some movement between the two areas. This sort of analysis assumes that all the information that can be gained from lithics is present in the artefact itself (Holdaway & Douglass, 2012).

Functional approaches to analysing lithics appear in North African archaeology in the 1970s and 1980s (Lucarini & Tomasso, 2020). Their popularity during the 1970s-1980s surveys of prehistoric sites in Eastern Sahara are well demonstrated in CPE publications (e.g., Close et al., 1984; Wendorf & Schild 1980). The subsequent adoption of their typologies and methods for identifying assemblage variability has significantly affected the application of legacy assemblages to current archaeological research. This period coincided with a change in archaeological methods towards analysing artefacts. Odell (1982) notes that archaeologists in the 1970s began using artefactual material to discuss potential ‘prehistoric behaviour’ rather than using them to classify cultures based on ‘style’. As this was a transitionary period, the methods employed to identify past activity from artefactual remains were in a state of development. There was a strong focus on adapting traditional typologies to fit the new research focus. As this study incorporates data drawn from archaeological material collected during this period, it is important to identify the context in which the material was initially sampled and analysed.

Studies of lithics in North African prehistory were heavily influenced by the work of Bordes (1950; 1951, 1953). Bordes (1961) standardised the typological classification for the Lower and Middle Palaeolithic lithic assemblages and functional approaches to archaeological research in Europe and the Near East. Bisson (2000, p. 5) attributes the success of Bordes’ approach in studies of prehistory to its ‘aura of objectivity’ because it allowed independent analysts to achieve statistically comparable results that could answer the cultural-chronological questions that were of interest in prehistory at this time. Holdaway and Stern (2004, p. 49) noted ‘the Bordian method broadened the range of interpretive possibilities’, particularly in relation to inter and intra site variability analysis. Bordes (1950) cumulative frequencies were applied extensively to North African assemblages for compassions of ‘cultural’ traditions (e.g., Bar-Yosef, 1998; Bar-Yosef & Belfer-Cohen, 1989; Close et al., 1984;

Wendorf & Schild, 1980). These employ the approach to identify groups based on techno-typological similarities in order to create successive ‘cultural’ chronologies (e.g., Wendorf & Schild’s El Nabta Type or El Ghorab Type). As a result, variation in lithic assemblages is well established as a method for dividing sites into specific time periods in North African prehistory.

Following the work of Bordes (1950), Jacque Tixier (1963) established a typology for the Epipalaeolithic of Maghreb which described Moroccan, Algerian, Libyan and Saharan assemblages. This typology was manipulated to fit the local prehistoric lithic assemblages and was used extensively in morphological comparisons throughout North Africa. (e.g., Chmielewska, 1968; Close & Wendorf, 1987; Close et al., 1984; Mussi et al., 1984; Wendorf & Schild, 1980, 1998, 2001; Wendorf et al., 1976). Although, Wendorf and Schild (1980, p. 10) highlight that the typology was never a good fit for early Holocene sites in the Eastern Sahara, it was adopted because it was already being used at sites along the Niles and provided the opportunity to perform comparisons.

While Bordes’ typology was gaining popularity in studies of prehistory, Binford published a series of articles posing the supposition, following observations made regarding contemporary hunter-gatherer communities, regarding whether differences identified within the composition of Lower and Middle Palaeolithic artefact assemblages could be the result of how tools were used (function) rather than how they were made (style) (e.g., Binford, 1972; Binford & Binford, 1966; 1969). Binford suggested that assemblage formation is dependent on the activities carried out at a site in the past and that archaeological sites can therefore be linked with specific activities based on the functional interpretation of the discard of stone tools found within the site (see Binford & Binford 1966). Binford and Binford (1966) argue that modern hunter-gatherer communities demonstrate the use of different ‘tool kits’ containing equipment to process resources at different times and places in response to seasonal variability, and therefore exploring the co-occurrence of artifact types within archaeological assemblages should indicate differences in these activities.

However, using lithic material as a proxy to identify different types of sites based on function relies on a reasonable justification that different lithic artefacts represent various activities. Following the identification of ‘tool kits’ within the ethnographic record, determining the specific function of a certain lithic tool or a collection of tools is hypothesised to provide evidence for the types of activities performed at a specific site, with different collections of functionally distinct artefacts expected to indicate functionally distinct sites (e.g., base camps or hunting camps). These distinctions, in theory, provide the evidence for different models of settlement, and variation in land use. However, directly associating groups of lithic ‘types’ to specific ‘activities’ based on perceived functions related to morphology and ethnographic analogy is distinctly problematic. Odell (1981, p. 321) argued ethnographic studies of ‘modern’ groups demonstrate that approaches to the production of lithic objects exist on a continuum where some groups have a demonstratable relationship between function and an ideal form (e.g. ethnographic examples from some Alaskan and North American native groups), and others do not (e.g. examples from New Guinea and Australia Aborigines), highlight that form and function can be linked in some instances, and be utterly discreet in others. This would make it nearly impossible to identify whether the variation is a product of function, style or some other factor related to production or the composition of the raw material when only examining the form of a lithic artefact. Furthermore, the approach laid down by Binford remained untested until the late 1980s when Beyries (1988, p. 221) demonstrated that even with careful analysis of use-wear, it was impossible to exclude that variation observed within assemblages classified using Bordes’ typology is due to differences in style (also see Beyries, 1990; Shea, 1991).

The CPE led by Wendorf & Schild attempted to analyse lithics using both of these approaches, but their most well-known development was the identification of lithic ‘tool kits’ used as markers for different periods during the early Holocene. They focused on distinguishing characteristic tool types or clusters of tool types, providing a basis to compare other ‘cultural groups’ associated with the early Holocene. This would be seen as the more ‘traditional’ approach to using lithics at the time. The CPE splits early Holocene lithics found at sites in Nabta Playa and Bir Kiseiba into four ‘stylistic’ types associated with chronological positions (an approach common within North African Archaeology). These are El Adam Type (9800 – 8900 BP), El Kortein (8800 – 8500 BP), El Ghorab (8500 – 8200 BP) and El Nabta (8100 – 7900 BP)(Close et al., 1984, p. 7; Wendorf & Schild, 2001, pp. 52-55). It is thought that the characteristic types should also occur in a larger part of the Eastern Sahara. In this instance, the lithics are used as an index fossil. They do not necessarily reflect ‘actual’ early Holocene groups, but their use as a general indication of the different periods is well established and continues to be employed to identify similarities between sites across the Eastern Sahara (e.g., McDonald, 2009; Mutri et al., 2020; Usai, 2005). All published sites for the early Holocene East Sahara have been placed within this classification system. They also attempted to demonstrate differences in assemblage composition by examining the frequency of different types of artefacts and their proportions with some discussion of raw material and cores. This resulted in a range of theories for settlement pattern based on the movement of populations (see Usai, 2005).

Lucarini and Tomasso (2020) note the continued persistence of a combined techno-functional approach to archaeological research in North Africa. However, contemporary approaches focus on establishing the most direct and robust relationship between a specific object and a past action. As a result, they have shifted the emphasis away from assemblage composition and focused on what can be learnt from lithic artefacts themselves (e.g., Bajeot et al., 2020; Clemente-Conte et al., 2020; Lucarini & Radini, 2020; Rots et al., 2011; Tomasso et al., 2020). Contemporary functional approaches to lithics in Africa focus on addressing research questions related to particular 'activities' that leave clear 'markers' on lithic material such as the reconstruction of hafting techniques, the formation and development of micro-wear on different raw materials and the potential use of an artefact as indicated by organic and inorganic residue analysis (Lucarini & Tomasso 2020). These approaches to understanding functional variation identified from use-wear also rely on rigorous experimental studies of specific raw materials and endeavour to replicate past actions (such as cutting or scraping) in a controlled environment to identify specific types of wear patterns (Holdaway & Stern 2004). Tomasso and associates (2020, p. 31), argue that integrating use-wear analysis, such as hafting techniques, into broader functional studies can assist in improving understanding of assemblage variability and changes through time, while also identifying the co-occurrence of different technical solutions. Clemente-Conte and associates (2020, p. 16) emphasise that typological characteristics of tools often do not correspond with their function. As such, traditional morphological typologies, like those still employed in North Africa (e.g., Mutri et al 2020), have minimal application when discussing direct functional distinctions although they continue to provide a useful means to compare assemblages. The only currently accepted identification of functional distinctions between different lithic artefacts requires verifications based on use-wear analysis.

There are two additional aspects of lithic assemblage composition that are also sometimes incorporated into studies of settlement pattern in North Africa. These are raw material and the number of cores. These are both considered useful in reconstructing past human movement. The quality and type of raw material have been demonstrated to affect the manufacture of lithic artefacts, influencing the quality, size, and shape of artefacts (Andrefsky, 1994; Gould & Saggers, 1985; Holdaway et al., 2010; Proffitt et al., 2022). Discussions of raw material sources are often employed in studies of mobility or differential use. Kelly (1992) notes that archaeologists often use the distribution of lithics in relation to the geological location of raw material sources to demonstrate degrees of mobility (e.g., Carter et al., 2021; Mackay et al., 2022; Manninen & Knutsson, 2014). This is based on assumptions around cost-benefit. It is assumed that as mobility increases there is more regular access to 'distant' sources of raw material, assuming that tools are always carried between sites, while more sedentary sites would be forced to use local materials or recycle objects (see Close 1996). Raw material sourcing also provides some evidence for linking two different locations, for example, linking an artefact to the material source it was made from (e.g., Bavay et al., 2000). Linking the site at which the artefact was found and the site where the material was sourced from can infer patterns of behaviour in relation to the movement of artefacts and portable material culture (Close, 2000). However, while these studies identify evidence that is indicative of movement, this movement can be associated with both mobile and sedentary groups. These studies are restricted to the proportion of a lithic assemblage that is assumed to have come from a non-local origin and this assumption is not often demonstrated (Lin et al., 2016). They are also only able to assess a single aspect of past human movement related to the procurement of raw material, and cannot account for further movement, or movement-related to other processes. Furthermore, as Healey (2022, p. 11) observes, quality and distance are not the only factors that affect raw material choices although the current scientific analysis of raw materials is rarely integrated into technological, functional, and contextual studies of complete lithic assemblages.

Lithics can also be analysed in relation to cores and morphometric core analysis (solid geometry) (Holdaway & Douglass, 2012). Using geometric models to estimate the extent of artefact transport represented in assemblages is a method that has been applied in Egypt for early-mid Holocene assemblages in the Fayum and provides a useful way of quantifying differences in rates of movement between sites. This method was presented by Dibble et al (2005) and further developed by others (see Douglass et al., 2008; Lin et al., 2016; Lin et al., 2010; Neeley & Lee, 2020; Phillipps et al., 2012; Phillipps & Holdaway, 2016). It quantifies the amount of cortex and/or volume within a lithic assemblage using solid geometry in order to determine what proportion of the products of production are present within the assemblage. Identifying whether a proportion of products of production are 'missing' (or were carried away from the location) is interpreted as an indication of movement in the past. However, as with studies of refit, these approaches require specific assemblage conditions to be met including careful recording of the provenience for each artifact or specific measurements for all lithic artefacts (Douglass et al., 2008). They also usually require a complete collection or a systemic sample or subsample of the assemblage that is representative of all material present at the site.

In summary, the current approaches for modelling early Holocene settlement pattern in the Eastern Sahara that draw their evidence from lithic assemblage continue to rely on the ability to identify on describing assemblage composition. They usually identify differences by examining the number and frequency of tool types. This can be largely related to data availability, as techno-typological and techno-functional analysis continues to be a popular focus of North African archaeology. Although some discussions of raw materials and cores are also incorporated. When used as evidence to support settlement models, these analyses are usually applied to identify different site types, that can be employed to infer mobility or sedentism.

2.6 Incorporating Legacy Data

Incorporating data obtained from legacy collections and past publications requires further consideration related to the composition of the sample, what the sample represents, and any curation process that may have changed how it reflects the archaeological record from the original site. This is particularly important when considering the composition of lithic assemblages as using lithics as proxies to support models of settlement pattern requires certain assemblage conditions to be met, as noted above. Therefore, data drawn from legacy collections need to be able to fulfil the conditions to be used as a proxy. Understanding what data represents requires understanding the sample. Studies of legacy data have demonstrated that important details about the context and condition of assemblages can be obtained through an investigation of past research and curation processes

Adrian Currie (2021, p. 104) purported that one approach for moving beyond underdetermination in historical sciences is 'knowledge of science's past'. In this, Currie means understanding the processes that generate data, its curation, and how this affects current and future studies. Legacy data exists in all sciences. It can be defined as data that was generated using different technologies and systems of practice. Archaeological approaches to using legacy data are not well documented or published. This is because, except for a few rare examples (e.g., Baird & McFadyen, 2014; Wylie, 2016), it is not often a central topic of archaeological research. As a result, the literature is often scattered throughout other research projects and publications. However, as the discipline of archaeology matures, and more and more assemblages are recorded or held in archives for future use, approaches for effectively using legacy material become more crucial for effectively fulfilling the goals of archaeology to understand past human behaviour.

Extensive collections of archaeological material and their associated meta-data exist within thousands of repositories worldwide. These collections are often housed with the intention that they will be able to provide data for and add valuable information to current and future archaeological and heritage studies. King (2016) points out all archaeological collections are legacy collections (or will become legacy collections); however, the serviceability of collections can vary greatly depending on their age or methods of acquisition. The quality of a collection directly affects how it can be used in further research. Collections can range from material associated with prominent archaeological research programs and Cultural Resource Management (CRM) to unpublished material and private collectors. These collections often include the only surviving material from the original site. When it is well-curated, data from legacy collections can be employed to answer new questions about the past (e.g., Amand et al., 2020) and highlight potential biases held in current archaeology (e.g., Boozer, 2014). They can also provide data for a critical examination of commonly held assumptions about the past drawn from past research. Despite these uses, legacy collections continue to be an underutilised resource in archaeological studies (Wylie, 2016).

In 2013, Ixhel Faniel and associates reviewed archaeologist's experience of reusing data. They found that archaeologists reused data despite a persistent lack of archaeological context within legacy collections, either by making do with the minimal context which was supplied or by taking steps to uncover more detail through other means (Faniel et al., 2013). Their research reiterates the common narrative that archaeology needs more clarity detailing the way in which data is collected in the field beyond what is currently recorded in research methodologies (see King 2016). Such discussions look toward the future of archaeology to prevent potential issues created in current and future research. This hypothetically solves the problem for research produced now, but, in many ways, it also resigns most old collections to the realms of history. A preventable failure to be overcome in future research. However, as Leonelli (2018b, p. 752) points out, controlling data production will not always guarantee good (re)usable data. Furthermore, archaeologists that take this approach are unwilling to address the elephant in the room. The historical collections do not become 'more usable' through the introduction of new and 'better' recording standards (also see Leonelli, 2018a).

Alternative approaches for thinking about legacy data are best articulated by Wylie (2016) who highlights that information can still be learnt from legacy collections, but it requires innovative approaches which can utilise the available material and information (also see Currie, 2018; 2021; King, 2016; Stoler, 2010). The development of methodological approaches to examine legacy collections in archaeology is still in its infancy. There is ongoing debate regarding what methods best use and analyse legacy material, and how to best incorporate the associated literature. However, a few reoccurring themes within the studies are beginning to emerge. Approaches can be split broadly into three categories: secondary retrieval, recontextualising data, and experimental simulation. These categories are not mutually exclusive, but studies tend to focus on one or the other (Wylie 2016).

In this way, the content of the legacy collection will dictate what kind of analysis is the most suitable to perform. For example, Wylie (2016) observed studies focus on secondary retrieval and creating new data from old assemblages (perhaps the most recognised use of legacy assemblages) require collections of artefacts and ecofacts with good preservation, comprehensive provenance, and intact samples from archaeological contexts that are sufficient to perform further analysis. These studies usually focus on employing new methodologies and technologies. There are examples concerning taphonomic traces, trace element and stable isotope analysis, DNA, radiocarbon dating or use-wear analysis (e.g., Dibble & Fallu, 2020; Eckardt et al., 2009; Nicoll, 2001). While secondary retrieval is proven to provide results that enhance the field of archaeology, its application is limited to specific assemblages and specific questions. The alternative approaches which focus on recontextualising data or developing experimental simulations are significantly more reliant on unpacking the theories and assumptions in archaeological research to make informed and critical commentary about the conclusions of past studies, particularly when they play a significant role in influencing currently held beliefs in archaeology (e.g., Boozer, 2014; Ellis, 2008). As such, they require a comprehensive review of the data and related literature to unpack what underpins interpretations.

It is not always possible to use data from legacy collections for purposes that were not anticipated during the original survey or excavation. It will always remain constrained by the biases and assumptions of the original study. For example, Ellis et al. (2008) note that when they attempted to apply a new method for interpreting structural remains at Pompeii to the archive of legacy material associated with the previous 30 years of excavations, changes in archaeological research strategies and priorities resulted in complications and in some cases, loss of data due to an incoherent record. They observed that the stratigraphic relationship between features and structures was only sometimes recorded in detail, with the earlier excavations prioritising the artefactual record. Similar issues arise from the development, adoption, or abandonment of specific archaeological typologies. These choices affect subsequent archaeological research and how the material is recorded, stored, and applied to future studies (see Ellis 2008; Boozer 2015).

Furthermore, legacy collections are also products of curation processes once they enter archaeological archives. Stoler (2010) notes archivists recognise that understanding archival material requires acknowledging they are a product of the institutions they serve. The archaeological record is an archive; however, the archive only exists as a union of the physical material collections and the value and knowledge we attribute to it (see Lucas, 2010). Baird and McFayden (2014) also emphasise the need for archaeologists to consider how legacy collections are created during excavation and post-excavation analysis and what implications this will have on knowledge formation (also see Currie, 2018; 2021; Leonelli, 2018). Other humanities disciplines have well-demonstrated approaches for examining an archive as the subject of a study, rather than simply the source. However, these studies will not seek to draw conclusions that are fundamental truths or 'absolute knowledge'. Rather, they provide an opportunity to explore many potential factors that contribute to how we understand the archaeological record today, and how this is fundamentally different from other periods. While archaeology employs this kind of approach to examine the developments of theories and methodologies or specific critiques of individual sites, studies of older, larger, or unpublished areas often do not receive this sort of attention. Interrogating the legacy collection provides both the archaeological context required for a critical discussion of the evidence represented by the assemblage, identifying assemblage condition and aspects of assemblage composition which are not recorded in the lithic data alone. Furthermore, it offers the opportunity to explore how archaeological assemblages change through time and how these factors culminate to affect the applicability of measures commonly used as proxies to support models for settlement pattern.

2.7 The Problem and the Solution

Early Holocene sites in the Eastern Sahara are often predominantly comprised of lithic artefacts. These artefacts provide some of the evidence to support models of settlement pattern. Observations from studies of the climate and environment suggest that this area must have experienced a range of adaptive strategies throughout the early Holocene allowing people to thrive in an increasingly unpredictable environment. However, following 2011, there has been very limited access to do further archaeology in the Eastern Sahara. A large depository of data resides in legacy collections and past publications, but this material has restricted application due to the context in which it was originally sampled. Contemporary studies of legacy collections have demonstrated that critically analysing or reanalysing legacy collections requires an interrogation of the original context in which the data was created and any further processes that may have distorted the sample.

