THE MIDDLE STONE AGE FAUNA FROM OLIEBOOMSPOORT, SOUTH AFRICA: AN ARCHAEOZOOLOGICAL PERSPECTIVE.

Humphrey Nyambiya

THESIS SUBMITTED FOR THE DEGREE OF MASTER OF PHILOSOPHY
IN ARCHAEOLOGY IN THE DEPARTMENT OF ARCHAEOLOGY AT THE
UNIVERSITY OF CAPE TOWN.

SUPERVISOR: ASSOCIATE PROFESSOR DEANO D. STYNDER

CO-SUPERVISOR: DR AURORE VAL

Abstract

Olieboomspoort is an archaeological site, which has evidence of human occupation going back possibly to the Earlier Stone Age, but more substantially to the Middle and the Later Stone Age. This site is located in the Waterberg Mountains of Limpopo Province, within the South African Savanna Biome. Archaeological excavations at this site began with the late Revil Mason in 1954, who attributed lithics from the Middle Stone Age deposits to the Pietersburg Industry. Mason did not mention any faunal remains from these Middle Stone Age layers. The site was later investigated by Maria van der Ryst, who excavated the Later Stone Age layers. In 2018, a new project led by Aurore Val and colleagues from the University of the Witwatersrand started at the site. This study focuses on the faunal material excavated in 2018 and 2019 from the Middle Stone Age layers.

In southern Africa, Middle Stone Age archaeological research and, consequently, archaeozoological research, is concentrated on coastal and near coastal sites. While the research from these coastal and near coastal sites is insightful, little is known for the interior of southern Africa. The current study forms part of a series of renewed research at inland archaeological sites, aimed at aiding our understanding of the diversity of Middle Stone Age societies.

This work presents the first taphonomic and archaeozoological analyses of the Middle Stone Age fauna from Olieboomspoort. A total of 1296 specimens were analysed. These include specimens that were plotted during excavations and those retrieved from the sieving refuse. This study identified the following species *Alcelaphus* sp., *Oreotragus oreotragus*, *Raphicerus campestris*, *Raphicerus* sp., *Redunca* sp., *Sylvicapra grimmia*, *Syncerus caffer*, *Tragelaphus oryx*, *Equus* sp., *Proteles cristata*, *Felis silvestris*, *Papio* sp., *Lepus* sp., snakes and tortoises. Thus, the faunal assemblage is taxonomically relatively diverse with 16 species

identified. Bovids are the most represented and there is an abundance of small bovids. The presence of the extinct equid *Equus capensis* is suspected. Two species of carnivores, aardwolf (*Proteles cristata*) and African wild cat (*Felis silvestris*) were also identified.

The taphonomic signatures of the faunal assemblage are indicative of several biotic modifiers including invertebrates. There is limited evidence for carnivore and porcupine action. Evidence of human modification is low and attested by only six pieces with cut-marks. This study identified the role of water, which likely transported some faunal material, and could have led to recovery biases.

The taxonomic composition of the faunal assemblage provides a window onto the palaeohabitats present at the site. Several taxa, including the steenbok (*Raphicerus campestris*) and *Equus* sp. prefer open habitats. The identification of species that are water-dependent such as the buffalo (*Syncerus caffer*), and one species of reedbuck (*Redunca* sp), is suggestive of the presence of a nearby water source. This is consistent with the proximity of the Riet Spruit, which at present is a small river running a few meters below the site. Finally, the identification of baboons, leporids and klipspringers (*Oreotragus oreotragus*), animals which thrive in rocky areas, underpins the rocky morphology of the site's locality.

Recent dating of two fossil bones from the Olieboomspoort Middle Stone Age layers by Val *et al.* (2021) gives a range of 150 kya, which places those layers within the Marine Isotope Stage (MIS) 6. MIS 6 was a glacial phase, which exact palaeoclimatic and palaeoenvironmental characteristics are still poorly understood for southern Africa, where there are also few dated archaeological sites from that period. Thus, we know relatively little about the subsistence strategies of MIS 6 human groups. In light of the above data, the current study adds some information about MIS 6 human subsistence strategies within the Savanna Biome.

Acknowledgements

A number of people have made this research possible. I would like to thank my supervisors Associate Prof. Deano Stynder and Dr. Aurore Val, for your patience in reading and correcting one of the roughest drafts. A very big thank you for the many hours you spent with me, going through the assemblage, the critiques and the new perspective. Sometimes the journey became daunting, but you remained close to assist and to support me.

I would like to thank Dr. Ancila Nhamo (University of Zimbabwe), who invited me to a research project in the Matopos in 2018 where I met Dr. Guillame Porraz and Dr. Camille Bourdier. It was from this project that my interest in archaeozoology was kindled. Dr. Porraz and Dr. Bourdier introduced me to Dr. A. Val, who is an archaeozoologist.

At the University of Cape Town, I would like to thank Louisa Hutten for the patience she had with me and for assistance in taxonomic identifications and the numerous discussions we had, *Dankie*. I also thank Bedone Mugabe, Precious Chiwara-Maenzanise and Dr. Robert Nyamushosho for the time we had, the laughs and support. *Makaita basa*.

The Olieboomspoort assemblage is housed at the Evolutionary Study Institute (ESI) at the University of the Witwatersrand, as such, I thank Dr. Bernhard Zipfel, the curator at ESI for the permission to transport this assemblage to the University of Cape Town. In the same line, I thank Drs. Marc van der Brandt and Paloma de la Peña, who transported the material to Cape Town. At the Ditsong Natural History Museum, I thank Dr Annie Antonites for accessing the brilliant comparative collection.

The support of the DST-NRF Centre of Excellence in Palaeosciences (CoE-Pal) and the National Research Foundation (NRF) towards this research is hereby acknowledged.

Opinions expressed and conclusions arrived at, are those of the author and are not necessarily to be attributed to the CoE or NRF. The funding from the Palaeontological Scientific Trust (PAST), Johannesburg, South Africa and that from the University of Cape Town Post Graduate Funding Office through the international and refugee scholarship are also hereby acknowledged.

The time I started this study at the University of Cape Town coincided with the outbreak of the global COVID-19 pandemic. While a lot of plans had to change due to this pandemic, the love and support of my family did not change. Thank you. I am always indebted to my mother Rubbee Mutanda-Nyambiya. It is unfortunate that my father (Clement Nyambiya) left us before he saw the completion of this work. Lastly, I would like to thank my lovely wife Nomusa N.E Mabena, who has stood with me during the most painful times and who had to endure my long absences. Thanks for your understanding especially during the writing of this thesis.

Table of Contents

List of Figures

List of Tables

CHAPTER 1: INTRODUCTION

1.1 General Introduction

In this research, the faunal assemblage from the Middle Stone Age (MSA) layers of Olieboomspoort, hereafter referred to as OBP, a site in the Waterberg Mountains of South Africa, was analysed. I performed the first archaeozoological analysis of the material, in order to provide a palaeoenvironmental context to the site and to explore human subsistence strategies. The deposits were recently dated to Marine Isotope Stages (MIS) 6 using U-series combined with Electron Spin Resonance on fossil material (Val *et al.* 2021). This chronological interval is poorly documented in southern Africa.

MIS 6 was a glacial period, which shows human resilience to extreme environmental conditions. Due to the cold conditions of this period, Marean (2010a) suggests a population bottleneck, which resulted in decreased genetic diversity, where few populations that survived relied on coastal environments from which marine resources were exploited. In this chapter, after highlighting the aims of my research project, I introduce its geographical and environmental context and I summarize the human anatomical and cultural developments associated with MIS 6 in southern Africa.

1.2 Aims

This research seeks to contribute to our knowledge on MSA human populations' interactions with animal resources during the MIS6 in the Savanna Biome of South Africa, with the macrofaunal assemblage from the site of OBP as a case study. It provides a taxonomic and taphonomic analysis of this assemblage. Focus is on the taxonomic composition of the faunal spectrum, as well as pre- and post-depositional processes that explain the modes of accumulation of the remains inside the site and that might have affected them until their recovery. The research questions, which guided this study are:

-What is the origin of the faunal remains at OBP (i.e. anthropogenic, carnivore accumulation, natural)?

- What is the impact of post-depositional processes, and particularly water given the proximity of the site to a river, on the general preservation and characteristics of the faunal assemblage from OBP?

-What was the palaeoenvironment around the site like at the time the fauna accumulated?

-What were the subsistence strategies of the inhabitants of the shelter?

1.3 Chronological context

1.3.1 The hominin fossil record of the Middle Pleistocene in Africa

The Quaternary is an important phase in human history as it was during this period that the genus *Homo* evolved. The Quaternary is also one of the most studied periods of the earth's history. The Quaternary is divided into the Pleistocene, from 2.5 mya to 12 thousand years ago (kya), and the Holocene dated from 12 kya to the present (Cohen *et al.* 2013). The Pleistocene has been subdivided into three successive phases, the Early, Middle and Late Pleistocene. The Early Pleistocene began 2.5 mya and lasted until ca. 781 ka, the Middle Pleistocene covers the period from 781 ka to 126 kya (Cohen *et al.* 2013). The Late Pleistocene started at the beginning of MIS 5, ca 126 kya and ended with the beginning of the Holocene at 12k BP (Cohen *et al.* 2013).

The beginning of the Middle Pleistocene marked several key events in human prehistory. During the Middle Pleistocene, there was a major shift in lithic industries with the transition from the Early Stone Age to the MSA. As elsewhere in Africa, the Early Stone Age of southern Africa includes a succession of the Oldowan technology by Acheulean industries. The Oldowan started at around 2.6 mya and ended at 1.7 mya (Kuman 2014). In southern

Africa, the Oldowan has been identified at sites such as Sterkfontein (Kuman & Field 2009), Swartkrans (Sutton 2012), and Wonderwerk (Chazan *et al.* 2008; Chazan 2015). The industry is characterized by a simple stone tool kit, bipolar reduction method and the assemblages have few flake scars (Kuman 2014; Kuman *et al.* 2018).

At the end of the Oldowan industry, the Acheulean began at 1.7 Mya. The Acheulean is identified by the presence of oval hand axes, simple core reduction techniques, retouched edges on flakes and large cutting tools (Lotter & Kuman 2018). In southern Africa, the appearance of Acheulean has been associated with the emergence of *H. ergaster/erectus* at sites such as Swartkrans (Pickering *et al.* 2012), Sterkfontein (Kuman & Clarke 2000). The Acheulean has been divided into three phases: the Early Acheulean dated from 1.7 mya to 1 mya, Middle Acheulean from 1 mya to 600 kya and Later Acheulean stretching from 600 kya to 300 kya (Lotter & Kuman 2017). In East Africa, both industries (Oldowan and Acheulean) have been found in association with early *Homo* and *Homo erectus* (Semaw *et al.* 2020).

Within southern Africa, Wilkins *et al.* (2012) argued that the development of projectile technology started from around 500 ka. These projectiles were likely hafted to a shaft and used as spears. This evidence of hafting shows complex cognition in hominin behaviours as this was the first time hominins could manufacture a composite tool using different elements (see Wynn 2009; Wadley *et al.* 2009).

Regarding the anatomical evolution of our species, the Middle Pleistocene corresponds to a critical moment since it is associated with the divergence between *Homo sapiens* and Neanderthals. These two species likely diverged from their last common ancestor, *Homo heidelbergensis,* at around 530-450 ka (Endicott *et al.* 2010; Stringer 2012). Palaeoanthropological research indicates that Africa is the cradle of genus *Homo*, where it emerged and occupied the landscape from about 2 million years ago (Schlebusch *et al.* 2017).

It is from this continent that anatomically modern humans evolved and later dispersed into other continents (Nielsen *et al.* 2017; Hublin *et al.* 2017).

Genetic and palaeoanthropological data points to the development of *Homo sapiens* in Africa, which developed from either *H. heidelbergensis* or *H. rhodesiensis* (Hublin *et al.* 2017, Ritcher *et al.* 2017; Stringer & Galway-Witham 2017). In Ethiopia, archaic humans have been recovered at Omo Kibish and dated to 195 kya (Brown *et al.* 2012). Currently, human fossils from Jebel Irhoud, Morocco, dated by thermoluminescence to 315 ± 34 kya makes this site the earliest anatomically modern human site (Ritcher *et al.* 2017; Hublin *et al.* 2017).

Few hominin remains have been found in southern Africa. The few existing remains, however, are crucial to the understanding of the peopling of Africa. In southern Africa, hominin fossilised cranium was recovered from Zambia, known as the 'Kabwe Man,' whose age is still unknown. This cranium was assigned to *H. rhodesiensis* while others ascribe it to *H. helmei* or *H. heidelbergensis* (McBrearty & Brooks 2000). *Homo naledi* dated between 236-335 kya was another fossil remain that was recovered in South Africa, northwest of Johannesburg (Dirks *et al.* 2017; Berger *et al.* 2017). At the open-site of Florisbad, a cranium of *Homo* genus was dated by ESR to 250-300 kya (Grün *et al.* 1996).

Evolutionary events taking place within the different regions in Africa have been analysed largely by palaeoanthropologists and palaeogeneticists. In literature, there are distinct models, which try to explain the tempo and nature of the emergence of anatomically modern humans. Henn *et al.* (2018) summarize four models, which are key, yet show the complexity of the development of hominins. Here I only summarize three models since the fourth model in Henn *et al.* (2018: 148) "has not been formally described...". The first model is called African Multi-regionalism, which is based on temporal, spatial variability and morphological diversity within Africa. Despite these diversities, the African populations were related to each other rather than being divergent (Wadley 2015; Henn *et al.* 2018).

Another model closely related to the African Multi-regionalism is Archaic Hominin Admixture in Africa. This model is based on admixture outside of Africa between modern humans and other species like Neandertals as attested by morphological similarities between recent African fossils and archaic humans (Meyer *et al.* 2012).

The third model is the Single Origin with Local Extinction, which is part of the broader 'Out of Africa' hypothesis that is premised on the argument that modern humans were confined to a specific region of Africa either southern or eastern, then spread to other parts of the continent, where they outcompeted other species. The spread from regions such as southern Africa was motivated by change in climate, from warm to cold periods (Schlebusch *et al.* 2020). Palaeoanthropological and genetic evidence supporting this model comes from (Grine *et al.* 2007; Henn *et al.* 2011; Wadley 2015; Schlebusch *et al.* 2017, 2020).

Hence, the various models on the emergence of modern humans in Africa (e.g. Hublin 2009; Henn *et al.* 2018) shows variability and complexity of this topic within the continent. Nonetheless, in Africa the MIS 6 period is associated with fully anatomically modern humans.

1.3.2 Marine isotopic stages and the MIS 6

Marine Isotope Stages are chronological markers used to understand the various periods related to the evolution of the earth's climate. These stages alternate between generally warm and generally cold periods. They are based on the analysis of the ratio between two oxygen isotopes, namely O^{16} and O^{18}, which are found in foraminifera sampled in deep-sea cores. Foraminifera preserve original isotopic values for millions of years (Pearson 2012). The variations in the O^{16}/O^{18} ratios document changing sea temperatures and volumes of ice-sheets on the planet, which in turn can be used to reconstruct past climates. The lighter O^{16} evaporates from aquatic sources and is released in large quantities into the oceans during interglacial phases, thus increasing the O^{16}/O^{18} ratio. This ratio is lower during glacial phases, when more O^{16} is trapped in the ice at the poles (Pearson 2012).

Based on deep-sea cores, researchers have established a succession of MIS, to provide a chronological and palaeoclimatic framework to the evolution of earth's climate and associated geological, biological and cultural events. The Middle Pleistocene includes 14 MIS, from MIS 19 to MIS 6 (Cohen *et al.* 2013). Table 1 presents MIS associated with the Middle Pleistocene and the corresponding climatic conditions.

Table 1: Middle Pleistocene Marine Isotope Stages, dating and their associated climatic conditions from Wenban-Smith *et al.* (2010).

MIS	**Beginning date (ka)**	**Climatic conditions**
6	190	Glacial period with few warm cycles
7	240	
8	300	
9	340	
10	380	
11	425	Interglacial period
12	480	Glacial period
13-16	620	Cold and warm oscillations
17-19	780	

1.3.3 MIS 6 in southern Africa: archaeological record

The recent dating of Olieboomspoort by Val *et al.* (2021) places the site within MIS 6 (190-130 ka), likely around 150 kya. In southern Africa, archaeological sites dated to MIS 6 are scarce (Marean *et al.* 2007; Table 2). As a consequence, and despite the fact that this phase is critical to our understanding of human anatomical and cultural evolution, little is known for

MIS 6. South Africa has seven sites, which have deposits containing archaeological material that were dated to MIS 6. These sites are diverse in their morphology (caves, rock shelters, and open-air localities) and they are distributed mostly in the interior of the region, with the exception of Pinnacle Point. Below, I provide a brief description of these sites.

Wonderwerk Cave is a large cave found in Kuruman Hills between the towns of Kuruman and Danielskuil in Northern Cape (Chazan *et al.* 2020). This site is found in the Summer Rainfall Zone of the Savanna Biome. Archaeological excavations began in the 1940s and are still ongoing (see Chazan *et al.* 2017, 2020; Rhodes *et al.* 2022). These excavations have identified extended hominin occupations from the ESA to the end of the Later Stone Age (LSA), based on Oldowan, Acheulean, Fauresmith, Early MSA (sometimes referred to as Pietersburg), Oakhurst and Wilton industries (e.g. Beaumont & Vogel 2006; Chazan *et al*. 2020; Rhodes *et al*. 2022). The early Acheulean occupation, which is associated with possible evidence for early control of fire by hominins, has been dated to approximately1.0 Ma (Matmon *et al*. 2012; Berna *et al.* 2012). The early MSA layers were dated by TT-OSL between 238 and 153 ka (Chazan *et al.* 2020). During the MIS 6, prepared core technology and Levallois technique were major patterns in lithic production centred on the production of flakes and to a lesser degree blades (Chazan *et al.* 2020).

Border Cave is a large rock shelter located in the Lebombo Mountains of South Africa, at the border between eSwatini and South Africa (Backwell *et al.* 2018). It is in the Summer-Rainfall Zone, in the Savanna Biome. Archaeological investigations at this site started in the 1930s, with several excavations to date. The deposits cover a long period of human occupation from 227 ka until 41 ka (Backwell *et al.* 2018). Industries associated with the MSA 1 (or Pietersburg), the MSA 2b (or Howiesons Poort), the MSA 3 (or post-Howiesons Poort) and Early Later Stone Age were identified. The site is particularly known for its rich organic preservation, including early evidence for burnt plant bedding at 200 ka (Wadley *et al.* 2020) and for the earliest traces of the Later Stone Age technological expressions in South Africa at 40 ka (d'Errico *et al.* 2012; Villa *et al.* 2012; d'Errico & Backwell 2016). The older members (5 BS and 5 WA) date to MIS 6 and the very beginning of MIS 5. Several ESR dates place these deposits between 227 to 161 ka (Backwell *et al.* 2018). The industry of the MIS 6 deposits has been attributed to the Pietersburg or an early MSA and faunal remains are well preserved throughout the sequence (Klein 1977).

Pinnacle Point 13B is a large coastal cave in the Winter Rainfall Zone, located in the Fynbos Biome. Archaeological excavations at this site were carried between 2000-2006. The site provides evidence of MSA cultural occupation, with limited LSA usage. The stratigraphy of the site has been dated from 175 ka to the end of the Holocene (Marean *et al.* 2010). PP13B is one of the few sites that has early manifestation of marine resource exploitation during MIS 6 (Marean *at al.* 2007; Marean 2010a; Thompson 2010). Archaeological material dated to MIS 6 was recovered from the Lightly Cemented MSA (LC-MSA) layers (Marean *et al.* 2010). Mean OSL dates from the LC-MSA Lower layer was dated to 162±5 ka (Marean *et al.* 2010). Fine grained local quartzite was the most preferred raw material, and Levallois technique used in lithic production although there is a low frequency of Levallois products (Thompson *et al.* 2010). Within the MIS 6 phases, there was high density of lithic and faunal remains (Marean *et al.* 2010; Thompson 2010).

Bundu Farm is an open-air pan site found in the Northern Cape Province, about 60 km south of Marydale and 70 km west of Prieska (Kiberd 2006). It is located in the Summer Rainfall Zone in the Nama-Karoo Biome (Kiberd 2006). Quarry mining in the 1970s exposed animal remains, which led to archaeological research of this site. Archaeological excavations by Kiberd took place between 1998 and 2003. Five samples from Groups 4 and 5 were dated and produced a range between 226-144 ka based on early uranium uptake and a range of 394-248 ka based on linear uptake (Kiberd 2006). The lithics from Bundu farm are typical of transitional ESA, Final Acheulean, MSA1 and LSA (Kiberd 2006). Deposits associated with MIS 6 were obtained from Group 4 where one equid tooth was dated to 145.7±16 kya based on coupled ESR/U-series (Kiberd 2006). This layer had artefacts typical of early MSA, and an abundance of unmodified flakes (Kiberd 2006). The faunal remains are well preserved (Kiberd 2001).

Wonderkrater is a large peat mound, found in Driefontein, in the Limpopo Province. The site is located within the Summer Rainfall Zone and in the Savanna Biome. A long sequence of pollen record stretching beyond 35 ka was recovered (McCarthy *et al.* 2010). Human occupations were dated by OSL between 138 and 30 ka (Backwell *et al.* 2014). Based on lithic analysis, Backwell *et al.* (2014) observed that the Wonderkrater assemblage does not match well with any of the existing MSA nomenclature, hence they assign the assemblage a generic MSA industry. The MIS 6 at Wonderkrater has been dated by OSL to 138±7.7 ka (Backwell *et al.* 2014). During this period, points and blades are nearly absent. Faunal remains are well preserved, slightly weathered and the assemblage is dominated by large game (Backwell *et al.* 2014).

Wonderkrater has layers that show evidence of human occupation as demonstrated by stone tools. These were found within the gritty sand layer (2.20-2.30 m below surface). This layer was dated to around 140 kya by OSL (Backwell *et al.* 2014). The lithic assemblage in association with MIS 6 occupation shows a preponderance of flakes and chips while blades are nearly absent.

Another site dated to the MIS 6 is Florisbad, which is an open-air spring in the Free State found near Blomfontein. The site is located in the Summer Rainfall Zone, of the Grassland Biome. In 1932, hominin remains were recovered and site has continued to offer insights on human evolution. The occupation sequence of Florisbad shows early MSA, MSA and LSA affinities (Grün *et al.* 1996). Florisbad is one of the most dated sites where a number of dates from different layers have been recorded. Material found in association with a hominid cranium were dated between 327 and 208 ka by ESR and OSL (Grün 2006), a human tooth was dated to 259±35 ka (Grün *et al.* 1996). Hornfels were the dominant raw material from which most of the side scrappers were manufactured and there are few formal tools (Grün *et al.* 1996). The layers that are associated with MIS 6 at Florisbad were dated by OSL and produced dates between 157 ± 21 kya and 128 ± 22 kya (Grün *et al.* 1996). Within these layers, side scrapers and formal tools are scarce although laminar flakes are common (Kuman 1989).

Pniel 6 is located to the south of Vaal River, about 30 km from Kimberly and southeast of Barkly West (Hutson 2018). The site is within the Summer Rainfall Zone located in the Savanna Biome but near the borders between Grassland and Nama-Karoo Biomes (Ecker *et al.* 2021). Archaeological research started in the 1920s and ongoing research by Ecker and colleagues is in place. The majority of the early reports were based on surface collections by Peter Beaumont, where ESA lithics were described. In 1984, archaeological excavations started, and identified four strata, where stratum 3 was ascribed to MIS 6 (Beaumont 1999). Stratum 4 has lithics typical of the Acheulean, has low frequency of formal tools and Levallois cores, Stratum 3 is characterized by Fauresmith industry. LSA artefacts were recovered from Stratum 1.

The dating of Pniel 6 by Beaumont (1999) by OSL produced a date of >120 ka. The sample for this dating was collected from the base of Stratum 2, implying that Strata 3 and 4 might be older. The lithics in association with Stratum 3 are typical Fauresmith, with few scrapers and blades (Beaumont 1999). The faunal material is well preserved and dominated by equids and bovids (Hutson 2018).

Table 2: Archaeological sites in South Africa dated to MIS 6, the method(s) used to date them and the associated literature references

Site Name	**Dating method**	**Dates (kya)**	**References**
Wonderwerk Cave	U-series; TT-OSL	238±13 -153±15	Beaumont & Vogel (2006); Chazan *et al.* (2020)
Border Cave	ESR	183±20 -168±5	Backwell *et al.* (2018)
Pinnacle Point 13B	OSL; U-series	164±12	Marean *et al.* (2007); Thompson (2010); Jacobs (2010)
Bundu Farm	ESR/U-series	145.6±16	Kiberd (2006); Hutson (2012)
Wonderkrater	OSL	138±7.7	Backwell *et al.* (2014)
Florisbad	ESR	133±31	Grün *et al.* (1996)
Pniel 6	OSL	>120	Beaumont (1999)

1.4 Ecological and environmental context of South Africa

The rainfall patterns affect the vegetation, temperatures and climatic conditions. There are three rainfall zones identified in South Africa, the winter rainfall zone (WRZ), summer rainfall zone (SRZ) and year-round rainfall zone (YRZ). These different rainfall zones are a result of the positioning of southern Africa (Braun *et al.* 2017). During winter, high-pressure currents rotating in an anti-clockwise direction inhibit precipitation in the interior of South Africa, apart from the winter rainfall zone, as the westerlies bring rainfall (Chase & Meadows 2007; Dedekind *et al.* 2016; Roffe *et al.* 2019). WRZ is found in the south-western Cape, receiving precipitation between April and September

The SRZ is mainly confined to the interior and this zone receives rainfall between October and March. During summer, the high-pressure currents shift south causing rainfall in this zone (Miller *et al.* 2019). The SRZ receives convective rainfall caused by high temperatures (Miller *et al.* 2019; Roffe *et al.* 2019). The YRZ located in the southern coast, receives precipitation from both of the two zones above. Rainfall seasonality in this zone is unnoticeable (Engelbrecht & Landman 2016; Miller *et al.* 2019).