Current approaches to settlement pattern that use assemblage composition as a proxy for past human mobility or sedentism primarily rely on the number and frequency of different tool types as well as some discussion of raw materials and cores to identify different site types. These site types have been developed from ethnography and ethnoarchaeological studies that observed modern day hunter-gatherer populations (e.g., !Kung hunters) (see Marshall & Hildebrand, 2002; Shott, 2010). These studies demonstrate micro-scale processes that are not always easily visible within the archaeological record. However, they also demonstrate that it should also be possible to determine differences in site use from variation in assemblage composition (Phillipps et al., 2022; Shott, 2010). The CPE models for settlement pattern drew significantly on evidence for changes in the environment (e.g., wet and dry periods) and archaeological cultures and typological fossil indexes (e.g., Early Neolithic, Middle Neolithic and El Nabta Type or El Ghorab Type). This is primarily a result of their approach to archaeology, and the questions they endeavoured to answer. Their approach to fieldwork and sampling is outlined in detail in Chapter 4. The CPE primarily focused on stratified sites and an interest in developing a chronology for early Holocene settlement. This is based around 'cultural' changes derived from chronostratigraphic divisions that were linked to changes in the environment (usually changes in lake levels) (see Close et al. 1984; Wendorf & Schild 2001). These were linked to settlement pattern through evidence of 'increased' sedentism often identified from site size and the presence of certain features and the movement of raw material from source to site.

However, archaeology often grapples with the ability to demonstrate clear links between theories of settlement patterns and what is represented by the archaeological record. Studies of variation of lithic assemblages rely on the ability to compare the composition of assemblages, and the differences in the composition can be attributed to differences in human behaviour. But archaeological assemblages are always samples, and as samples, they contain numerous invisible biases. Shott (2010) argues that approaches to settlement pattern that rely on finding representative types identified from examining lithic assemblage composition often fail to recognise or understand the complex processes that create archaeological samples, and fail to examine fundamental assemblage characteristics which may provide further insights related to the condition of the sample (also see Bailey, 2007; Perreault, 2011). Phillipps and associates (2022, p. 3) note that Shott highlights a common unacknowledged issue in archaeological studies of settlement pattern, that site types are often assumed to exist because there are some ethnographic examples, but this is rarely tested for in archaeological contexts. Samples of the lithic assemblages used to identify site types employed by the CPE are contained in the Wendorf Collection within the British Museum and past publications. As a result, there is an opportunity to explore whether it is possible to differentiate site types from assemblage composition when accounting for fundamental assemblage characteristics such as sample size. This study focuses on material from sites within the Nabta-Kiseiba area that contained sufficient samples to perform further analysis (detailed in Chapter Four and Five).

Based on lithic material drawn from legacy assemblages and data drawn from CPE, are there differences in diversity in addition to those that reflect assemblage size that would support changes in site types either through time or across space?

Shott (Shott, 2008, p. 46; Shott, 2010, p. 889) maintains that all assemblages contain intrinsic properties, including their size (number of artefacts), composition (the proportion of objects of a specific type), and spatial distribution that should be examined when seeking further information about what the assemblage represents. Highlighting that actual measurements for size and composition in lithic assemblages also require the ability to quantify the number of whole artefacts and an understanding of the temporal scale represented to best understand assemblage diversity (Shott, 2008; 2002). This is because the composition of archaeological assemblage changes in relation to the duration of past occupations, the durability of objects, and how frequently they are discarded. As a result, relative frequencies (which are one measurement for composition) change with the occupation span and lose distinguishability when assemblage mixing is too low or too high (Perreault, 2019). Therefore, studies of variation and assemblage diversity in archaeology need to be able to test whether those observations are not size-dependent. Shott (2010) argues that this can be provided using a diversity index.

Diversity measurements are commonly employed within ecology to distil the information contained in species abundance distribution into a single statistic and allow for comparisons between populations (Magurran, 2004). Shott (2010) notes that the diversity measure, SHE (Richness, Heterogeneity, Evenness) diversity indices are sometimes applied in archaeology to lithics, fauna and ceramics. SHE diversity index is an example of a non-parametric heterogeneity measure developed by Buzas and Hayek (1996, 1998). Non-parametric diversity measures are not explicitly associated with 'known' patterns related to the rareness or commonness of specific categories which can be compared to normal distribution models. Mangurran (2004) notes that this measure is vulnerable, as its success is tied to the underlying distribution of objects within an assemblage and varies with assemblage size. But in archaeology, Shott (2010) demonstrated this is actually the utility of diversity index's as it allows for identifying size-dependency (and assemblage mixing), while also allowing for the comparison of assemblages. Diversity measures provide an opportunity to explore whether the difference in sample variability falls outside the realms of normal distribution and therefore indicate differences in activity which allow it to be used as a proxy for past human activity provided that the sample has sufficient resolution. In this way, SHE diversity analysis provides the opportunity to investigate whether divisions of groups of lithic types derived from studies of variation in lithic assemblages (both for tool types and raw material diversity) are still present when the effects of sample size are taken into consideration. This provides a means to test whether the current divisions can be used as proxies to support models for settlement pattern in archaeology.

This thesis explores the application of the SHE diversity index as a proxy to identify variation that supports models for settlement pattern at early Holocene sites in the Eastern Sahara when drawing on material from a legacy context. Following the theory put forwards by Shott (2010), this analysis presents the opportunity to examine the distribution of different categories of artefacts (functional and material) and identify where variation represents differences beyond what can be attributed to sample size. Hypothetically, if the presence of specific raw materials or types of tools is indicative of a specific site type, the SHE diversity analysis should demonstrate that the diversity falls outside of what would be expected from the normal distribution. The chapter that follows (Chapter Three) outlines the specific methods involved to perform this investigation.

Chapter Three: Method

Current approaches to settlement models employed to describe human activity in the Eastern Sahara during the early Holocene that use lithics as a proxy to provide evidence for mobility or sedentism or a succession of ‘cultures’ rely on exploring variability in assemblage composition to identify different site types. The selections of evidence that are used to identify site types currently conflate subsistence practices, environmental circumstances, and the archaeological evidence, using the evidence of one to determine the existence of the other (e.g., the evidence of cattle bone has been used to indicate pastoralism and seasonal movement). However, this approach is unsatisfactory as they are primarily based on assumptions drawn from ethnographic analogies that are focused on short term microscale processes that are not well represented in the archaeological record (Holdaway & Davies, 2020; Shott, 2010; Phillipps et al., 2022). They also do not easily allow for discussion of any quantifiable variability between sites. Furthermore, the archaeological proxies that are commonly used to demonstrate and test the validity of these models are often insufficient and often contradictory (Holdaway & Davies, 2020). They do not easily allow for discussion of variability between sites that are connected to quantifiable archaeological evidence. More recent studies of the early Holocene climate of the Eastern Sahara suggest that there was significant local variation in environmental conditions (Nicoll, 2018; Claussen et al., 2017). This indicates that localised settlement pattern studies at early Holocene sites will be necessary to understand the broader picture of settlement pattern across the Eastern Sahara. It also demonstrates it would be unwise to assume that any observations made at one site should be applied universally across the whole region.

SHE diversity analysis provides an opportunity to explore variability within and between artefact assemblages. SHE diversity index is an example of a non-parametric heterogeneity measure developed by Buzas and Hayek (1996,1998). Non-parametric diversity measures are not explicitly associated with ‘known’ patterns related to the rareness or commonness of specific categories. They measure relative abundance, richness and evenness within a sample. This study explores how lithic material drawn from legacy collections can be applied to provide proxies for current approaches to settlement pattern reconstruction. It examines the specific assemblage conditions of samples from sites in the Nabta-Kiseiba area, whether they allow for the use of measures that demonstrate aspects of human mobility and whether analysing tool diversity and raw material diversity is sufficient to differentiate different types of sites, and therefore variation in human-environment interactions and adaptive approaches discussed in models for settlement pattern. It evaluates archaeological evidence derived from lithic assemblages used to support models for the way humans lived in the Eastern Sahara during the early Holocene by evaluating assemblages from sites in this area including E-75-6, E-75-7, E-79-5, E-79-8, E-80-1 and E-80-4. The samples are drawn from the British Museum and CPE publications. Because of the differences in the number of artefacts represented within both collections, they are treated as separate samples. Examining the lithic material provides an opportunity to determine whether perceived differences in site type and, therefore settlement pattern are reflected in the composition of the lithic assemblages and different lithic types.

Due to the age and condition of early Holocene sites in the Eastern Sahara, lithic artefacts are the most consistently recorded for all sites that could be examined using a diversity index. This is especially true of the surveys and fieldwork performed by the CPE. This is common at prehistoric sites, and there are numerous studies demonstrating methods that use lithic material as a proxy for human activity and human movement in the past in the Eastern Sahara (e.g. Close, 1996; 1999; 2000; Holdaway & Wendrich, 2017; Phillipps, 2012; Phillipps & Holdaway, 2016). The Nabta-Kiseiba area contains the earliest known examples of early Holocene sites within the Eastern Sahara. This area experienced some form of human occupation throughout the early Holocene (~10,000-7000BP). Archaeological investigation into sites in the Eastern Sahara faced numerous unique logistical difficulties due to the hyper-arid conditions, accessibility, and preservation conditions (Bubenzer & Bolten, 2007). These difficulties have implications for the scope and type of data obtained by past research. Furthermore, early Holocene sites are particularly vulnerable to more degradation, looting, and industrial developments as time goes on (see Barford, 2020; Ikram, 2013; Ikram & Hanna, 2013; Parcak, 2017; Parcak et al., 2016). As a result, developing approaches that allow for the incorporation and reassessment of legacy assemblages is becoming increasingly important. However, this also requires a detailed understanding of what stored and recorded samples represent. As the CPE originally excavated the data used in this study a summary of the original context in which it was obtained is outlined in Chapter 4.

Contextual information was not contained within the British Museum in sufficient detail, so the context for both samples had to be inferred by examining the work undertaken by the CPE in the Eastern Sahara by identifying the original aims, approaches, and outcomes as well as noting any external pressures, contemporary focuses, and goals. Once the context was understood to a sufficient degree, the material was cleaned and categorised to be compared. The SHE diversity analysis was performed to investigate the assemblage composition and evaluate lithic evidence for settlement models concerned with different site types and different types of occupation using lithic data collected from previous publications and legacy collections. This was applied to both samples independently.

3.1 Sampling

The sample within this research is restricted to what is available in the CPE published collection and what was gathered from British Museum's Wendorf Collection. The sample obtained from the Wendorf Collection was originally analysed by Rebecca Phillipps, Simon Holdaway, Joshua Emmitt, Matthew Barrett in 2017 with funding from the Royal Society of New Zealand Marsden Fund UOA1106. It was part of a project titled "The Agricultural Foundation of Predynastic Egypt; climate change and opportunism in the Fayum". This analysis will be referred to as the UOA1106 BM Analysis. The sample obtained from the CPE published collection was originally analysed over their numerous field seasons.

The two samples also provide an opportunity to further interrogate the condition of the assemblage held within the Wendorf Collection, and how faithfully the sample reflects the original site and demonstrates that differences in diversity support changes in site types. These samples are comprised of all the available data related to the lithics identified for sites E-75-6 and E-75-7 at Nabta Playa and E-79-5, E-79-8, E-80-1 to E-80-4 at Bir Keseiba within both collections that contained a sufficient sample to perform diversity analysis. These sites represent a spread of locations across the Nabta-Kiseiba area (see Figure 4.2). They include the number of flakes, cores and tools (where recorded), the raw materials, and the tool types that are present. A summary of both samples is displayed in Chapter 5.

The sites E-75-6 and E-75-7 at Nabta Playa and E-79-5, E-79-8, E-80-1 to E-80-4 at Bir Kiseiba were selected because they had the largest sample sizes for these areas within the 2017 analysis. All lithic material from the past publications related to these sites were incorporated in a second document as a point of comparison and form the second sample. These were obtained from Wendorf & Schild (1980), Close et al. (1984) and Wendorf & Schild (2001). However, as it is difficult to track down what happened to parts of the collection, these have been treated as two independent samples within this study. The diversity index (SHE) will be applied to both samples. This will provide some indication of the accuracy of the variety of types within the assemblage, both for tools and raw materials and indicate if there are any complications for using lithics from the Wendorf Collection in these kinds of studies. This should highlight whether the assemblage of lithic artefacts from the Wendorf Collection contains a representative sample of the archaeological record present at each site, as well as serving as the data to answer the question posed in Chapter 2.

3.2 Contextualising the Assemblage and Obtaining Data from Past Publications

To use the lithic data from the Wendorf Collection produced by the University of Auckland, it became clear that it needed to be contextualised within the past research produced by the CPE. The initial focus of this review was to identify what portion of the total excavated assemblage is held in the Wendorf Collection, as the material excavated by the CPE is not stored in one collection, and parts of assemblages are housed in different countries. The published counts of lithic artefacts were also identified and collected to form a second sample for comparison, for both lithic tools and raw materials. This was achieved by undertaking a systematic review of the publications and reports related to the excavations. The review highlighted that there were differences between the published collection counts and those measured for the Wendorf Collection, indicating that they are different samples. The processes that led to the creation of the sample in the Wendorf Collection are difficult to unpack. While Holdaway and associates analysed all the material within the collection, it is clear some information has been lost and is hard to follow the history of its curation.

During the review process, it also became apparent that many aspects of the original research by the CPE would require further discussion, as they impact several commonly held assumptions and the quality of the sample. There are three significant publications related directly to the work of the CPE at Nabta Playa and Bir Keseiba, including Wendorf & Schild (1980), Close et al. (1984) and Wendorf & Schild (2001). These were searched to obtain any information related to the division of assemblages, the exportation of artefacts, the approaches to field methods and sampling (including any variations between field seasons or sites), the significant questions and concerns for each field season, relevant observations of deviations from the field reports, research agreements and funding. A description of each site, including detail on the features present and any observations that could affect the sample from that area are summarised in Chapter Four.

Additional publications, such as Fred Wendorf's autobiography (2008), were also consulted to cross-reference and better understand the field 'culture' (also see Close & Wendorf, 1987; Wendorf, 1968; Wendorf & Chielewski, 1965). Contextualising the Wendorf Collection also required gathering information related to the main interests and concerns of archaeology undertaken in Egypt when these sites were excavated. This included observing the changing politics and policies towards heritage and heritage management between the 1960s and early 2000s and exploring how the CPE rose to prominence within Egyptian archaeology. Discussion of these aspects falls outside of the scope of the thesis but is important to note as they drive many of the choices behind what was excavated and studied.

3.3 Lithic Analysis

3.3.1 The Lithic Analysis of the Material from the Wendorf Collection

The analysis of lithic artefacts by Phillipps et al. (2017) on the Wendorf Collection at the British Museum in 2017 followed the methodology described in Holdaway and Wendrich (2017) and Holdaway and Stern (2004). This approach first divides artifacts into flakes, cores or tools. A flake is identified as a smaller piece that is detached from a core and displays a dorsal and ventral surface, a bulb of percussion, a platform and termination. The term flake is used in place of debitage and encompasses non-flake by-products such as angular fragments (see Holdaway & Stern: Figure 3.23.1) (Holdaway & Stern, 2004, p. 108; Phillipps et al., 2012, p. 104). A core is defined as a remnant nodule. A tool is defined as an artefact that has one or more edges with evidence of regular retouch (Holdaway & Stern, 2004, p. 33). This classification system does not attempt to imply function from tool morphology but divides tools into different classes such as complete tools, proximal tools, or complete split tools. The broken artifacts are also recorded with the direction of the break recorded (latitudinal or longitudinal) (see Holdaway & Stern 2004: Figure 3.3.1 and Figure 3.4.1). This approach focuses on attributes related to the use and reduction of raw material, as demonstrated in a study of lithics from the Fayum (e.g., Phillipps, 2012; Holdaway & Wendrich, 2017). The techno-typological categories were based on the degree of retouch and the forms identified within the established typologies for Early Holocene Egyptian sites following Tixier (1963) (see Phillipps, 2012, p. 111-112). These categories included: utilized, backed blade, projectile point, drill, denticulate, scraper, notch, and microlith (see Wendorf & Schild 1980: Figure 3.75).

3.3.2 Creating Comparable Assemblages

The analysis in this research is restricted to using the lithic types and tool types published in the CPE's original reports from 1980, 1984 and 2001, and the adjusted categories used within the UOA1106 BM Analysis. This also means that there is limited leeway for adjusting the typology or adopting an alternative method of categorisation despite known limitations. The typology primarily employed by the CPE to categorise lithic technology is based on morphology (or form). This is not the optimal approach to examining specific functional variability, but an examination of assemblage diversity should still theoretically provide an indication of settlement pattern if there is sufficient resolution.

Close et al. (1984) note their categorisation of tool types is limited due to consistency in classification, notably as the CPE placed particular interest in the dynamic aspect of technological processes rather than morphologically identical forms, relying on the skill and knowledge of the analyst to make classifications between certain types of flaked and cores, especially concerning tool production. This may explain some of the low recorded numbers for cores. Later, students often performed the lithic analysis in the field (see Wendorf & Schild 2001 regarding field seasons during the 1990s). As most of the material excavated during the field season after 1970 remains in Cairo, there has been no further analysis of the complete assemblage. The CPE excluded categories such as undetermined fragments of cores and flakes, undetermined flakes, simple chips, and crushed chips from much of their final analysis as it was thought that the presence of these taxa could distort the proportions of the other groups, particularly when applying the indices (Close et al. 1984). These indices mostly followed Bordes (1961) and Bordes and Bourgon (1951), and included the indices; typological Levallois index, sidescraper index, backed knife Index, biface index and others (see Close et al., 1984, p. 8-11).

To examine variation in assemblage composition, the material from each site needed to be divided into distinct categories which hypothetically can be determined to represent different functions. In this instance, the categories are very loosely related to a perceived difference in function, although the dominant distinction remains morphology. The limitations of the dataset mean that it is not possible to draw a convincing link between many of the categories and specific activities in the past however they are sufficient to explore differences in assemblage diversity.

The categories used are;

Endcrapers, Perforators, Burin, Composite tools, Backed bladelets, Notches and Denticulates, Truncated pieces, Geometric microliths, Microburin, Scaled pieces, Continuous retouch, Sidescrapers and Points.

These broadly fit with the overarching categories identified within Tixier (1963) and material from the analysis of the Wendorf Collection was reorganised to also align with these categories. There are also numerous sub-categories within each of the groups identified within the tool typology set out by Close et al. (1984 also see Wendorf & Schild, 2001) which is a variation on Tixier’s (1963) *Typology for the Epipaleolithic of Maghreb*. This is the recognised typology for lithic tools used for early Holocene North African archaeological sites, and it continues to be used in early Holocene lithic studies (see Mutri et al., 2020). However, these sub-categories were only included in the publications from 1984 onwards and not recorded for every excavation. The CPE also edited this tool typology throughout the course of their project splitting some categories and grouping others. The CPE also included a category called Other (1980) or *Varia* (1984 onwards) for sub-categories that did not clearly fit into any other group.

The category which included the mixed types has been omitted from this study as the tool types within this group range between unidentifiable objects and specific projectile points.

The categories above are the most complete representation of different tools drawn from past publications in a form that allows for cross-comparison and includes material from all the field seasons. Due to the grouping of lithic artefacts in the 1980 publication, it was not possible to broaden the categories.

3.4 Diversity Analysis

The published data for lithics related to Nabta Playa and Bir Kiseiba primarily focuses on the production of lithic artefacts and categorisation based on perceived functional differences and raw material differences. As a result, it made the most sense to re-examine the available data by applying new theories and methodologies, testing its empirical sufficiency, and examining whether new methods can demonstrate any calculatable variation between sites that is not a product of sample size. This is tested using the SHE diversity index following Shott (2010). A diversity index is a valuable tool for demonstrating differences in assemblage composition between multiple sites. Assemblage composition is identified as one of the aspects of a site that can be used to differentiate the function of a site. Settlement models rely on identifying site types to build a picture of human movement and activity in the past. Hypothetically, if variation in the composition of the assemblage reflects differences in the way the sites were used in the past, the differences between the assemblages should be clearly indicated by the SHE diversity analysis results and not normally distributed. In this instance, it can be assumed that it is possible to distinguish early Holocene sites into functional categories and differences in assemblage composition sufficiently reflect the cumulation of discard from specific activities. Alternatively, if the differences between assemblage compositions are normally distributed, then the variation can be attributed to sample size, and it is not possible to distinguish site types from these early Holocene lithic assemblages.

3.4.1. Methods for SHE Diversity Analysis

A *diversity index* is a quantitative measure that echoes how many categories there are in a dataset while accounting for changes in the individual distribution of ‘items’ within the categories, such as richness, divergence or evenness. Diversity measurements are commonly employed within ecology to distil the information contained in a species abundance distribution into a single statistic and allow for comparisons between populations (Mangurran 2004). A diversity measure, SHE diversity index, is sometimes applied in archaeology to lithics, fauna and ceramics (Shott 2010). As archaeological assemblages are usually samples, and SHE diversity analysis is sensitive to sample size, this index can be employed to demonstrate whether the differences in diversity within a sample can be distinguished from what would be expected from differences in sample size.

The method for calculating SHE developed by Buzas and Hayek (1996, 1998) is different from other diversity indexes because it accumulates the data, so that S, H, and E are examined as a function of N (the number of individuals). *S* represents richness, referring to the number of types present within an assemblage. *H* represents heterogeneity, a diversity index that considers the number of individuals and taxa, and *E* is evenness or the degree of variation among the type proportions. The underlying premise when using the SHE diversity index to identify differences in assemblages is to identify demarcations or departures from non-increasing linear trends.

Deviations can be summarised into five groups;

1. identical richness, evenness, and relative abundance of data points irrespective of sample size,
2. species richness remains constant, but evenness changes,
3. H remains constant because changes in S and E offset one another,
4. E remains constant, but S, and therefore H, changes,
5. H changes because differences in S and E do not offset one another (Hayek & Buzak 1997).

To demonstrate that different types of assemblages exist, sufficient to allow inferences concerning the variation in function or raw material at a particular archaeological site, variance in artefact proportions must go beyond that accountable by assemblage size alone (Phillipps et al., 2022). Data from the Early Holocene sites in the Eastern Sahara investigated by the CPE are currently often treated as incapable of providing any additional archaeological information – or completely the same as one another based on the similarity of the assemblage in terms of the artefacts which they include based on relatively simplistic frequency counts, and Bordes *Levallois* index. This methodology also relied on idealised manufacture, use and discard sequences and assumptions regarding what is a completed object. However, as Shott (2010) indicates, most assemblages are not the outcome of such linear sequences and discussion of assemblage composition should consider the broader context of assemblage formation, including taphonomic processes. The sample analysed here is restricted to previously published data by the CPE and an analysis of some data from the Wendorf Collection filed in the Anthropology Department at the University of Auckland. As such, categories had to be divided morphologically due to the restrictions of the original data. However, a quantitative investigation of the relationship between artefact diversity, and different archaeological sites should still provide insights into the homogeneity of site use. This is because it provides the opportunity to test the statistical significance of the divisions identified within lithic assemblages that are used to distinguish site types used as proxies within models of settlement pattern.

A potentially problematic observer bias may be responsible for differences in artefact frequency among sites; however, the diversity analysis should highlight any significant issues. Diversity indexes help compare assemblages; however, the sample size significantly impacts their performance. A visual indicator that an index has wholly encapsulated the diversity of an assemblage is where the diversity curve reaches an asymptote. How this relationship changes as a function of sample size when using the SHE diversity index can also be very informative.

Methods for assessing sample completeness are also well demonstrated in ecology and can be applied to archaeological assemblages. As nonparametric species richness estimators can draw on the information contained in the samples to predict where an asymptote lies within a trend, sampling does not always need to be exhaustive. The combination of *S, H,* and *E* reflect assemblage variation and allow for the comparison of multiple assemblages. If assemblage diversity correlated with site type, the accumulated SHE plot will show a series of slope changes (Phillipps et al., 2022). The overall composition is closely related to sample size, and assemblage richness is correlated with sample size. The SHE method plots *H* and the natural log of *S* and *E* against the natural log of artefact number (n) for accumulated assemblages.

The equations for SHE analysis are as follows.

H is defined by the equation

$$H = \sum_{i} \frac{n_i}{n} \ln \frac{n_i}{n}$$

Where n is the number of individuals, and *i* is the number of individuals of type *i.*

E is defined by the equation,

$$E = \frac{e^H}{S}$$

A joint measure of richness and evenness can be defined as,

$$H = \ln S + \ln E$$

The assemblages from each site are ranked by sample size from smallest to largest. The analysis for *S, H,* and *E* are performed on the smallest sample before the next biggest assemblage is added and the analysis is recalculated. This repeats until all the assemblages are incorporated. The accumulation by assemblage size in this way provides the means to investigate the sample size effects of each added assemblage on the diversity measures. The results of this analysis on tool types and raw materials from the early Holocene sites described above are presented in Chapter Five.

3.5. Summary

Archaeological proxies used to support current settlement models to describe human activity in the Eastern Sahara are unsatisfactory as the scale of activity they are based on is not easily identifiable within the archaeological record. SHE diversity analysis provides an opportunity to explore one of the proxies used to support models for settlement pattern by measuring assemblage diversity in relation to sample size. Exploring assemblage diversity for lithic artefacts and raw materials in this way provides an opportunity to statistically test whether differences in lithic assemblage diversity can be used to support changes in site types through time or across space. However, in order to apply this test effectively, the condition of assemblages and what the sample represents must also be understood. The method outlined in this chapter identified that there were two separate approaches to lithic analysis that created the data for each assemblage. The context for both assemblages (outlined in Chapter Four) is derived from past publications. This investigation is performed to explore the condition of the sample and what the sample represents in terms of the original record, as the number of artefact types identified within an assemblage will be influenced by the original study and the type of analysis. The SHE diversity analysis will be applied to both samples independently. The chapter that follows (Chapter Four) summarises the CPE field methods and approach to archaeology along with their biases and sampling strategies that have influenced the composition of the assemblages within the Wendorf Collection. It also identifies specific concerns related to each site. Chapter Five contains the results of this investigation, including summary tables of the data obtained from past publications and where it was lacking. It summarises the results of the analysis drawn from the Wendorf Collection, that are related to this study along with the results of the SHE analysis.

Chapter Four: Data

Bir Kiseiba and Nabta Playa are heralded as prime examples of early-Holocene sites. The CPE performed almost all archaeological fieldwork in these areas. Samples of this material now reside in numerous museums and institutes worldwide, including within the Wendorf Collection in the British Museum. However, as archaeological material from the Nabta-Kiseiba area has also been the focus of over 30 years of ongoing archaeological research much of the critical information is part of a series of publications with changing priorities, approaches, and questions. Documenting these changes requires an investigation of the publications and reports produced by the CPE to contextualise the lithic data and the original project to understand the sample used in this thesis. This includes unpacking the external factors driving decisions as well as identifying the changes in approach, sampling strategies, survey and excavations methods. The investigation also highlights some of the pervasive biases and assumptions that drive the current understanding of human habitation of the Eastern Sahara during the early Holocene. While the Eastern Sahara is currently treated as an important location for humans during the early Holocene and a fascinating case study for human adaptation, there are comparatively fewer critical archaeological studies into human prehistory in this area.

This chapter provides the context for the results provided in Chapter Five. It describes the history of fieldwork performed by the CPE in the Eastern Sahara, along with their underlying goals and assumptions. It also briefly summarises the collection history of the Wendorf Collection (an archaeological collection containing a sample of the CPE's fieldwork, currently housed in the British Museum). It also outlines the fieldwork undertaken at sites E-75-6, E-75-7, E-79-5, E-79-8, E-80-1 and E-80-4. These insights are drawn from CPE publications, including Wendorf and Chielewski (1965) Wendorf (1968), Wendorf & Schild (1980, 2001) and Close et al. (1984).

4.1 The Combined Prehistoric Expedition

The CPE was brought together as a joint effort supported by several American, European and Egyptian foundations, universities and research organisations to work within an archaeological salvage campaign. They were directed by Fred Wendorf and provided a concession to study the entire western bank of the reservoir area in both Egypt and Sudan and the east bank south of the Second Cataract between 1962 and 1966 (Wendorf & Chielewski, 1965). The CPE also negotiated with other expeditions to examine the prehistory in almost all other consigned areas

(Wendorf, 1968). It was the only expedition to work across the whole salvage area in Egypt and Sudan (Säve-Söderbergh, 1987).

The CPE project aimed to provide evidence that would enable a review of the prehistory of Nubia and North Africa following what they perceived to be a stagnation of the prehistoric scholarship for Egypt (Wendorf, 1968). They believed this would be best achieved by several scholars investigating what was the actual archaeological evidence for the commonly held assumption regarding the prehistory of the Nile Valley, particularly in relation to the origins of people inhabiting the area and their subsistence strategies through broad surveys and sampling. However, this project was also the first foray into North African prehistory for much of the team. While there had been numerous studies into prehistory alongside some parts of the Nile and oasis in North Africa before 1938, the subject had been comparatively neglected in the years that followed. There was no fundamental understanding of the potential extent of prehistoric sites across the region. The gap in knowledge and the size of the project resulted in a good portion of the Nubian Campaign becoming dedicated to developing the 'scientific' methods used in all the CPE's later projects. It is in their publications concerning the Nubia campaign that the CPE articulate how they designate their units of study, what they deem to be a site or 'settlement', how they performed rapid large-scale surveys, and how they would manage any post-fieldwork analysis and publications when the team returned to their respective countries after the excavation seasons were finished (Wendorf, 1968). Due to the wide range of backgrounds and approaches of the individuals working within the CPE, Wendorf (1968, p. 18) notes that rather than attempting to create a single interpretation for North African prehistory, they opted to publish all the different interpretations and conclusions regardless of inconsistencies with the intention that the opposing viewpoints could provide a breadth of opinion otherwise lost. While this is never mentioned again, all their later publications also often lack cohesion with sections written entirely independently of each other, different formats, omissions of certain types of data and inconsistencies in results even when discussing the same sites. A significant drawback of this decision for anyone drawing on CPE research is that individual chapters cannot provide any guarantee of the conclusions drawn being an opinion shared across the whole project. However, the general concept of encouraging multiple interpretations echoes comments by Säve- Söderbergh (1987) regarding the scholarly approach to the entire rescue project, where a multi-faceted approach was encouraged to avoid the dominance of any one interpretation of the archaeological record.

4.2 The Eastern Sahara

Following their success within the rescue project, the CPE wished to coordinate further work along the sections of the Nile Valley north of Aswan or South of the Reservoir (Wendorf &

Schild, 1980). However, political unrest, tensions between Egypt and Israel and a breakdown in the relationship between Egypt and the United State of America resulted in rising uncertainty around the project. The CPE was able to negotiate permission to work between 1966 and 1969 due to the continued support of a high government official, Dr Rushdi Said, an advisor to President Nasser (Wendorf & Schild, 1980). They focused on the Nile Valley north of Aswan towards the Mediterranean and the Fayum (although a group also spent a season in Ethiopia in 1967). In this time, they laid the foundations for a long-range survey of prehistoric sites across the Nile Valley. The project was brought to an abrupt end when security regulations imposed in 1969 stifled the movement of all foreigners in Egypt. Efforts were made to shift focus to examining prehistoric sites in Ethiopia, resulting in a field season spent there in 1971. Permission to resume work in Egypt was granted in 1972, on the condition, it was not in the security-sensitive areas along the Nile Valley.

Forced to shift focus, the CPE turned their attention to the Eastern Sahara (Schild, 2018; Wendorf & Schild, 1980, 2001). The project had briefly dabbled with surveys in the desert in the 1960s, but this was their first major investigation in the area (Wendorf, 1968, p. 14-16). Despite later assurances that it was always their intention to investigate the Eastern Sahara Desert (see Wendorf & Schild, 2001, p. 1-2), in the early 1970s, this was not their preferred location of fieldwork (see Wendorf & Schild, 1980, p. xv-xvi; Schild, 2018). In fact, due to their earlier preliminary investigations of Dungul Oasis returning only evidence of 'disappointing sites' destroyed by deflation, the CPE's interest in survey sites in the desert was described as very limited. As a result, the first few field seasons focused on oases, starting with Dakhla in 1972. Survey and other work undertaken at this time was also restricted by the locations of military installations in the desert, a factor which sometimes is touched upon in the anecdotal information provided alongside surveys undertaken by vehicle.

The Eastern Sahara was surveyed between 1972 and 1977 over several six to eight-week field seasons staged during the winter (mid-January to mid-March). The CPE worked at numerous sites across the Eastern Sahara focus on oases and playa lakes and performed surveys and excavations in Bir Sahara (1973), Bir Tarfawi (1974), Kharga (1976), Nabta Playa (1975, 1977, 1990-1994, 1996-1999) and Bir Kiseiba (1979 and 1981). Their goal in these areas was to document environmental changes and the human adaptation that occurred alongside them. The surveys of prehistoric sites undertaken during the 1970s are now considered crucial to understanding the extent of prehistoric sites across the desert.

Initially, the project was informally sponsored by the Geological Survey of Egypt, the Institute for the Historic and Material Culture, the Polish Academy of Sciences, and the Southern Methodist University (SMU) (Wendorf & Schild, 1980). The three main sponsors also dictated how and where the archaeological material was divided and stored for further analysis. The material collected during this period was split three ways, with a portion sent to Dallas, Warsaw, and Cairo. There is frustratingly little information regarding exactly how the assemblages of excavated material were split or where they are now housed. However, Close et al. (1984, p. ix) note that by this point, there was no guarantee that antiquities could be exported out of Egypt. This directly affected their field methods and forced a shift to onsite analysis as most of the material from the field seasons undertaken (from at least) from the late 1970s onwards remained in Egypt. A little more is known about the field seasons undertaken at Bir Kiseiba, as the division of the material was outlined within the Acknowledgements section of the Close et al. (1984). A small sample collection of all sites at Bir Kiseiba was sent to the Department of Anthropology in Dallas, and a sample collection from site E-79-4 was sent to the Institute of Material Culture in Warsaw. The archaeological material which made its way to Dallas now resides in the British Museum after it was gifted to the institution in 2001. This collection is known within the British Museum as the Wendorf Collection and is considered the largest repository of prehistoric material from Egypt and Nubia housed outside of North Africa. The Wendorf Collection is also most likely to be the only place to find sample assemblages from all the sites excavated by the CPE collated together in one place, as the material which remained in Egypt was not always sent to the same institution.

Nabta Playa and Bir Kiseiba became key areas of focus following the discovery of evidence for extensive early Holocene occupation, and potential evidence for cattle pastoralism. Studies focused on establishing both a regional chronology for early Holocene settlements, typologies for early Holocene lithics and pottery and archaeofaunal evidence for the exploitation of plants and animals that could provide evidence of human-environmental interactions, seasonality, and subsistence strategies. The identification of cattle bone at sites in Bir Kiseiba also spurred investigations into the potential evidence for cattle domestication (Wendorf & Schild, 1994), and the development of the model for early Holocene cattle pastoralists.

Anecdotal evidence from the 1980 and 2001 publications indicate that the archaeology material at Nabta Playa was discovered by chance during a rest stop in 1973 while travelling between Bir Sahara and Abu Simbel. The perceived richness of the archaeological material in association with the paleolake basin spurred the CPE to switch its primary efforts to understanding the archaeology of the Nabta area, and this remained the focus of CPE field seasons for many years (Schild, 2018).

4.2.1 Field Methods and Approaches

Current studies of legacy collections indicate that identifying the archaeological context (as well as the provenience) of material within legacy assemblages significantly improves their usefulness in new studies. This section reviews the field methods and approaches used at

Nabta Playa and Bir Kiseiba to identify any underlying biases and the condition of the sample used in the analysis of this thesis. Other studies of legacy data indicate that the approaches and goals of the original fieldwork have a significant impact on the data they produce (e.g., Ellis, 2008; Ellis et al., 2008; Wylie, 2016). This provides insights into the contextual information required to understand the condition of the Wendorf Collection, what it represents and how it can be applied to future studies.

Precisely identifying the field methods and approach to archaeology used by the CPE in the Eastern Sahara is complicated. Later publications constantly refer to Wendorf & Schild (1980) for an outline of their field approach, but this publication lacks precise detail. However, it does provide some descriptions of onsite analysis, the logistical difficulties, and amendments to their technological and typological approach to lithics. A more detailed description can be found in Wendorf (1968, p. 3-18); but it is clearly stated that this methodology underwent some adaption to better suit archaeology in the desert in the later publications. Other aspects of field methodology can be drawn from a close reading of numerous supplementary publications such as Close (1989; 1993), which provides details related to the onsite lithic analysis. It is also clear that the quality of fieldwork significantly varies within and across field seasons. This forces interpretation of sampling methods to rely on anecdotal information supplied within site reports for each location of interest. Details related to fieldwork and sampling strategy are best documented when small methodological changes were made to meet the needs of a specific research question or the conditions of a specific site.

A large portion of the CPE project in the Eastern Sahara in the 1970s consists of preliminary investigation and survey work of the surrounding area and adapting the field methods developed for examining prehistory in the Nile Valley to the types of archaeological material which occurs within the desert. The methods and approaches the CPE used to survey and excavate sites across Egypt developed out of the need to cover vast areas quickly and efficiently within a short timeframe. Descriptions of the field methods from all the earliest publications highlight the significant concerns around fieldwork logistics in the desert, including anecdotes such as the transportation of fuel and water the construction of the base camp (see Wendorf & Schild, 1980, p. 81). Due to the region's vastness, only sites with 'promising-looking surface archaeology' were excavated. A series of observations from the initial survey period during 1972 notes that while the Western Desert contained a widespread and 'surprisingly rich and varied complex of archaeological remains', many of the sites were eroded and deflated, and relatively intact sites only occur in a few significantly restrict circumstances (Wendorf & Schild, 1980). In many regards, much of their approach shares more similarities with preliminary surveys than an in-depth archaeological investigation. Some individual sites received a more systematic and in-depth archaeological study, but this appears to closely correlate with significant individuals working to answer a specific question independent of the overall project. There are often references of a clear intention to return to perform further research; however, this commonly never came to fruition.