Chase & Meadows (2007) show how the Winter Rainfall Zone of southern Africa has fluctuated during the Pleistocene. They identified three axis, where axis A extends northwards from Cape Peninsula, axis B extends eastward from Cape Town and axis C stretches from the west coast into the interior (Chase & Meadows 2007). The first axis showed a period of high humidity between 35 and 23 kya. The second axis shows decrease of summer rainfall but an expansion of winter rainfall particularly within the Agulhas Plain, which led to an increase of fynbos vegetation during MIS 4-3 (Chase & Meadows 2007). Stuut *et al.* (2002) studied grain-size variability within sediments related to MIS 6. Their study indicated a fluvial regime resulting from a shift towards the equator leading to high precipitation. The third axis shows an increase in humidity from 40 kya, however, within the same period, they were sand dune formations in the Kalahari that indicate aridity (Thomas *et al.* 1997; Stokes *et al.* 1997), making palaeoclimatic reconstructions using different proxies complex (Backwell *et al.* 2014).

Human adaptation and behavioural changes are responses to prevailing environmental conditions. Southern Africa has nine biomes that separates the region based on the ecology and environment (Fig 1). These biomes are the Desert, Savanna, Forest, Grassland, Fynbos, Albany Thicket, Indian Ocean coastal Belt, Succulent Karoo and Nama-Karoo. The presence of two oceans, Indian and Atlantic, both with different atmospheric conditions, the geology and the nature of the soils contribute to the various biomes. The Agulhas warm currents from the Indian Ocean move in a clockwise direction leads to rainfall in SRZ, while the Benguela currents from the Atlantic Ocean move in an anti-clockwise direction that leads to rainfall in the WRZ (Lutjeharms *et al.* 2001; Mucina & Rutherford 2006).

The Desert Biome is found in north-west coastline of South Africa. This biome is characterised by therophyte vegetation and canopy covers, with low or unpredictable precipitation (Mucina & Rutherford 2006). The Forest Biome is found in the southern Cape and north-eastern Cape of South Africa. This biome falls within the YRZ. The biome is dominated by tall tress probably resulting from high annual precipitation in the tropics (Mucina & Rutherford 2006).

The Grassland Biome is located in the centre of South Africa and within the SRZ. It is dominated by grasses, and the weather is characterized by cold and dry winters (Finch & Meadows 2019).

The Succulent Karoo Biome is found in the Western Cape of South Africa, within the WRZ. It is characterised by dwarf shrubs. The Nama-Karoo Biome is located in western parts of South Africa and falls within the SRZ. The Nama-Karoo Biome experiences semi-arid to arid conditions, with frequent droughts (Hoffman 1996). Erratic rainfall characterizes this biome, with peaks in precipitation between December and March (Palmer & Hoffman 1997).

The Savanna Biome (the ecology of the study area) is typical of tropical vegetation, characterized by trees and shrubs, and is within the SRZ (Mucina & Rutherford 2006). This vegetation is a mixture of trees and grasses and includes forests whose species shed leaves throughout the year as well as deciduous woody species (Wadley *et al.* 2008). The Savanna Biome stretches into the Nama-Karoo Biome in the centre, to the Grassland Biome in the east and to the Albany Thicket in the Eastern Cape (Mucina & Rutherford 2006).

The Fynbos Biome is found within the WRZ, in southern and south-western Cape of South Africa (Klein 1983). Fynbos (derived from the Dutch ‘fijn-bosch’ and pronounced ‘feinbos’) means ‘fine bush’ (Klein 1983; Rebelo *et al*. 2006). The Fynbos Biome is a mixture of grasses, dwarf shrubs and evergreen trees and shrubs. It is a Mediterranean Biome with a remarkable degree of plant and animal endemism (Mucina & Rutherford 2006). The Albany Thicket Biome is at the boundary between YRZ and SRZ. It is characterized by dry, dwarf forest (Finch & Meadows 2019). The Indian Ocean Coastal Belt Biome extends along the Indian Ocean coastline in the Eastern Cape of South Africa. This subtropical biome is dominated by Afromontane evergreen forests and epiphytes (Mucina & Rutherford 2006).

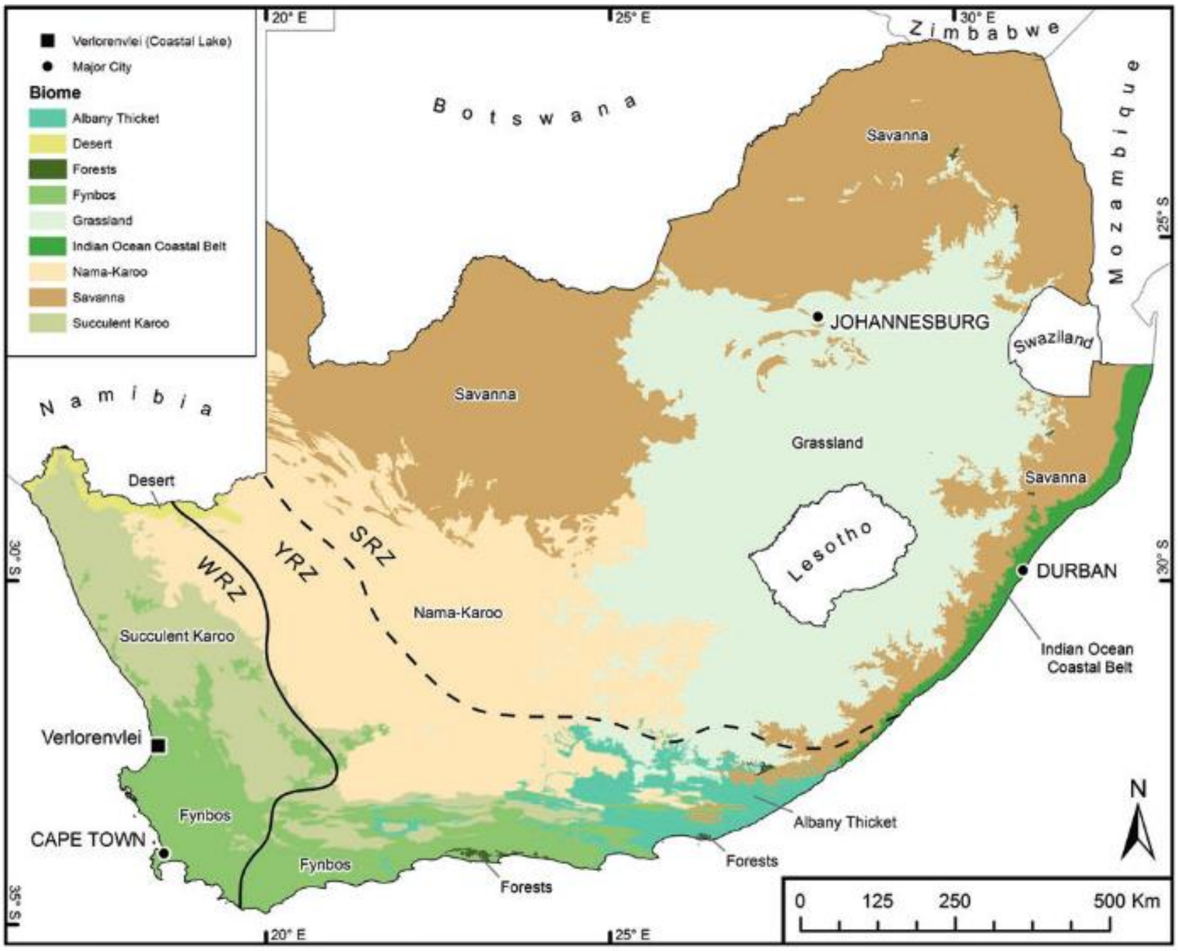

Figure 1: Biomes of South Africa showing their geographical extent, major towns and rainfall zones. SRZ: Summer Rainfall Zone, YRZ: Year-round Rainfall Zone, WRZ: Winter Rainfall Zone (from Finch & Meadows 2019).

Data on palaeoenvironments from MIS 6 sites in southern Africa is scarce and comes mostly from coastal and near-coastal sites. Within the coastal regions, proxies such as pollen and marine cores have been useful in determining past climates of MIS 6 (Ramsay & Cooper

2002; Scott & Neumann 2018). In coastal areas of South Africa, the MIS 6 was a glacial period with wet oscillations. During these wet phases, sedges, which are indicative of moist conditions expanded (Scott & Neumann 2018) and mean sea levels decreased (Ramsay & Cooper 2002).

1.5 The emergence of the so-called modern human behaviour

The MSA (300 kya-30 kya) of southern Africa is a period that is associated with the development of anatomically modern humans and behaviour (McBrearty & Brooks 2000; Wurz 2008, 2014; Wadley 2015). Linked to these developments are the debates on when did archaic forms transformed to modern behaviour and the traits that characterize modernity.

Traditionally, the emergence of modern human behaviour was argued to have originated in Europe around 40 kya and this was termed the “human revolution” (Mellars & Stringer 1989; Klein 1989a). However, recent research has challenged this origin and instead proposes southern Africa as the region with some of the earliest manifestations of modern human behaviour (Wadley 2001; Wurz 1999, 2008). In fact, McBrearty & Brooks (2000) argue that the Upper Paleolithic Revolution of Europe was “the revolution that wasn’t,’’ because of evidence of symbolic behaviour from southern Africa dated to around 100 kya (Wadley 2001)

Although early manifestations of modern human behaviour are linked to symbolism, recent research has suggested the presence of complex cognition. To achieve the various tasks, stable working memory is important in these behaviours (Wyn & Coolidge 2011; Coolidge *et al.* 2016). For example, problem solving and planning in efficient ways such as through the production of composite tools, bow hunting required complex cognition (Wyn 2009; Wadley *et al.* 2009; Coolidge *et al.* 2016; Lombard & Gärdenfors 2021).

What has confronted the study on the emergence of modern human behaviour is the lack of agreed set of traits that characterize modernity. Although developing a trait list is often used, the trait list approach has been questioned by McBrearty & Brooks (2000). Nonetheless, most researchers have used evidence of symbolic expressions, increase in cognitive abilities and effective resource exploitation as evidence of modernity.

Forms of anatomically modern humans are found from around 300 kya but evidence of modern human behaviour appeared later (Klein 2001, 2003, 2008). This has led researchers to suggest that the development of modern human behaviour was a gradual process. However, Klein (1995, 2000, 2001, 2003, 2008) views this as ‘human revolution’, where genetic mutation led to the developed of modern human behaviour in Europe around 50 kya.

1.6 The archaeological record of southern African MSA

The Early Middle Stone Age is associated with MIS 8 to MIS 6 (300-130 kya) (Lombard *et al*. 2012; Wurz 2014), a period that was cool with warm oscillations (Wadley 2015). The technological characteristics and sequencing of this industry in southern Africa is poorly understood. Generally, the industry has discoidal and Levallois flake technologies and a generalized toolkit.

Much of what we know regarding the MSA technological industries comes from recent sites within MIS 5 and 4. Generally, lithic production during this period is characterized by Levallois technique, recurrent blades, denticulates, and convergent flake production with elongated products that are relatively thin and curved profiles. Retouch is rare in this industry and platforms are often small with diffused bulbs (Lombard *et al*. 2012; Wadley 2015). Techno-complexes associated with MIS 5 and 4 are the Still Bay and Howieson’s Poort.

The Still Bay is dated to 77-70 kya and bifacial points and semi-circular butts are typical of this industry (Lombard *et al*. 2010). Fine-grained material was preferred for stone tool production. Methods of production include pressure flaking, and hard and soft hammer technique. There is evidence of hafting and some tools were subject to heat treatment (Lombard *et al*. 2012; Wurz 2014). The Howieson's Poort techno-complex is dated to 66-58 kya and is associated with MIS 4-3, which was cold with warm oscillations (Wadley 2015). The technology is characterized by blade and bladelets, small, backed tools that were hafted such as segments and trapezes. There are denticulated blades but pointed forms are rare (Wurz 2013, 2014).

The Post-Howieson's Poort is dated between 58-45 kya and is associated with MIS 3 when it was cold with warm oscillations (Wadley 2015). Technological characteristics include points produced from Levallois technique, abundance in formal retouch aimed at producing unifacial points that are elongated or triangular, retouched bifacial points are rare. The platforms are faceted (Lombard *et al*. 2012). The Final Middle Stone Age is dated to 40-20 kya associated with MIS 3 and is believed to be a transitional industry to Later Stone Age (LSA). This techno-complex is characterized by high regional variability that may include bifacial tools, bifacially retouched points, hollow-based points, triangular flake and blade technologies, small bifacial and unifacial points. The industry can include bipolar technology and backed geometric shapes such as segments, as well as side scrapers (Lombard *et al*. 2012; Wurz 2013, 2014).

1.7 Middle Stone Age subsistence strategies in southern Africa

Stone tools are used to identify techno-complexes but archaeozoology can help in documenting technologies and subsistence strategies. Archaeozoological analyses of MSA faunal assemblages have addressed several questions that aid in the understanding of past human societies. For the Middle Stone Age of South Africa in particular, these questions concern palaeoenvironments (e.g. Klein 1972, 1974, 1983; Reynard *et al.* 2016; Reynard & Wurz 2020), foragers' subsistence strategies (e.g., Klein 1975; Milo 1998; Cain 2005, 2006; Dusseldorp 2012; Marean *et al.* 2000), and the emergence of so-called behavioural modernity (e.g. Klein 1975, 2001, 2003, 2008; Faith 2008; Val *et al.* 2020).

1.7.1 Subsistence strategies during MIS 6

During MIS 6, Thompson (2010), through the taphonomic study of faunal remains from Pinnacle Point 13B, observed a different pattern to most coastal sites as large mammals were exploited more than small mammals. These large animals were exploited for meat and marrow, while carnivores such as felids also contributed to the faunal assemblage by transporting a small proportion of small ungulates as evidenced by the presence of tooth marks (Thompson 2010).

In another archaeozoological study at Pinnacle Point during the MIS 6, Marean *et al.* (2007) showed evidence of shellfish exploitation. They argued that marine resource exploitation indicates an expansion of human diet in addition to terrestrial resources, which was the focus some thousand years ago. They further suggest that possibly whales were scavenged or processed on the coastline with some parts like blubber taken back to the cave.

Zooarchaeological and taphonomic analyses by Hutson (2018) at Bundu Farm shows hunting as the major subsistence strategy. This is because of repetitive cut-marks observed on an astragalus, and this may indicate disarticulation of limb bones. Animal remains at Bundu Farm are characteristic of the Florisian Land Mammals, which are primarily grazers (Hutson 2018).

There is limited published information on the faunal remains associated with the MIS6 deposits of Wonderwerk. Chazan *et al.* (2020) describes a small assemblage of 250 identified remains and abundant non-identifiable bone and tooth fragments. These faunal remains are poorly preserved and highly fragmented, as a result of burning, as well as porcupine and carnivore damage. Large herbivores dominate the sample and a few carnivores, tortoises and other reptiles and birds were also identified. Habitat-sensitive species indicate the existence of a wetland environment close to the site. Chazan and colleagues (2020) proposed hunting and trapping as some of the subsistence strategies.

At Pniel 6, Hutson (2018) identified the remains of large grazing ungulates typical of the Florisian Land Mammal Age. These animals are indicative of an expansive grassland environment, while the presence of proboscidean, which are water depended species may indicate the presence of riverine woodland. Hutson (2018) suggests that seasonal water could have attracted large ungulates from nearby grassland and savanna habitats to drink, where they fell as prey to predators. At Pniel 6, the role of humans is quite minimal, and it is suggested that humans scavenged from predator kills (Hutson 2018).

The faunal spectrum from Wonderkrater shows a significant amount of large game, which was better preserved. Carnivore gnawing was observed on some of the specimens, but it does not seem to suggest human agency in the accumulation of the faunal assemblage given that no evidence of butchery marks was observed (Backwell *et al.* 2014: 51). Stable isotope analysis of the remains indicated a savanna climate (Backwell *et al.* 2014).

1.7.2 Subsistence strategies from MIS 5-MIS 3

While the MSA begins at least during MIS8, most of the available data on MSA subsistence strategies comes from sites dated from MIS5 to MIS3. Besides, most MSA research in southern Africa has concentrated at coastal and near coastal sites, particularly in the Fynbos Biome) (Klein 1972, 1974, 1975, 1976, 1995, 2001; Wurz 1999, 2008; Reynard 2011, 2016; Thompson & Henshilwood 2014; Reynard *et al.* 2015, 2016; Reynard & Wurz 2020; Armstrong 2016; Badenhorst *et al*. 2016).

Most archaeozoological research has examined evidence for complex subsistence behaviours during the MSA (e.g. Klein 1975; Cain 2005; Faith 2008; Clark & Plug 2008; Clark 2009; Val *et al*. 2020). For a long time, research on subsistence has focused on comparing

MSA and LSA hunting abilities. For example, Klein (1975, 1976, 1979) and Klein & Cruz-Uribe (1996, 2000) suggested that MSA people were less effective hunters than their LSA counterparts as they lacked projectiles, as well as bows and arrows to hunt effectively. This observation was mostly based on the presence or absence of large, dangerous prey such as buffalos and suids and on mortality profiles. The large number of passive elands at some MSA sites suggested less developed technology to effectively hunt dangerous prey. However, these observations have been questioned with direct evidence of the use of spears in hunting activities during the MSA (Milo 1998; Dusseldorp 2010, 2012), the exploitation of large and dangerous prey (e.g., Cain 2005, 2006; Faith 2008; Clark & Plug 2008; Clark 2009, 2017), and the capture of fast, flying birds (Val 2016; Val *et al*. 2016).

At Klasies River Mouth, Klein (1976, 1989b) found that the ratio of cranial to post-cranial elements increases with bovid size, while the ratio of upper limbs to lower limbs decreases with bovid size. He explains this pattern by invoking the 'schlepp effect' (Perkins & Daly 1968) that assumes that small mammals were brought to the site intact while larger animals were butchered at the site and selected body parts carried back to the site. This implies that lower limbs could have been used as handles to carry meat. As an alternative explanation to the skeletal part representation of Klasies, Binford (1984) suggested that small mammals were hunted while larger game was scavenged from predator kills, hence the low ratio of upper limbs to lower limbs. On another note, Klein (1975, 1976) argued that the Klasies River MSA inhabitants had a less effective hunting toolkit and avoided large and dangerous prey. However, Marean *et al.* (1992) and Milo (1998) showed that the MSA population at Klasies River were effective and capable hunters even of large and dangerous prey.

Reynard *et al.* (2016) investigated subsistence intensification at Blombos Cave and Klipdrift Shelter during MIS4, a period associated with the Still Bay and the Howieson's Poort techno-complexes. They argue that during the Still Bay at Blombos, subsistence intensity is lower than for the Howieson's Poort phase at Klipdrift. Through intra-site spatial analysis of faunal remains from Blombos Cave, Discamps & Henshilwood (2015) have shown that in some areas of the site, bones were potentially used as fuel.

At sites such as Sibudu Cave and Bushman Rock Shelter, there is evidence of deliberate hunting of large mammals that could represent a threat for the hunters, including aggressive bushpigs and large bovids (Plug 2004; Badenhorst & Plug 2012). Clark & Plug (2008) analysed Howieson's Poort and post-Howieson's Poort fauna from Sibudu Cave. They found a declining focus on the smallest bovids during the post-Howieson's Poort, which coincided with an increase in large and very large bovids. Small mammals and suids are more common during the Howieson's Poort. The transition from the Howieson's Poort to post-Howieson's Poort at Sibudu Cave seems to have been gradual rather than abrupt (Clark & Plug 2008).

Wadley *et al*. (2008) have shown how changes in the environment affected the animal economy and subsistence strategies at Sibudu Cave. Between 50 kya and 37 kya, the propagation of woody species encouraged small browsers that were trapped than hunted. Taphonomic analysis of fauna from Sibudu Cave shows human agency as the primary contributor to the faunal assemblage because of intentional burning, pattern of bone discard and waste management in the Howieson's Poort and Post-Howieson's Poort (Cain 2005, 2006; Plug 2006; Clark 2009).

There is variation in the exploitation of animals of various sizes in the different MSA phases at Sibudu Cave (Clark & Plug 2008; Clark 2009, 2011, 2017; Wadley 2010) with small game being more common during the Howieson's Poort and larger game more abundant during Post-Howieson's Poort. Collins (2015, 2016) suggests that during the final MSA at Sibudu cave, small ungulates were acquired closer to the site while larger game was obtained further away from the site. Interestingly, Val (2016); Val *et al*. (2016) have shown evidence of bird capture at around 77 kya at Sibudu cave which has contributes to the complexities of subsistence strategies during the MSA.

At Diepkloof, small game was more preferred (Parkington *et al*. 2005). Nonetheless, this reliance on small game does not imply archaic behaviours and poorer hunting capabilities. While small game is abundant in the assemblages from most coastal sites, the faunal assemblage from Pinnacle Point shows a divergent pattern with a focus on large ungulates (Klein 1976; Parkington *et al*. 2005; Steele & Klein 2013; Thompson & Henshilwood 2014; Discamps & Henshilwood 2015; Armstrong 2016; Badenhorst *et al*. 2016).

Based on skeletal element abundance, mortality patterns and the presence of carnivore gnaw marks, early studies argued that scavenging was the mode by which MSA people procured animals for consumption (Binford 1984; Stiner 1993). This model has been criticized by Marean (1998), Marean *et al*. (2000) based on the abundance of high utility long bones over few lower utility long bones.

Armstrong (2016) argued that MSA populations from Die Kelders focused on small mammals implying habitual utilization of mole-rats possibly for their fur. This pattern represents the first evidence for the habitual skinning of fur-bearing mammals by MSA humans. Badenhorst *et al*. (2016) have shown that at Blombos, small prey dominates the assemblage. Through evidence of chop marks and cut marks, their study pointed to the role of humans in the accumulation, modifications and utilization of these animal resources.

Reynard *et al*. (2015, 2016) have shown that at Klipdrift Shelter, small prey is dominant. Also, although butchery marks are rare, the burning of fauna is related to human activities because of the presence of hearths. Their study showed that most animal bones were fractured while fresh. Their study also shows various animal processing techniques that include skinning, filleting, disarticulation and bone marrow extraction.

Klein (1978) and Cruz-Uribe (1983) analysed faunal remains from Redcliff cave in the Midlands Province of Zimbabwe and observed that four of the five extinct species whose bones were recovered favoured wet environments and thrived in Late Pleistocene era than in the Holocene. Based on mortality profiles, Cruz-Uribe (1983) argued that humans were the principal agent of bone accumulation in the Bambata period, while hyaenas were responsible during all other periods that followed. Within the Bambata phase, hunting of antelopes was by trapping which resulted in mixed age profiles of individuals found in the assemblage. However, the Tshangula hunting practices at Redcliff remains unknown due to small sample sizes and other agents of bone accumulation besides humans (Cruz-Uribe 1983).

Brain (1981) analyzed the Pomongwe cave faunal assemblage that was excavated by Cooke (1963). This assemblage was highly fragmented because of intentional breakage for marrow extraction and trampling by animals and humans. The MSA occupations had the most animal diversity, the Tshangula period marked the peak with the highest number of faunal remains showing a general increase in animal exploitation through time. Brain (1981) observed a systematic breakage pattern of the bone flakes from Pomongwe cave. Most of the bone flakes were within the 2.5-5 cm size category regardless of the different cultural or technological attributions. This, he explains, was a result of the use of hammerstones in bone marrow extraction. The exploitation of bovid size III was high in all the phases of the occupation of Pomongwe cave.

Clark & Kandel (2013) explored the extent of variability in MSA human hunting strategies during between MIS 6-3 (170-40 kya). Their synthesis illustrates the scarcity of data for MIS 6, since they only had data for three faunal assemblages from a single site (Pinnacle Point Cave 13B), contra more than 50 faunal assemblages from eight sites for the period MIS 5-MIS 3. In their study, they highlighted that there is little evidence of subsistence intensification during MIS 6. Between MIS 6 and MIS 4, there seems to be gradual increase in exploitation of small ungulates (Size 1) and small mammals but a decrease of these species in MIS 3. The authors invoke multi-causal factors such as changes in the environment, demography, technology, and cognition to explain such variation.

During the MSA of coastal sites in South Africa, marine resource exploitation became common. Cape fur seals (*Arctocephalus pusillus*) and molluscs contributed most of the faunal remains at sites like Ysterfontein (Avery *et al.* 2008; Steele & Klein 2008). At Hoedjiespunt 1, granite limpets (*Cymbula granatina*) and black mussels (*Choromytilus meridionalis*) dominate the faunal assemblage (Kyriacou *et al.* 2015) probably due to high meat yields (Dusseldorp & Langejans 2013). Marine fish was exploited though at low intensity at Klasies River and Blombos (van Niekerk 2011). At Klasies River and Blombos, net-hunting was the primary method of marine resource acquisition (Dusseldorp & Langejans 2016). At these coastal sites, researchers have used the exploitation of shellfish as an indicator for distances to shorelines, were low shellfish density receded shorelines (Steele & Klein 2008; Marean 2010b; Dusseldorp & Langejans 2013).

1.8 Structure of the thesis

This chapter provided an introduction and background to the research project. It has also provided a chronological and environmental context of this research. Chapter 2 presents the study area, the site of OBP and the history of research there. Chapter 3 introduces the sample analysed and focuses on the various methods that were employed in this research. Notably, it describes the taphonomic methods that I used to understand the origin of the faunal assemblage at the site, as well as the post-depositional processes that have affected it.

Chapter 4 presents the results from the taxonomic identification and quantification of the faunal remains from OBP, as well as the results of the taphonomic and archaeozoological analysis. Chapter 5 discusses the implications of human subsistence strategies at

Olieboomspoort, the preservation of the assemblage and comparison to other MIS 6 sites in South Africa is provided.

CHAPTER 2: BACKGROUND TO STUDY AREA

2.1 Site Description

Olieboomspoort (23°52’42’’S;’ 27°38’17’’E) is a rock shelter with archaeological deposits, found in the Waterberg plateau of northern Limpopo Province, South Africa (Fig 2 and 3). This site is the only locality in the area with occupations spanning from the Earlier to the Later Stone Age. Together with Red Balloon Shelter (Wadley *et al*. 2021), it is one of the few sites with Middle Stone Age deposits. Mason (1962) uses the name Olieboompoort but this work follows van der Ryst (2007) in referring to the original name given to the place by early Europeans of “Olieboomspoort.”

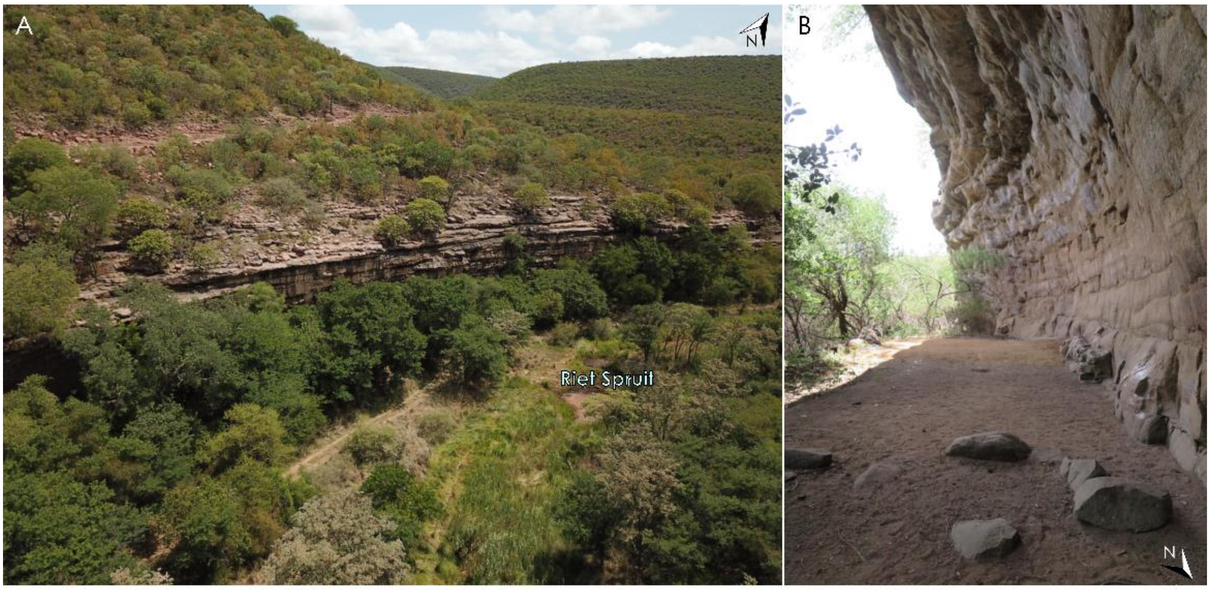

Figure 2(a): Cliff where Olieboomspoort is found and Riet Spruit flowing at the bottom of the site (picture courtesy of S. Küsel). (b) View of the shelter before the 2018’s excavation (picture courtesy of D. Stratford). Pictures from Val et al. (2021).

Olieboomspoort is a conflation of two words, “Olieboom”, which refers to either the exotic castor oil bush (*Ricinus communis*) or thorn apple (*Datura stramonium*); and “poort”, which refers to the deep trough that forms an overhang at this rock shelter (van der Ryst 2007; Val *et al.* 2021). Because both tree species that refer to Olieboom grow around this site, the naming is difficult to reconstruct (van der Ryst 2007) but the name literally means an "oil tree pass."

The surrounding of OBP is characterised by the growth of diverse itchy trees. Chacma baboons (*Papio hamadryas*) can be seen today on the summit of the mountain that overhangs the shelter. The Riet Spruit, a tributary of the Moloko River, runs a few meters from OBP. The Moloko River joins the Limpopo River some 80 km north-east of OBP.

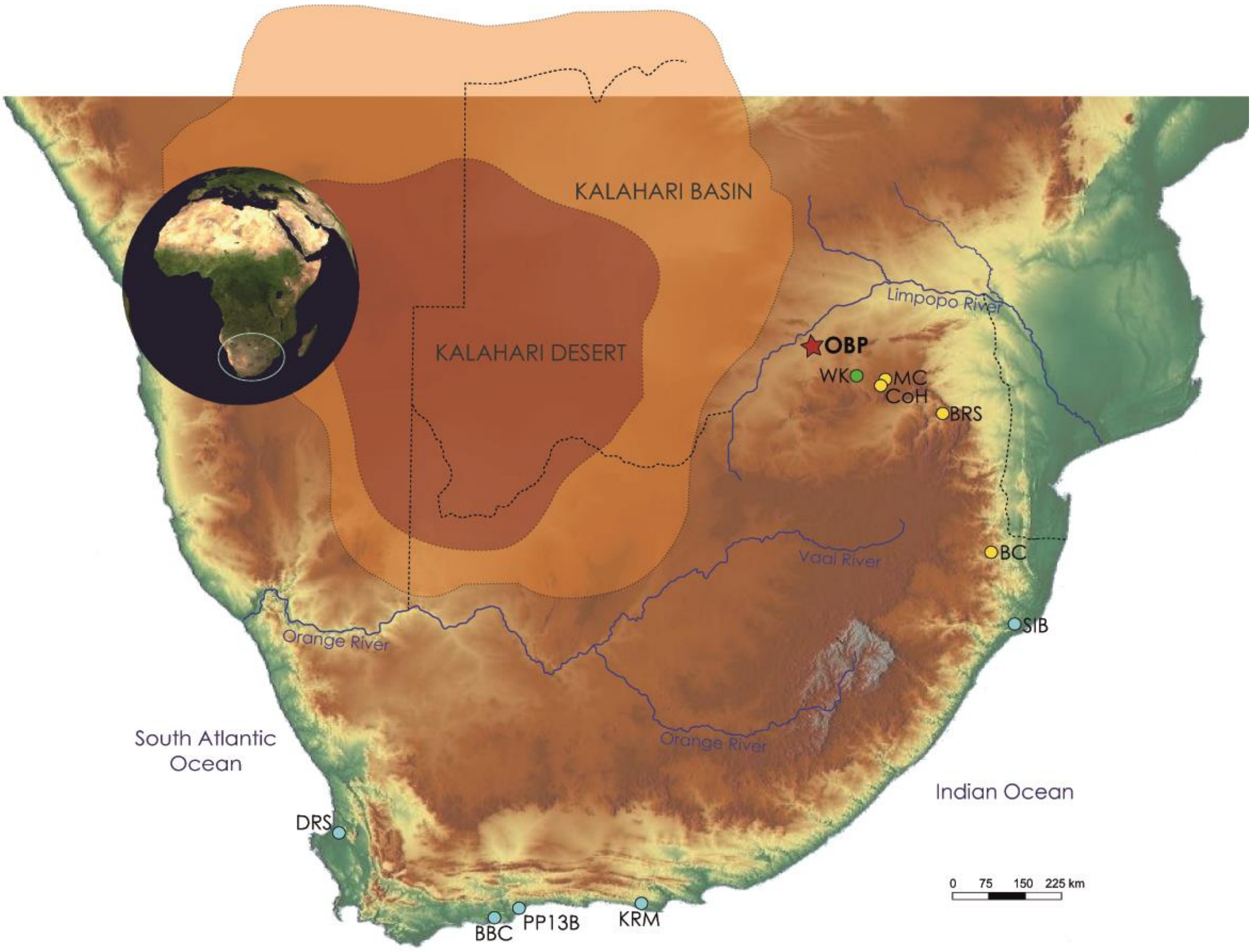

Figure 3: Map showing the location of Olieboomspoort (OBP) and other key Middle Stone Age sites (from Val *et al*. 2021). The green circle shows Wonderkrater (WK). Yellow circles are sites in the Savanna Biome, MC: Mwulu's Cave, CoH: Cave of Hearths, BRS: Bushman Rock Shelter, BC: Border Cave. Blue circles are coastal and near coastal sites, SIB:

Sibudu, KRM: Klasies River Mouth, PP 13B: Pinnacle Point Cave 13B, BBC: Blombos Cave, DRS: Diepkloof Rock Shelter.

2.2 Vegetation

OBP is located within the Savanna Biome at the transition between the Limpopo Sweet Bushveld and the Waterberg Mountain Bushveld (Mucina & Rutherford 2006). Hence, the surrounding area has components of both vegetation types. i.e dense, short bushveld and open tree savanna. This biome is dominated by woody plants and C_4 grasses.

Some of the common trees and shrubs found in the Waterberg Mountain Bushveld (SVcb 17) are acacias, *Burkea Africana*, *Protea caffra*, *Croton spp*., *Euclea crispa*, *Combretum spp*.; *Senegalia spp.*, *Faurea saligna*, *Olea capensis*, *Elephantorrhiza burkei* and *Diplorhynchus condylocarpon*. The Limpopo Sweet Bushveld (SVcb 19) is characterised by acacia trees, *Combretaceae, Dichrostachys cinerea*, *Grewia flava*, *Terminalia sericea, Rhigozum obovatum*, *Commiphora pyracanthoides* and *Felicia muricata* (Mucina & Rutherford 2006).

Large terrestrial mammals are common in the Savanna Biome. This biome is home to a number of extant small, medium and large ungulate species, which have influenced the plants they feed on (Mucina &Rutherford 2006). Animals such as elephants, buffalos and impalas are found within this biome.

2.3 Climate

The site falls within the Summer Rainfall Zone, which means that the area receives most of its precipitation during the summer months. The Savanna Biome is characterised by hot and humid summers and mild and dry winters (Mucina & Rutherford 2006). In the surroundings of OBP, annual average temperatures are around 21°C and receives most precipitation in January (Mucina & Rutherford 2006; van der Ryst 2007).

In South Africa, the Savanna Biome is associated with the bushveld and lowveld and altitudes of not more than 1500 m.a.s.l. (Mucina & Rutherford 2006). The average temperatures of the Savanna Biome are higher compared to other biomes also located at high altitudes.

2.4 Geology

The geology of the Savanna Biome of southern Africa is dominated by an ancient continental crust known as the Kaapvaal Craton, which formed as a process of accretion that began around 3.5 billion years ago (Mucina & Rutherford 2006). The study area is located at the fringe of the Kalahari Basin (Fig 3) that is generally dry. OBP is a long narrow shelter within the Waterberg red sandstones that formed between 1.9 and 1.7 billion years (Eriksson *et al.* 2000). The Waterberg Group consists of thirteen formations and OBP is part of the Mogalakwena Formation that is characterised by coarse to fine sandstones, shales and conglomerates. In terms of lithic raw material, the area is surrounded by Crypto-crystalline silicates (CCS) such as quartz and chert, and haematite feature prominently (Watts 2002; van der Ryst 2007).

2.5 Previous research on OBP

Olieboomspoort was discovered and first excavated by Mason in 1954 (Mason 1957; 1962). He excavated uncovered a ~2-metre-thick archaeological sequence spanning from an ephemeral Earlier Stone Age (ESA) phase to the Iron Age, with most of the deposits associated with Middle and Later Stone Age occupations. Later, van der Ryst (2007) excavated the LSA layers. The few ESA tools retrieved by Mason were attributed to the Acheulean industry, while he assigned the MSA artefacts to the so-called Pietersburg industry. Mason (1957, 1962) considered the Pietersburg as characterised by triangular, quadrilateral and irregular flakes (Mason 1957: 241) that were made from quartz, quartzite, felsite and chaldony in the case of

OBP. During Mason's time, the only dating method available was radiocarbon dating and the age of the Pietersburg was therefore considered greater than 33 kya (Mason 1962).

Mason (1957) classified the LSA of the former Transvaal as Smithfield A, B and C and these cultures are stratigraphically located between the MSA and Iron Age levels. At OBP, the Smithfield C was identified based on the presence of quadrilateral flakes, burins, scrapers, and bone tools (Mason 1957). Currently, the term Smithfield is not in use anymore and a re-examination of Mason's excavation by van der Ryst (2007) indicates a Wilton industry for the Smithfield. Mason did not describe any faunal remains from his excavation.

In the late 1990s, M. van der Ryst started excavations at OBP with a focus on the Holocene layers. The archaeological deposits of this site are estimated to be 50 m^2 (van der Ryst 2007). van der Ryst first excavated a test trench of 50 cm x 5 m to bedrock at a depth of 2 m, before extending the excavations to a large area of 20 m^2 (van der Ryst 2007: 59). Due to difficulties in defining natural stratigraphy, she excavated in 5 cm spits until the contact between the LSA and MSA deposits was clearly visible, mainly due to the presence of roof spalls, which indicate a hiatus in occupation like at other inland MSA sites in South Africa and Zimbabwe (Cooke 1963; Brain & Cooke 1967; Larsson 2007).

The LSA faunal remains retrieved during van der Ryst's excavation were analysed by Louisa Hutten and Drienie Beukes, who proposed the first available list of taxa (van der Ryst 2007). The majority of the faunal remains were non-identifiable and the concretions on the fauna posed a challenge in identifying bone surface modifications. Within the sample of identifiable remains, mega-herbivores, small-medium bovids, avifauna, microfauna and tortoises were identified. Based on the composition of the faunal spectrum (Table 3), van der Ryst (2007) recognized a number of subsistence strategies. She proposed that the LSA community at OBP used snares, traps, hunting as well as occasional scavenging prey from carnivore kills. Although no specialised hunting was documented, the OBP inhabitants preferred adult prey to juveniles with the exception of tortoises, for which juveniles were preferred and, in some cases, probably used as containers (van der Ryst 2007).

Table 3: Taxonomic attributions of the faunal assemblage retrieved from the Later Stone Age deposits at Olieboomspoort in van der Ryst (2007: 152-155)

Species	**Common name**
Crocidura sp.	Shrew
Papio ursinus	Chacma baboon
cf. *Papio ursinus*	
Canis mesomelas	Black-backed jackal
Civettictis civetta	African civet
Genetta genetta tigrina	Small spotted genet
Galerella sanguinea	Slender mongoose
Mungos mungo	Banded mongoose
cf. *Crocuta crocuta*	Spotted hyaena
Felis lybica	African wild cat
Carnivore (small)	
Carnivore (medium)	
Diceros bicornis	Black rhino
Equus quagga	Plains zebra
cf. *Equus quagga*	
Procavia capensis	Rock dassies
cf. *Orycteropus afer*	Antbear
Phacochoerus africanus	Warthog
cf. *Phacochoerus africanus*	
Potamochoerus larvatus	Bushpig
Hippopotamus amphibius	Hippopotamus
cf. *Hippopotamus amphibius*	
Giraffa camelopardalis	Giraffe

Bos taurus	Cattle
cf. *Bos taurus*	
Ovis/capra	Sheep/goat
cf. *Ovis/capra*	
cf. *Connochaetes taurinus*	Blue wildebeest
cf. *Connochaetes gnou*	Black wildebeest
cf. *Damaliscus lunatus*	Blesbok
cf. *Damaliscus pygargus*	Tsessebe
Sylvicapra grimmia	Common duiker
cf. *Sylvicapra grimmia*	
Oreotragus oreotragus	Klipspringer
Raphicerus campestris	Steenbok
cf. *Raphicerus campestris*	
cf. *Raphicerus sharpei*	Sharpe’s grysbok
cf. *Raphicerus* sp.	
Aepyceros melampus	Impala
cf. *Aepyceros melampus*	
cf. *Pelea capreolus*	Grey rhebok
Hippotragus equinus	Roan
Hippotragus sp.	
Syncerus caffer	Buffalo
cf. *Syncerus caffer*	
Tragelaphus oryx	Eland
cf. *Tragelaphus strepsiceros*	Kudu
cf. *Tragelaphus scriptus*	Bushbuck
cf. *Taurotragus oryx*	
Redunca arundirum	Reedbuck
Redunca fulvorufula	Mountain reedbuck
cf. *Redunca* sp.	
cf. *Kobus ellipsiprymnus*	Waterbuck
Bov I	

Bov II	
Bov II (non-domestic)	
Bov III/IV	
Bov IV	
cf. *Paraxerus cepapi*	Tree squirrel
Pedetes capensis	Springhare
cf. *Pedetes capensis*	
Hystrix africaeaustralis	Porcupine
cf. *Thryonomys swinderianus*	Greater cane rat
Otomys sp.	Vlei rat
cf. *Tatera leucogaster*	Bushveld gerbil
Tatera sp.	
Aethomys sp.	Mouse
cf. *Aethomys* sp.	
cf. *Rattus rattus*	Common house rat
Rodent (small)	
Rodent (medium)	
Lepus sexatilis	Scrub hare
cf. *Lepus sexatilis*	
Lepus sp.	
Pronolagus randensis	Jameson's red rock rabbit
Mammal (small)	
Mammal (very large)	
Struthio camelus	Ostrich
Francolinus sp.	Francolin
cf. *Francolinus* sp.	
Tockus sp.	Hornbill
Bird (small)	
Bird (medium)	
Bird (medium-large)	
Geochelone pardalis	Leopard tortoise

cf. *Geochelone pardalis*	
Tortoise	
Pelomudusa subrufa	Marsh terrapin
Snake (small)	
Varanus sp.	Monitor lizard
cf. *Varanus* sp.	
Reptile (small)	
Reptile (small-medium)	
Frog	
Pyxicephalus edulis	Bullfrog
cf. *Clarias gariepinus*	Barbel
Fish (small)	
Fish (medium)	
Fish (large)	
Achatina zebra	Giant land snail
Achatina sp.	
Freshwater snail	
Unio/Aspatharia	Freshwater mussel

In 2018, Val and colleagues started a new project focusing on the MSA of OBP. Their excavation was situated in the area where van der Ryst excavated the LSA layers. Val *et al.* (2021) dated two *Equus* sp. teeth from stratigraphic unit "GS" using ESR/U-series to about 150 kya. The dating of these MSA deposits places the site within MIS 6. This age provides a context of the MSA assemblage from OBP, including the faunal material, which is the focus of this study.

A number of geogenic and biogenic processes have led to the formation of this site. The role of a perennial water source in close proximity to the site is evidenced by wall breakdowns, cobbles, cultural and non-cultural material, which are fluvial in nature (Val *et al.* 2021).

Evidence of bioturbation was observed through root growth and burrowing (Val *et al.* 2021). Thus, at OBP, water action has been a major factor in site formation processes.

Val *et al.* (2021) provides a taxonomic list of faunal remains from identifiable specimens (Table 4). The taxonomic list underscores the proximity of water source as evidenced by southern reedbuck, zebra, species with high water requirements. It also highlights the abundance of an open habitat as evidenced by wildebeest, roan/sable antelope and hartebeest. The recovery of klipspringers and baboons, animals which thrive in a rocky area is also suggested by the species list (Val *et al.* 2021).

Table 4: Taxonomic identifications of the faunal assemblage retrieved during the 2018 excavation of the MSA layers at Olieboomspoort (from Val *et al.*, 2021).

Species	**Common Name**	**NISP**
Raphicerus campestris	Steenbok	2
Raphicerus sp.	Steenbok/grysbok	1
Redunca arundium	Southern reedbuck	2
Redunca sp.	Reedbuck	4
Oreotragus oreotragus	Klipspringer	2
Alcelaphus sp.	Hartebeest	3
Connochaetes sp.	Wildebeest	2
Hippotragus sp.	Roan/sable antelope	2
Tragelaphus oryx	Eland	1
Equus cf. *capensis*	Extinct giant Cape zebra	7
Equus sp.	Zebra	5
Papio sp.	Baboon	1
Lepus sp.	Hare	3
Pronolagus sp.	Rabbit	1
Proteles cristata	Aardwolf	1

Felis lybica	African wild cat	1
Stigmochelys pardalis	Leopard tortoise	8
Kinixys sp.	Hinge-back tortoise	1
Serpentes indet.	Large snake	
Achatina sp.	Giant land snail	1
TOTAL		**48**

CHAPTER 3: MATERIALS & METHODS

3.1 Sample studied

The material analysed here was collected during the 2018 and 2019 excavation campaigns of the MSA deposits at Olieboomspoort. A total of 1296 specimens were analysed: n= 783 from Grey-Sediment (GS), n= 468 from Yellow-Reddish-Sand (YRS), and n= 45 from Dark-Reddish-Grey (DRG) from two squares (Table 5). It includes all plotted specimens as well as identifiable material retrieved from the sieve. The faunal assemblage is mostly composed of macrofaunal material. The remains of micromammals and other small vertebrates with live weight smaller than 1 kg were not included in this study.

Table 5: Quantities of faunal remains analysed in this study and the provenance from which they were recovered.

Square	**GS**	**YRS**	**DRG**	**TOTAL**
B2	602	468	-	**1069**
B3	181	-	45	**227**
TOTAL	**783**	**468**	**45**	**1296**

3.2 In the field: excavation and post-excavation methods

The area excavated is a vertical extension of the main excavation conducted in the 1990s by van der Ryst (2007) in squares B2 and B3. Figure 4 illustrates the location of van der Ryst's and of the 2018-2019 excavation inside the rock shelter (after Val *et al*. 2021).

Three sedimentary units, GS, YRS and DRG, which were distinguished based on their colour and texture. The GS unit was the first from the surface, characterized by medium to large clasts (Val *et al.* 2021). The second unit was YRS, which had reddish and coarse sediments and the third unit was DRG, with dark-red sediments. From the GS unit, 326.3 litres of sediment were excavated, 48.5 litres from YRS and 45 litres from DRG.

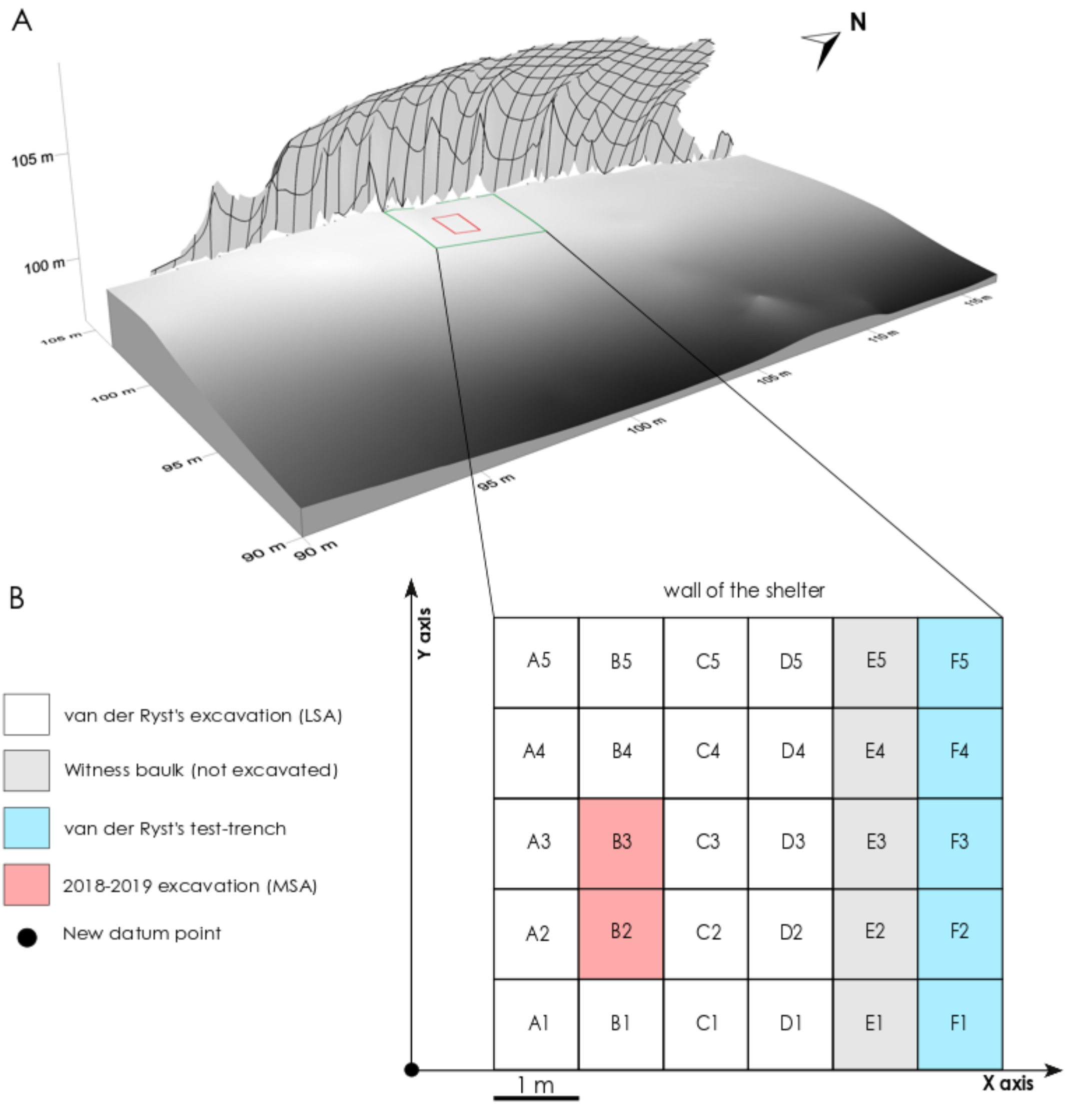

Figure 4: Excavation map of Olieboomspoort showing van der Ryst's excavation of the LSA deposits and the 2018-2019 excavations of the MSA deposits, modified from Val *et al.* (2021)

The excavation protocol followed the natural stratigraphy and used *decapages* (i.e. smallest excavation unit consistent with an archaeological surface and defined by the base of archaeological material; Val *et al*. 2021). All archaeological material longer than 2 cm was plotted using a Nikon Nivo 2.M Total Station. The sediments were sieved using 3 mm and 1 mm mesh sizes.

In the field, archaeological material from the 3 mm sieve was separated into lithics, ochre and fauna. The plotted faunal remains were gently cleaned using water and soft brush. The material was left to dry outside.

3.3 In the lab: light acid preparation

Most of the material was encrusted with calcium carbonate concretions, which posed a challenge for the identification of remains and the observation of bone surface modifications. As highlighted by Shipman & Rose (1983) for instance, removing concretions using tools may mimic past human activities on bones. Light acid preparation was therefore preferred. A dilution of acetic acid with water following a ratio of 1:1 was used. Depending on the thickness of the concretions, some specimens were left in the solution for at least 24 hours while others were left for about 48 hours. Light acid preparation was performed only on plotted material (n=898).

3.4 Recording

Identifiable bones were separated from non-identifiable bones. Identifiable bones are those that could be assigned to taxon and/or a skeletal element with, for instance, articular surfaces or other diagnostic landmarks. Non-identifiable bones include those that could not be identified to taxon or skeletal part. When possible, non-identifiable bones were assigned to a class size based on cortical thickness. Non-identifiable material largely includes long bone fragments. An MS Excel database was created to record information on the archaeological context (stratigraphic provenance, square and depth), taxonomical attribution, anatomical description, age estimate, breakage patterns, dimensions and bone surface modifications for all specimens analysed.