These first few field seasons consisted of numerous brief trips by vehicle to identify locations and 'sites' of interest, better understand the area, and establish methods for working in the desert (Wendorf & Schild, 1980). These unsystematic surveys were performed by vehicle in locations deemed of interest involved driving back and forth looking for clusters of rock or bone. Only particularly promising areas were surveyed on foot, and only areas which included clusters of artifacts that were considered statistically significant were recorded (Wendorf, 1968). Subsequent seasons during this period split time between performing more detailed analysis at sites of particular interest, undertaking further surveys within a 2-hour driving distance of the base camp, and undertaking an additional survey in a distinctly new area. No material was removed during these surveys, and any surface material examined was returned to its original position to perform later spatial analysis. Sites were selected for their potential to contribute meaningful data on one or more specific problems, which was the focus of a particular field season, such as intra-site settlement pattern (Wendorf & Schild 1980).

> "There is a certain opportunistic aspect to surveys, for they occasionally check those areas not thought to be promising, and those checks sometimes result in the discovery of important new sites that do not relate to the field topic of that season but are worthy of later investigation" (Wendorf & Schild 1980, p. 7).

The CPE's field methods are built around their basic unit of study, which was a site. The CPE defined an archaeological site as 'settlements' containing an abundance of archaeological material which could be found 'undisturbed'. To efficiently survey vast areas, sites were selected as important and worthy of further investigation when 'living floors' could be documented, and some material occurred in situ within a geologic unit (Wendorf, 1968). This selection bias is demonstrated in the survey strategy employed at Bir Kiseiba. The investigations were focused on areas that included potential stratigraphic profiles despite the well-documented presence of vast surface collections slightly further afield (Close et al. 1984). Part of their singular focus in finding stratigraphic profiles was their interest in establishing a regional stratigraphic sequence. Surface sites were sometimes collected when there was no obvious later disturbance, and adequate samples of a particular assemblage could not be obtained from other areas. Their earliest fieldwork material was also not collected when there was evidence of reworked or the sample size was too small. Assemblages were obtained for each site and each 'cultural horizon' within a site. The CPE defines a 'cultural horizon' as a spatially distinct occupation area. Each assemblage is thought to represent a sample of artifacts produced by a social group during a restricted time interval when this group occupied that locality. Building on their pre-established methods of techno-typological analysis, the CPE also often focused on defining ‘industries’ within a stratigraphic sequence.

In the instances where excavations were considered constructive, they were performed by small groups of six to ten individuals. Excavations were primarily undertaken by local labour (or archaeological students post 1990) and supervised by one or more archaeologists. Generally, one archaeologist oversaw a team of about five excavators. The excavators prior to the 1990s were Bedouin, employed from the same group since 1962. The use of amateur excavators often affects what material was collected, as studies have demonstrated that objects which do not directly look like artefacts are often missed. The potential impact of the use of local excavators on archaeological studies in Egypt and how it has indirectly shaped the archaeological record and heritage in Egypt is discussed by Doyon (2014).

The results of the expeditions are detailed in a series of significant reports in the years that followed. The reports contained a mix of general reporting of each site, small amounts of anecdotal information from the expedition itself, and a more detailed analysis of certain aspects of each site. Lithic analysis was included within chapters dedicated to the sites themselves, while geomorphology, chronologies, and any significant commentary regarding faunal or floral material are commonly given their own dedicated chapters. Overall, the methods and approaches to survey and sampling the archaeological record used by the CPE exhibit some significant biases that will be discussed in more detail in Chapter Six.

4.2.2 CPE Approach to Lithic Analysis

The laboratory analysis of artefacts was undertaken on-site and coordinated with the excavation schedule. These were completed during the field season, anticipating the division and loss of access to the material. It was the only opportunity to gather data from the complete excavated assemblage. This required analysis that could be used for potential future questions as it was unlikely there would be opportunities to reanalyse the complete assemblage at any point in the future. For lithic artefacts, the CPE recorded the raw material, artefact class, dimensions, technological features and additional attributes prescribed by the artefact class; however, conditions within the field limited the analysis, so it excluded studies of refit and usewear (Wendorf & Schild, 1980; Close et al., 1984). The analysis was rapid and low tech and had to be achievable in an environment without electricity or much water (Close, 1993, 1989). Measurements were made using callipers and recording using paper and pencil as these proved resilient in the harsh desert conditions. Later field seasons recorded information on coded forms to streamline the process. This recording scheme was applied to all lithic artefacts except chips and chunks and other similar debris, recorded as counts and raw material. A preliminary manuscript that described all the tools individually and a brief report of the site throughout the excavations was collected for every site, including the general appearance before excavation, geomorphological elements, observations during excavations and features. Maps and stratigraphic profiles were also produced on-site and later copied in Cairo before copies were distributed three ways as with the rest of the material.

The CPE's approach to classifying lithics consisted of a techno-typological analysis of the artefacts embedded in the dominant theories surrounding typologies and tools employed in archaeology during the 1970s and 1980s. For North African archaeology, this was a period of transition, where a combination of old and new methods and theories were being applied to lithic assemblages, some with more success than others. This period coincides with an increase in interest around what archaeological research could tell us about past human behaviour, and away from the development of chronologies and identification of different cultural groups. As a result, the earliest publications for the fieldwork at Nabta Playa and Bir Kiseiba employ lithic artefacts to attempt both approaches categorising lithics into groups based on both production and type. The scope of the research was limited to the measurements which were possible to perform on-site. Optimising an on-site analysis and predicting what sort of measurements to make to answer later questions with a restricted timeframe and limited equipment is an ongoing problem that is still prevalent when working at sites in Eastern Sahara and Egypt in the 21st Century (Holdaway & Wendrich, 2017) concerning the analysis performed in the field at the Fayum. It should also be noted that the CPE also attempted a spatial analysis of the surface material at some of the sites as well.

4.3 A Summary of CPE Fieldwork and Observations at Nabta Playa and Bir Kiseiba

Conclusions drawn from the CPE’s archaeological studies at Bir Kiseiba and Nabta playa continue to be used to support various models for human settlement strategies during the early Holocene across the Eastern Sahara. Archaeological investigations of prehistoric sites across this area are comparatively few and far between compared to other parts of North Africa. Most of the key sites identified to provide the important evidence for early Holocene adaptation can be found within the Nabta-Kiseiba area and have been solely excavated by the CPE. As a result, CPE publications and the material from the Wendorf Collection continue to represent a significant portion of the archive available for future analysis. The following section summarised the field observations from sites E-75-6, E-75-7, E-79-5, E-79-8, E-80-1 and E-80-4 (see Figures 4.1 and 4.2). These insights are compiled from CPE publications, including Wendorf & Schild (1980), Close et al. (1984) and Wendorf & Schild (2001). The descriptions are limited to what was is contained in the published reports which varied greatly depending upon the original author, field season and year of publication. Comparative summary tables of the lithic artifacts will be included in the Chapter Five.

4.3.1 Nabta Playa

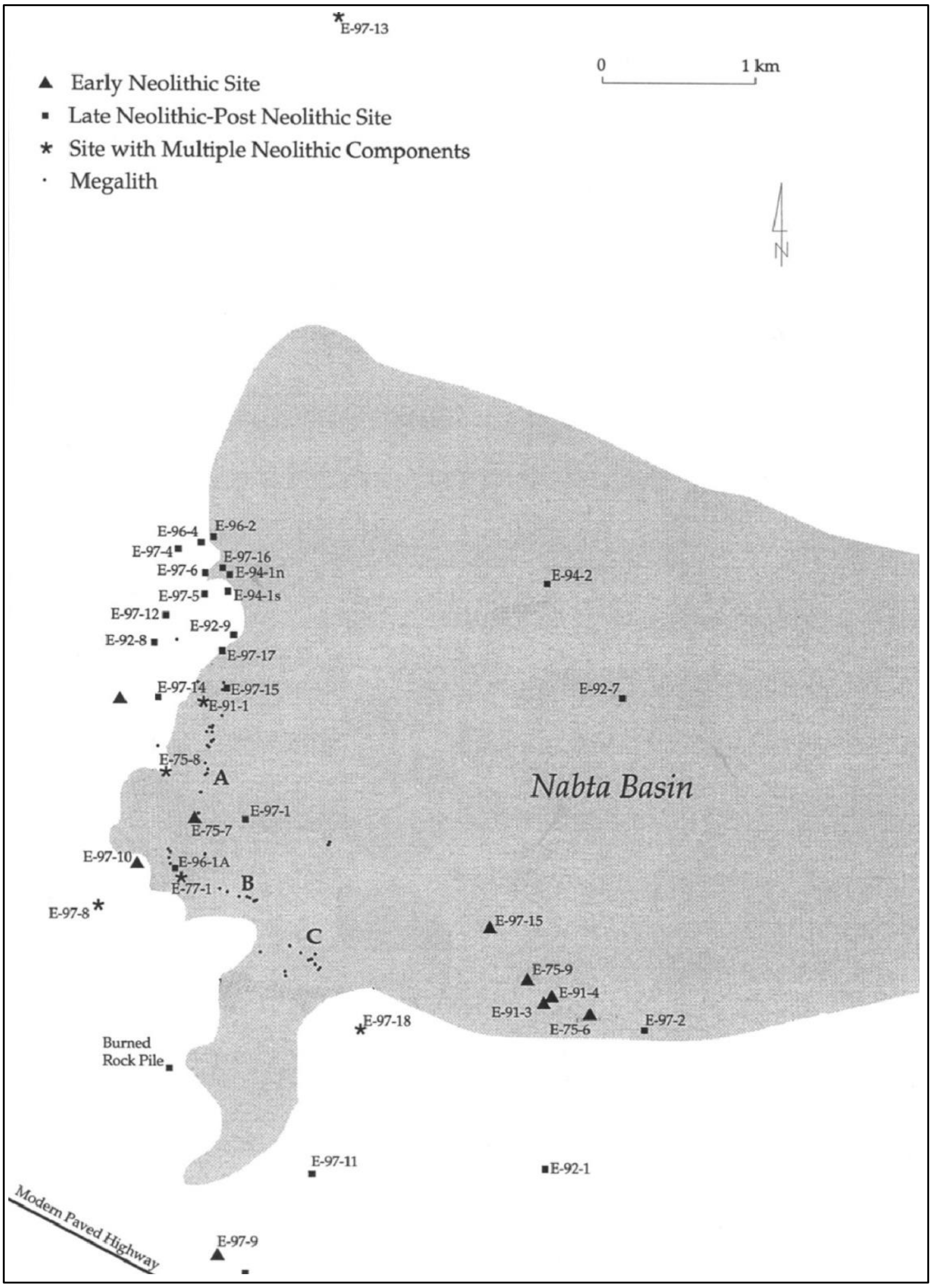


Figure 4.1: Map of Excavated sites in the Nabta Basin (following Wendorf & Schild 2001: Figure 1.2)

Nabta Playa is located near the south-eastern edge of the Western Desert of Egypt, about 100km west of Abu Simal and 30km north of the Sudanese border. The Nabta Playa basin is the second-largest internally drained basin in the southern Western Desert with a catchment of about 1500km^2 (Wendorf & Schild, 2001). The central section of the basin is irregular and has been described as kidney or slightly T-shaped, measuring 10 km north-south and 14 km west-east and is filled with clays, silts and fossil and modern aeolian sediments. The stratigraphy revealed a sequence of episodic climate change between 10,000 and 4000 BP. During wet episodes within the AHP, the basin filled and retained water sporadically following the movement of the ITCZ and summer rainfall forming seasonal lakes.

The area was occupied sporadically during the early to mid-Holocene, reflecting the fluctuations in precipitation, with at least three significant phases of Playa formation (Wendorf & Schild 1980; 1998; 2001; Nicoll 2001; 2004). Nabta Playa is considered the location of one of the most prolonged complete sequences of occupation within the Sahara (Wendorf & Schild 1998). It was identified as an area of particular interest in 1974 when a significant number of artefacts were found within the Nabta Basin at the site now known as E-75-6 in association with several dominant features. Early Holocene sites from Nabta were studied in the 1970s, 1990s and 2000s by the CPE. Numerous sites have been identified within the basin and along the western edge of the central fossil dune field. Others were identified within the western dune field. Some of these sites (including E-75-6, E-75-7 and E-75-9) have been identified as related to the early-Holocene activity. All the sites at Nabta Playa and the surrounding areas are heavily deflated and exposed. Many of the recovered artefacts are from the surface.

4.3.2 Sites at Nabta Playa

E-75-6 or E1010K1

The site E-75-6 is the largest site excavated in the Nabta Basin (see Wendorf & Schild 2001: Figure 7.3). It is in the southern section of the basin and provides the most detailed description of the stratigraphy of the area. E-75-6 was excavated throughout numerous field seasons (1974-1975, 1977 and 1990-1992). In the original report produced in 1980, it was noted that the cultural strata at this site are very compact, with a total thickness of 20cm in some places, which contained evidence for more than one occupation (mixed assemblage). Over the first three field seasons, 1000m^2 were excavated. Several of the excavations exposed complex stratigraphy, which informs much of the settlement and depositional history of Nabta Playa (Wendorf & Schild, 2001). The archaeological material at the site was split into Lower, Middle and Upper Cultural Levels (or *Archaeological Horizon A, B and C*). In many places, the stratigraphic relationship between artefacts is not clear, and there is also evidence for erosion and disturbances caused by pits cut by later occupation This earliest period is associated with lithic El Adam (9800 – 8900 BP), and El Ghorab (8500 – 8200 BP) types (Wendorf & Schild, 2001, p. 52).

Unfortunately, there are no published numbers of a breakdown of raw materials from the 1970 excavations. However, anecdotally it is noted quartz were the most common followed by dark grey chert, chalcedony, agate and petrified wood (Wendorf & Schild, 1980, p. 112-114, 132-140). Most of the cores and debitage was made of quartz, most of the tools were made of chert. E-75-6 was re-excavated and extended in the 1990s to perform a more detailed study of the features which could not be examined as part of the original study. An additional 20m^2 were opened concentrated in the south and south-eastern part of the site along with a series of 5 cuts and 9 test trenches. Observations of the lithic assemblage note that the qualitative distribution of tool types was similar across the whole site regardless of spatial distribution or time period. However, there were two trends observed. First, the numbers of notches and denticulates seem to decrease with time, while the proportion of continuously retouched pieces increases. Second, there are differences in the range of raw materials used during the two earlier occupations of El Ghorab and El Nabta. The main raw materials found in El Ghorab assemblage are flint and chalcedony which account for ~80% of artifacts, while quartz and flint which form ~90% of raw material in El Nabta assemblages (Wendorf & Schild, 2001).

E-75-7 or E1010K2

Site E-75-7 is located at the foot of a low projecting knoll. This site lies 6 metres higher than E-75-6. Evidence for the earliest occupation is embedded in the top of a layer of laminated sand that rests on the Nubian Sandstone. This material was interspersed with playa clay, sometimes up to 15cm thick. It is interpreted as indicative of instances of low-velocity surface runoff or periods of surface wash. A further lay of laminated lacustrine sands and silt lay above this containing reworked artefacts. E-75-7 is also the site of several wells sunk 2.5m below the surface. These demonstrated at least two phases of refilling, one potentially during their use and occurred in the middle period of occupation. Only a small number of artefacts were produced from the site, and these were grouped with the surface material for analysis. The raw materials present were chert, agate, chalcedony, and quartz however no numbers or percentages were given. The surface survey spanned 200m^2, and the material collected forms most of the artefacts from the site. Six wells were also excavated, and grinding stones are noted as present. There was no specific lithic type associated with this site although the CPE did note a similarity to the earlier material at E-75-6.

Wendorf & Schild (1980) associate site E-75-7 with drinking water extraction associated with an early-Holocene 'settlement' of the wider area. They hypothesised the site might be associated with E-75-8, which lay about 300m northwest of the wells on a heavily deflated hill formed around outcrops of Nubian sandstone. This area of around 500m x 300m has cultural material exposed on the surface; fire-cracked rock and other 'cultural debris' indicate an area that has seen numerous occupations over a long period of time. There was no image of the excavation area included within the publication.

4.3.3 Bir Kiseiba

Bir Kiseiba contains archaeological sites from the early Holocene, dated between 11,000 BP and 5,000 BP; however, greater emphasis was also placed on the sites that pre-dated 6500 BP (see Figure 4.2) (Close et al., 1984). This restriction was due to a lack of time and resources and the focus of the questions the CPE wished to answer during their field seasons dedicated to this area. The CPE noted that later sites were situated along the margins of basins and have been the most effected by wind deflation, making investigations of their material time-consuming.

The fieldwork method performed at Bir Kiseiba followed what was previously established for other areas in the Western Desert and outlined for Nabta Playa. However, surveys and excavations focused on the lower portion of the basins and other areas where playa sediments were preserved due to the field season's focus. Excavations and detailed studies were restricted to locations that provided the best stratigraphic sequence. The divides between the basins and the dune areas were surveyed for sites, but this was not extensive or systematic (Close et al., 1984). During the field seasons, a total of thirteen localities were surveyed, and excavations were undertaken in areas where there was a 'significant part of the cultural horizon remaining in situ which could also be related to the local stratigraphic sequence'. Even so, descriptions of most excavated sites also note high deflation and wind erosion. A separate survey of the Kiseiba Scarp was also performed.

The surviving traces of past human activity at Bir Kiseiba outside of those found within the playa silts mainly consisted of scattered fire-cracked rocks and the occasional large, flaked stone artefacts. However, the CPE also noted that the survey of the scarp surface suggested that a revised methodology could assist future work in the area to obtain helpful information from the deflated sites (Close et al., 1984, p. 3-5). Work at Bir Kiseiba was ambitious in the timeframe and resulted in a varying degree in the quality of the surveys and excavations. Time restrictions led to rushing at some sites, and a reduction in the material, which was collected, creating assemblages that represent different scales and resolutions.