Faunal remains were classified based on the type of bone. Four classes were established based on the nature of the bone. Cranial elements (i.e. skull, mandible, teeth, and horncore) were recorded as “CRA”. Flat and spongy bones including ribs, vertebrae, innominate and scapula were recorded as “FBN”, while long bones including femora, tibiae, humeri, radii-ulnae, and metapodials were coded as “LBN”. Short bones including sesamoids, carpals and tarsals were classified as “SHBN”. When a detailed anatomical identification was not possible, the bone specimens were attributed to one of these categories.

3.5 Species Identification

As common in the southern African archaeological record, the MSA faunal assemblage from OBP is highly fragmented. The degree of taxonomic and anatomical identifications varies from researcher to researcher, and this partly depends on experience. What is categorised as non-identifiable by some might be identifiable to others (Klein & Cruz-Uribe 1984; Reitz & Wing 2008). In practice, morphological features characteristic of skeletal parts are used to distinguish between identifiable and non-identifiable remains.

For the OBP assemblage, taxonomic identifications were made using the extensive comparative collections of modern South African mammals and reptiles from the Archaeology Department of the University of Cape Town and from the Ditsong National Museum of Natural History in Pretoria. The taxonomic nomenclature follows Skinner & Chimimba (2005). When not identifiable to species or family level, the faunal remains were attributed a size class. In this study, bovid size classes followed Brain (1974), while size classes for non-identifiable, non-bovid remains (mammals) followed Reynard *et al*. (2016). Table 6 presents the size classes used.

Table 6: Size classes used during the analysis of the OBP faunal assemblage. Bovid size classes are from Brain (1974: 2); non-bovid size classes are from Reynard *et al*. (2016: 6).

Live weight range (kg)	**Bovid size class**	**Indeterminate ungulate size class**	**Indeterminate mammal size classes**
0-23	I	Small bovid	Small mammal
23-84	II	Medium bovid	Medium mammal
84-296	III	Large ungulate	Medium/large mammal
>296	IV	-	Large mammal
>900	-	Very large ungulate	Very large mammal

3.6 Age estimates

Estimating the age of animals present in a faunal assemblage can help documenting the economic choices, hunting strategies and culinary preferences of past human societies. At OBP, when possible, age was estimated in order to reconstruct the mortality profile of the fossil population. Age estimates were based on the degree of bone epiphyseal fusion and tooth wear. Epiphyseal fusion line was recorded as ‘unfused’, ‘fused’ or ‘fusion line still visible’ following Grody (2016). In this study, tooth wear stages were used rather than dental eruption stages because the level of fragmentation of the assemblage did not allow us to assess dental eruption since most of the assemblage only had isolated teeth.

There are two main systems of recording tooth wear, developed by Payne (1973) and by Grant (1982). Most researchers are influenced by these two systems in either assessing the effectiveness of each or in using these in actual research. For example, Jones (2006) observed sheep tooth eruption and wear using Payne’s system and found that individual tooth wear is less informative than combined tooth wear in a row. Given the fragmentary nature of the assemblage analysed, I could only score individual tooth wear. Zeder (2006) used epiphyseal fusion together with Payne's occlusal wear stages for wild sheep (*Ovis vigni* and *O. orientalis*) and goats (*Capra aegagrus*). However, this system did not use samples with known-age-at-death. Greenfield & Arnold (2008) used known-age-at-death samples from sheep and goats, and they argue that Payne's system is less useful than Grant's system. For this reason, I used tooth wear scores based on classifications developed by Grant (1982) and illustrated in Figure 5.

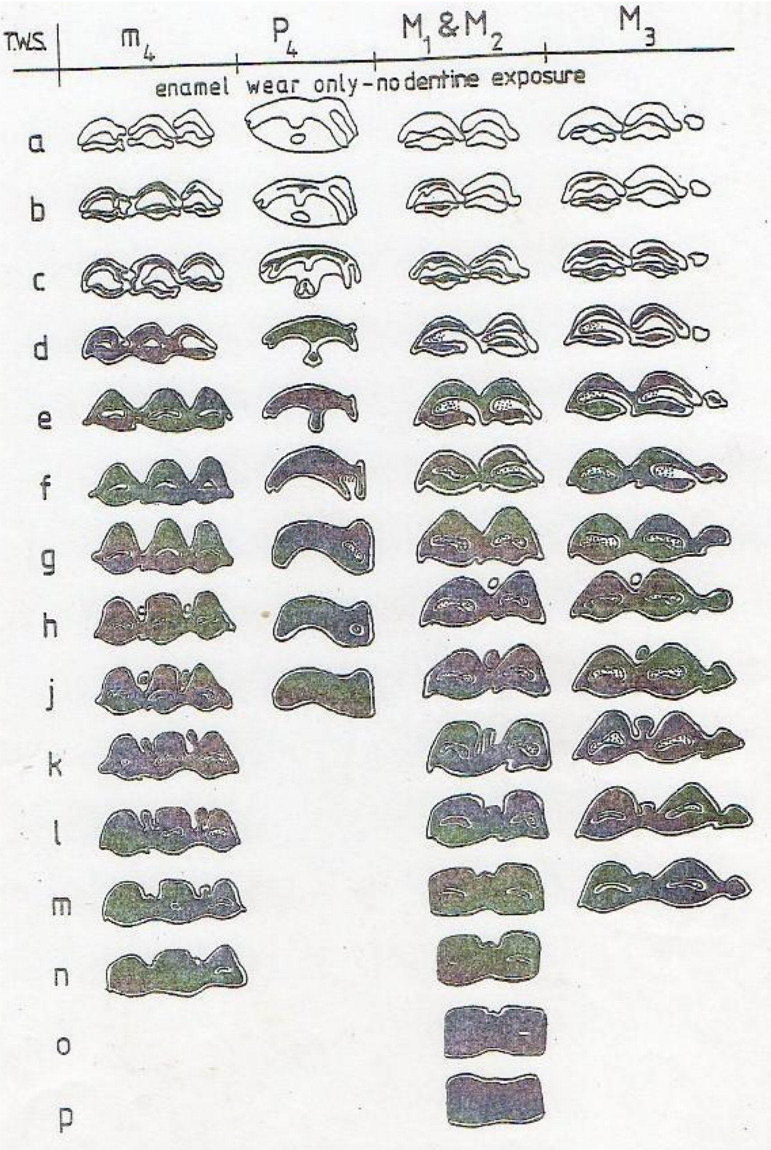

Figure 5: Grant’s scores for cattle teeth wear stages (Grant 1982: 92). M_1: lower first permanent molar; M_2: lower second permanent molar; M_3: lower third permanent molar; m_4: deciduous fourth premolar; P_4: lower fourth permanent premolar.

3.7 Quantification

Archaeozoologists are interested in the proportion of different taxa in the faunal assemblages that they study, as well as in skeletal element representation. Quantification of skeletal parts helps in discussing the role played by density attrition, human choices in transport of carcasses and butchery patterns in animal resource exploitation. Different researchers have used different terminology for quantitative units in archaeozoology (e.g. Plug & Plug 1990; Lyman 1994a, b, 2008; van Pletzen 2000).

I have used quantitative units commonly used in archaeozoological studies, namely the Number of Identified Specimens (NISP), the Minimum Number of Individuals (MNI), the Minimum Number of Elements (MNE), the Minimal Animal Unit (MAU) and the percent Minimum Animal Unit (%MAU) following the definitions proposed in Lyman (1994b, 2008) and Gifford-Gonzalez (2018). The NISP is a primary tally of number of specimens identified to skeletal element and at least taxonomic family level. The NISP is affected by differential preservation, recovery and may overestimate sample sizes for some taxa (Grayson & Frey 2004; Lyman 2008).

The MNI is the lowest number of individuals that could account per taxon within studied assemblage. The MNI is calculated using the most commonly occurring skeletal element of a given taxon in the assemblage (Plug & Plug 1990; Lyman 1994b, 2008). Unlike the NISP, which is a primary count, MNI values are secondary counts are calculated using the MNE (Lyman 2008). However, MNI values tend to be underestimates while NISP values increase within a taxon.

The MNE is the minimum number of skeletal elements necessary to account for the specimens under study. The MNE, when compared to the NISP, is an indicator of the degree of fragmentation. The MNE is derived by determining how many elements are represented by the fragmentary remains and uses the presence of overlapping morphological features (Lyman 1994b). If there are overlaps of specimens for a skeletal element, the MNE value decreases. In this case, the premise is that there was fragmentation of a skeletal element into many specimens, and the overlapping specimens are all from the same skeletal element. As such, the MNE informs on skeletal part representation. The bone portions for which MNE values were considered to test the impact of density-mediated attrition follow the regions defined by Lam *et al.* (1999).

The MAU normalises skeletal abundance in an assemblage. The MAU is obtained by dividing the MNE recovered for each element by the number of times this element occurs in a complete skeleton (Lyman 1994b). For example, a complete bovid skeleton has two femora. If one has an assemblage with an MNE of eight femora (regardless of the sides of the elements), the MAU is four. After deriving the MAU, the largest MAU value is used as a standard. All the other MAUs in the assemblage are divided by the standard and multiplied by 100 to establish a normed scale called %MAU (Lyman 1994b). The %MAU helps discerning similarities and differences in the frequencies of different skeletal elements and portions.

3.8 Measurements

The length of all pieces was recorded in millimetres (mm) using a digital calliper. Each specimen was also weighed in grams using a digital scale. Each bag containing faunal material from the sieve was weighed after the identifiable specimens were removed. The circumference of the long bones was recorded using a score of 1-5, where 1= 0-25%, 2= 25-50%, 3= 50-75%, 4= 75-99%, 5= 100% to estimate the circumference preserved.

The degree of completeness of each specimen was recorded as either complete, nearly complete or fragmented.

3.9 Long bones

Breakage patterns and general preservation were assessed for long bones. Breakage patterns inform on when and how the breakage took place. Preservation of long bones was assessed to determine the nature of fragmentation, anatomical parts and side represented.

a) *Long bone breakage*

The analysis of breakage patterns is useful in understanding some of the taphonomic processes that might have affected the assemblage. Although long bone breakage patterns do not necessarily relate to human action, they provide information on when the breakage took place. For example, fresh (green) breakage is usually associated with a primary modifier (e.g. human butchery, carnivore consumption) while dry breakage is associated with a secondary modifier (e.g. sediment compaction, trampling). Dry fractures tend to have right angles, transverse outlines and a jagged edge, while green bone fractures tend to have an oblique angle, curved outline and a smooth edge (Villa & Mahieu 1991).

Variables for long bone breakage pattern based on fracture outline, fracture angle and fracture edge followed the work of Villa & Mahieu (1991). Fracture outline was recorded as transverse, curved or spiral, or intermediate. Transverse outline describes fractures that are perpendicular to the bone axis. Curved or spiral fractures are characterised by complex outlines that are multidirectional. Intermediate includes fractures that are straight but diagonal, and those with a stepped outline.

Fracture outlines strongly correlate to how fracture angles formed. Fracture angle is the angle formed between the fracture structure and the bone cortical surface (Villa & Mahieu 1991). Such angles were recorded as oblique (either acute or obtuse) or right. Fracture edges were recorded as either smooth or jagged, where smooth fracture edges are associated with green bone breakage, while jagged are associated with dry bone breakage.

b) *Long bone preservation*

Long bone preservation is linked to the degree of fragmentation. An assessment of parts preserved on long bones has been used in archaeozoology in reconstructing taphonomic events.

For example, carnivores scavenging on defleshed bones tend to destroy cancellous proximal epiphyses of long bones, as well as vertebrae and pelvises (Brain 1981; Marean *et al*. 1992).

In this research, I assessed preservation of the five portions that compose long bones. The five parts are "P" for the proximal epiphysis, "PSH" for the proximal shaft, "SH" for the middle shaft, "DSH" for the distal shaft and "D" for the distal epiphysis, after Gifford & Crader (1977) and Costamagno (1999). This is illustrated in Fig 6.

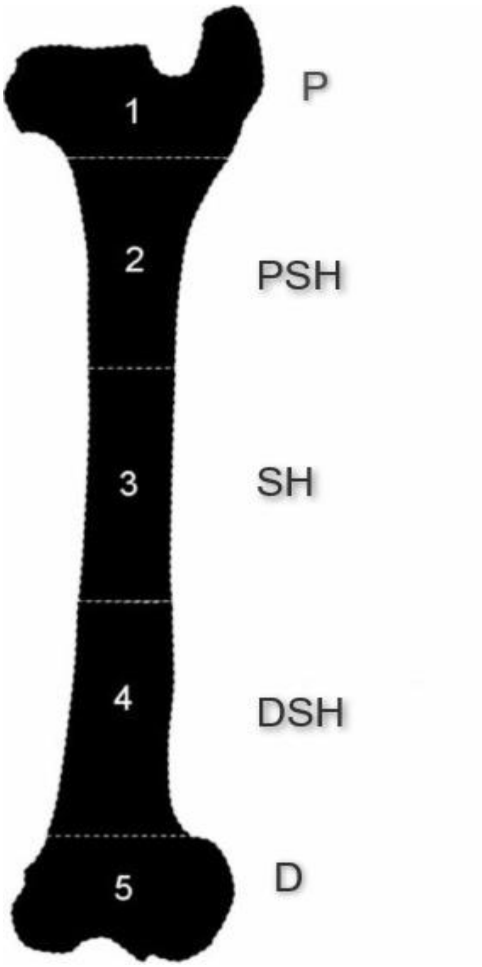

Figure 6: The five anatomical portions of long bones (here a femur is used as an example), which were used to record their degree of preservation.

The anatomical sides preserved for long bones were also noted. The sides were recorded as "Ant" for anterior (or cranial), "Post" for posterior (or caudal), "Lat" for lateral and "Med" for medial. In a few instances, particularly when it was not possible to identify whether the portion preserved was lateral or medial, the abbreviation “Lat/Med” was used. Figures 7-9 illustrate the four sides of bovid long bones, using selected examples of three different long bones of impala (*Aepyceros melampus*).

Figure 7: The four anatomical views of a left humerus of *Aepyceros melampus*. From left to right, the sides are posterior, anterior, medial and lateral respectively.

Figure 8: The four anatomical views of a left femur of *Aepyceros melampus*. The sides are anterior, posterior, lateral and medial respectively.

Figure 9: The four anatomical views of a left radius of *Aepyceros melampus*. The sides are anterior, posterior, medial and lateral respectively.

3.10 Taphonomy and bone surface modifications

a) Taphonomic approach

The separation of cultural from natural processes is critical in understanding the interaction between humans and animals (Lyman 1994b) and it helps deciphering the origin(s) of bone accumulation in a fossil site. Efremov (1940) first coined the term taphonomy, which means 'laws of burial.' Taphonomic analysis in archaeology became particularly relevant for researchers grappling with questions on early hominid behaviours and subsistence strategies (e.g. Brain 1981; Binford 1981; Shipman & Rose 1983). Taphonomy is the study of the processes that accumulate, affect and modify organic matter such as bones and inorganic matter from the time an animal dies until its remains are excavated and analysed (e.g. Lyman 1994b; Fernández-Jalvo & Andrews 2016). It aims at identifying the agents of accumulation at a site, as well as the pre- and post-depositional factors affecting the faunal assemblage (Brain 1981; Lyman 1994b, 2008).

A number of taphonomic proxies were considered in this research, which include composition of faunal spectrum, breakage patterns, skeletal part representation and surface modifications. These proxies were based on the age and context of the site, such water abrasion because of the proximity of water, the role of birds and carnivores given that the site is a rock shelter.

Analysis of bone surface modifications

Detailed studies of bone surface modifications on faunal material from archaeological sites are key in the understanding of past human subsistence strategies. Such studies also inform on the taphonomic processes that affected the assemblage and, more broadly, on site formation processes. Bone surface modifications are morphologically distinct patterns that are typical of the agent or implement (e.g. stone tool, carnivore teeth, invertebrate mouthparts, water current) that caused the modification. Surface modifications are any alteration in structure, size, texture or appearance of the bone surface (Marshall 1989).

In this research, taphonomic analysis aimed at identifying agents of modifications and to provide a relative chronology (taphonomic history) that affected the assemblage. The assemblage was taphonomically analysed to identify bone surface modifications present on each fragment following notably Fernández-Jalvo & Andrews (2016; and references therein). Inspection of bone surfaces was conducted with a hand lens and a multifocus digital microscope (Nikon SMZ 800). Surface modifications were grouped into two categories, consistent with abiotic and biotic processes.

Cortical preservation

The depositional and post-depositional conditions of the assemblage largely affect the preservation of bone cortical. For example, cortical preservation is affected when assemblages are weathered or burnt, which in turn also affect the ability to recognize other surface modifications on the bones. In this research, cortical preservation was coded on a scale of 1 to 5, where 1= 0-25%, 2= 25-50%, 3= 50-75%, 4= 75-99%, 5= 100%. This means that specimens with a score of 1 have between 0-25% of the cortical preserved and so on.

Abiotic processes

Weathering is a process disintegrating the original macroscopic and microscopic components of bones due to the physical and chemical action of natural agents such as sun and rain, when these bones are in subaerial context, i.e. mostly prior to burial even though this process continues after burial (Behrensmeyer 1978). Weathering affects the preservation of the original surface, hence, there is a close relationship between weathering and cortical preservation. Although bone weathering tends to increase with time of exposure (Behrensmeyer 1978), its effects are affected by local, microenvironmental conditions (i.e. humidity, temperature, degree of exposure to light and soil pH), which vary depending on the depositional context (e.g. Lyman & Fox 1989; Tappen 1994). For the OBP sample, the intensity of weathering on faunal remains were recorded following the stages established by Behrensmeyer (1978) as presented in Table 7.

Table 7: Weathering stages, after Behrensmeyer (1978).

Stage	**Definition**
0	Greasy, no cracking of flaking. May have soft tissue attached.
1	Longitudinal cracking, articular surfaces with mosaic cracking, splint lines begin to form.
2	Flaking of outer surface (exfoliation), cracks present, cracks of edges are angular.
3	Compact bone has rough, fibrous texture, weathering penetrates 1-1.5 mm, cracked edges are rounded.
4	Coarsely fibrous and rough surface, loose splinters present, weathering penetrates to inner cavities, cracks are open.
5	Bone tissue very fragile and falling apart, large splinters present.

Concretions

The presence of encrustations on most specimens prevented the identification of bone surface modifications. In order to remove concretions, specimens were treated with light acid, after which the level of concretions was recorded. The degree of concretions was recorded on a scale from 1 to 5, where 1= 0-25%, 2= 25-50%, 3= 50-75%, 4= 75-99%, 5= 100% of the specimen with concretions.

Water abrasion

Faunal remains, which have been affected by fluvial conditions exhibit some rounding and polishing on the surface. Several factors affect water abrasion since it is dependent on the strength of the water channel, duration of exposure to the channel, the nature of sediments in the water channel, the type of bone and the state of the bone, i.e fresh or dry or weathered (Voorhiers 1969; Fernández-Jalvo & Andrews 2003; Thompson *et al.* 2011; García-Morato *et al.* 2019). The presence or absence of evidence water abrasion on specimens was recorded as Yes or No.

Manganese coatings are black stains associated with manganese oxide deposits. They maybe results of wet conditions and the involvement of bacteria or lichens (Fernández-Jalvo & Andrews 2016; Thackeray 2016). Manganese coatings affect the ability to recognize surface modifications. Thus, it is critical to know the degree of manganese coatings present in an assemblage. For the OBP sample, a score of 1 to 5 was used to describe the level of manganese coatings, 1= 0-25%, 2= 25-50%, 3= 50-75%, 4= 75-99%, 5= 100% as slightly modified from Val & Stratford (2015).

Biotic processes

Root etching produces patterns of shallow grooves on bone surfaces. Microscopically, evidence of root etching is characterised by broad, U-shaped grooves that are smooth towards the bottom (Lyman 1994b). The presence of root etching indicates that the faunal assemblage was deposited or buried within a plant-supporting sedimentary environment. Root etching on the OBP material was recorded either as present or absent.

Invertebrate damage includes small perforations and pits on bone, but these pits are smaller and morphologically different from those made by larger animals. It also includes tiny, parallel striae, sometimes around pit. Several invertebrates, such as termites feed on bones or bore their pupation chambers, thereby damaging faunal assemblages (e.g Tappen 1994; Backwell *et al.* 2012; Parkinson 2016). Invertebrate damage was recorded as either present or absent.

Carnivore damage includes the different types of bone modifications caused by small to large non-human, mammalian predators and scavengers. Carnivores chew bones during consumption of animal carcasses and can ingest some, which may be found in faunal assemblage in the form of regurgitated specimens. Regurgitated bones have rounded edges and a shiny appearance (e.g. Maguire *et al.* 1980). Carnivore gnawing damage includes pits, punctures, scores, notches and acid etching (e.g. Brain 1981; Fernández-Jalvo & Andrews 2016 and references therein).

Pits and punctures are roughly circular depressions produced by carnivore teeth on compact bone in the first case and on spongy bone, penetrating into the bone cortex, in the second (e.g. Binford 1981; Fisher 1995). Scores are usually short, parallel and linear marks perpendicular to the long axis of the bone; they are V- or U-shaped in cross section (Lyman 1994b). Scoring is caused by dragging the teeth along the surface of the bone producing blunt rather than sharp marks (Brain 1981; Lyman 1994b). Acid etching, pits, punctures, scores and notches were recorded as either present or absent. I did not measure the dimensions of the pits and punctures at this stage of the analysis.

Bird of prey damage is particularly relevant on faunal remains of leporids, hyraxes and small bovids (Brain 1981; Armstrong & Avery 2014). The different modifications of birds are punctures, scores, digestion, crenulated edges and notches (Armstrong & Avery 2014). Scores resulting from bird damages are straight, shallow in depth and U-shaped in cross-section.

Crenulated edge are modifications resulting from edge chewing caused by either carnivores or raptors. This modification is identified by broken edges, which show internal crushing along the ragged edges (Brain 1981; Landt 2007; Pobiner et al. 2007). Crenulated edges are formed when teeth penetrate the cortex and remove parts of the edge of the bone (Maguire et al. 1980). This modification is common on elements with thin cortical bones, such as rib shafts and vertebral processes (Lyman 1994b; Pobiner et al. 2007; Armstrong & Avery 2014). In raptor modifications, crenulated edges follow the pattern of beaks (Armstrong & Avery 2014), and in carnivore modifications, they follow the pattern of the teeth (Fisher 1995). Bird of prey usually show digestion marks on bones. The intensity of these digestion marks is used to infer to identify the predator as some bird predators like the ban owl produce light digestion marks (Fernandez-Jalvo & Andrews 2016).

Rodent gnaw marks are alterations, which are shallow, broad and parallel (e.g. Maguire *et al.* 1980; Brain 1981). They could indicate a contribution or a modification of the initial bone assemblage by porcupines or smaller rodents. Rodent gnaw marks was recorded as either present or absent.

Rodents especially porcupines gnaw bone surfaces to obtain calcium as well as wear down their incisors, which grow continually through their life. Due to this reason, porcupines can either accumulate bone assemblages themselves or disturb existing bone assemblages.

Trampling can be a result of animal and/or human action, which produces scratches on the bones. Trampling marks can mimic cut-marks (Behrensmeyer *et al.* 1986) but the consideration of location, trajectory, shape and microscopic morphology following Domínguez-Rodrigo *et al*. (2009) can help distinguish them from cut-marks. Trampling marks tend to be more randomly distributed or multi-directional relative to butchery marks. Trampling marks are usually located on the shafts of long bones rather than on the ends and tend to be shallow relative to butchery marks (e.g. Lyman 1994b; Fernández-Jalvo & Andrews 2016). Trampling marks were recorded as either present or absent.

Anthropogenic modifications

Butchery marks are direct evidence of human processing of animal carcasses (e.g. Binford 1981; Lyman 2008; Fernández-Jalvo & Andrews 2016). Butchery marks include cut-marks, chop marks and percussion marks. They are produced during various butchery activities, such as bone marrow extraction, skinning, disarticulating, defleshing, and tendon removal. Ultimately, butchery marks can be used to interpret subsistence strategies (e.g. Binford 1981; Lyman 1994b; Soulier & Morin 2016). The exact anatomical location of cut-marks on the skeletal element were recorded.

Burning in an assemblage can result from human consumption of animal carcasses or portions of carcasses. It can also result from dumping of butchery leftovers in the fire. In the case of burning related to human consumption, its location on the skeleton can inform on cooking methods. For instance, if burning is concentrated on the epiphyses, it is likely that the carcass was cooked with the meat still attached, whereas if the shafts are also burnt, it indicates that burning occurred after meat removal (e.g. Speth & Clark 2006; Clark 2009).

Burning can also be post-depositional and accidental. It can result from natural causes, in which case it is unintentional and unrelated to human activity. To assess this, burning on the OBP material was recorded following the six colour-code established by Stiner *et al*. 1995, representing a scale from not burned to fully calcined, as shown in Table 8. The location of burning on skeletal elements was also recorded.

Table 8: Burning codes from Stiner *et al.* (1995).

Burn code	**Description**
0	Not burned (cream/tan)
1	Slightly burned/localized and <half carbonized
2	Lightly burned and >half carbonized
3	Fully carbonized (completely black)
4	Localized and <half calcined (more black than white)
5	< Half calcined (more white than black)
6	Fully calcined (completely white)

CHAPTER 4: RESULTS

This chapter presents results from the taphonomic and archaeozoological study of the Olieboomspoort faunal assemblage. The first section provides general observations on the sample size, the preservation of the assemblage, while the second presents the taxonomic composition. The final section describes bone surface modifications.

4.1 Sample size

I have analysed 1296 bones, which were excavated during the 2018 and 2019 field seasons. Of these, 898 were plotted during excavation while 398 were retrieved from the sieved material. The faunal remains were collected from the three distinct stratigraphic units, GS, YRS and DRG (Fig 10).