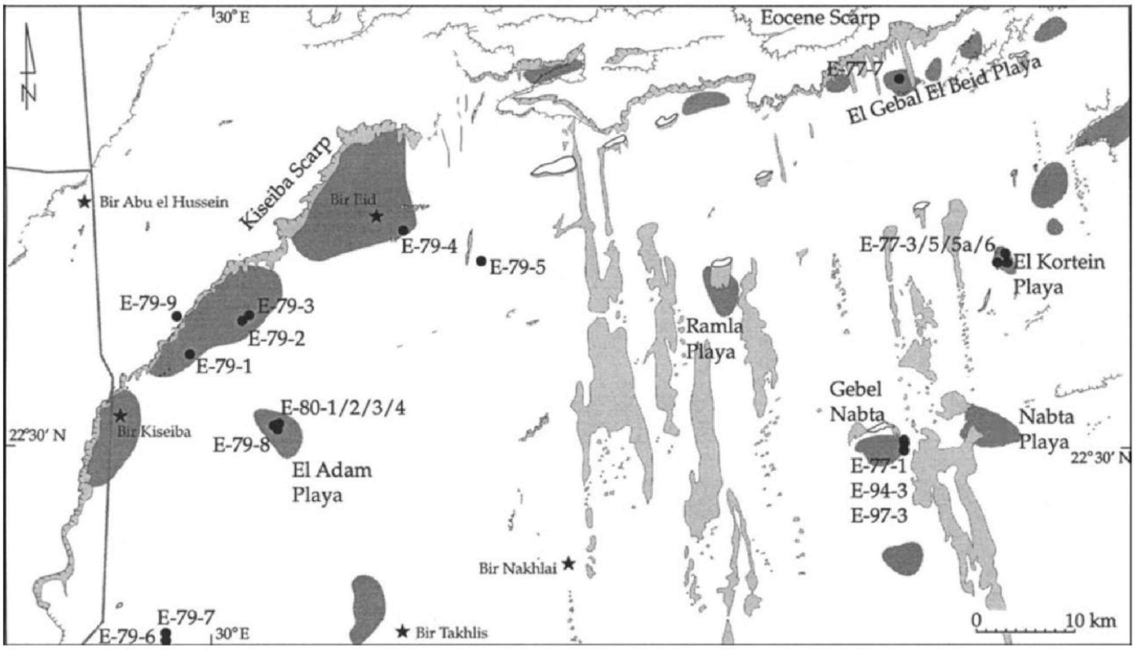


Figure 4.2 Location of Major Playa and Excavated Sites in the Nabta-Kiseiba Area (source Wendorf & Schild 2001; Figure 1.1)

4.3.4 El Balaad Playa: Site E-79-5

Site E-79-5 is situated within the central portion of the deflated El Balaad playa basin, within a highly dissected length of the Kiseiba escarpment. It was identified by senior members of the CPE during a reconnaissance trip in 1979. It was surveyed and excavated in the same year, during which time the site was split into four smaller areas; E-79-5, E-79-5a, E-79-5b and E-79-5c, although all the material collected was treated as one assemblage. The CPE expressed disappointment they were unable to establish a chronology at E-79-5 as erosion had stripped the truncated sedimentary record of original deposits to an unknown depth, and the sandy deposits along the edge of the basin were too cemented to excavate a stratigraphic trench. However, the site was dates to around 8260-7880 BP (Close et al. 1984, p. 167). This and the composition of the lithic assemblage led the CPE to associate it with the EL Nabta Type (8100 – 7900 BP) (Wendorf & Schild, 2001). Some of the artefacts were found in desiccated cracks suggesting redeposition was likely due to churning caused by the expansion and contraction of playa sediment. As a result, the sequence the CPE puts forward for site E-79-5 is drawn from their analysis of the lithic assemblage and observations made at sites in Nabta Playa. No precise stratigraphic information was provided in the report. The CPE tentatively suggest that E-79-5 could coincide with the Playa II phase at Nabta Playa, while E-79-5B is assumed to occur during the range for Playa III (Close et al., 1984).

A total of 437 tools, 101 burin spalls, 72 cores and 4741 pieces of debitage (chips and chunks) were collected from across all four locations. While several observations were made about the distribution of raw material, these were only published for the core. This decision was made on the basis that there were no observed differences in the assemblage diversity between the raw material observed for cores and that observed for debitage (Close et al., 1984, pp. 167-170).

4.3.5 El Adam Playa: Site E-79-8, E-80-1 to E-80-4

The El Adam playa is cited to be one of the most important in the whole of the Eastern Sahara. The lower section of sediments in the playa are the oldest dated beds in the AHP. El Adam lies within the Kiseiba Anticline about 16 km south of Bir Kiseiba and 20km south of the Kiseiba Scarp. It would have been surrounded by several basins which are now heavily destroyed. The site is heavily deflated and almost all the deposits and the archaeological material is totally or partially exposed on the surface.

E-79-8

Site E-79-8 is one of the earliest sites in the Western Desert dating to the early Holocene attributed to ~9000BP. The site spans 2500m^2, it is an undulating surface that is thought to have seen possibly 900 years of 'occupation'. An area of 105m^2 was surveyed in 5x5m sections which were divided internally into 1m squares. 64m^2 was also excavated, although the material from both the survey and the excavation was treated as a single assemblage (Close et al., 1984).

Due to the presence of a significant scatter of faunal remains, thought to be associated with domesticated cattle, E-79-8 was predominantly investigated in relation to its faunal assemblage. The CPE note that an investigation of the stratigraphic profile from the excavation at E-79-8 indicated that this area once had an undulating surface that was which was stabilised, possibly from the presence of vegetation impeding the migration of surface sands. They also note evidence of hearths indicated by basin hollows and ash layers containing charcoal fragments (Close et al., 1984). Near the northern edge of the site, there was also a well. Silts deposited in the bottom of the well suggest that it was used outside of the rainy season when standing water in the playa itself made wells unnecessary. The combined surface and excavated samples from this site produced at a total of 5110 pieces of debitage. Lithic material from E-79-8 is associated with the CPE's El Adam Type (9800 – 8900 BP) (Wendorf & Schild, 2001, p. 52).

E-80-1

Site E-80-1 is in el Adam playa, about 150m northeast of Site E-79-8. The site was first observed as a large ovaloid scatter about 100m north-south and 50m east-west of lithic artefacts mixed in modern loose sand (Close et al., 1984). Artefacts at E-80-1 occurred as diffuse clusters. These contained pottery, bone and ostrich eggshells, lithics and fire-cracked rock. The outlines of hearths and features of various sizes were also indicated within the silt. Due to the clustering of the material, the CPE split E-80-1 into three areas: Area A, Area C and Area D. Archaeological material from Area A was only collected from the surface and treated as homogeneous, although some of the artefacts were considerably aeolised. A total of 3075 artefacts were collected, including 61 cores. The area also contained traces of a hearth, but a small trench placed across it did not reveal any charcoal or other archaeological material (Close et al., 1984, p. 258).

Area C was situated over the largest concentration of archaeological material. The site is heavily truncated by wind erosion; however, it is also the least deflated area across the whole of E-80-1. The surface and excavated material of Area C were treated as one assemblage by the original excavation, and this included 5260 artefacts, including 103 cores (Close et al., 1984).

Area D was the largest, spanning 40 x 25 m square and consisted of surface scatters of artefacts over hard yellow sand, which bore the evidence of features on its surface. All the collect material (except those associated with features) were treated as belonging to a single assemblage and included 209 artefacts and no cores. Site E-80-1 is associated with the CPE's El Nabta Type (8100 – 7900 BP) (Wendorf & Schild, 2001, p. 52).

E-80-4

Site E-80-4 is located in El Adam playa, about 40 m northwest of Site E-79-8. It was treated separately from Site E-79-8 due to a number of distinct features. The surface concentration was oval, measuring 15m east-west 8 m north-south, and included two hearths and a well. Extensive excavations could not be undertaken at the site, but the large central playa remnant was excavated along with a 2.6 x 1.7 m ovaloid excavation of a well that extended 1.7m below the surface (Close et al. 1984). The well was not dated. The proximity of Site E-80-1 and the occurrence of very similar large wells suggest that the well at E-80-4 might date from about the same period (but this was not tested).

A 6 x 10m surface survey was performed, and the material collected from this along with excavation was treated as one assemblage. There was no apparent mixing of the later material across the site. The report also notes that there is an unusually high representation of cortex on flint artefacts at this site for the early Holocene (23.8% of the artefacts); this was attributed to the sample size. The CPE associated this site with the El Adam Type (9800 – 8900 BP) (Wendorf & Schild, 2001, p. 52).

4.3.6 Summary of Sites

The information that could be obtained from past publications about the sites described above within the Nabta-Kiseiba area indicates that most of these excavations (with the exception of E-75-6) were performed primarily as preliminary surveys of the sites across the region with a particular interest in identifying stratified material. Due to the focus, all sites are also associated with some form of water source. However, it is also clear that a significant majority of the material was collected from the surface due to a lack of stratified material, and the deflated condition of all the sites. The assemblages that are described within the publication are a mix of all surface and stratified material. The differences between the information provided at each site also indicate that there was no standard procedure for what information was expected to be included in the publication. As a result, the data available ranges with sites like E-80-1 and E-80-4 contain the most complete information in relation to the lithic assemblage, lithic analysis from E-75-7 contains the least. A minimum of information related to tool types was recorded for each site, but information in relation to flakes (or debitage), cores, and raw materials varied greatly depending on the author of the chapter the information was obtained from.

4.4 The Wendorf Collection

The Wendorf Collection is the name given to a significant portion of the excavated material exported from Egypt by the Combined Prehistoric Expedition that now resides in the British Museum associated with the department dedicated to Egypt and Sudan. The material was donated to the museum by Fred Wendorf and SMU in 2001 along with an assortment of notes and slides from the accompanying field seasons in Egypt and Sudan. The collection contains over six million artefacts including pottery, beads, lithics, faunal and human skeletal remains obtained from the field seasons held between 1962 and 2000. Many of the artefacts are from the earliest field seasons carried out in the area now flooded by Lake Nasser. However, sample assemblages and reference pieces used for illustrations within the CPE publications from sites across the Eastern Sahara can also be found with the donated material.

In the original press release for the transfer of the collection, SMU expressed their hope that housing the material in the British Museum would provide better access for scholars from around the world to visit and use the material in future studies (Mayou, 2001). The British Museum also expressed a keenness to expand their own collections to be able to better represent the prehistory of the ancient Nile Valley, filling a 'huge gap' in the British Museum's holdings and 'extending the archaeological reach both geographically and chronologically.'

As a legacy collection, the material from the CPE fieldwork is generally considered of particular importance because it contains a substantial portion of the only prehistoric artifacts that remain from rescue fieldwork performed in Sudan before the construction of the Aswan Dam. It is certainly the most traceable collection related to this period of fieldwork, as it is difficult to ascertain where archaeological material from the related field seasons which remained in Egypt are stored (if they continue to be held in storage at all). In many instances, the collection also contains prehistoric material from sites and areas in the Eastern Sahara which are now difficult to access or have had no further fieldwork in many years. New fieldwork in the Sahara has been limited following the Arab Spring since 2011 (Di Lernia, 2021). As a result, the Wendorf Collection also performs a role in providing physical examples of material from prehistoric sites across the Eastern Sahara while the desert remains mostly inaccessible for further work. Unfortunately, although the collection is considered of significant importance to scholars who study North African Prehistory, only a very small portion of the collection is accessible online through the British Museum's public database with around 500-600 artefacts provided with an entry and even less with images.

Phillipps et al. had the opportunity to analyse lithic and ceramic material from the CPE excavations held in the Wendorf Collection in the British Museum in 2017 as a part of a broader project in the Fayum. The data produced from this exercise was digitally recorded and relevant lithic data related to Nabta Playa and Bir Kiseiba will be summarised within this study in the following chapters. Although the Wendorf Collection contains an extensive number of artefacts when the UOA1106 BM Analysis was performed on a selection of the lithic and ceramic artifacts, it was noted that it was sometimes difficult to ascertain what certain boxes of artefacts relate to what part of a site. Furthermore, while anecdotal information which can be obtained from CPE publications identifies that the material related to sites in the Eastern Sahara are sample collections, no information could be found that relates to how these samples were made and whether they should be considered representative samples. This information could not be rectified by the few associated notes found with the material at the time. The implications for how the data can be feasibly applied to studies will be discussed further in Chapter five and Chapter six. The UOA1106 BM Analysis of lithic material from the Wendorf Collection re-analysed 5688 lithic artefacts from the Nabta-Kiseiba area dating to the early to mid-Holocene.

4.5 Summary

This chapter outlined the biases, assumptions and field conditions that contributed to the creation of the assemblages initially analysed by the CPE and the material that is contained within the Wendorf Collection. This review is focused on the Nabta-Kiseiba area because this area is often used as a point of comparison for studies at other early Holocene sites across the Eastern Sahara, and it has sufficient detail within the publication in order to be able to perform some evaluation related to the composition of the assemblage, and the sample and explore tool diversity, and raw material diversity across the sites. However, as it has been the focus of over 30 years of ongoing archaeological research, understanding the changing focus of the fieldwork, and how this has influenced the sample and what it represents from the archaeological record is not simple. The information that could be obtained from the publication on each site varied widely, and the type of archaeological fieldwork performed at each locality could also range significantly. The review of the publications highlighted that in many instances the fieldwork and analysis performed across this area were meant to be preliminary, in order to find new areas to perform further work and provide a point of comparison to site E-75-6. The investigation also highlighted that lithic material within the Wendorf Collection is very unlikely to be a representative sample of the archaeological record at any site, especially as the material excavated included a combination of the tools identified for illustration in publication and a small sample of the tools for each location. As a result, it is difficult to follow what has happened to parts of the collection or what sort of curation processes have impacted the assemblages held within the British Museum. Furthermore, all of the assemblages conflate the timeframe represented, as the CPE treated all material as one entity, spanning several thousand years. This indicates that all the material will be time averaged.

The CPE's early research at Bir Kiseiba and Nabta Playa was focused on two primary goals. Firstly, they attempted to better understand the environment of the Western Desert during the early Holocene by examining the deposition of playa silts and the associated cultural material. Secondly, they focused a portion of their research on understanding the lithic assemblage and what it could tell us about the humans who occupied the desert during the early Holocene. Lithic artefacts represent the overwhelming majority of cultural material associated with this period. The dominance of lithic material is probably due to preservation, as lithic artefacts tend to be more resilient to deterioration through time (see Holdaway & Stern, 2004).

Most of the lithic material collected from sites at Nabta Playa and Bir Kiseiba was collected from the surface. However, the CPE's methods for surveying and collecting surface material was rarely systematic. Their sampling strategy often had a narrow focus (e.g., focusing on the earlier sites or material that was closely related to playa). In some instances (notably the 1980 publication for site E-75-7), data is omitted and lost. It should also be noted that lithic data published in Wendorf & Schild (1980) did not include counts for different types of tools. All counts of tools from this publication have been derived from a calculation based on the total number of tools and associated percentages, which was published for almost every group.

Close et al. (1984) note that adjustments to their survey and sampling methods would be required to further the work at Bir Kiseiba, where surface material rapidly became the most significant proportion of the collected assemblages; however, this was never actualised. The CPE often treated surface material and excavated material as a single assemblage in their early field seasons, particularly when the sample of excavated material was small. Treating the assemblages as homogenous in this way will have implications concerning the breadth of the timeframe considered when performing further analysis. The sample will represent a time-averaged deposition of multiple activities which occurred in the landscape. Their focus on the chronostratigraphic divisions that linked cultural change to environmental change has led to most of the material only being associated with a single date range that span the length of the early Holocene.

Chapter Five: Results

This chapter presents the results of the of the investigation into the two legacy samples along with the results of the SHE analysis. The sample are treated independently because there are clear differences between the artefact counts found in published collections and those from the British Museum (detailed below). It was also difficult to determine what has happened to the collections that has led to this deviation (as discussed in Chapter Four). However, because SHE analysis test sample diversity, and is sensitive to sample size, the samples from both collections should be sufficient to explore the proposed research question. This thesis seeks to explore whether there are differences the diversity of tool types and raw material types in addition to those that reflect assemblage size that would support changes in site types either through time or across space from the sites identified in the Nabta-Kiseiba area. If sample diversity is sufficient to support the identification of site types from the accumulated SHE plots, the assemblages will demonstrate difference in diversity that fall outside of log series distribution, indicating the identification of different site types can be employed to discuss changes in settlement pattern. However, if the accumulated SHE plots are aligned with a log series distribution, then the differences in assemblage composition are closely linked to sample size, and insufficient to identify disite types.

5.1 Tool Frequencies from the Nabta-Kiseiba Area compiled from CPE Publications.

Information regarding the complete counts for lithic artefacts are only intermittently published in full within CPE published collections. Generally, the CPE followed a relatively formulaic approach to recording their lithic data. At a bare minimum, there is a record of the total number of tools analysed, a qualitative description of the raw materials and any observations of unusual frequencies. All sites include a breakdown of tool types, although some of the smallest categories were grouped, causing data loss. In many instances, the fundamental analysis of flake, core and tool is not supplied in Wendorf and Schild (1980) and Close et al. (1984), with most of the detail, focused on categorising artifacts into tool types. Studies of the elements of lithic production were added in Close et al. (1984) and the subsequent publications along with more consistent recording of raw materials for tools and cores. The complete number of flakes are often referenced for all site, but this was intermittently published.

As a result, there are inconsistencies in detail provided for lithic material excavated at sites across the Nabta-Kiseiba Area that relate to the year the field work was performed and the year the collection was published. The details about tool types are some of the more consistently recorded, but there are still numerous omissions and errors. In some cases, the number of tools in each category had to be calculated using the given percentage value and the total provided elsewhere in the text. A summary of the results of this process is provided in the table below (Table 5.1). The N value was calculated from the percentages for the columns compiled from Wendorf and Schild (1980). Also, while half of site E-75-6 can be found in a table demonstrating differences between sites, another section is only described in paragraphs of text (see Wendorf & Schild, 1980, p. 110-112, 132-140). The descriptive text omitted 20% of the assemblage, and the table cited for cross-reference did not contain any corresponding details. As a result, this material is treated separately as E-75-6.1.

Details collected from Close et al. (1984) and Wendorf and Schild (2001) are much more straightforward, as detailed breakdowns of specific tool types are supplied in both texts. These details are simplified into broader categories that correspond with the categories found within the earlier publication to allow for cross-comparison. Although some of these sites were split in the original excavation, their relevant homogeneity, evident from the diversity analysis, led to the amalgamation of groups for this study. The summary of tool types demonstrates that these assemblages tend to be dominated by one or two types. Most commonly, these are backed bladelets, however, notches and denticulates, and continuous retouch are often also in the top three most frequently occurring types. The occurrence of each type within these top three categories ranges between ~10% and ~30% of the total assemblage. Most other types occur <10% of the time. The range of tools represented is fairly consistent, with assemblages exhibiting 10-14 different types of artefacts.

5.2 Raw Material Frequencies from Nabta Kiseiba Area compiled from CPE Publications.

Quantitative data related to raw materials is inconsistently documented in CPE publications. Tables of the breakdown of raw materials of flakes, cores and tools are only listed in tables for E-80-1 and E-80-4 in Close et al. (1984) and are documented for all sites of interest in Wendorf and Schild (2001). Some additional percentages are supplied cores for site E-79-5 and cores and flakes for E-79-8. All data relating to the raw material composition of sites obtained from publications is recorded in Table 5.2 above including flakes and tools where it was provided. There does initially appear to be some differences in the composition of raw materials of cores identified in the table, although the assemblage continues to be dominated by a few types. Quartz or chert are the most commonly occurring cores although flint or petrified wood were also frequent at some sites. The details provided for flakes and tools indicate there is some difference between the material that occurs as tools and the material that occurs as cores or flakes, particularly in relation to quartz which occurs in less than 2% of tools despite being a common raw material at several sites.