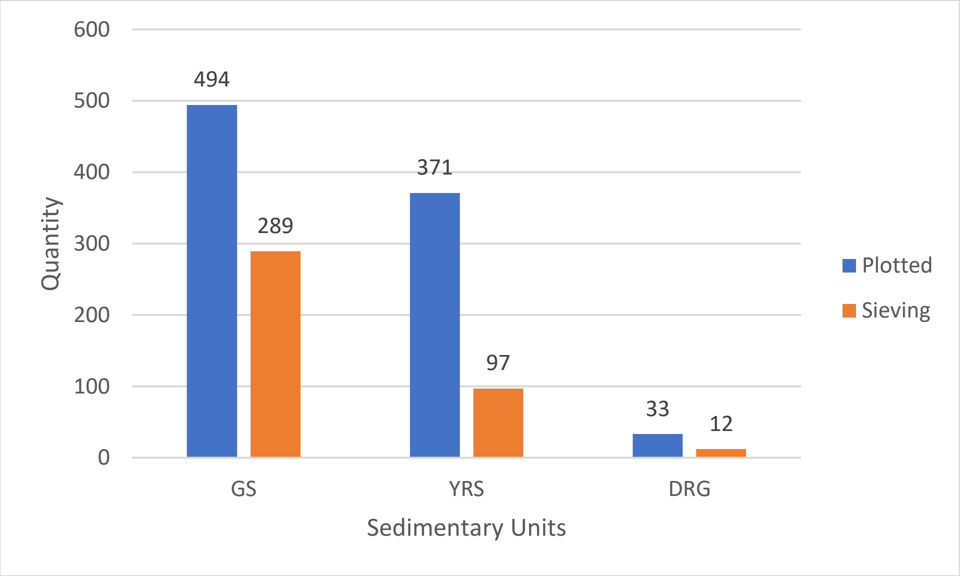

Figure 10: Distribution of Olieboomspoort recorded specimens by sedimentary units.

The total weight of all fauna is 4979.7g, with plotted fauna accounting for 4631.9g (93%), and that from the sieve accounting for 347.8g (7%). A total number of 783 specimens, with a weight of 2921.7g (58.7% of total weight of all recorded specimens), were excavated from the GS unit. The weight of the plotted component is 2673.3g (91.5% of weight of specimens in the GS unit), and that of the sieved component, 248.4g (8.5% of weight of specimens in the GS unit). The YRS sedimentary unit produced a total of 468 specimens, with the plotted component weighing 1722.4g (94.9% of weight of specimens in the YRS unit) and the sieved component, 92.5g (5.1% of weight of specimens in the YRS unit), giving a combined weight of 1814.9g (36.4% of total weight of all recorded specimens). The DRG unit produced a total of 45 recorded specimens with a total weight of 243.1g (4.9% of total weight of all recorded specimens). Of this, the plotted material weigh 236.2g (97.2% of weight of specimens in the DRG unit) and the specimens from the sieve, 6.9g (2.8% of weight of specimens in the DRG unit)

The density of faunal material per sedimentary unit was assessed. The bulk of the sediment removed during excavation were from the GS unit. However, bone density in the GS unit was found to be lower than that in the YRS unit (Table 9).

Table 9: Faunal material density in the different MSA stratigraphic units at OBP. The density is given in number of faunal specimens per litre of sediment

Unit	**Number of specimens**	**Volume (litres)**	**Density**
GS	783	326.3	2.4
YRS	468	48.5	9.6
DRG	45	45	1
TOTAL	**1296**	**419.8**	**13**

To test whether the density of faunal material by unit is significant of sampling distribution, a chi-squared test was performed for recorded specimens (as in Table 8). The density of faunal material is significantly different between the three units GS, YRS and DRG ($\chi^2 = 110.64$; p = 9.418E-25). The density of non-identifiable faunal material derived from the sieving refuse is presented in Table 10.

Table 10: Density and weight of faunal remains from the sieving refuse by bone type and stratigraphic unit.

Faunal type	**Unit (weight)**		
	GS	**YRS**	**DRG**
Bone fragments	12340g	4839.9g	226.4g
Tortoise shell	340.1g	179.7g	12.5g
Tooth Fragments	115g	40.7g	3.4g
OES	0.4g	-	-
Total	**12795.5g**	**5060.3g**	**242.3g**
Density	39g/l	104.3g/l	5.4g/l

The OBP faunal assemblage is mostly composed of bone. Bones account for 92.9% of the plotted material (n=834), teeth for 5.5% (n=49), and mandibles with preserved teeth for 0.1%. The plotted material also consists of 12 tortoise carapace fragments (1.3 % of the plotted assemblage) and two horncores (0.2% of the plotted assemblage). With regards to specimens retrieved from the sieve, bones make up 97.7% of the assemblage (n=389) and teeth 2.3% (n=9).

The faunal remains were analysed by bone type. The bulk of the specimens from both plotted and sieve component comprises of long bone fragments constituting 74.1% of the assemblage (n=960), flat bones 13.3% (n=172), cranial elements 5.3% (n=69) and short bones 6.3% (n=82). Plotted tortoise shell accounts for 0.9% (n=12) of the assemblage, as illustrated in Fig 11.

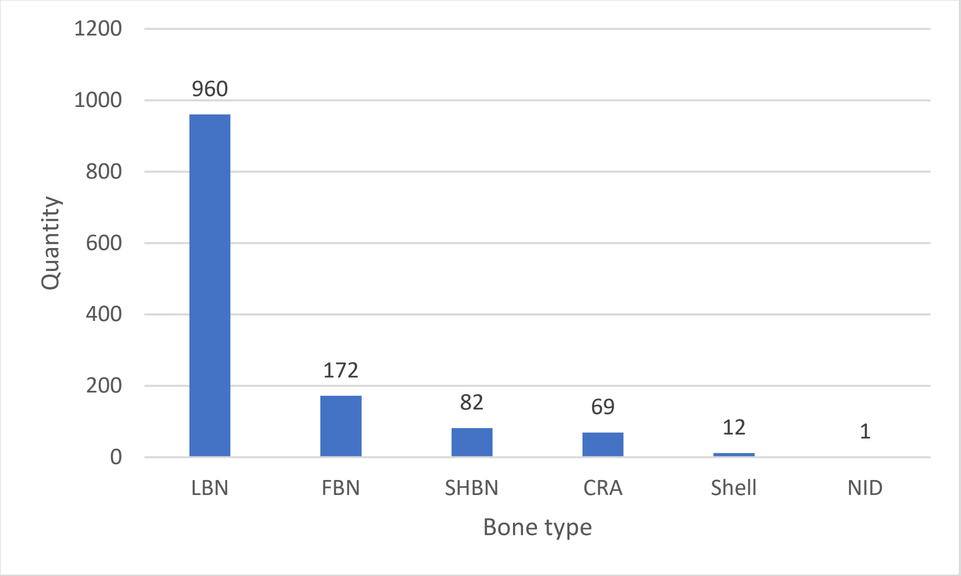

Figure 11: Distribution of faunal remains based on type of bone. LBN: Long bones, FBN: Flat bones, SHBN: Short bones, CRA: Cranial remains.

4.2 Bone fragmentation

The faunal assemblage is heavily fragmented with only 6.6% (n=85) of bones completely preserved. Specimens that are almost complete make up 0.2% (n=3), while the remaining 93.2% (n=1208) are incompletely preserved.

The specimens from OBP are short as pieces with a maximum length of 20 mm make 38% (n= 492), those that are long to 40 mm make up 50.8% (n= 659), of 60 mm make 9.7% (n=126), of 80 mm make 1.3% (n=17) and of 100 mm make 0.2% (n=2) of the whole assemblage as shown in Table 11 and Figure 12.

Table 11: Length range of Olieboomspoort faunal assemblage per class size.

Class size	**Length range (mm)**					**TOTAL**	**% of assemblage**
	0-20	21-40	41-60	61-80	81-100		
Bov I	150	250	16	-	-	**416**	**32.1%**
Bov II	99	257	53	3	-	**412**	**31.8%**
Bov III	26	84	44	6	1	**161**	**12.4%**
Bov III/IV	-	7	4	3	-	**14**	**1.1%**
Bov IV	1	12	3	2	1	**19**	**1.5%**
Small	201	29	-	-	-	**230**	**17.7%**
Medium	13	8	1	-	-	**22**	**1.7%**
Large	2	12	5	3	-	**22**	**1.7%**
TOTAL	**492**	**659**	**126**	**17**	**2**	**1296**	
%	**38%**	**50.8%**	**9.7%**	**1.3%**	**0.2%**		**100%**

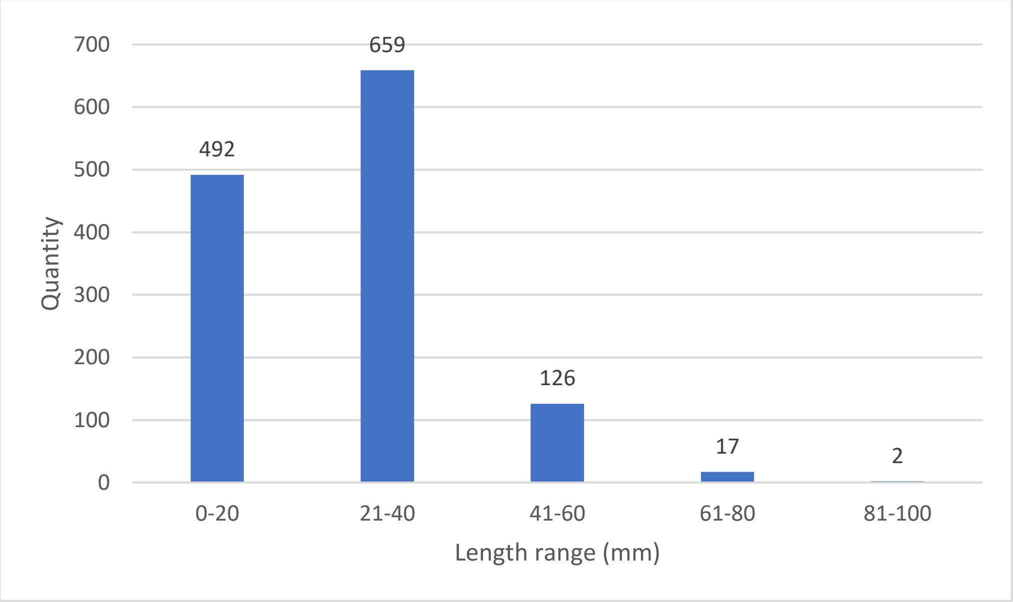

Figure 12: Lengths of all specimens from Olieboomspoort analysed in this study.

Complete long bones are few (n=19 or 2% of the long bone sample) and most of these are first phalanges. The long bone sample is predominantly comprised of shaft fragments (n=701 or 73% of the long bone sample), while epiphyses are underrepresented. Fig 13 and 14 shows the anatomical parts preserved for long bones.

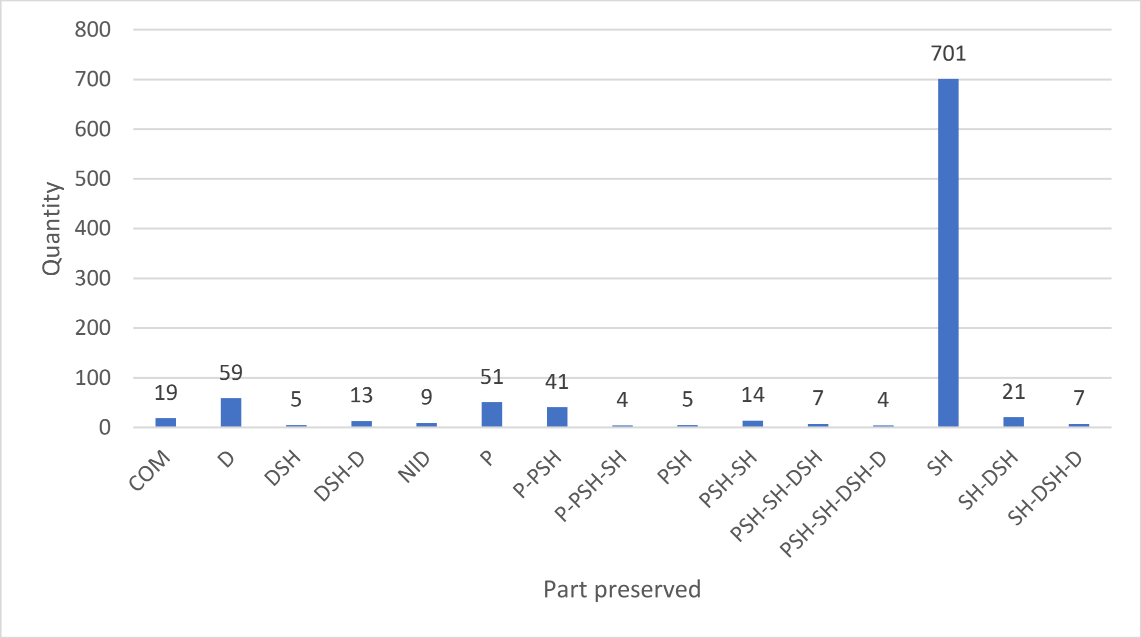

Figure 13: Anatomical parts preserved on long bones where P: Proximal, PSH: Proximal shaft, SH: Shaft, DSH: Distal shaft, D: Distal, COM: Complete.

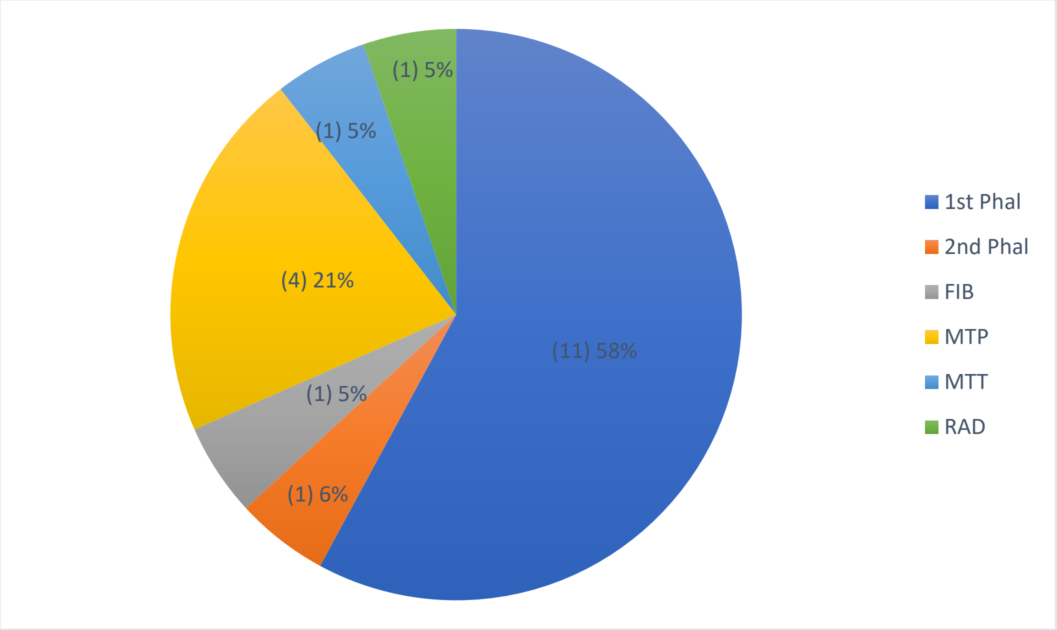

Figure 14: Complete long bones per element. NISP in brackets. 1st Phal: 1st Phalange, 2nd Phal: 2nd Phalange, FIB: Fibula, MTP: Metapodials, MTT: Metatarsals, RAD: Radius.

A combination of the section preserved and part preserved shows that mid-shafts are more common in the assemblage. However, most of the section preserved for these specimens could not be determined. Table 12 shows the section preserved and anatomical part preserved.

Table 12: Long bone part and section preserved. COM: Complete, P: Proximal end, PSH: Proximal shaft, SH: Shaft, DSH: Distal shaft, D: Distal end

Section preserved	COM	D	DSH	DSH-D	NID	P	P-PSH	P-PSH-SH	PSH	PSH-SH	PSH-SH-DSH	PSH-SH-DSH-D	SH	SH-DSH	SH-DSH-D	Total	%
Ant	-	1	-	1	-	8	9	-	-	2	-	-	15	2	-	38	3.9%
Ant/Post	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	0.1%
Ant-Lat/Med	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	0.1%
Ant-Lat-Med	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1	0.1%
Ant-Lat-Post	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	0.1%
Ant-Post-Lat-Med	19	2	5	9	-	5	26	4	5	8	5	4	19	14	6	131	13.8%
Lat	-	6	-	2	-	2	2	-	-	-	-	-	-	-	-	12	1.2%
Lat/Med	-	5	-	-	-	4	-	-	-	1	-	-	4	-	1	15	1.5%
Med	-	1	-	-	-	1	-	-	-	-	-	-	-	-	-	2	0.2%
NID	-	44	-	1	9	30	2	-	-	-	2	-	652	1	-	741	77.2%
Post	-	-	-	-	-	-	-	-	-	2	-	-	7	4	-	13	1.3%
Post-Lat	-	-	-	-	-	-	1	-	-	1	-	-	1	-	-	3	0.3%
Post-Lat/Med	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	0.1%
Total	19	59	5	13	9	51	41	4	5	14	7	4	701	21	7	960	100%
%	2%	6.1%	0.5%	1.4%	0.9%	5.3%	4.3%	0.4%	0.5%	1.5%	0.7%	0.4%	73%	2.2%	0.7%		

The level of fragmentation of the long bone assemblage was assessed on the basis of maximum fragment length. The longest long bone fragment length recorded was 92.4 mm, while the shortest was 2.9 mm. The majority of long bone fragments fall within the 21-40 mm range, with a mean of 27.5 mm. Fig 15 shows the length ranges of long bone fragments.

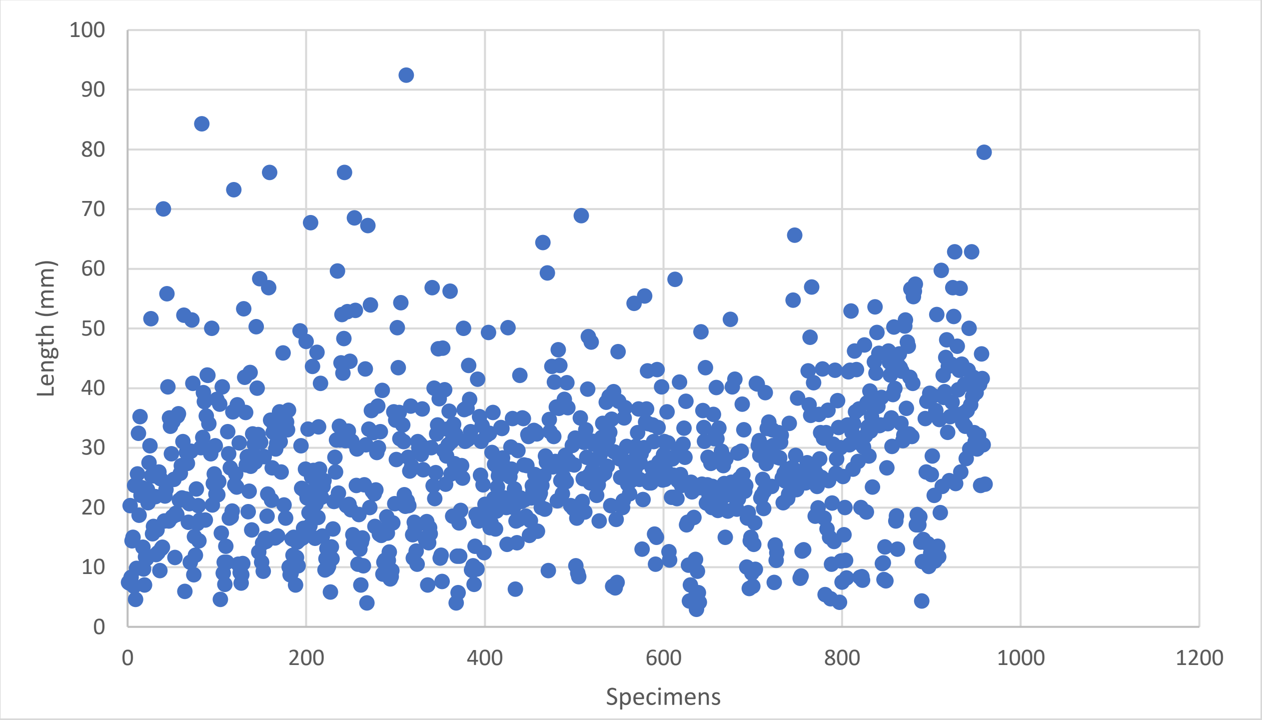

Figure 15: Scatterplot showing the length of long bones from Olieboomspoort.

Figure 16 shows the distribution of lengths of faunal remains from OBP. These lengths are represented in groups, where pieces with length between 0-20 make 30.8% (n =296), those between 21 and 40 mm make 56.4% (n = 541), while those between 41 and 60 mm accounts for 11.3% (n = 108), lengths between 61-80 mm make 1.4% (n = 13) and those with length between 81-100 mm make 0.2% (n = 2).

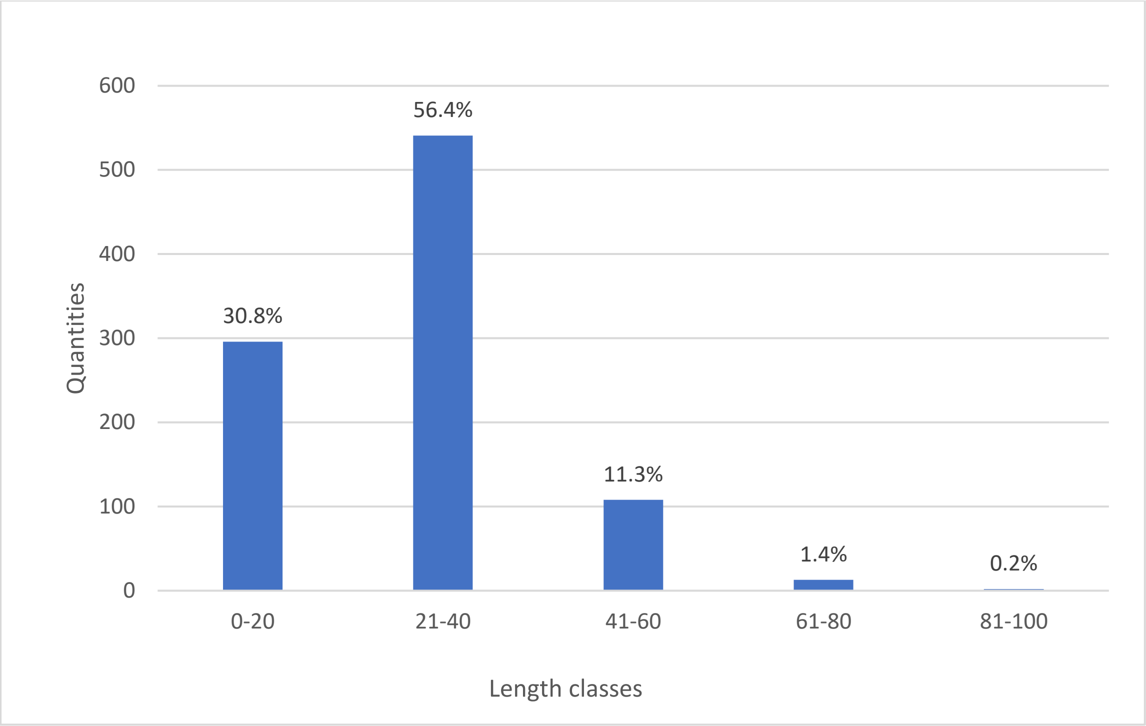

Figure 16: Summaries lengths of long bones grouped into five categories.

The circumference of long bones was also analysed based on the ranges that shows the level of circumference preserved. This attribute also indicate that the assemblage is heavily fragmented. The majority of long bones have a circumference range of only 0-25% complete (55%). Long bones with a circumference range of 25-50% make 23%, while that of 50-75% makes 3%. Despite the fragmented nature of the assemblage, long bones that have all the circumference preserved make 23% (Fig 17).

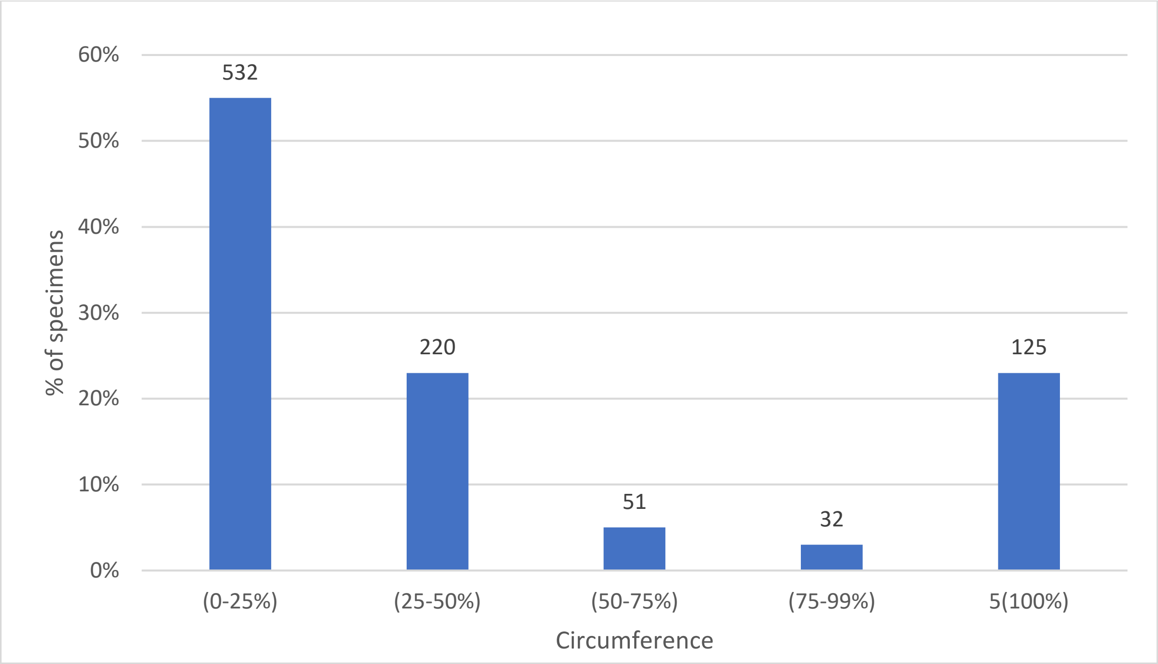

Figure 17: Range of circumferences preserved on long bones.