Only qualitative data was available through anecdotal information supplied within site descriptions for the rest of the sites. The earliest excavations at E-75-6 separated the site into three distinct cultural horizons (Chapter Four). The composition of raw material found in the lowest cultural level outlined by the CPE is not described independently but identified as similar to site E-77-3 that occurs in the vicinity. E-77-3 includes predominantly grey chert, with some chalcedony, quartz, jasper and petrified wood. For later cultural levels, quartz and quartz crystal are the most common raw material, followed by chert with some chalcedony, agate and petrified wood (Wendorf & Schild, 1980, p. 135). It is also noted that most of the cores and flake trimming elements across the site were quartz, while the tools are made of chert. This is not entirely consistent with later excavations, which note the high occurrence of both quartz and flint across the site (see E-75-6). Very minimal detail was supplied for E-75-7, and raw materials were only discussed for the tools. These were mostly made from light and dark grey chert and a few agates, chalcedony, and quartz occurrences.

For the E-79-5 and E-79-8 at Bir Kiseiba, while it is clear that an analysis of all lithic material was performed to identify the distribution of different types of raw material across both sites, the information is insufficient to convert into a table for further analysis beyond the list given for cores. Percentages were given for the two most commonly occurring materials across E-79-8 related to two different deposits (excavated and surface). These were chert (76.6% and 64.8%) and petrified wood (14.9% and 21%). The rest of the raw materials were lumped together as the remaining 8.5% (and 14.2%), although the distribution is noted to be like that of the cores (Close et al., 1984, p. 224). The raw material composition of lithic assemblages can provide insights about potential resource exploitation and/or potential movement between areas, particularly when the geological source of the material is known. The occurrence of specific raw materials may reflect both the dominance of specific tools and the availability of resources. This is also linked to theories about how people moved in the past, as it is expected that more sedentary groups will be required to exploit resources that are closer to hand, while those with increased mobility are able to seek out other material resources further afield. Therefore, a significant difference in the occurrence of certain types of raw material may indicate different levels of movement.

Table 5.1: Frequencies of Tool Types from CPE Published Collection

	E-75-6 (1980) El Ghorab		E-75-6.1 (1980) EL Nabta		E-75-6 (2001) EL Nabta		E-75-7 (1980) EL Ghorab?		E-79-5 (1984) EL Nabta		E-79-8 (1984) EL Adam		E-80-1 (1984) EL Nabta		E-80-4 (1984) EL Adam	
	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N
Endscrapers	4.8	7	1.6	5	1.9	4	0.9	4	0.7	3	8.3	47	3.3	27	17.5	74
Perforators	3.4	5	22.8	71	13.6	28	11.4	51	9	39	5	29	9.9	80	2.8	12
Burins	1.3	2	6.4	20	2.9	6	1.8	8	14.3	62	3.3	19	13.2	107	1	4
Composite tools	0	0	0	0	0.5	1	0	0	1.4	6	1.2	7	0	0	0	0
Backed bladelets	30.3	44	17.6	55	20.9	43	17.6	79	13.7	59	32.7	186	14.8	120	41.4	175
Notches and denticulates	24.8	36	9.3	29	8.7	18	23.7	106	9.3	40	13.9	79	11.8	96	7.6	32
Truncated pieces	4.8	7	3.5	11	1.9	4	4.2	19	1.2	5	4.4	25	1.9	15	6.6	28
Geometric microliths	6.9	10	8.3	26	11.7	24	12.7	57	3.2	14	3.5	20	3.7	30	2.6	11
Microburins	2.1	3	1.9	6	1.5	3	2.2	10	0.9	4	6.7	38	3	24	9.7	41
Scaled pieces	0	0	6.4	20	1	2	1.8	8	14.4	62	0.2	1	0.6	5	0.2	1
Continuous retouch	11.7	17	0	0	26.2	54	16.7	75	29.5	127	18.1	103	23.8	193	9	38
Sidescrapers	0	0	0	0	1.5	3	0	0	0	0	0	0	0	0	0	0
Points	8.3	12	1.9	6	2.4	5	0.7	3	0	0	0.2	1	7.8	63	0	0
Varia	1.4	0	0	0	5.3	11	6.3	28	2.3	10	2.3	14	6.2	50	1.7	7
Not published/lost	0	0	20.2	63	0	0	0		0	0	0	0	0	0	0	0
Total	100	145	100	312	100	206	100	448	100	431	100	569	100	812	100	423

Source: Compiled from Close et al. (1984) and Wendorf & Schild (1980, 2001)

Table 5.2: Frequencies of Raw Materials from the CPE Published Collection

	E-79-5 EL Nabta	E-79-8 El Adam	E-80-1 El Nabta			E-80-4 El Adam			E-75-6 (2001) El Nabta		
N (%)	Cores	Cores	Cores	Flake	Tool	Cores	Flakes	Tool	Cores	Flake	Tool
Chert	18 (25)	32 (41)	47 (28.3)	2660 (31)	269 (33.1)	64 (55.6)	3583 (55.9)	199 (47.2)	0 (0)	440 (7.6)	52 (14.5)
Flint	24 (33.4)	3 (3.8)	20 (12.1)	1702 (12)	383 (47.2)	2 (1.2)	84 (1.3)	21 (5)	19 (17.6)	2083 (36)	293 (81.4)
Quartz	23 (31.9)	5 (6.4)	59 (35.5)	1671 (19.6)	9 (1.1)	4 (3.5)	171 (2.7)	4 (0.9)	74 (68.5)	2387 (41.2)	6 (1.7)
Petrified Wood	7 (9.7)	18 (23)	32 (19.3)	1557 (18.2)	133 (16.4)	34 (30)	1562 (24.4)	130 (30.7)	0 (0.0)	18 (0.3)	2 (0.6)
Jasper	0 (0)	0 (0)	0 (0)	83 (1)	3 (0.4)	0 (0)	0 (0)	0 (0)	0 (0.0)	553 (9.5)	0 (0)
Chalcedony	0 (0)	3 (3.8)	0 (0)	0 (0)	0 (0)	12 (10.4)	538 (8.4)	53 (12.5)	15 (13.9)	226 (3.9)	7 (1.9)
Sandstone	0 (0)	1 (1.3)	1 (0.6%)	324 (3.8)	6 (0.7)	2 (1.7)	473 (7.4)	16 (3.8)	0 (0)	4 (0.1)	(0)
Ferruginous Sandstone	0 (0)	0 (0)	7 (4.2)	542 (6.4)	6 (0.8)	0 (0)	6 (0.1)	0 (0)	0 (0)	42 (0.8)	0 (0)
Granite	0 (0)	0 (0)	0 (0)	6 (0.1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	25 (0.4)	0 (0)
Agate	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (0.4)	0 (0)
Unknown	0 (0)	16 (20.5)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	13 (0.2)	0 (0)
Total	72 (100)	78 (100)	166 (100)	8545 (100)	812 (100)	115 (100)	6415 (100)	423 (100)	108 (100)	5793 (100)	360 (100)

Compiled from Close et al. (1984) and Wendorf and Schild (2001)

5.3 Tools and Raw Material for the Nabta-Kiseiba Area compiled from the Wendorf Collection.

The UOA1106 BM analysis of lithic material from the Wendorf Collection re-analysed 5688 lithic artefacts from the Nabta-Kiseiba area dating to the early to mid-Holocene. Unfortunately, many of these artefacts lacked sufficient detailed meta-data to retrace their origin to specific sites or survey areas. In the end, only 17% (987) of the lithic artefacts existed within assemblages from specific sites in sufficient numbers to consider performing the diversity analysis. This material was initially analysed without any understanding of how it related to the work performed by the CPE or what it represented while it was possible to access the legacy collection, as a result, it was not until after the process of reviewing the past literature that many aspects of the assemblage made sense. The material within the collection is associated with all different parts of the sites including surface surveys, and specific features. In many instances, the codes associated with specific artifacts do not relate to anything that is referenced within the final publications. As a result, some of the provenances have been lost (unless detailed field notes are found).

An examination of flakes, cores and tools for each site revealed unusually high proportions of tools over any other lithic types (Table 5.3). The unusually high distribution of tools over any other flakes or cores may be attributed to a sampling strategy, and differences in methods for analysis. The anecdotal evidence from past publications suggests that the exported material from Bir Kiseiba was almost exclusively tools and cores, however, tools in the original analysis were identified by their morphology rather than evidence of retouch edges.

Table 5.3: Distribution of Flakes, Cores and Tools

N (%)	E-75-6	E-75-7	E-79-5	E-79-8	E-80-1	E-80-4
Flake	97 (27.8)	8 (8.2)	131 (42.1)	26 (20.9)	10 (12.3)	7 (12.7)
Core	29 (8.5)	13 (13.4)	7 (2.3)	19 (15.2)	9 (11.1)	10 (18.2)
Tool	216 (63.2)	76 (81.4)	173 (55.6)	79 (63.7)	62 (76.5)	38 (69)
Total	342 (99.5)	97 (100)	311 (100)	124 (100)	81 (99.9)	55 (99.9)

When the distribution of flakes, cores and tools were compared from published numbers of these categories from CPE sites it is clear this bias was not present at the original sites and related to the curation of the sample for export. This reflects the interests of the original study (outlined in Chapter Four). There was only one direct reference to how the assemblage was split, and from this, I have inferred that most of the excavated material from field seasons after

1965 remains stored in various institutions across Egypt. The material which became part of the Wendorf Collection was a small sample assemblage and all the objects that were illustrated within the publication. This suggests that there is likely a bias towards unusual or particularly interesting pieces. The bias towards tools is further reinforced by the distribution of raw materials with an overwhelming number of flint artefacts compared to all other types as counts in the CPE publications suggest that tools were more commonly constructed from this material.

Table 5.4 provides a summary of the frequency of tool types. Unlike the distribution of material from the CPE publications, the types of tools are much more evenly distributed. This, along with the clear bias towards selecting tools as part of the overall sample collection for each site indicated that the Wendorf Collection does not contain a representative sample of the material originally excavated (Table 5.4). Once again, the assemblage is dominated by two main groups, however, within the Wendorf Collection, Endscrapers are more prevalent (12.5-32%), with Back bladelets also common (8-44%). Other types continue in frequencies lower than 10% however the range of tools represented has also decreased with sites exhibiting 6-8 types. This may be an attribute of the sample size which is much smaller than the original assemblages.

Similarly, the distribution of raw material summarised in Table 5.5, exhibits a reduction in the number of different types present within the assemblage. The assemblages are almost completely dominated by flint, although E-75-6 also includes a more significant number of quartz artefacts. This result does not reflect the distribution of material occurring within any assemblage identified from the original publication. It further reinforces the result that the material within the Wendorf Collection does not represent a representative sub-sample of the original assemblage.

Table 5.4: Frequencies of Tool of Types from the UOA1106 BM Analysis

	E-75-6 El Nabta		E-75-7 EL Ghorab		E-79-5 EL Nabta		E-79-8 EL Adam		E-80-1 EL Nabta		E-80-4 EL Adam	
	%	N	%	N	%	N	%	N	%	N	%	N
Endscrapers	12.5	27	25	19	31.8	55	22.8	18	30.6	19	15.8	6
Perforators	5.1	11	14.5	11	8.6	15	7.6	6	17.7	11	5.3	2
Burins	2.3	5	1.3	1	8.1	14	5	4	8.1	5	2.6	1
Composite tools	0	0	0	0	0	0	0	0	0	0	0	0
Backed bladelets	4.6	10	22.4	17	15.6	27	16.5	13	14.5	9	55.3	21
Notches and denticulates	2.8	6	10.5	8	2.8	5	6.4	5	8.1	5	13.2	5
Truncated pieces	0	0	0	0	0	0	0	0	0	0	0	0
Geometric microliths	0.5	1	0	0	0.6	1	0	0	0	0	0	0
Microburins	0	0	0	0	0	0	0	0	0	0	0	0
Scaled pieces	1.9	4	0	0	0	0	0	0	0	0	0	0
Continuous retouch	0	0	0	0	0	0	0	0	0	0	0	0
Sidescrapers	0	0	0	0	0	0	0	0	0	0	0	0
Points	2.8	6	0	0	0	0	0	0	0	0	0	0
Utilised	12.5	27	13.2	10	25.4	44	11.4	9	21	13	7.9	3
Not Defined	55.1	119	13.2	10	6.9	12	30.4	24	0	0	0	0
Total	100	216	100	76	100	173	100	79	100	62	100	38

Compiled from UOA1106 BM Analysis of Wendorf Collection

Table 5.5: Frequencies of Raw Materials from UOA1106 BM Analysis

N (%)	E-75-6	E-75-7	E-79-5	E-79-8	E-80-1	E-80-4
Chert	3 (0.9)	0 (0)	4 (1.3)	2 (1.8)	0 (0)	1 (1.8)
Flint	248 (72.5)	86 (97.7)	300 (96.5)	91 (82.7)	76 (93.8)	52 (94.5)
Quartz	77 (22.5)	1 (1.1)	7 (2.3)	5 (4.5)	2 (2.5)	0 (0)
Petrified Wood	11 (3.2)	1 (1.1)	0 (0)	2 (1.9)	3 (3.7)	1 (1.8)
Sandstone	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (1.8)
Quartzite	2 (0.6)	0 (0)	0 (0)	10 (9)	0 (0)	0 (0)
Granite	1 (0.3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Total	342 (100)	88 (100)	311 (100)	110 (100)	81 (100)	55 (100)

Compiled from UOA1106 BM Analysis of Wendorf Collection

5.4 Results of the Diversity Analysis

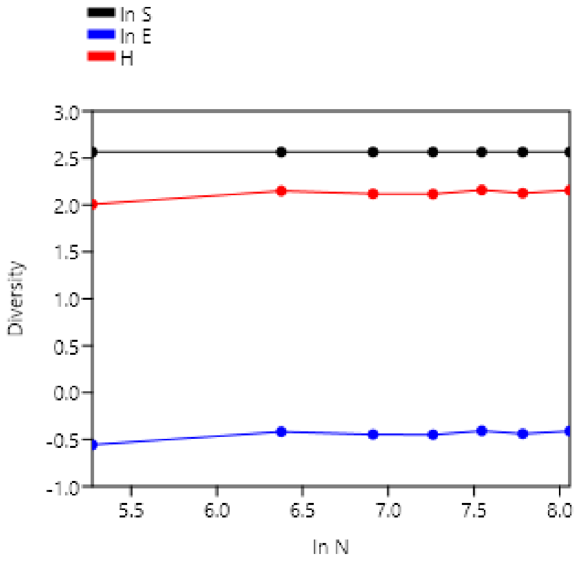
SHE diversity analysis can be employed to demonstrate differences in assemblage composition by highlighting deviations from a non-increasing linear trend. Differences in assemblages are indicated on the accumulated SHE plot by a series of changes in slope gradient. Any differences in site use that result in a different accumulation of artefacts should contrast with the proportions in assemblages accumulated up until that point (Phillipps et al., 2022; Shott, 2010). If the assemblage diversity can be correlated with different site types (either through time or across space), like those proposed by the CPE for the identification of lithic types used to identify chronostratigraphic divisions (e.g., El Nabta, and El Ghorab), then the accumulated SHE plots should indicate this through a series of slope changes. If the differences in the collections of artefacts are sufficient to support the divisions, the proportions of tools and/or raw materials should contrast with the proportions of the accumulated assemblages (see Shott 2010). If the assemblage is heterogenous, following the standard distribution from ecology, the distribution should fit a log normal model (Buzas & Hayek 2005). However, a distribution that shows a relatively consistent pattern may better fit a log series model where assemblage are dominated by a few types and the overall composition is closely related to sample size (Hayek & Buzas, 1998; Shott, 2008).

Figure 5.1 below shows the SHE plot for accumulated diversity measures for lithic tools ranked by assemblage size and calculated using PAST 4.03. *lnS* remains more or less constant at a value of 2.5. *ln*E and H briefly rise but then also remain constant. There are almost no additional tool groups added as the sample size increase. The results show a clear dominance for a few categories and the assemblage size largely reflects the rate of discard. This most closely fits the log series model where differences in diversity within the assemblage are closely related with sample size. Aside from the number of artefacts increasing, there is almost no indication of differences between these assemblages in relation the distribution of tool types contained within them.

Conversely, the SHE plot for the accumulated tools from the Wendorf Collection (Figure 5.2) demonstrates slightly more variation in the diversity of tool with an indication that the number of types may be increasing with the size of the sample. This plot continues to follow the log series model for assemblages dominated by a few types, however sites E-75-6 (with *lnS* increasing to 2.1972). The differences may be due to history of curation and observer differences. However, it is interesting to note that E-75-6 contained the most diverse raw material distribution within the collection containing a proportion of quartz that is not present in any other assemblage (Table 5.5). The dominance of quartz as a raw material was one of the indicators the CPE used to distinguish El Nabta types, however this is not reflected in any of the other El Nabta assemblages (E-79-5 and E-80-1).

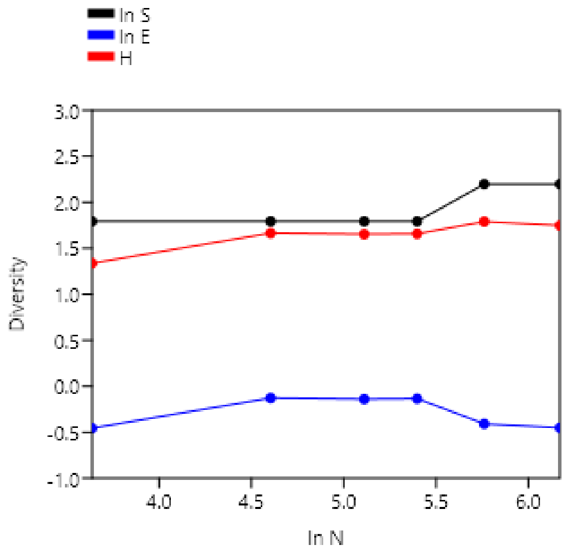
Figure 5.3 contains the SHE plot for raw material cores from the CPE published collection. While there is more variation in diversity than that demonstrated by the tools, the distribution of raw material also fits the log series model. There is a small increase in diversity as the sample size increases but it is not pronounced. This sample suggests that raw material diversity may correlate with sample size and as sample size increases, the number of different types within the assemblage also increases. This pattern is more or less also reflected in relation to the SHE plot for raw materials within the Wendorf Collection (Figure 5.4). However, there is a reduction in the overall number different types present within the Wendorf Collection. The results of the SHE analysis for both the collections indicate that despite some differences that may relate to history of curation and observer differences, the main factor influencing the diversity of these early Holocene assemblages is sample size.