4.3 Long bone breakage pattern

The breakage patterns of all long bones regardless of size was analysed. Due to the fragmented nature of the assemblage, most long bone fragments presented two broken edges, which were assessed. In total, I analysed 1161 edges (Table 13). Based on fracture outline and angle, the majority of the remains are indicative of dry breakage. Fracture edge is dominated by jagged edges, which are typical of fresh breakage. At OBP, it is likely that the edges were smoothed by taphonomic processes especially water abrasion resulting in smooth edge.

Table 13: Olieboomspoort long bone breakage patterns, outline, angle and edge.

Category	**Description**		
Fracture outline	Curved/V-shaped	Transverse	Intermediate
	265 (22.8%)	888 (76.5%)	8 (0.7%)
Fracture angle	Oblique	Right	
	271 (23.3%)	890 (76.7%)	
Fracture edge	Jagged	Smooth	
	167 (14.4%)	994 (85.6%)	

4.4 Taxonomic composition of the Olieboomspoort faunal assemblage

The faunal assemblage from Olieboomspoort is taxonomically relatively diverse. The number of taxa (NTAXA) identified in this study is 16. The assemblage is composed mostly of small mammals as defined by Reynard *et al.* (2016). Small mammals identified include hyraxes. Some of the bovids identified include steenbok, common duiker, klipspringer, reedbuck, while large bovids identified include buffalo and eland based on the size classes defined by Brain (1974). Of the specimens identified to family level, Bovidae are well represented followed by Testudinidae and Equidae as shown in Table 14.

Table 14: Taxonomic composition of the Olieboomspoort's faunal assemblage by Number of Identified Specimens (NISP) and Minimum Number of Individuals (MNI).

Order	**Family**	**Tribe**	**Taxon**	**NISP**	**MNI**
ARTIODACTYLA	Bovidae	Alcelaphini	*Alcelaphus* sp.	5	2
		Oreotragini	*Oreotragus oreotragus*	4	1
		Antilopini	*Raphicerus campetris*	2	1
			Raphicerus sp.	1	1
		Reduncini	*Redunca* sp.	4	1
		Cephalophini	*Sylvicapra grimmia*	1	1
		Bovini	*Syncerus caffer*	2	1
		Tragelaphini	*Tragelaphus oryx*	1	1
		Gen. et sp. indet.	Size I	116	3
			Size II	163	3
			Size III	84	4
			Size III/IV	5	1
			Size IV	9	2
	Total Artiodactyla			**397**	**25**
PERISSODACTYLA	Equidae		*Equus* sp.	22	2
CARNIVORA	Hyaenidae		*Proteles cristata*	1	1
	Felidae		*Felis silvestris*	1	1
			Gen. et sp. indet.	2	2
	Herpestidae		Gen. et sp. indet.	1	1
	Total Carnivora			**5**	**5**
LARGOMORPHA	Leporidae		*Lepus* sp.	10	2
HYRACOIDAE	Procaviidae		Gen. et sp. indet.	3	1
PRIMATES	Cercopithecidae		*Papio* sp.	5	3
AVES			Gen. et sp. indet.	2	1
TESTUDINES	Testudinidae		Tortoise	101	7
SQUAMATA			Snake	9	2
REPTALIA			Gen. et sp. indet.	14	1
MAMMAL	NID		Size I	156	2
			Size II	328	1
			Size III	119	1
			Size III/IV	15	2
			Size IV	7	1
			Small	90	3
			Medium	13	2
	TOTAL mammal (Gen. et sp. indet)			**728**	**12**

GRAND TOTAL				**1296**	**61**

4.5 Non-identifiable remains

Specimens recorded as non-identifiable were those that could neither be identified to a specific skeletal part nor to a taxon. In this study, 54.9% (n=711) were recorded as non-identifiable, while 45.1% (n=585) were recorded as identifiable. Of the 585, 169 could be identified to either skeletal element or species and 416 to skeletal part. Table 15 shows the distribution of non-identifiable specimens by bone type and size.

Table 15: Quantities of non-identifiable faunal remains per class size. CRA: Cranial elements, FBN: Flat & irregular bones, LBN: Long bones, SHBN: Short bones, NID: Non-identifiable.

Size Class	**Bone Type**					**TOTAL**	**%**
	CRA	FBN	LBN	SHBN	NID		
I	-	10	286	2	-	**298**	**41.9%**
II	1	18	272	2	-	**293**	**41.2%**
III	-	4	83	1	1	**89**	**12.5%**
III/IV	-	2	12	-	-	**14**	**2%**
IV	-	-	7	-	-	**7**	**1%**
Small	2	-	6	-	-	**8**	**1.1%**
Med	-	1	1	-	-	**2**	**0.3%**
TOTAL	**3**	**35**	**667**	**5**	**1**	**711**	**100%**
Percentage	**0.4%**	**4.9%**	**93.8%**	**0.7%**	**0.1%**	**100%**	

4.6 Skeletal part representation

Although the faunal assemblage is fragmented, the MNE values are close to the NISP values (see Tables 16-20). This suggests that the specimens recovered were fragments from many identical skeletal elements rather than many fragments from the same skeletal element or from several individuals of the same species. In this case, there seem to be other post-depositional activities on transportation of the assemblage affecting the recovery of faunal remains.

4.6.1 Density mediated attrition

The MNE:NISP ratio of the assemblage shows that compact bones are more common than long bones. However, to test whether the assemblage was affected by density mediated attrition, where dense bone elements are preserved better than elements that have less dense components, a comparison of bone mineral density value to that of Lam *et al.* (1999) was performed (Table 17 and Fig 18). A spearman correlation coefficient test was run on PAST (PAleontological STatistics) software, which produced $r_s = 0.041388$, $p = 0.70855$, which does not indicate a relationship between bone density and density mediated attrition.

Table 16: MNE, MAU and %MAU of bovid family by class size.

Element	**Size I**				**Size II**				**Size III**				**Size IV**			
	NISP	**MNE**	**MAU**	**%MAU**	**NISP**	**MNE**	**MAU**	**%MAU**	**NISP**	**MNE**	**MAU**	**%MAU**	**NISP**	**MNE**	**MAU**	**%MAU**
1st Phal	16	6	0.75	37.5%	8	3	0.375	15%	4	2	0.25	25%	3	2	0.25	50%
2nd Phal	2	2	0.25	12.5%	4	3	0.375	15%	2	1	0.125	12.5%	1	1	0.125	25%
3rd Phal	4	4	0.5	25%	4	4	0.5	20%	3	3	0.375	37.5%	1	1	0.125	25%
Femur	1	1	0.5	25%	2	1	0.5	20%	-	-	-	-	-	-	-	-
Humerus	4	1	0.5	25%	4	1	0.5	20%	2	2	1	100%	-	-	-	-
MTC	5	4	2	100%	7	2	1	40%	4	2	1	100%	2	1	0.5	100%
MTP	8	1	-	-	3	0	-	-	1	0	-	-	1	0	-	-
MTT	6	1	0.5	25%	13	2	1	40%	8	1	0.5	50%	1	1	0.5	100%
Radius	1	1	0.5	25%	-	-	-	-	-	-	-	-	-	-	-	-
Tibia	1	1	0.5	25%	2	1	0.5	20%	1	1	0.5	50%	-	-	-	-
Ulna	2	2	1	40%	-	-	-	-	-	-	-	-	-	-	-	-
Carpal indet.	-	-	-	-	1	1	-0.25	-10%	-	-	-	-	-	-	-	-
Cub-Nav	5	3	2	100%	6	5	2.5	100%	2	2	1	100%	-	-	-	-
Lat.Malleolus	-	-	-	-	3	3	1.5	60%	-	-	-	-	-	-	-	-
Magnum	-	-	-	-	-	-	-	-	2	2	1	100%	-	-	-	-
Pisiform	-	-	-	-	-	-	-	-	1	1	0.5	50%	-	-	-	-
Sesamoid	10	10	0.42	20.8%	5	5	0.2	8%	9	9	0.375	37.5%	1	1	0.04	8.3%
Scaphoid	-	-	-	-	-	-	-	-	1	1	0.5	50%	-	-	-	-
Talus	1	1	0.5	25%	-	-	-	-	-	-	-	-	-	-	-	-
Acetabulum	1	1	0.5	25%	-	-	-	-	-	-	-	-	-	-	-	-
Cervical vert	5	2	0.28	14.3%	2	1	0.14	5.7%	-	-	-	-	-	-	-	-
Thoracic vert	3	2	0.17	8.3%	3	1	0.08	3.3%	-	-	-	-	-	-	-	-
Lumbar vert	3	2	0.4	20%	4	2	0.4	16%	2	1	0.2	20%	-	-	-	-
Caudal vert	1	1	0.1	5%	2	1	0.1	4%	-	-	-	-	-	-	-	-
Rib	8	1	0.04	1.9%	7	1	0.04	1.5%	2	1	-	-	-	-	-	-
Scapula	3	1	0.5	25%	-	-	-	-	2	1	0.5	50%	-	-	-	-
Mandible	1	1	0.5	25%	1	1	0.5	20%	-	-	-	-	-	-	-	-
Horncore	-	-	-	-	1	1	0.5	20%	1	1	0.5	50%	-	-	-	-
TOTAL	**91**	**49**	**12.41**		**82**	**39**	**10.46**		**47**	**31**	**8.325**		**10**	**7**	**1.54**	

Table 17: Bone mineral density (BMD) data from Lam et al. (1999) for Connochaetes taurinus compared to %MAU for the bovids (I, II, III and IV class-sizes combined) from OBP.

Bone	**Portion**	**BMD**	**NISP**	**MNE**	**MAU**	**%MAU**
Acetabulum	AC1	0.64	1	1	0.5	10
Astragalus	AS1	0.67	1	1	0.5	10
	AS2	0.77	1	1	0.5	10
Atlas (cervical)	AT1	0.55	-	-	-	-
	AT2	0.57	-	-	-	-
	AT3	0.66	-	-	-	-
Axis (cervical)	AX1	0.87	-	-	-	-
	AX2	0.41	-	-	-	-
	AX3	0.45	-	-	-	-
Calcaneum	CA1	0.57	-	-	-	-
	CA2	0.76	-	-	-	-
	CA3	0.67	-	-	-	-
	CA4	0.75	-	-	-	-
Cubo-navicular	Average value	0.61	13	10	5	100
	Caudal	0.41	3	2	0.28	5.71
Other cervicals	CE1	0.52	-	-	-	-
	CE2	0.47	-	-	-	-
	Cervical average	0.50	7	3	0.6	12
Thoracic	TH1	0.38	-	-	-	-
	TH2	0.47	-	-	-	-
	Thoracic average	0.43	6	3	0.25	5
Tarsal	Cuneiform	0.79	-	-	-	-
Mandible	DN1	0.46	-	-	-	-
	DN2	0.83	-	-	-	-
	DN3	0.71	1	1	0.5	10
	DN4	0.62	1	1	0.5	10
	DN5	0.47	1	1	0.5	10
	DN6	0.65	-	-	-	-
	DN7	0.83	1	1	0.5	10
	DN8	1.03	-	-	-	-
Tarsal	Ext-med cuneiform	0.84	-	-	-	-
Fibula	Fibula	0.75	-	-	-	-
Femur	FE1	0.41	2	2	1	20
	FE2	0.42	-	-	-	-
	FE3	0.50	-	-	-	-
	FE4	0.65	-	-	-	-
	FE5	0.49	-	-	-	-
	FE6	0.38	1	1	0.5	10
	FE7	0.31	-	-	-	-

Humerus	HU1	0.31	4	3	1.5	30
	HU2	0.42	-	-	-	-
	HU3	0.70	-	-	-	-
	HU4	0.61	-	-	-	-
	HU5	0.51	6	2	1	20
	hyoid	0.26	-	-	-	-
Ilium (pelvis)	IL1	0.39	-	-	-	-
	IL2	0.62	-	-	-	-
Ischium (pelvis)	IS1	0.65	-	-	-	-
	IS2	0.31	-	-	-	-
Lumbar vertebra	LU1	0.58	-	-	-	-
	LU2	0.52	-	-	-	-
	LU3	0.56	-	-	-	-
	Lumbar average	0.55	9	5	1	20
Carpals	lunate	0.70	-	-	-	-
	magnum	0.67	2	2	1	20
Metacarpal	MC1	0.58	11	5	2.5	50
	MC2	0.72	6	4	2	40
	MC3	0.86	6	4	2	40
	MC4	0.62	2	1	0.5	10
	MC5	0.56	-	-	-	-
	MC6	0.62	-	-	-	-
Metatarsal	MR1	0.63	10	4	2	40
	MR2	0.71	6	3	1.5	30
	MR3	0.84	18	3	1.5	30
	MR4	0.65	2	1	0.5	10
	MR5	0.54	-	-	-	-
	MR6	0.65	-	-	-	-
First phalanx	P1-1	0.47	8	5	0.63	12.5
	P1-2	0.51	1	1	0.13	2.5
	P1-3	0.76	21	7	0.88	17.5
Second phalanx	P2-1	0.47	4	4	0.5	10
	P2-2	0.56	7	6	0.75	15
Third phalanx	P3-1	0.42	12	12	1.5	30
Radius	RA1	0.51	1	1	0.5	10
	RA2	0.62	1	1	0.5	10
Rib	Average value	0.52	17	3	0.12	2.31
Sacrum	SC1	0.35	-	-	-	-
	SC2	0.41	-	-	-	-
Scapula	SP1	0.68	5	3	1.5	30
	SP2	0.71	-	-	-	-
	SP3	0.74	-	-	-	-
	SP4	0.65	-	-	-	-
	SP5	0.50	-	-	-	-
Tibia	TI1	0.42	1	1	0.5	10

	TI2	0.55	1	1	0.5	10
	TI3	0.77	3	2	1	20
	TI4	0.57	1	1	0.5	10
	TI5	0.48	-	-	-	-
Ulna	UL1	0.46	2	2	1	20

A scatterplot of the %MAU of bovids from OBP against the bone mineral density values of Lam *et al.* (1999) does not shows a visual relationship between bone density and the rate of recovery of elements with dense properties.

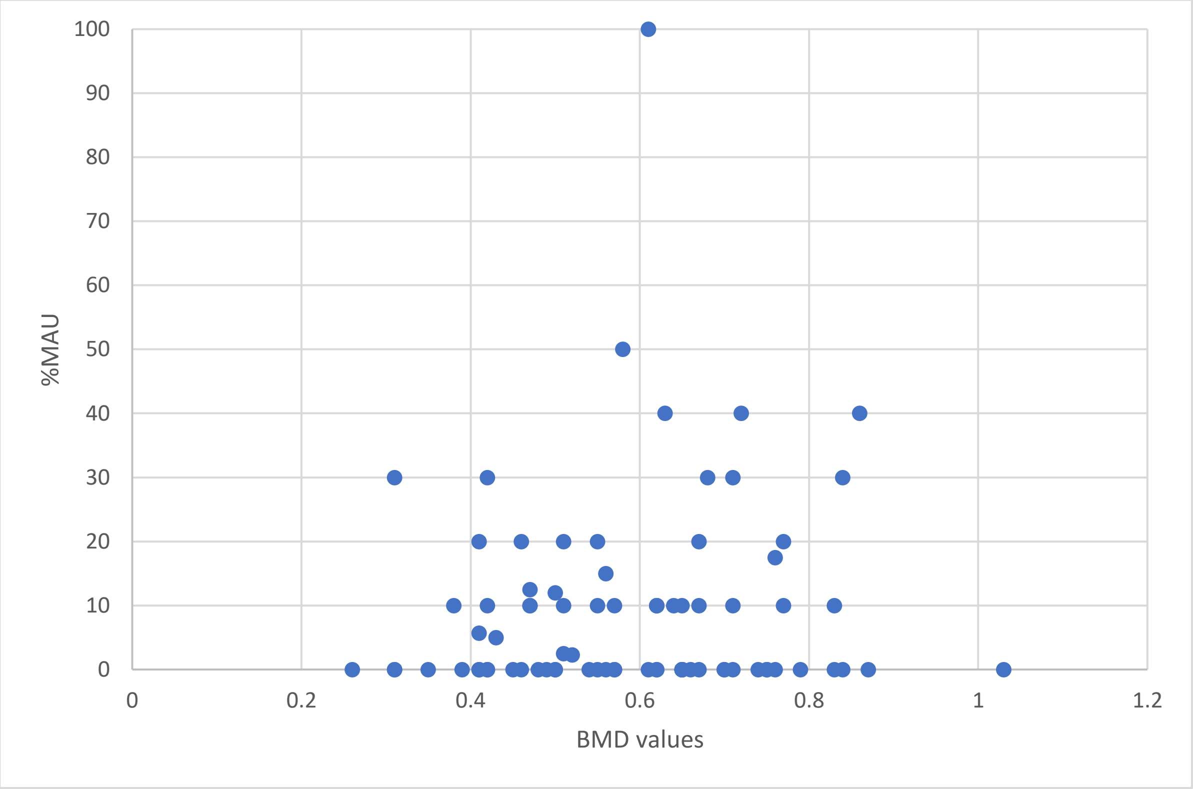

Figure 18: A scatterplot of %MAU for bovids (I, II, III and IV class-sizes combined) from OBP against against bone mineral density (BMD) data for *Connochaetes taurinus* from Lam *et al.* (1991).

Table 18: MNE, MAU and %MAU of Testudinidae, Equidae, Leporidae and Procaviidae families.

	Testudinidae				**Equidae**				**Leporidae**				**Procaviidae**			
Element	**NISP**	**MNE**	**MAU**	**%MAU**	**NISP**	**MNE**	**MAU**	**%MAU**	**NISP**	**MNE**	**MAU**	**%MAU**	**NISP**	**MNE**	**MAU**	**%MAU**
1st Phal	-	-	-	-	-	-	-	-	5	5	0.625	9.6%	2	2	0.25	3.8%
2nd Phal	-	-	-	-	-	-	-	-	-	-	-	-	1	1	0.125	1.9%
Femur	28	13	6.5	100%	-	-	-	-	1	1	0.5	7.7%	-	-	-	-
Fibula	2	2	1	15.4%	-	-	-	-	-	-	-	-	-	-	-	-
Humerus	20	10	5	76.9%	-	-	-	-	-	-	-	-	-	-	-	-
MTT	-	-	-	-	-	-	-	-	1	1	0.5	7.7%	-	-	-	-
MTP	-	-	-	-	-	-	-	-	2	0	-	-	-	-	-	-
Radius	2	2	1	15.4%	-	-	-	-	-	-	-	-	-	-	-	-
Tibia	4	4	2	30.8%	1	1	0.5	7.7%	-	-	-	-	-	-	-	-
Ulna	4	3	1.5	23.1%	-	-	-	-	-	-	-	-	-	-	-	-
Sesamoid	-	-	-	-	5	5	0.4	6.2%	-	-	-	-	-	-	-	-
Cub-Nav	-	-	-	-	-	-	-	-	1	1	0.5	7.7%	-	-	-	-
Ischium	4	4	2	30.8%	-	-	-	-	-	-	-	-	-	-	-	-
Scapula	1	1	0.5	7.7%	-	-	-	-	-	-	-	-	-	-	-	-
Illium	2	2	1	15.4%	-	-	-	-	-	-	-	-	-	-	-	-
Corac	1	1	0.5	7.7%	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	**68**	**42**	**21**		**6**	**6**	**0.9**		**10**	**8**	**2.125**		**3**	**3**	**0.375**	

Table 19: MNE, MAU and %MAU of Cercopithecidae, Felidae, Herpestidae and Hyaenidae families.

	Cercopithecidae				Felidae				Herpestidae				Hyaenidae			
Element	**NISP**	**MNE**	**MAU**	**%MAU**	**NISP**	**MNE**	**MAU**	**%MAU**	**NISP**	**MNE**	**MAU**	**%MAU**	**NISP**	**MNE**	**MAU**	**%MAU**
1st Phal	5	5	0.625	9.6%	2	2	0.125	1.9%	-	-	-	-	-	-	-	-
Calca	-	-	-	-	1	1	0.5	7.7%	-	-	-	-	1	1	0.5	7.7%
Cub-Nav	-	-	-	-	-	-	-	-	1	1	0.5	7.7%	-	-	-	-
TOTAL	**5**	**5**	**0.625**		**3**	**3**	**0.625**		**1**	**1**	**0.5**		**1**	**1**	**0.5**	

Table 20: MNE/NISP ratio by skeletal element per family and by bovid size classes.

Skeletal element	**MNE/NISP Ratio**											
	Bov I	**Bov II**	**Bov III**	**Bov IV**	**Testudinidae**	**Equidae**	**Leporidae**	**Procaiividae**	**Herpestidae**	**Hyaenidae**	**Felidae**	**Ceropithecidae**
1st Phal	0.375	0.375	0.5	0.6	-	-	1	1	-	-	1	1
2nd Phal	1	0.75	0.5	1	-	-	-	1	-	-	-	-
3rd Phal	1	0.75	0.5	1	-	-	-	-	-	-	-	-
Femur	1	0.5	-	-	0.5	-	1	-	-	-	-	-
Tibia	1	0.5	1	-	1	1	-	-	-	-	-	-
Humerus	0.25	0.25	1	-	0.5	-	-	-	-	-	-	-
Fibula	-	-	-	-	1	-	-	-	-	-	-	-
MTC	0.8	0.29	0.5	0.5	-	-	-	-	-	-	-	-
MTT	0.167	0.15	0.125	1	-	-	1	-	-	-	-	-
MTP	0.125	0	0	0	-	-	0	-	-	-	-	-
Radius	1	-	-	-	1	-	-	-	-	-	-	-
Ulna	1	-	-	-	0.75	-	-	-	-	-	-	-
Sesamoid	1	1	1	1	-	1	-	-	-	-	-	-
Lat.Malleous	-	1	-	-	-	-	-	-	-	-	-	-
Cub-Nav	0.6	0.83	1	-	-	-	1	-	1	-	-	-
Ischium	-	-	-	-	1	-	-	-	-	-	-	-
Illium	-	-	-	-	1	-	-	-	-	-	-	-
Scapula	0.33	-	0.5	-	1	-	-	-	-	-	-	-

Calca	-	-	-	-	-	-	-	-	-	1	1	-
Corac	-	-	-	-	1	-	-	-	-	-	-	-
Carpal	-	1	-	-	-	-	-	-	-	-	-	-
Talus	1	-	-	-	-	-	-	-	-	-	-	-
Acetabulum	1	-	-	-	-	-	-	-	-	-	-	-
Scaphoid	-	-	1	-	-	-	-	-	-	-	-	-
Magnum	-	-	1	-	-	-	-	-	-	-	-	-
Rib	0.125	0.14	0.5	-	-	-	-	-	-	-	-	-
Cervical Vert	0.4	0.5	-	-	-	-	-	-	-	-	-	-
Thoracic Vert	0.67	0.33	-	-	-	-	-	-	-	-	-	-
Lumbar Vert	0.67	0.5	0.5	-	-	-	-	-	-	-	-	-
Caudal Vert	1	0.5	-	-	-	-	-	-	-	-	-	-
Mandible	1	1	-	-	-	-	-	-	-	-	-	-
Horncore	-	1	1	-	-	-	-	-	-	-	-	-

4.7 Age estimate

Identifiable bones were assigned to three broad age categories when possible: juveniles, sub-adults and adults. A total of 56 specimens could be assigned to age categories. These specimens include dental remains (n=14 or 25%), flat bones (n= 4 or 7.1%) and long bones (n=38 or 67.9%). Age estimates shows a uniform pattern for adults and juveniles as illustrated in Table 21 and 22.

Table 21: Age estimates per size class and bone type.

	Juv			**Juv Total**	**Sub-adult**	**Sub-adult Total**	**Adult**			**Adult Total**	**Grand Total**	**%**
Size	**CRA**	**FBN**	**LBN**		**LBN**		**CRA**	**FBN**	**LBN**			
I	**-**	**1**	**4**	**5**	**-**	**-**	**1**	**2**	**3**	**6**	**11**	**19.6%**
BONE	-	1	4	5	-	-	-	2	3	5	10	
BONE+TTH	-	-	-	-	-	-	1	-	-	1	1	
II	**-**	**-**	**1**	**1**	**-**	**-**	**2**	**1**	**-**	**3**	**4**	**7.1%**
BONE	-	-	1	1	-	-		1	-	1	2	
TTH	-	-	-	-	-	-	2	-	-	2	2	
III	**-**	**-**	**-**	**-**	**-**	**-**	**4**	**-**	**1**	**5**	**5**	**8.9%**
BONE	-	-	-	-	-	-	-	-	1	1	1	
TTH	-	-	-	-	-	-	4	-	-	4	4	
III/IV	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**-**	**1**	**1**	**2**	**3.6%**
BONE	-	-	-	-	1	1	-	-	1	1	2	
IV	**1**	**-**	**-**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**1**	**1.8%**
TTH	1	-	-	1	-	-	-	-	-	-	1	
Large mammal	**-**	**-**	**-**	**-**	**-**	**-**	**6**	**-**	**-**	**6**	**6**	**10.7%**
TTH	-	-	-	-	-	-	6	-	-	6	6	
Med	**-**	**-**	**1**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**1**	**1.8%**
BONE	-	-	1	1	-	-	-	-	-	-	1	
Small	**-**	**-**	**19**	**19**	**1**	**1**	**-**	**-**	**6**	**6**	**26**	**46.4%**
BONE	-	-	19	19	1	1	-	-	6	6	26	
Grand Total	**1**	**1**	**25**	**27**	**2**	**2**	**13**	**3**	**11**	**27**	**56**	**100%**
% per type	**3.7%**	**3.7%**	**92.6%**	**100%**		**100%**	**48%**	**11%**	**41%**	**100%**		
% total per age				**48%**		**4%**				**48%**		**100%**

Table 22: Age estimates by taxon. Data is given in MNI.

Taxon	**Age (MNI)**		
	Juvenile	**Sub-adult**	**Adult**
Alcelaphus sp.	-	-	1
Tortoise	5	1	1
Equus sp.	-	-	2
Lepus sp.	1	-	-
Raphicerus campestris	-	-	1
Redunca sp.	-	-	1
Sylvicapra grimmia	-	-	1
Syncerus caffer	1	-	-
Bov I	2	-	1
Bov II	1	-	2
Bov III	-	1	3
Size I	2	-	-
Size II	1	-	-
Small	1	-	2
TOTAL	**14**	**2**	**15**

4.8 Bone surface modifications

Because of the heavy concretions covering most of the faunal material from OBP and due to time constraints, we decided to use light acid preparation to expose bone surfaces and to conduct a systematic microscopic investigation of bone surface modifications only for the plotted material. Hence, for consistence in recording, only plotted specimens, composed of bone, dental remains and teeth are reported here (n = 898).