Figure 5.1: SHE Plot for accumulated Tools ranked by size (CPE Published Collection)



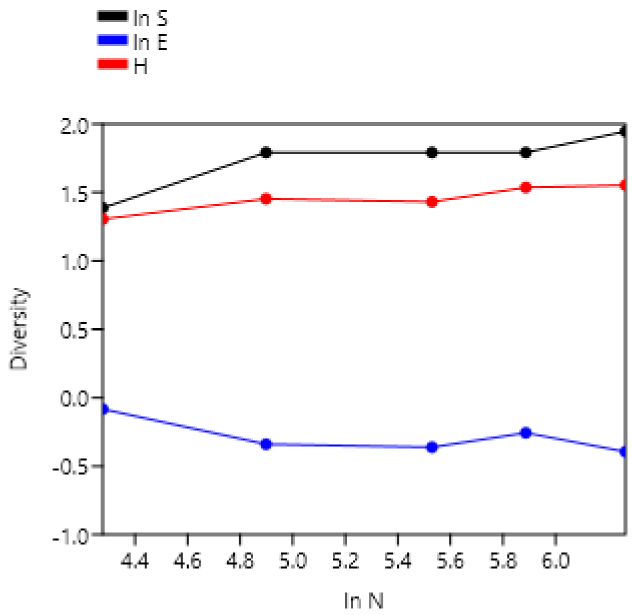
Site	N	ln N	ln S	H	ln E
E-75-6.1	195	5.273	2.5649	2.0084	-0.55659
E-75-6	587	6.375	2.5649	2.1489	-0.41602
E-80-4	1003	6.9108	2.5649	2.119	-0.44593
E-79-5	1423	7.2605	2.5649	2.117	-0.44793
E-75-7	1892	7.5454	2.5649	2.1587	-0.40629
E-79-8	2401	7.7836	2.5649	2.1266	-0.43837
E-80-1	3161	8.0586	2.5649	2.1561	-0.40883

Figure 5.2: SHE Plot for accumulated Tools ranked by size (UOA1106 BM Analysis)



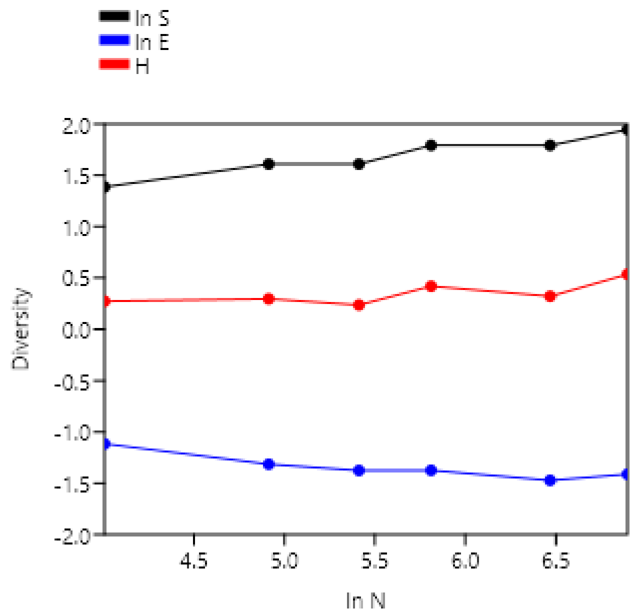
Site	N	ln N	ln S	H	ln E
E-80-4	38	3.6376	1.7918	1.3372	-0.45456
E-80-1	100	4.6052	1.7918	1.6653	-0.12649
E-75-7	166	5.112	1.7918	1.6536	-0.13816
E-79-8	221	5.3982	1.7918	1.6583	-0.13346
E-75-6	318	5.7621	2.1972	1.7893	-0.40791
E-79-5	479	6.1717	2.1972	1.7484	-0.44882

Figure 5.3: SHE Plot for raw materials cores ranked by size (CPE published Collection)



Site	N	ln N	ln S	H	ln E
E-79-5	72	4.2767	1.3863	1.3039	-0.082374
E-79-8	134	4.8978	1.7918	1.4526	-0.33913
E-80-4	252	5.5294	1.7918	1.4303	-0.36143
E-75-6	360	5.8861	1.7918	1.5362	-0.25559
E-80-1	526	6.2653	1.9459	1.552	-0.39393

Figure 5.4: SHE Plot for raw materials ranked by size (UOA1106 BM Analysis)



Site	N	ln N	ln S	H	ln E
E-80-4	55	4.0073	1.3863	0.27161	-1.1147
E-80-1	136	4.9127	1.6094	0.29507	-1.3144
E-75-7	224	5.4116	1.6094	0.23458	-1.3749
E-79-8	334	5.8111	1.7918	0.41811	-1.3737
E-79-5	645	6.4693	1.7918	0.32033	-1.4714
E-75-6	987	6.8947	1.9459	0.53442	-1.4115

All of the patterning in the SHE plots from both collections correlated much more closely with the log series model, rather than the log normal distribution following Buzas and Hayak (2005: Table 1). The distribution of tool types is most similar to the trend identified in Phillipps et al. (2022: Figure 6) SHE plot for accumulated Aotearoa faunal assemblages where aside from the increase in sample size there is very minimal differences among assemblages using fauna groups into categories. This almost flat distribution indicates that a maximum number of types is reached very quickly within a small sample, and this distribution remains the same as the sample size increases. It suggests that the variation found in the larger samples within this collection are only bigger versions of what can be found within the smaller samples with sample size reflecting the discard rates of different tool types.

The SHE plots for the distribution of raw materials on the other hand do appear to demonstrate that the number of types present in the assemblages increase as the sample size increases In this instance, *H* a slight but stead increase. This follows what was demonstrated in a long timescale example in Shott (2010) in relation to a Palaeolithic example from Combe-Capelle Bas. This SHE plot for Combe-Capelle Bas (Shott 2010: Figure 6) shows assemblage that vary with richness and evenness but not heterogeneity, demonstrating that there is a continuous relationship with sample size. The SHE plot artefacts that were classified according to the Bordean typology, with assemblages assigned typical Mousterian facies (see Dibble & Lenoir 1995). The trends displayed within the plot are interpreted as reflecting the presence of a few dominant artefact types that are the product of differential artefact history and rates of discard (Shott 2010).

However, neither sets of assemblage from either collection support that there are major differences in assemblage composition that is not related to samples size from sites in the Nabta-Kiseiba area excavated by the CPE. This indicates that differences in diversity of tool assemblages and raw material assemblages do not support changes in site types either though time or across space. It also suggests that using the division for lithic material that are based on the chronostratigraphic divisions linked to environmental changed and cultural changes proposed by the CPE are insufficient to identify divisions between sites (at least in relation to the data available for the sites analysed in this study.

5.5 Summary

The initial examination of both samples indicated that there are notable differences between the published collection and the collection contained within the British Museum. Comparing the collection indicated that the Wendorf Collection is primarily composed of tools. It was difficult to track down what has happened to parts of the collection however the information that could be drawn from the original publications suggest that it is likely to be a sampling choice due to the interests and emphasis of the original study. The SHE analysis was applied to both collections independently. The results of the SHE analysis suggest that sample size is significantly influencing trends in diversity within both collections, although there are some differences that relate to the history of curation, and observer differences related to the analysis. However, neither set supports significant evidence for major differences in assemblage composition un-related to sample size. The analysis also demonstrates that the assemblages reflect the dominance of a few types and that the assemblage size largely reflects rates of discard. For the tools, the number of different types remained mostly constant even as the sample size increased, while raw material demonstrates a slight increase in the number of different types within the assemblage as sample size increased. The implications of these results and what they mean for models of settlement pattern in the Eastern Sahara and for archaeology, in general, are discussed in the following chapter.

Chapter Six: Discussion

This thesis investigates whether differences in diversity in lithic assemblages can be used as proxies to support models for settlement pattern in archaeology and how assemblage conditions affect the applicability of measures commonly used as proxies. The approaches for developing models for hunter-gatherer settlement pattern are usefully focused on observing the archaeological evidence for mobility in the past. In many instances, mobility is inferred from the distribution of lithic artifacts, differing densities and varied locations (Holdaway & Davies, 2020). Close (2000) highlights that the commonly cited proxies for mobility are based around the potential to move rather than direct indications of human movement. For early Holocene sites in the Eastern Sahara, these were in part supported by perceived connections between sites supported by similarities in lithic assemblages. These are used to identify links between areas either through time or across space. This is related to settlement pattern through concepts such as sedentism or the movement of raw materials. These proxies are usually based on assumptions about how patterns within assemblages or the presence of specific features represent past human behaviour. The link between different aspects of human behaviour and specific patterns within the archaeological record is most often illustrated by ethnographic analogies (Kelly, 1995). In theory, an examination of assemblage diversity could demonstrate settlement pattern by identifying different site types. These distinctions have been made for ethnographic examples such as Shott (2010) SHE plot for !Kung San. However, the analogies and models based on ethnographic examples tend to represent comparatively short periods of time. These have a limited application to describe areas used for many hundreds or thousands of years in the past.

The lithic artefacts contained within the Wendorf Collection were primarily tools; and as a result, a SHE diversity analysis can be employed to explore tool assemblage diversity. Additional information from CPE publications provided the contextual information required to understand the assemblage condition. Incorporating both streams of data needed a shift in mindset to follow that of broader anthropology and other humanities subjects, to change from considering legacy collections solely as a source of archaeological data to examining legacy collections, archives, and the past publications that relate to them as a subject of archaeological research.

6.1 Diversity Analysis and Settlement Pattern

The results from the SHE diversity analysis for tool types demonstrate that the differences in the distribution fit the log series model for assemblages dominated by a few types. They also provided the opportunity to compare these data to the case studies reported by Shott (2010) and Phillipps et al. (2022). Shott establishes examples of Palaeolithic archaeological context (long-term) and an ethnographic context (short term). The results from the analysis of this study correlate most closely with the archaeological examples, where the overall composition of the assemblages is more closely related to the sample size. For tools, diversity remains constant for all assemblage sizes, indicating the samples exhibited the same spread of tool types regardless of the size of the sample. The SHE diversity analyses for raw material demonstrated a similar distribution pattern, but with a trend toward diversity increasing as the sample size increased. Shott indicated that these patterns possibly reflect the presence of a few dominant categories within an assemblage that are likely related to artifact use-life and discard rates. This implies that the variation within lithic assemblages (at least for the assemblages used in this study) do not exhibit differences to support an identification of changes in site types either through time or across space. Identification of different ‘cultural’ groups at different sites based on the assemblage types outlined by the CPE do not appear to be reflected within this analysis. It suggests that the application of techno-typological data within reconstructions of settlement pattern is a problematic proxy and requires careful consideration of whether the differences detected are beyond what reflects differences in assemblage size. Variation in assemblages does not demonstrate the different periods of occupation suggested by the CPE linked with the sequence of occupation for early Holocene sites and often cited to support the interconnection between areas across the desert.

The exploration of the assemblage condition revealed that early Holocene sites in the Eastern Sahara are predominantly heavily deflated surface scatters of lithic material. The temporal range represented at these sites is several thousand years of human activity. It is doubtful (with current approaches and methods) that defining aspects of sites using techno-typological analysis to search for short scale changes in activity at sites to make inferences about settlement pattern would be discernible from this context. As noted above, archaeological assemblages represent a distinctly different temporal scale from the scale described in ethnographic studies and settlement typologies based on ethnographic analogy (Holdaway & Davies, 2020). The issue with identifying variation in settlement pattern at sites in the Nabta-Kiseiba area using the SHE diversity analysis is more to do with the level of resolution the assemblage offers rather than an inability of the analysis to identify differences. As Phillipps et al. (2022) note, the failure of the analysis to identify such distinctions does not disprove the existence of site types; rather it suggests that the current archaeological proxies for identifying these phenomena are insufficient to differentiate this phenomenon. Due to the difference in scale, it is impossible to detect the microscale processes that indicate the kind of variation that may be sensitive to comparatively brief changes in activity because the length of time the assemblage represents flattens any small-scale deviations that could have indicated this (Perreault, 2018, 2019). The range of different activities, with varying numbers of people at different points in time, will produce complex assemblage variation, including size dependence in derived measures (Shott, 2010).

Furthermore, because the results indicate that the patterns are interconnected with the sample size, the issues associated with using lithic tool types or raw material diversity as a proxy for distinguishing different distinct sites in this context are unlikely to be resolved by increasing the size of the sample. A larger sample may only appear to have increased diversity because all types have increased proportionally. As Bailey (2007) asserts, the resolution available within the material record influenced the type of research questions specific assemblages can answer.

Most of the theories developed for a settlement pattern that describes activity at this scale continue to be untestable for archaeological contexts (Phillipps et al., 2022). Holdaway and Davies (2020) note that while landscape use may be demonstrated by the accumulation of different types and numbers of artefacts, the surface archaeological record can be viewed as a palimpsest (also see Bailey, 2007). The repeated use of the location for various activities over time creates assemblages that are comprised of a mixture of materials that relate to multiple activities and occupations (Davies et al., 2021; Davies & Holdaway, 2017; Davies et al., 2018; Holdaway & Davies, 2020). In this, the record becomes time-averaged, and the ability to identify microscale processes is lost as time passes (Perreault, 2019). One solution to understanding past human activity from a record produced under these circumstances is to spend time unpacking the processes that lead to that patterning that can be seen across archaeological sites and employ proxies that can better account for time-averaging. This requires a focus on understanding formation and specific lithic assemblage conditions (e.g., a large representative sample of the complete assemblage, including all flakes, cores and tools and their individual spatial distribution). As these are not systematically recorded for all archaeological sites, these methods are much more suitable for integration into new excavations and fieldwork. However, they do not provide a solution for incorporating legacy material.

Understanding what these assemblages represent makes it possible to examine them at an appropriate scale. Current approaches rely on analogies and definitions of mobility that only occur over a short timescale (Phillipps et al., 2022). As identified in Chapter Two, hunter-gatherer settlement pattern studies have built many of their definitions around theories put forward by Binford (1980; 1983). These were ethnographic in focus and based on modern-day indigenous populations and primarily focused on describing patterns for annual mobility. The settlement 'types' Binford (1980) identified were never intended to describe long term patterns of artefacts found within the archaeological record or function as discrete groups to differentiate specific activities in the past. However, the appeal of the models proliferated their continued use in discussions of mobility and models for settlement pattern (see Holdaway & Wandsnider, 2006; Kelly, 1992; Perreault & Brantingham, 2011). These models cause hunter-gatherer settlement patterns to depend on the identification of basecamps and extraction sites which oversimplifies the record (Holdaway & Davies, 2020). Shott (2010) also highlights that the difference in scale between the ethnographic examples and the time frame that forms the archaeological record will also mean that specific sites may experience multiple forms of occupation. Shott emphasises that ancient people are unlikely to use the same location for the same activities or with the same number of individuals consistently over several hundred or several thousand years (also see Dibble et al. 2017). Therefore, deriving individual activity or specific temporal instances of behaviour from the accumulation of material culture within the archaeological record is problematic (Shott 2010; Phillipps et al., 2022). However, it is also possible to take time averaging into consideration when analysing the archaeological record, and by doing so, it is still possible to achieve insights related to human-environment interactions and place use histories that occur within an appropriate timeframe.

For example, Schlanger (1992) suggested a model for examining past settlement pattern by considering the occurrence of 'persistent places'. These are places are defined as locations that were repeatedly used during the long-term occupation of an area. This approach allows for the incorporation of isolated finds, traditional sites and specific features into the discussion around settlement pattern. Differences in assemblage size in this instance can be related to different rates of repeated activities that lead to artifact deposition. Here, the discussion of locations that received different levels of activity also represents different levels of variability and therefore variability in the nature of persistence. Holdaway and Phillipps (2021) note that areas that contain higher densities of lithic material (or other resources) also become the areas people continue to return to multiple times. Rather than attempting to describe specific activities at specific sites, this model emphasises long term land use across a wide area. Numerous recent studies have discussed how repeated activities in the past produce different sized assemblages related to the rate of artefact deposition (Davies et al., 2021; Davies & Holdaway, 2017; Holdaway & Davies, 2020). These studies indicate that artefact depositional patterns amalgamate around the outcome of specific repeated actions. Examining prehistoric assemblages from this perspective allows for a discussion of place use histories that derive their evidence from the archaeological record.

SHE diversity measures are only one derived measure for past human activity. However, the results of the analysis highlight the importance of considering how assemblages accumulate and how this affects the resolution and likelihood of being able to define site types from lithic assemblages. As Phillipps et al. (2022) point out, in this context, the diversity measures challenge the value of the conceptual bases of functional settlement model analysis, especially for prehistoric sites. This is clearly demonstrated within the results of this study where distinctions identified within techno-typological analysis of lithic artefacts do not continue to maintain their differences in diversity when sample size is also considered. Dibble et al. (2017) note that there are numerous processes that contribute to how and why lithic artefacts were discarded in the past and that the objects within an archaeological assemblage will reflect and represent the totality of all behaviours that took place. These will include what people did and discarded at a site as well as the situational contexts at each site. Some of these lithic artefacts may survive in a form that reflect purposeful manufacture with characteristics of design and functionality that can be identified through techno-typological analysis however, some may not (e.g., a partially manufacture form) (Dibble et al., 2017).

If it is not possible to determine that differences in the diversity of the composition lithic tool types and raw material types within archaeological assemblages are unrelated to sample size (as demonstrated in relation to the site in this study), then the techno-typological analysis of lithic artefacts lacks the specificity required to demonstrate differences in site types that are needed to discuss variation or changes in settlement pattern. These results, therefore, also support the application of alternative measures that can account for time averaging within the assemblage. The utility of such measures is demonstrated by Phillipps and Holdaway (2016) who employed cortex and volume ratios to indicate differences between the degrees of movement at different early to mid-Holocene sites in the Fayum which could successfully be employed as a proxy within settlement models (also see Holdaway & Wendrich, 2017; Holdaway et al., 2010; Phillipps et al., 2012). However, as al Nahar and Olszewski (2016, p. 50) observe, there is no 'one size fits all' set of parameters for interpreting lithic assemblages. Many lithic measures require certain assemblage conditions to be performed, their application is dependent on understanding the nature of the curated sample especially when applying them to legacy assemblages.

6.2. The Context of the Wendorf

A substantial portion of the contextual information related to the Wendorf Collection has been lost due to the time that has passed, and the lack of usable meta-data contained within the collection. However, by reviewing the work produced by the CPE through their publications it was possible to regain some of this context to a level that is sufficient to provide insight related to the condition of the assemblage, the underlying sampling strategies, and the kind of approaches would be appropriate for future studies. The process of reviewing the collection highlighted that at the time the research was performed an understanding of theories and assumptions that led to the creation of the data, including what questions it was originally curated to answer were equally important factors driving the creation and curation of the sample I was trying to evaluate. As Currie (2021, p. 127) argues, data that is provided through legacy contexts can be a rich source of information about the past if there is active engagement in understanding the conditions that create legacy data and how this data changes through time.

A degree of recontextualization was achievable in this instance because the sites in the Nabta-Kiseiba area were the subject of numerous years of archaeological fieldwork and the organisation that worked on the project published consistently throughout the period that they worked on the site. Through an analysis of the texts, it was possible to unpack the conditions that were required for certain artefacts to be chosen for the collection, and how the original sites were sampled. These indicated that only a small sample of the material was exported from Egypt, and a portion of this material was items selected for illustration within the publications. The SHE diversity analysis provided the opportunity to compare the sample assemblage within the Wendorf Collection to the assemblage originally published from the site to provide further insights not immediately apparent from a reading of the texts. The results of both approaches revealed insights that were not clear from the raw data obtained from the analysis performed by the UOA1106 BM Analysis.

A basic comparison of the frequencies of different lithic artefacts (flakes, cores or tools) demonstrated that there is a clear bias towards tools, over any other lithic form. It appears likely that the sample was in fact meant to be comprised entirely of tools. The identification of flakes during the UOA1106 BM Analysis may be due to different prerequisites for the identification of tools, especially as Wendorf & Schild (1980) note that tool identification in the CPE onsite analysis predominantly relied on morphology rather than the retouched edge. The frequencies of raw materials also reflect this bias, as materials that were equally common within the original sample identified in the CPE publications are almost completely absent. These results were supported by the results from the SHE diversity analysis which also demonstrated that the data contained within the Wendorf Collection is not a representative sample of the lithic material excavated at sites from the Nabta-Kiseiba area. The diversity of both the tools and the raw materials follows different trends from the sample drawn from the publications. This observation has significant implications in relation to how this collection could be used in future studies as it does not provide the resolution to perform many of the analyses used in modern archaeological studies. It is also a working example of how archaeological assemblages are dynamic and change through time even after the excavation and analysis have been performed through general curation processes. In this instance, it appears the sample was distorted through the initial choice of what to export followed by its storage in at least two institutions. The loss of fieldnotes associated with the material and the loss of individuals who knew and understood the collection have caused further loss of critical information related to the context of significant portions of the material.

The insights outlined in the above section relate directly to the material that resides within the Wendorf Collection, however, there are several other assemblage conditions related to the goals and processes undertaken by the original study that should be addressed. Legacy material from CPE excavations, like that of many other legacy assemblages, suffers from a lack of context that is sufficient for it to be applied to many traditional archaeological research questions. However, the publications do contain details that shed light on aspects of the CPE's field methodologies and approaches to archaeology, which can be critiqued and discussed. A more nuanced application of the empirical data drawn from the Wendorf Collection and publications to answer the questions outlined in this study is achieved by incorporating an archivist's approach to examining historical records from fieldwork and publications related to the work of the CPE produced between 1963 and 2000. This process is focused on resolving issues identified by incorporating legacy data into new research.

A large body of the material and the observations made concerning Egyptian prehistory relates in some way to the CPE. The CPE played an important role in the documentation and promotion of Egyptian prehistory in archaeology. Their approach to archaeology can be split into three phases. The CPE initially began as a rescue project, during which time the primary goals were to observe and record as much prehistoric material as possible before they were lost to the rising waters of Lake Nasser. The second phase of their archaeology, beginning in the mid-1960s was a shift to increasingly broad surveys. During this phase, the CPE focused on identifying the extent of prehistoric material across Egypt and identifying areas for further research. The final phases from 1990 shifted the focus to specific preidentified regions, involving concentrated studies at specific sites.

Generally, the CPE produced work in a constant state of time pressure. This is made abundantly clear through the process of scouring past publications for any references to methods used in the field, amendments to methodologies, sampling choices and recording protocols. Their publications suggest a strong emphasis on producing the largest amount of data possible within the least amount of time, in the hope that this would be sufficient to perform statistical tests during analysis. This allowed the CPE to survey vast areas every field season, recording new sites and providing good detail on the scope of early Holocene material found across the Eastern Sahara. Unfortunately, the speed at which many of these surveys were performed was detrimental to the amount of detail recorded at each site. In many regards, the CPE was often trying to do too much rather than attending to finer details. It is reflected in their publications that cover vast areas of the desert but also contain many simple errors that become quickly apparent with a close reading of the text.

The CPE also never completely standardised their approach to archaeology, preferring to allow each component of their work to stand alone, especially in publication. Chapters are clearly written in isolation, acting as their own mini-report. This led to many contradictions within their published work regarding what the analysis represented, and what information was important to include. 'Who' performed the fieldwork, and 'who' wrote up the description plays a huge role in the amount of contextual data which was recorded for each site. Examples of this can be found in all CPE publications. For example, in Close et al. (1984) the chapters related to site E-80-1 and E-80-4 contained a level of detail for lithic data and how the fieldwork was performed completely absent from E-79-5 resulting in a loss of lithic data during the publication process, because of the omission of a basic detail. This kind of inconsistency is common in legacy collections. Faniel et al. (2013) observed that archaeologists working with legacy collections often identified a preference for the work of certain past scholars over others because of their perceived skill in fieldwork and analysis, and their ability to articulate the context of data. All archaeological material has sample bias, and the CPE material is no exception, although the underlying biases are not immediately clear from CPE publications. The observations made within the data and results required careful unpacking of the text further reinforcing the value of a careful examination of past publications when incorporating legacy material into new studies.

The first clear bias was in site sampling. A major goal of CPE was to develop chronologies for prehistoric settlements. In order to create a focus for the surveys performed in the Eastern Sahara between 1972 and 1980, the CPE investigated areas within or beside oases or playa remnants. Within these areas, the CPE also chose to direct their interest specifically to places that contained cultural material embedded in stratified layers (of playa silts), passing by the numerous surface assemblages (although they noted they could be investigated in later studies), and the material from more heavily deflated ‘newer’ sites. They also focused on sites with better preservation, because they were (as the CPE described) ‘less complicated’ to excavate and record. Therefore, the high concentration of known prehistoric sites near these water sources observed during CPE surveys is in fact the result of a significant sample bias. This is important to note because CPE surveys contribute a substantial proportion of the data for the distribution of known prehistoric sites across the Eastern Sahara. While this does not completely negate the hypothesis that humans prefer the areas in proximity to permanent water sources, the evidence supplied by CPE surveys also cannot be used to support this claim without additional survey work to prove that material does not also reside further from lake edges or elsewhere in the desert. Comparisons of sites within the corpus of their work will be unable to address this question.

The preference for stratified material also led to an over-representation of stratified sites. In fact, the CPE often appear to be at a complete loss on how to survey or analyse surface material effectively, preferring to ignore it or note it as a problem to be tackled later. Some of this can be attributed to when most of the work was completed. The largest surveys were undertaken prior to 1985 using field methods developed in the 1960s. The methods for sampling, surveying, and using surface material (beyond site identification) only began to gain traction during the late 1970s and 1980s. During this time, there was an increase in recognition that surface material could provide information beyond locating sites or establishing regional cultural histories (e.g., Clarke, 1968; Flannery & Sabloff, 2009; Schiffer, 1972). Using surface material optimally in archaeological investigations requires a more nuanced consideration of the natural and human actions that are operating upon it, particularly consideration of post-depositional processes. For the CPE, this would have required a significant shift in field approach and retraining of excavators. As a result, the site reports and publications contain very little information related to possible processes operating at the site that may have caused the deflation of the surface and the mixing of archaeological material.

In adopting Tixier’s (1963) typology for lithic tools, Wendorf & Schild (1980) note the issues and ill-suitability of the typology for early Holocene sites but pursued using it because of its popularity across other parts of Egypt. Small amendments were made to better incorporate the early Holocene material however it continues to be problematic despite its continued use. Because some sites only recorded the lithic data in relation to this typology, it has significantly limited how these sites can be compared or incorporated into future studies if the typology changes. Boozer (2014, p. 105) observed when descriptive categories (typologies) are empirically problematic they have ‘downstream’ effects directing future questions in ways that reproduce the original errors, however, they are very difficult to move away from as the many methods of analysis may rely on the comparability they provide. Ellis (2008) highlights many of the issues of taking typologies at face value, emphasising that the interpretation can transform archaeological data, and they create ambiguous results for later researchers who do not have access to all the material. All three of these issues are demonstrated by the analysis performed within this study.

The observations and conclusions drawn by the CPE regarding the Nabta-Kiseiba area, especially sites at Nabta Playa, are often cited in studies of early Holocene sites across the Eastern Sahara as a point of comparison in relation to the distribution and frequencies of certain types of artefacts, and their proximity to lakes or other water sources. However, following the interrogation of the condition of the lithic assemblage, the sample bias, and the focus of the original approach that produced these conclusions, the results of this study indicate that these sites should not be treated as a 'type' for early Holocene 'settlements'. These sites are currently providing 'data focus' for models of early Holocene settlement pattern. Gero (2007) highlights that data focus occurs when theories and ideas are developed around one specific site because it is the 'only example'. Nabta Playa is often treated as an exceptional example of an early Holocene site due to the level of preservation found at the site. Similar situations have been demonstrated at Karanis in Egypt, where another 'exceptional' site was used to fill knowledge gaps about other sites under the assumption that the data was more secure than it was (Boozer, 2014).

Boozer (2014) argues that enabling and promoting ambiguity, heterogeneity, and complexity in archaeological interpretations has significant advantages for understanding the past (see Adams, 1991). What often happens instead is that these sites and studies run the risk of misuse, with the data being stretched to make sweeping claims and conclusions based on specific cases and sites (e.g., settlement models based on pastoralism) that are used to demonstrate a broader pattern or process and are often not only vaguely based on evidence from the archaeological record. They can also become misused when interpretations or observations become disconnected from the context in which they were developed, as can be seen with the prevalence of sites near water sources, and the bias towards selecting sites near water sources and contained examples of stratified deposits. This phenomenon is also discussed by Ellis (2008) concerning the misuse of legacy data at Pompeii, which was borne from a lack of actual engagement with the existing archaeological data. Ellis attributed some of the avoidance to the size of the legacy collection for the area being overwhelming. However, the issues identified for all the collections discussed imply that areas that become focal points for archaeological research could benefit immensely from active engagement and careful curation of their legacy material (including publications) to avoid the loss of context, and re-test theories built around historic typologies which may be critical for future studies.

Archaeological writing often conceals the inconsistencies of archaeology by erasing the ambiguities characteristic of tangible archaeological evidence (Gero, 2007).

Using legacy data is complicated by varying methods and theories regarding curating archaeological collections (both objects and associated records). As a result, there are discrepancies in access, curation, and preservation to all (or part) of some legacy assemblages because of; changes in laws or protocols related to heritage management, differences in policies and procedures developed within curation facilities as well as differences in the treatment of material between public and private institutions and differences in attitudes towards ownership (Amand et al., 2020; Kersel, 2015). It is further complicated when collections are transported or moved between institutions. These issues concerning the management of archaeological collections are often referred to as the "Curation Crisis" (MacFarland & Vokes, 2016). These complications and the changes they produce are equally crucial to understanding legacy collections as they reflect the shifting values of the institutions they represent. In this, the archaeological archive is not a static entity.

The Wendorf Collection is probably the largest traceable collection of prehistoric material produced by a single organisation and exported from Egypt that is housed within a museum. It contains samples of material from Egypt and Sudan collected between 1962 and 2000. However, most of the material now remains in storage and significant portions of the original context are lost. This collection contains a sizable sample of prehistoric material, from sites across the Eastern Sahara related to the early Holocene often cited in current studies as a point of comparison when discussing settlement pattern. Therefore, it seemed pertinent to review the condition of the assemblages to identify the best approaches to re-examine them, and what sort of questions the collection is best employed to answer. It is possible to recover some of this context by understanding the process that created the original sample, and the curation processes that continue to affect it after it is placed into 'storage' (see Currie, 2021 and Wylie, 2016).

Context is required to be able to evaluate data. When examining legacy collections, the original context is not always initially apparent. As other studies note (e.g., Wylie, 2016; Holdaway et al. 2022), the process of reconstructing the context of legacy collections in archaeology is totally reliant on the information that was stored with the material, what is included within publications, and in some lucky instances interviews with individuals who worked on the projects. The limited use of legacy collections is often attributed to difficulties in this process of recontextualising the primary data. However, Leonelli (2018, p. 752) suggests the hyper fixation on looking for 'new' datasets arises from a lack of recognition of the sophistication of methods involved in data processing and how understanding these processes can be used to reconstruct a record of the context and provide further insights about the past. Leonelli (2018a, 2018b) also argues that historical scientists often hold an exaggerated optimism about the potential of experimental methods in contemporary science, and these experience similar issues, especially in relation to legacy data. Archaeology is not a static discipline, the standards change, and the way we conceive of sites changes. The way data changes through time is clearly demonstrated through the examination of the CPE legacy collections, however, the difference between the published collection and the Wendorf collection were not drastic. Nevertheless, the further research into the context of both samples demonstrates the utility of attempting to gather as much context as possible before performing analysis on legacy collections, as it was the study of the literature that revealed the underlying biases and sampling approaches which affect the way the samples can be applied to future questions. Furthermore, while archaeology endeavours to employ scientific approaches to obtain and record data, there have been numerous deviations in theory and methodology in archaeology that have shifted in response to changing social, cultural, and political pressures. Exploring the way social and cultural pressures influenced the way archaeology was produced in North Africa is beyond the scope of this study, however for a commentary related to politics and archaeology, there are several recent studies that discuss these issues (see Carruthers, 2017; Doyon, 2014; Hassan, 2007; Hill, 2021).

All archival collections become more difficult to contextualise as time passes, however, Leonelli (2018, p. 752) observes that data can also be lost or become unusable at a faster rate if they are not curated properly. The information critical to understanding some legacy collections can vanish through the destruction of a hard disk, a misleading annotation, or the loss of specific people who know the collection well (Currie, 2018; Wylie, 2016). In essence, reconstructing the condition of the assemblage and understanding the context becomes twofold. One portion relates to the phenomena originally being observed (e.g. the archaeological context) and the other portion relates to the fieldwork, analysis and curation process operating on the sample extending into the present. This is not a problem unique to archaeological data or archaeological collections or historical sciences, in fact, the concerns related to the differential survival of evidence and informational destruction are equally important for contemporary data collections in life sciences.

6.3 Summary

The results of the SHE diversity analysis for tool types and raw materials demonstrate that the variation that is observed correlates with the sample size. Because early Holocene sites are primarily comprised of surface material that accumulated over several thousand years, this is because SHE diversity analysis is not able to identify differences in time-averaged assemblages. This means that it is unable to be a proxy for micro-scale human activities like those observed in ethnographic settings. There is a disconnection between the models and timeframe represented within the archaeological record, particularly concerning sites within the Eastern Sahara. This makes the discussion of short-term variation in the face of climate fluctuation much more difficult. Adopting alternative proxies (such as cortex and volume ratios) could better account for the time-averaged nature of these sites and require certain assemblage conditions to be met. However, it is not always an option to adopt these proxies when using data drawn from legacy collections. Despite this legacy material can still be employed in other ways.

Rather than lamenting the lack of detail available to answer traditional archaeological questions, it would be more beneficial for the discipline of archaeology to allow these collections to show us what they can tell us about the past by incorporating knowledge systems beyond those solely produced by empirical analysis. Reviewing the research that led to the creation of legacy data highlights the biases and assumptions that underpin the conclusions of the original study, and provides the detail required to understand how to best apply the material to future studies. This research highlights how archaeological data continues to change and evolve even after excavations take place through various curation processes and loss of contextual information. It also highlights the importance of understanding the fundamental nature of the archaeological record that is being assessed and the fundamental nature of archaeological assemblages and how they continue to change and evolve.

The archaeological record (as an archive in the field and an archive created through archaeological methods and processes) dictates what can be learnt about the past (Perreault, 2019). Not all data within archaeology legacy collections are created equal, but this does not mean that there is no value gained from examining them. Working on legacy collections also provides valuable insights into what and what not to do when excavating and documenting archaeological sites moving forward (Kersel, 2015; King, 2016; MacFarland & Vokes, 2016)..

Chapter Seven: Conclusions

This thesis demonstrates that due to the nature of early Holocene lithic assemblages from the Eastern Sahara, it is (with current approaches) impossible to answer questions about micro-scale processes that relate to settlement pattern through a study of tool diversity, due to the underlying conditions of the assemblages and the realities of the archaeological record. The results from the SHE diversity analysis for tools and raw materials demonstrate that the techno-typological approach to lithic analysis lacks the specificity needed to show differences in site type that are needed to talk about changes in settlement pattern. The accumulated SHE plots demonstrate that the tool types and raw materials both fit a log series model of distribution that reflects assemblages that are dominated by a few types reflecting discard rates. This indicates that the assemblages are time averaged. Commentary related to the difference in the composition of assemblages is indicated to be related to sample size with diversity remaining the same or increasing as the sample size increases. This makes the discussion of short-term variation in the face of climate fluctuation much more difficult as the nature of the assemblage is dictating what questions can be answered.

There is a disconnection between the models and timeframe represented within the archaeological record, particularly concerning sites within the Eastern Sahara. Most models that have been developed to describe settlement pattern draw on activity demonstrated in ethnographic studies that occur at a scale that continues to be untestable in archaeological contexts due to the way archaeological sites are formed (e.g., Marshall & Hilderbrand, 2002; McDonald, 2009). The disconnection is especially true of surface assemblages, and sites that have formed over several hundred or thousands of years. The repeated use of a location for various activities and occupation causes the record to become time-averaged and represent a palimpsest of past activity (see Bailey, 2007). It may be possible to unravel some of the complexity within the record by exploring the process that leads to the patterning that can be seen across archaeological sites and employing proxies that can account for these conditions. As such, the results of this study further support the application of alternative methods for lithic analysis such as the cortex and volume ratios as proxies to support models for settlement pattern. However, these approaches require specific assemblage conditions to be met and so are dependent on understanding the nature of the curated sample. The application of alternative methods is more likely to be a solution for future studies in most instances. It does not resolve the issue of incorporating or discussing legacy material.

As a result, it may be beneficial to consider what sorts of models are sympathetic to the conditions and scale represented at prehistoric sites, and how to conceptualise discussions of human activity that create patterns over the long term. This concept is discussed and demonstrated by Schlanger (1992), and has been adopted for prehistoric sites elsewhere (e.g., al Nahar & Olszewski, 2016). Examining prehistoric assemblages from this perspective allows for a discussion of place use histories that derive their evidence from the archaeological record.

Legacy data is a rapidly growing archive of archaeological material which does require consideration for the future of archaeology. Legacy collections also contain an underutilised resource for assessing the data that supports commonly held assumptions, forcing archaeologists to acknowledge and 'honour the ambiguity' of many aspects of archaeological data (Gero, 2007). This material is restricted by the context and conditions put down by the original fieldwork and research. Successful incorporation of legacy material into new studies that can provide useful and meaningful insights requires innovative approaches. Context is required to be able to evaluate data. However, when examining legacy collections, the original context is not always initially apparent. Much of the scholarship about legacy collections laments the lack of detail available to answer traditional archaeological questions. However, this study demonstrates it would be more beneficial for the discipline of archaeology to allow these collections to show us what they can tell us about the past. It highlights the importance of being open to revising past interpretations of what we think we know about sites, emphasising the importance of understanding the fundamental nature of the archaeological record that is being assessed. It is clear from this study that the questions that drive archaeological studies impact the data that is collected and this in turn effects that how that data can be applied to future studies.

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