4.8.1 Light acid preparation to remove concretions

Acetic acid was diluted with water, and this light acid preparation proved to be highly successful in this study. This procedure ensured that bone surfaces could be easily observable once the concretions had been gently removed. Fig (19) illustrates some of the specimens before and after acid preparation.

Figure 19: Light acid preparation. (a) Examples of specimens from OBP before acid preparation, (b) Examples of specimens after acid preparation.

4.8.2 Processes affecting bone surface's visibility

After light acid preparation, most specimens 73.3% (n= 658) were recorded as having less than 25% of their bone surface covered with concretions. This is illustrated by Fig (20).

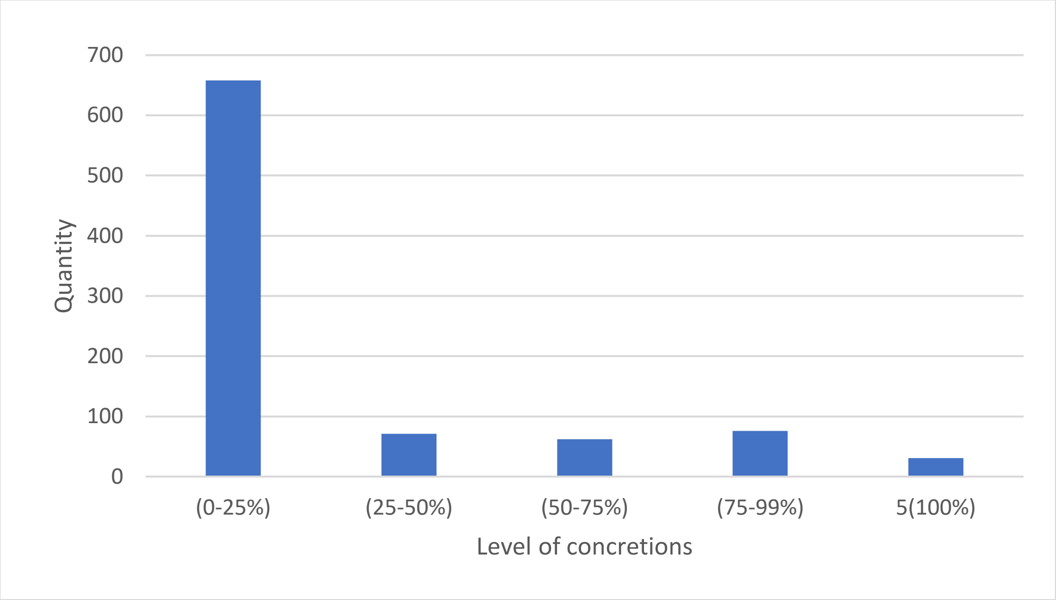

Figure 20: Graph showing the level of concretions after light acid preparation.

Several factors, including manganese staining, weathering and water abrasion, have affected cortical preservation. The assemblage presented limited cortical preservation. Specimens with < 50% of the cortical preserved accounted for 54.7% (n= 491), while those with > 50% of the cortical surface preserved accounted for 45.3% (n= 407) as illustrated by Fig (21).

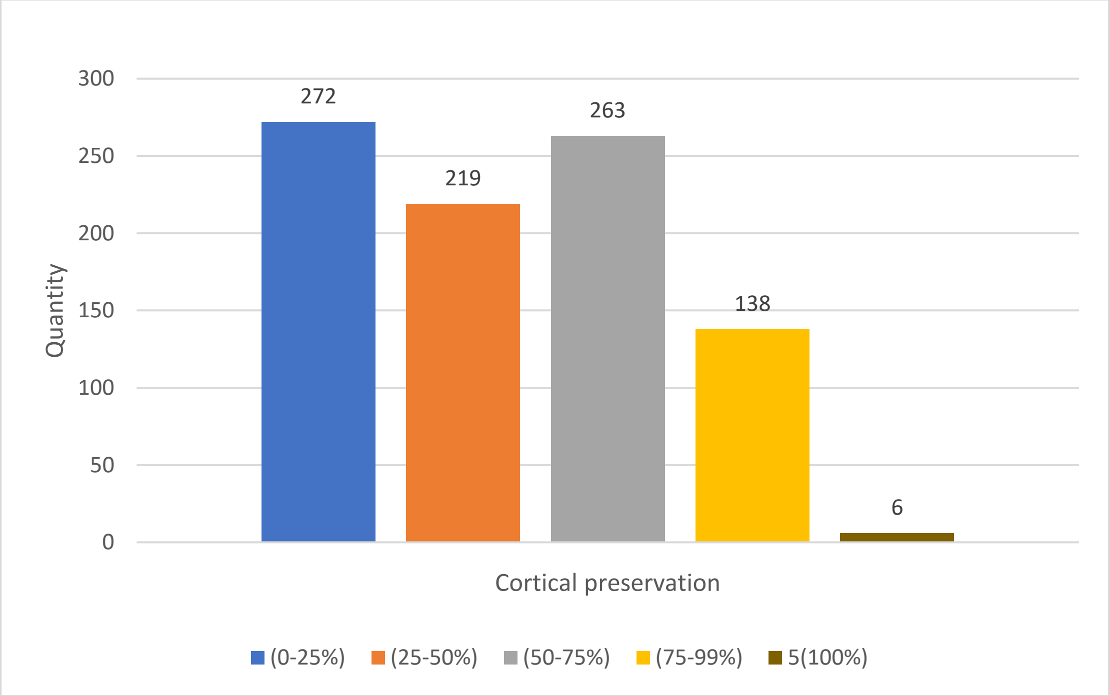

Figure 21: Degree of cortical preservation of the OBP faunal assemblage. The data (quantity) is given in numbers of plotted remains.

Manganese

Manganese coatings have affected cortical preservation. Most specimens showed various degree of manganese coatings, although this seem not to have been a major factor since 49.9% (n= 448) had only 0-25% of the bone covered with manganese coatings, as illustrated in Fig (22).

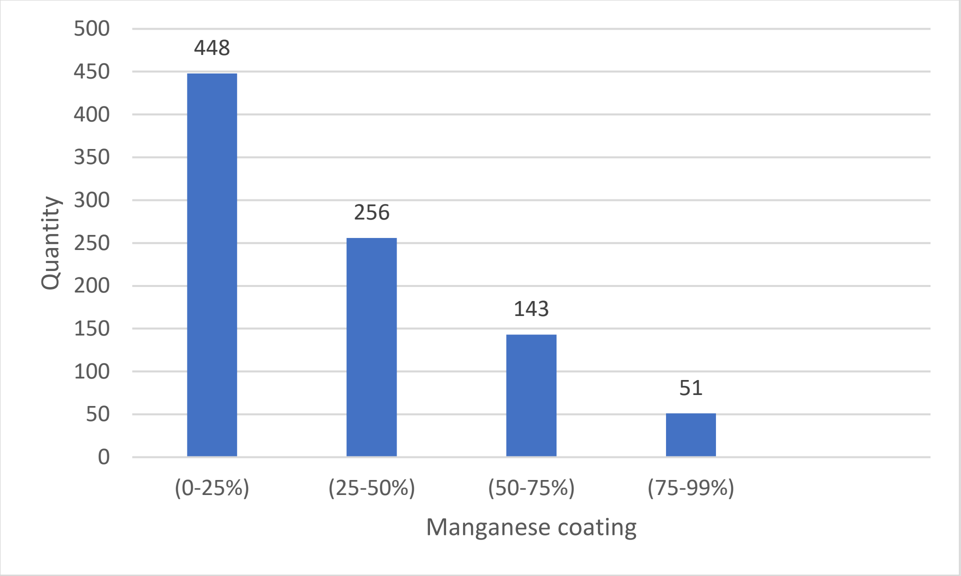

Figure 22: Extent of manganese present on the faunal assemblage. The data (quantity) is given in numbers of plotted specimens.

Water abrasion

The faunal assemblage from OBP was also affected by water abrasion. Of the 898 specimens, 168 showed evidence of water abrasion, which in most cases were heavily abraded while 730 were not abraded. Water abrasion was dominant in the YRS layer (n= 101 or 60.1%), compared to GS (n= 57 or 33.9%) and DRG (n= 10 or 6%).

To test whether differences in water abrasion between the sedimentary units are significant, a chi-test was performed. This chi-square test did not include specimens from the DRG unit as the sample was too small. The chi-square result shows that the difference observed in water abrasion between units GS and YRS is statistically significant ($\chi^2 = 23.784$; p = 1.0775E-06). Figure 23 shows some of the specimens abraded by water.

Figure 23: Example of OBP specimens abraded by water.

Weathering

The analysis shows that weathering has not heavily affected the faunal assemblage. Most pieces 99.2% (n= 891) fell into stages 0 or 1 of Behrensmeyer’s (1978), as shown by Table 23.

Table 23: Weathering stages of the plotted assemblage.

Weathering stage	**Total**	**%**
0	855	**95.2%**
1	36	**4%**
2	6	**0.7%**
3	1	**0.1%**
TOTAL	**898**	**100%**

4.8.3 Biotic modifications (non-human)

The assemblage shows little biotic modifications on the bones. About 11.5% had trampling marks, 5% showed marks of root etching, 0.6% had evidence of acid etching from carnivores, 0.3 % of animal pitting, 0.2% of rodent gnawing and 28.3% of invertebrate damage, as shown in Table 24.

Table 24: Summary of biotic modifiers on the OBP bone assemblage. The data given is only from plotted specimens, n=898.

	Trampling	Root etching	Acid etching	Pits	Rodent gnawing	Invertebrate damage	TOTAL
Yes	103	45	5	3	2	254	412
%	**11.5%**	**5%**	**0.5%**	**0.3**	**0.2**	**28.3%**	**45.8%**

Invertebrate damage

Most of the observed invertebrate damages are on the edges and surfaces, and their features are characteristic of termites, as shown in Fig 24.

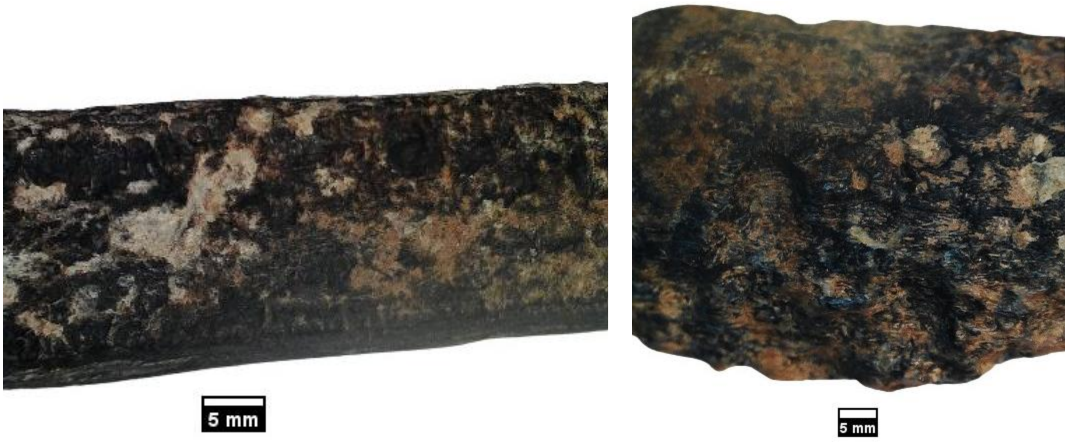

Figure 24: Examples of specimens affected by invertebrate damage.

Rodent gnawing

Two specimens showed evidence of rodent gnawing. One of the specimens (a metatarsal) was gnawed on both edges. The second specimen, which is a first phalange shows light gnawing, as shown in Figures 25 and 26.

Figure 25: A bovid metatarsal gnawed by rodents. Specimen number 322 from GS unit.

Figure 26: A bovid first phalange gnawed by rodents. Specimen number 510 from GS unit.

Acid etching and root etching

Five specimens showed acid etching, and these specimens were regurgitated by carnivores. These specimens are rounded and shiny. One specimen, which is a tortoise femur from GS unit also preserved evidence of root etching near the proximal end (Figs 27 and 28).

Figure 27: Specimens that have been regurgitated by predators showing evidence of acid etching. From left to right: Specimen number 1368 from GS unit; a tortoise femur from GS unit, Specimen number 938, a metacarpal from GS unit.

Figure 28: Non-identifiable faunal remain showing root etching on the surface.

Pits

Three specimens showed evidence of animal pitting. One of these specimens was heavily pitted probably by a larger predator while the other specimen was pitted by a smaller animal (Fig 29).

Figure 29: Specimens pitted by predators. From left to right: Long bone fragment specimen number 2452 from GS; Long bone fragment specimen number 4133 from YRS unit.

4.8.4 Anthropogenic modifications

Butchery marks

There are few specimens, which clearly showed human involvement. The only clear anthropogenic marks identified were cut-marks on some pieces. There is low frequency of cut-marks in the OBP assemblage since these occur only on 0.7% of the plotted material (n= 6). Four of these cut-marked specimens come from YRS unit and one from each of GS and DRG units. These cut-marks were all located along the shaft of long bones, and none was observed on the epiphyses. These observations are shown in Table 24. Most of the specimens with cut-marks could not be identified to skeletal element part nor to species level. The cut-marks identified are all diagonal to the bone axis.

Table 25: Shows sizes of specimen with cut-marks, skeletal part and location of cut-marks.

Size class	**Element**		**Location of cut-mark**
	MTC	NID	
II	1	3	SH
III	-	2	SH

The first specimen with cut-marks is a shaft of a non-identifiable long bone belonging to a bovid I. The cut-marks are perpendicular to the bone axis. This specimen shows that the object used to cut the bone was sharp since the cut-mark is deep (Fig 30).

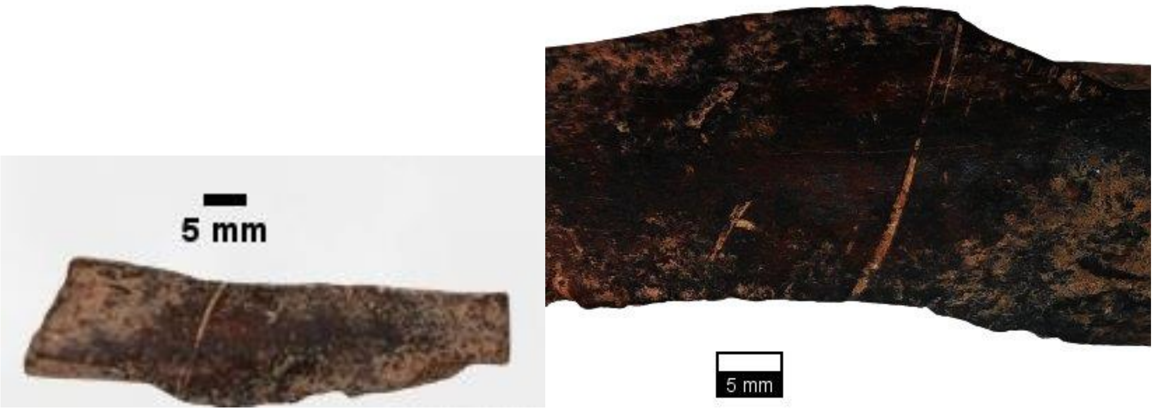

Figure 30: Specimen showing cut marks on the shaft with a microscopic view of the cut marks. Specimen number 3212 from YRS.

The second specimen with evidence of human butchery marks is a shaft of a long bone of a bovid I. The specimen has several small cut-marks diagonal to the bone axis. These cut-marks are deep and suggestive of a repetitive process (Fig 31).

Figure 31: Cut-marks on a shaft of a bovid long bone. Specimen number 3895 from YRS.

The third bone with cut-mark is from a non-identifiable medium size mammal. This specimen also shows light burning on the exterior side. The cut-mark on this specimen is superficial and diagonal to the bone cortex (Fig 32).

Figure 32: Cut-mark on specimen that is also lightly burnt. Specimen number 4822 from DRG.

The fourth specimen with cut-marks is a metacarpal of a size II mammal (Fig 33). The specimen has two cut-marks that are diagonal to the bone. These cut-marks are small but deep, covered with sediments. The specimen has another cut-mark that is deep and relatively large. There are scratching marks parallel to this specimen. However, these marks are recent because there is no sediment covering them to suggest depositional factors acting on the specimen. These marks most likely result from the cleaning process (see microscopic view for details).

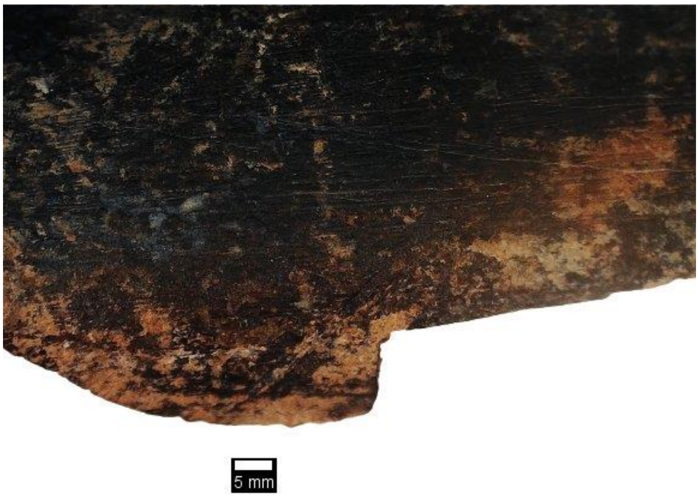

Figure 33: Diagonal cut-marks on a metacarpal. Specimen number 4170 from GS.

The fifth specimen showing evidence of cut-mark is a size III mammal. The specimen also shows evidence of polishing. The cut-mark is located diagonally on the shaft. The cut-mark is superficial (Fig 34).

Figure 34: Specimen with a superficial cut-mark. Specimen number 3655 from YRS.

The sixth specimen that has a cut-mark is a bovid I non-identifiable long bone shaft fragment. The cut-mark is diagonal to the bone axis. The cut-mark is superficial (Fig 35).

Figure 35: Specimen with a superficial cut-mark. Specimen number 3212 from YRS.

Burning

There is little evidence of burning within the assemblage. Only 0.9% (n=8) shows evidence of localized burning, consistent with a score of 1 following Stiner *et al* (1995) for specimens that are only slightly burned. One of these eight specimens also has cut-marks (see above).

One *Equus* sp. sesamoid is burnt on both the interior and exterior sides. A pisiform of a bovid III is also burnt on both sides. There are other two long bones of mammal II specimens that are burnt on the shaft. Three long bones of mammal III are also burnt on the shaft.

CHAPTER 5: DISCUSSION

5.1 Introduction

In this chapter, I discuss the results from the taxonomic and taphonomic analyses of the MSA fauna from OBP and place them within the broader context of subsistence strategies of hominins during MIS 6 in southern Africa. I will start by discussing the role played by different taphonomic agents in the accumulation and post-depositional modification of the faunal remains at the site. Based on the composition of the faunal spectrum, I propose some reconstructions of palaeohabitats around OBP during MIS 6. Since hominins likely accumulated a significant portion of the faunal assemblage, I will also discuss the subsistence strategies adopted by the occupants of the rock shelter. Finally, I compare the faunal assemblage from OBP with faunal assemblages retrieved from other MIS 6 sites across southern Africa.

5.2 Taphonomy of the OBP MSA faunal assemblage

5.2.1. Modes of accumulation of animal remains inside the site

A. Carnivore and raptor contribution

Acid-etching and gnawing damage are present in the OBP faunal assemblage, thus warranting a discussion of possible carnivore contribution to the accumulation of the assemblage. Carnivores identified at OBP are aardwolf (*Proteles cristata*) and African wild cat (*Felis silvestris*).

Hyaenids: there are several criteria that have been proposed by researchers to identify the contribution of hyaenids in the accumulation of fossil assemblages. One criterion is based on the taxonomic composition of the assemblage, where the carnivore-ungulate ratio of hyaenid-accumulated assemblages is typically ≥20%, while for hominin accumulations, the ratio would be <13% (Cruz-Uribe 1991; Pickering 2002). At OBP, the carnivore-ungulate ratio of 1.4% is more indicative of a faunal assemblage accumulated by hominins rather than hyaenas.

Another criterion relates to the nature of bone breakage in a hyaena-accumulated assemblage. Carnivores feeding on defleshed bones tend to destroy epiphyses of long bones, causing an abundance of bone cylinders. Bone cylinders are limb shafts that lack epiphyses but retain their original circumferences along their lengths (Pickering 2002). In an assemblage accumulated by hyaenids, epiphyses are few (Brain 1981; Cruz-Uribe 1991; Marean *et al.* 1992; Pickering 2002). At OBP, I did not observe bone cylinders and epiphyses are missing. I propose that their absence is a result of fragmentation and transport by water (see below).

Hyaena-accumulated assemblages also show evidence of acid etching and tooth marks (pits, punctures and scores). In a fossil assemblage, the extent of these modifications can be minimal compared to modern assemblage, where it can reach 50% (e.g. Cruz-Uribe 1991). According to Faith (2007) and Kuhn *et al.* (2010), 70%, or more, of faunal remains from contemporary hyaena lairs have evidence of gnawing or other bone modifications. In the OBP faunal assemblage, pits and acid etching were observed on eight bones (0.6%), which is significantly lower than what one would expect if hyaenas were the primary agent for bone accumulation.

Lastly, hyaena dens are characterised by the presence of either an abundance of coprolites or the remains of juvenile hyaenas (Cruz-Uribe 1991; Pickering 2002; Kuhn *et al.* 2010). At OBP, coprolites and juvenile hyaenas were not recovered. The presence of termite mounds from OBP (van der Ryst 2007) could have attracted *Proteles cristata* (Aardwolf) to this site. Termites contributes over 90% to the overall diet of aardwolves (Cooper & Skinner 1979; Richardson & Levitan 1994). Thus, it is not surprising to note the presence of both aardwolves and termite modifications on bones in the OBP faunal assemblage. Thus, when one considers the above listed criteria, significant hyaena involvement or carnivores in the faunal accumulation at OBP appears unlikely.

Leopards: leopards prefer to prey on small to medium animals. Observations of damage caused by leopards to the crania of their prey, indicate that punctures resulting from their canines are common (Brain 1981). Vertebrae and ribs tend to be underrepresented in leopard assemblages, while damage can be observed in other skeletal parts. Since OBP is located in a rocky area, it is common to find rock hyraxes. Leopard feeding on rock hyraxes leads to minimal cranial damage with a possibility of recovering the anterior parts of the skulls, while post-cranial remains are rarely recovered (Brain 1981). I did not observe this type of damage on the few hyrax bones from the OBP assemblage.

Observations in eastern and southern Africa indicate that leopards prefer to prey on bovids of size class II, and that juveniles make up the largest proportion of large mammals preyed upon (Brain 1981). Leopards also feed on small carnivores, like jackals (Brain 1981). After a successful kill, leopards usually transport their prey some distances before the feeding begin. Feeding can take place in trees or caves (Brain 1981). Given the morphology of OBP, it seems unlikely that this site was used by leopards as a feeding retreat or a breeding lair. Leopards prefer dark caves, dense thickets (Brain 1981), whereas OBP is too exposed. The taphonomic characteristics from OBP is not indicative of leopards as bone accumulators at OBP.

Birds of prey: Some diurnal (e.g. eagles and falcons) and nocturnal (e.g. owls and eagle-owls) birds of prey perch or roost inside caves and rock shelters and can accumulate faunal remains. Birds of prey feed on a wide range of small to medium mammals, including small and medium rodents, birds, fishes, reptiles, leporids, hyraxes and small bovids (Brain 1981; Andrews 1990; Armstrong & Avery 2014). The characteristic manner in which birds of prey modify skeletal remains is usually dependent on their specific killing and feeding methods, as well as on the morphology of their prey (e.g. bird versus mammal skeletons).

Birds of prey cause a number of bone surface modifications. These modifications include punctures, pits, scores, notches and crenulated edges, which result mostly from beak and talon damage. Based on the assemblage analysed by Armstrong & Avery (2014), punctures are the major modifications caused by Verreaux's Eagle.

An assessment of the prey remains from Verreaux's Eagle (*Aquila verreauxii*) nest sites, indicates an abundance of hyraxes, leporids, mole-rats and small carnivores, while few bovid remains were identified (Armstrong & Avery 2014). The small prey are primarily represented by cranial elements, while post-cranial elements are rare. At OBP, cranial remains are rare, and the possibility of birds preying on small mammals seems unlikely as no modifications on bone surfaces were attributable to birds of prey.

B. Role played by hominins

Burning affects the strength of bones, making burnt bones susceptible to further fragmentation. Several studies such as the ones led by Stiner *et al.* (1995) and Clark (2009) demonstrate that the colour of burnt bones depends on the intensity of burning, time and temperature. Bones burnt for longer periods become calcined, i.e. white in colour. Few bones from the MSA units of OBP showed evidence of burning. Those that are burnt, show that the burning was highly localised, of short duration and not intense based on Stiner *et al.*'s (1995) classification.

A number of processes may result in burnt bones. Such processes may be anthropogenic and intentional (e.g. cooking, roasting, use of bone as fuel, discard of bones into fire) or natural (bush fires). Usually, intentional burning results in calcine covering much of the bone surface area, while bones burnt due to natural processes are carbonized (David 1990). Burnt bones can relate to cooking practices or patterns of discard. Burning concentrated on epiphyseal ends may indicate roasting, while burning that extends to shafts may indicate meat removal prior to cooking (Clark 2009). In some cases, bones were discarded in campfires after consumption or were used as fuel (e.g. Discamps & Henshilwood 2015).

Intentional burning of bones during the MSA has been used as an indicator of meat processing activities. The location of burnt areas on bones from OBP has been assessed to determine whether burning was intentional or unrelated to human activities.

At OBP, the recovery of burnt bones from the MSA units is the only evidence of fire recorded during this period. The location of burnt areas on bones from OBP does not indicate intentional burning. The OBP bones are burnt on one side. This pattern is typical of accidental burning, where the side of the bone that is close to the fire shows evidence of burning.

Direct evidence of human butchery is attested by the presence of cut-marks. At OBP, six specimens show evidence of cut-marks. These cut-marks are all located along the shaft of long bones. Carcass disarticulation results in cut-marks near articulation ends. For instance, clusters of cut-marks on articular processes of mandibles, scapulae, vertebrae, ribs and limb bones are characteristic of dismemberment of carcasses (Binford 1981; Domínguez-Rodrigo 2002; Domínguez-Rodrigo & Pickering 2003; Reynard *et al.* 2016). I did not observe cut-marks related to disarticulation of animal carcasses at OBP.

One specimen (see #3895 in the Results section) from OBP had a cluster of cut-marks. A cluster of cut-marks can be related to skinning or filleting (e.g. Domínguez-Rodrigo 1999; Val & Mallye 2011; Reynard *et al.* 2016). The cut-marks on this specimen are of either skinning or filleting.

The presence of cut-marks indicates direct evidence of human exploitation of the faunal remains. However, the low frequency of cut-marks from OBP might be a result of two factors explained below, i.e human exploitation of faunal remains at OBP was minimal or alternatively, due to taphonomic processes, butchery marks were not preserved.

When one looks at subsistence strategies of hominins during MIS 6 in southern Africa, butchery marks are uncommon (see discussion on MIS 6 subsistence strategies). At sites where butchery marks are recorded, they constitute no more than 1% of the assemblage (see Hutson 2012, 2018; Backwell *et al.* 2014). In this instance, it seems that OBP does not differ from other MIS 6 sites, where hominin butchery activity was either limited and or poorly preserved.

Specifically, at OBP, a number of taphonomic processes have affected the faunal assemblage. Poor cortical preservation could have resulted in low cut-mark frequency include poor cortical preservation. At OBP, cortical preservation was affected by water abrasion and encrustations. Water abrasion affects original bone surfaces, which could have also resulted in the recovery of low cut-marks. The abundant concretions, which covered most of the faunal remains retrieved during the 2018 and 2019 excavation, could have covered areas with cut-marks, resulting in low cut-mark frequency. However, I used light acid preparation so that bone surfaces are visible from such concretions on the plotted specimens. This method did not work on some specimens, which had thicker concretions. Nonetheless, if cut-marks were more abundant, their presence would have been revealed, which was not the case.

The bones were recovered inside sediments, which contain abundant lithic implements and ochre pieces. It is likely that humans played a role in the accumulation of some of the faunal remains, despite the limited frequency of cut-marked bones. The post-depositional processes, such as water transport, have affected the assemblage but the composition of the faunal spectrum, the association between the faunal remains and the archaeological material and the limited impact played by non-human predators, support the hypothesis of an anthropogenic faunal assemblage.

C. Origin of small mammals

Small prey species such as leporids and rock hyraxes commonly occur in rocky areas that surround OBP. I did not observe any cut-marks, burning or percussion marks on these remains. The absence of butchery marks might not necessarily mean that humans were not involved. Although the sample used in age estimate is small, Bov I, II and small mammals are dominated by juveniles. The presence of juveniles could imply that these remains were a result of carnivore action (e.g. Thackeray 1990) or raptor accumulation (e.g. Armstrong & Avery 2014).

Armstrong & Avery (2014) reported that juvenile bovids dominated the prey of eagles. When one compares skeletal part representation typical of raptor accumulation as shown by Armstrong & Avery (2014), where bovid mandibles are most represented followed by post-cranial elements, the OBP data is most represented by compact bones followed by metapodials. This may suggest that bovid mandibles could have been transported by water given its effect on the OBP assemblage.

D. Role played by porcupines

Porcupines are known bone accumulators in the fossil record. Porcupines gnaw on bones to trim their ever-growing incisors. This action causes chisel-like modifications on the gnawed bones, while epiphyses are often missing as they are totally consumed by porcupines (Maguire 1976; Kibii 2009). Typically, active porcupine involvement in faunal assemblages results in 50% or more bones showing evidence of gnawing (e.g. Brain 1981; Kibii 2009). At OBP, only 0.2% (n=2) of the assemblage exhibit evidence of gnawing by porcupines. While porcupines might have occasionally modified the OBP faunal assemblage, their role is minimal.

5.2.2. Post-depositional processes

A. Density-mediated attrition

The survival and recovery of skeletal elements can be influenced by their density (Lam *et al.* 1999). Skeletal elements with high density, such as carpals, are more likely to be recovered if the assemblage has not been modified by other processes. The OBP assemblage is composed of several skeletal elements that have a high density. While the OBP assemblage is likely to have suffered density-mediated attrition (see results section), this signal is blurred by high fragmentation and recovery biases likely related to water transport. Consequently, a comparison of OBP bovid remains with data provided by Lam *et al.* (1999) did not establish a statistically significant correlation between bone survival and bone mineral density.

A similar pattern was observed by Klein (1976) and Bartram & Marean (1999). Such a pattern suggests that "high density long bone shaft fragments would certainly survive intra-site attrition if they were there to begin with" (Bartram & Marean 1999: 22). At OBP, high fragmentation of the assemblage means that most long bone shafts could not be identified to skeletal part, let alone species. This is in contrast to epiphyses and epiphyses fragments, which could be attributed to skeletal element due to the presence of the diagnostic features.

B. Water action

One of the aims of this research was to evaluate the impact of water on bone preservation. Van der Ryst (2007) already noted the effect of water on the LSA OBP assemblage. This research has also noted the effect of water to the MSA faunal assemblage.

Understanding the role of water at OBP is important because it might affect our ability to reconstruct carcass processing strategies by hominins. The presence of the Riet Spruit, a tributary of the Moloko River located a few metres from the shelter, likely made OBP attractive to hominins, possibly since the Middle Pleistocene (Val *et al.* 2021).

The proximity of a water source also had an effect on the assemblage. Due to the availability of water and calcium carbonates, concretions were formed on archaeological material. Although the concretions affected the visibility of surface modifications, it is plausible that this effect was partly responsible for preserving faunal specimens at OBP. On the other hand, high calcium carbonate content in sediments could have also preserved the assemblage. At other MSA sites in southern Africa, bone preservation is poor, which makes the OBP faunal assemblage interesting in this regard.

There are three sedimentary units from which the specimens were retrieved. These units (GS, YRS and DRG) relate to different sedimentological processes as reflected in different colours, texture and appearance. They seem not to relate to different occupational periods. Water abrasion is more evident in YRS than in GS. Differences in water abrasion between two sedimentary units (GS and YRS) is statistically significant ($\chi^2 = 23.784$; p = 1.0775E-06). This suggests that the water level was high and more powerful during the sedimentological process of YRS. At OBP, periods of high precipitation could have flooded the floor of the rock shelter, which could have transported faunal remains.

Experimental work on sheep (*Ovis aries*) and coyote bones (*Canis latrans*) transport in water by Voorhies (1966) established three groups based on susceptibility to water transport. Water transport of bone elements is affected by their shape and density. Elements with a low density, i.e. with spongy bone, sternum, sacrum, vertebrae) have a better transport potential (Group I of Voorhies) than compact and dense bones i.e. long bones, mandibles, pelvis, tarsals (Groups II and III of Voorhies), Table 26 from Voorhies (1966).

The survival and recovery of skeletal elements can be affected by the density of the elements (Brain 1981, Lyman 1994b; Lam *et al.* 1999). Skeletal elements that have spongy areas such as vertebrae and sacra are less dense, hence, they are susceptible to being transported. On the other hand, elements with compact bones such as tarsals are dense, making their transportation relatively difficult compared to less dense elements. In an assemblage where dense elements are common, it is highly probable that such an assemblage was affected by density mediated attrition. At OBP, density mediated attrition appears to have affected its faunal assemblage. While this appears to have been the case, water transportation likely also played a key role in the recovery bias of specimens.

Table 26: Susceptibility of transportation of skeletal elements by water based on coyote and sheep skeletons. Adapted from Voorhies (1966: 69). Elements italicized are intermediate in the Groups they appear.

Group I*	**Group II#**	**Group II≈**
Ribs	Femur	Skull
Vertebrae	Tibia	Mandible
Sacrum	Metapodials	*Ramus*
Sternum	Humerus	
Scapula	Pelvis	
Phalanges	Radius	
Ulna	*Scapula*	
	Phalanges	
	Ulna	
	Ramus	

*: immediately removed or transported by saltation or floatation.

#: removed gradually by traction.

≈: lag deposit.

Skeletal elements recovered from OBP seem to confirm the Voorhies Groups of water susceptibility. Skeletal elements that are in Voorhies Group (excluding intermediates), consists of ribs (n = 17) and vertebrae (n = 25) giving a total of 42 or 3.2% of the assemblage analysed.

It is probable that most of these elements with high water transport potential were transported from the site.

The action of water is illustrated by specimens that have been abraded. Most likely, the area where the site is located experienced periodic flooding, which transported faunal material from the talus towards the Riet Spruit tributary as supported by geoarchaeological observations (Val *et al.* 2021). Thus, water action at OBP has led to recovery biases and has affected skeletal representation.

C. Invertebrate damage

Invertebrates such as termites modify bones in a characteristic manner. Termite activity is seasonal as they do not feed during the winter. Foraging begins during summer with a peak of activity during the autumn and spring when temperatures are relatively high as well (Adam *et al.* 2008; Backwell *et al.* 2012).

Termites feed on bones regardless of state of preservation. Bones provide protein and lipids to termites. Termites prefer spongy, fresh bones with meat and marrow for calcium and other trace element requirements (Backwell *et al.* 2012). Given that termites modify bone assemblage at all stages of preservation, their activity can bias element representation and site formation processes.

Based on the experimental work by Backwell *et al.* (2012), star shaped marks and surface pits caused by termite foraging represent initial pits in search of lipids while destruction takes the form of parallel striations. The OBP assemblage shows that the majority of the bones have multiple parallel striations and a few with star shaped marks and boreholes as a result of gnawing. The destruction rate of bone by termites is seasonal since termite activity require humid conditions and high temperatures. Thus, the evidence of termite damage on the OBP assemblage is indicative of palaeoenvironment, palaeoecology, palaeoclimate and most importantly indicators of seasonality.

During the excavation of LSA layers by van der Ryst (2007), several chunks of termite mounds were observed. Although van der Ryst (2007) did not mention if the faunal assemblage was affected by termite and if so, to what extent, she notes that "…the chunks with termite chambers at OBP confirm that these much-relished foods, although always under-represented, were also certainly collected in the past" (van der Ryst 2007: 309). Hence, the presence of termite at OBP may imply that termites modified the faunal assemblage.

5.3 Palaeoenvironmental implications

5.3.1 Composition of the faunal assemblage

The OBP MSA faunal assemblage is taxonomically relatively diverse given the small size of the sample. It includes species that range from small vertebrates to large mammals. Mammals are most common with reptiles and squamata being least represented. This study identified klipspringers, baboons and leporids, which thrive in rocky areas like where the site is situated. Bovids that fall into size class I and II of Brain's (1974) classification were most exploited.

The MSA large fauna from the OBP MSA units is largely dominated by browsers and grazers (Fig 35). Carnivores are rare. Small animals such as tortoise are represented. Although van der Ryst (2007) did not provide MNIs of the faunal assemblage, her study through NISP showed a preponderance of tortoise remains in the Holocene layers. In the current study, tortoise have the highest NISP and MNI values of any other species recorded. In the LSA layers analysed by van der Ryst (2007), she argues that juvenile tortoises outnumber adult tortoises, and this pattern was also observed in this study. The abundant remains of tortoise is suggestive of its critical role to the subsistence base.

From the LSA faunal analysis of OBP material, van der Ryst (2007) identified 66 species, while the current work only identified 16 species. This can be a result of recovery biases, different size of the assemblages under study and differential preservation between MSA and LSA fauna. Van der Ryst (2007) analysed a bigger assemblage (NISP= 46 955), whereas the current study was carried out on a smaller assemblage (NISP= 1 296). Possible reasons that could account for the low number of identified taxa for the MSA units in comparison to LSA layers at OBP are sample size and preservation. Firstly, there is a huge difference in sample size between these time periods. Secondly, preservation of LSA faunal material is better compared to MSA remains, where MSA context has been dated to 150 kya (Val et al. 2021) and that of LSA to around 2800 BP (van der Ryst 2007).

5.3.2 Habitat-specific taxa

The identification of buffalo (*Syncerus caffer*), *Redunca* sp. and *Alcelaphus* sp. is telling since these taxa are characterised by high water requirements (Skinner & Chimimba 2005). Other species such as klipspringer (*Oreotragus oreotragus*), leporids and baboons thrive in rocky areas (Skinner & Chimimba 2005). Species such as *Equus* sp., steenbok (*Raphicerus campestris*) and common duiker (*Sylvicapra grimmia*) prefer an open environment like open grassland or open woodland (Skinner & Chimimba 2005).

Dietary preferences of ungulates from OBP was also investigated (Fig 36). *Syncerus caffer*, *Equus* sp., *Redunca* sp., and *Alcelaphus* sp., are classified as grazers and *Sylvicapra grimmia* as a browser (Gagnon & Chew 2000; Skinner & Chimimba 2005). Mixed feeders identified from OBP include *Oreotragus oreotragus*, *Raphicerus campestris*, *Raphicerus* sp. and *Tragelaphus oryx* (Gagnon & Chew 2000).

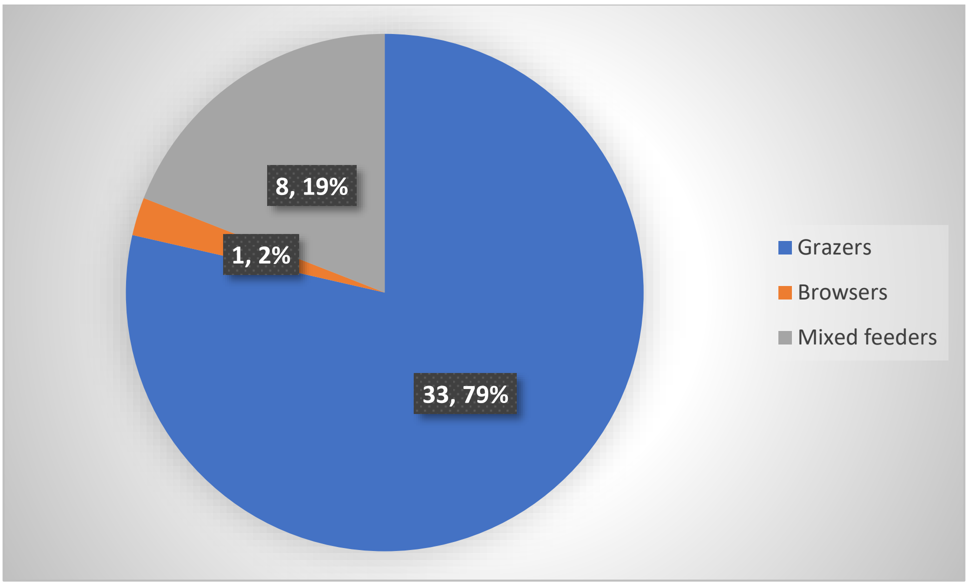

Figure 36: Dietary preferences of ungulates from Olieboomspoort. Percentages and numbers are based on NISP.

Based on data on dietary preferences of ungulates from OBP, grazers were prevalent, followed by mixed feeders and lastly browsers. However, because of the small sample size, caution is needed in this interpretation. For example, the number of grazers was affected by *Equus* sp. (n= 22).

Two carnivore species were identified, namely the Aardwolf (*Proteles cristata*) and African wild cat (*Felis silvestris*). Aardwolf are found where *Trinerviterms*, a termite species is present, as they constitute their main diet (Skinner & Chimimba 2005). The African wild cat prefers a rocky habitat and riverine bushes. Thus, the palaeoecological data from OBP suggest an open habitat and the presence of a water source within close proximity and rocky areas.

5.4 Human subsistence behaviours at OBP

Analysis of bone surface modifications indicates that several processes, from pre- to post-depositional, acted on the OBP bones. Interestingly, the assemblage shows minimal human agency. This is because of a number of reasons such as the presence of concretions evident on most specimens or by water abrasion or the fragmentation of specimens causing difficult identification of anthropogenic factors.

Nonetheless, the few pieces with evidence of human action points to animal exploitation by the society that lived at OBP. To reconstruct primary acquisition methods, researchers use surface marks. Linked to these reconstructions are evidence of carnivore tooth marks and butchery marks on same specimens. If cut marks are above tooth marks, it suggests that human societies scavenged from predators and if carnivore marks are above butchery marks, it suggests hunting was the primary exploitation strategy (Potts & Shipman 1981). The faunal assemblage from OBP shows that a large number of small mammals were exploited. Although large game is present, it is minimal. On the basis of species identified, there seem not to be an abundance of a specific species, which suggest specific species hunting. This can be explained by the small sample size.

A look at the age estimates of larger bovids shows that the majority were adults. This may indicate specialized hunting based on age. While the faunal data from OBP on bovids is indicative of small game hunting, there seem not to have age preferences. For tortoises, most of these were collected while young.

An analysis of the OBP LSA subsistence strategies by van der Ryst (2007) includes hunting, snaring, trapping and scavenging. For hunting, van der Ryst (2007) showed that opportunistic hunting of large and small animals was carried out with the use of specialized bow-and-arrows and pit trapping. The faunal assemblage from OBP includes a number of remains from small animals. Given the small sample size studied, it cannot be said with certainty whether MSA hominins at OBP preferred small game than large game. Thus, the challenge of sample size at OBP prevents one from suggesting concrete subsistence strategies.

5.5 Comparison with other MIS 6 faunal assemblages in southern Africa

MIS 6 was a period associated with glacial conditions. During this period, human subsistence strategies varied through space and time. Different ecological zones present different animals, which were exploited by humans.

Within the Fynbos Biome, the focus was on small and medium terrestrial animals and marine resources (Klein 1977; Marean *et al.* 2007; Thompson 2010). Pinnacle Point is a coastal archaeological site, which shows heavy reliance on small mammals and tortoises and marine resources (Marean *et al.* 2007). During MIS 6, Marean *et al.* (2007) showed evidence of shellfish exploitation. They argued that marine resource exploitation indicates an expansion of human diet in addition to terrestrial resources, which was the focus some thousand years ago. They further suggest that whales may have been scavenged or processed on the coastline with some parts like blubber taken back to the cave.

In another taphonomic study of MIS 6 fauna from Pinnacle Point, Thompson (2010), observed a different pattern where large ungulates are exploited more than small mammals. MSA people contributed large mammals where they extracted marrow, while carnivores such as felids also contributed to the assemblage by transporting a small proportion of small ungulates as evidenced by the presence of tooth marks. The data from OBP is dominated by small ungulate taxa, while large mammals are least represented. Unlike at Pinnacle Point where there is exploitation of marine resources, at OBP, there is a reliance on terrestrial resources. Apart from the recovery of carnivore remains, there are few OBP specimens with carnivore damage (mainly acid etching and pits).

An analysis of fauna from Border cave by Klein (1977) does not show differences in subsistence strategies between the LSA and the MSA, rather it shows changes in animal communities and environments. During MSA 1 and MSA 3 (49 kya), open vegetation species were abundant; but in the MSA 2 and Early Later Stone Age (38-36 kya), animals that prefer bushier environments were common. Klein further argues that the MSA inhabitants at Border cave avoided carnivores and focused on smaller animals that could be transported back intact rather than larger prey.

Klein argues that the MSA societies had a less effective hunting tool kit than the LSA societies. He also supports this through evidence of the exploitation of young buffalo as these were more vulnerable and less dangerous compared to adults. However, Faith (2008) criticizes the argument by Klein as she suggests that MSA humans were not ineffective hunters, as also supported by Brain (1969), Milo (1998), Plug (2004), Dusseldorp (2010), Badenhorst & Plug (2012) because of evidence of exploitation of dangerous prey like buffalo, elephant and wild pigs by inland MSA societies.

Kiberd (2006) shows that the faunal spectrum from Bundu Farm is characterized by large mammals. Zooarchaeological and taphonomic analyses by Hutson (2018) at Bundu Farm indicate that hunting was the major subsistence strategy. This is because of repetitive cut-marks observed on an astragalus, which indicates disarticulation of limb bones. Although hunting was identified as the primary subsistence strategy at Bundu Farm, the extent of this is questionable given that cut-marks were observed on a single specimen. Animal remains at Bundu Farm are characteristic of the Florisian Land Mammal Age (Kiberd 2006; Hutson 2018). At OBP like at Bundu Farm, hominins were involved in hunting and processing meat from small to large mammals.

At Pniel 6, Hutson (2018) suggests that seasonal water could have attracted large ungulates from nearby grassland and savanna habitats to drink, where they fell as prey to predators. At Pniel 6, the role of humans is quite minimal, and it is suggested that humans scavenged from kills by predators (Hutson 2018). At Florisbad, archaeozoological analyses of the assemblage shows the presence of hyena gnaw marks and the absence of cut-marks (Brink 1988). Carnivores were primary accumulators of the Florisbad assemblage, while hominins scavenged from these kills. Faunal analysis from Wonderkrater by Backwell *et al.* (2014: 51) shows no evidence of butchery marks, although there are a few specimens with evidence of carnivore damage.

Human exploitation behaviours from open-air sites dated to the MIS 6 within southern Africa is indicative of scavenging. Open-air sites such as Florisbad (Grün *et al.* 1996), Bundu Farm (Kiberd 2006; Hutson 2018), Pniel 6 (Hutson 2018) and Wonderkrater (Backwell *et al.* 2014) indicates that non-hominin carnivores were principal agents of faunal accumulation and site formation processes. Animals were attracted to pans and springs to obtain water, where they fell prey to predators. It was from these kills that hominins were in competition for resources with other scavengers. Although MSA hominins could have hunted from these water bodies, the taphonomic data is suggestive of scavenging as the primary acquisition method.

5.6 Conclusions

Recent dating of two equid teeth from MSA deposits at OBP by Val *et al.* (2021) provides a date of 150 kya, which falls within the MIS 6. This chronological phase is poorly documented in southern Africa in general and in the Savanna Biome in particular. There are few MIS 6 archaeological sites with faunal remains in southern Africa and OBP is the only site in the Waterberg Mountains with a substantial faunal assemblage. Archaeozoological information on the MSA in the Savanna Biome is generally patchy and, in this regard, OBP sheds light on human subsistence strategies and taphonomic processes during MIS 6 in this biome.

The taphonomic analysis of OBP assemblage sheds light into the various processes that affected this assemblage. Such an analysis provides a basis for other taphonomic studies especially within the Waterberg plateau. Major taphonomic signatures identified include water abrasion and transport, as well as invertebrate (possibly termite) activity on faunal remains. Such taphonomic processes have led to recovery biases and to bone modifications.

From the archaeozoological study of OBP MSA units, various proxies of palaeoenvironment were obtained. Although the sample size is small, most of the taxa identified were grazers. For example, the taxonomic identifications showed the presence of *Redunca* sp., and buffalo *(Syncerus caffer)* which have high water requirements. Therefore, these species are indicative of a nearby water source. This is consistent with the proximity of the Riet Spruit, a perennial river, which is also likely the source of water flooding inside the rock shelter at times.

At OBP, remains of tortoises were recovered in greater abundance than for any other species. Most of these remains were from juveniles. No direct evidence of human butchery marks was observed on tortoise remains and it is unclear whether humans accumulated these at this site. At OBP, small mammals and small bovids are dominated by juveniles while large bovids are rare and are represented by adult individuals.

Within the faunal assemblage, human modifications at OBP are evidenced by a few cut-marks on some specimens. Other modifications such as percussion marks were not observed. The low frequency of butchery marks observed on this assemblage makes any comprehensive reconstruction of human subsistence strategies challenging. Most of the cut-marks on OBP bone assemblage are deep and were probably produced by flakes, which might be products of Levallois technology. Although there are only a few cut-marks, their occurrence suggests that some degree of animal processing by the MSA people took place at OBP.

The analysis of faunal remains from OBP, an inland site dated to the MIS 6, provides a window to understand past human societies. Marean (2010) suggested that during MIS 6, there was hominin population bottleneck, where the few that survived relied on coastal resources. OBP is located inland and the evidence of human activities in this area attests to the presence of human populations not only at coastal regions during this glacial phase of human history.

References

Adam, R.A., Mitchell, J.D. & van der Westhuizen, M.C. 2008. Aspects of foraging in the harvester termite, *Trinervitermes trinervoides* (Sjöstedt) (Termitidae: Nasutitermitinae). *African Entomology* 16 (2): 153-161.

Andrews, P. 1990. *Owls, caves and fossils*. Chicago: The University of Chicago Press.

Armstrong, A. & Avery, G. 2014. Taphonomy of Verreaux's Eagle (*Aquila verreauxii*) prey accumulations from the Cape Floral Region, South Africa: implications for archaeological interpretations. *Journal of Archaeological Science* 52: 163-183.

Armstrong, A. 2016. Small mammal utilization by Middle Stone Age humans at Die Kelders cave 1 and Pinnacle Point 5-6, Western Cape Province, South Africa. *Journal of Human Evolution* 101: 17-44.

Avery, G., Halkett, D., Orton, J., Steele, T., Tusenius, M. & Klein, R. 2008. The Ysterfontein 1 Middle Stone Age rock shelter and the evolution of coastal foraging. *South African Archaeological Society Goodwin Series* 10: 66-89.

Backwell, L.R., d'Errico, F., Banks, W.E., de la Peña, P., Sievers, C & Stratford, D. 2018. New excavations at Border Cave, KwaZulu-Natal, South Africa. *Journal of Field Archaeology* 43 (6): 417-436.

Backwell, L.R., McCarthy, T.S.,Wadley, L; Henderson, Z., Steininger, C.M., de Klerk, B; Barré, M., Lamothe, M., Chase, B.M., Woodborne, S., Susino, G.J., Bamford, M.K., Sievers, C., Brink, J.S., Rossouw, L., Pollarolo, L., Trower, G., Scott, L. & d'Errico, F. 2014. Multiproxy record of late Quaternary climate change and Middle Stone Age human occupation at Wonderkrater, South Africa. *Quaternary Science Reviews* 99: 42-59.

Backwell, L.R., Parkinson, A.H., Roberts, E.M., d'Errico, F. & Huchet, J.B. 2012. Criteria for identifying bone modification by termites in the fossil record. *Palaeogeography, Palaeoclimatology, Palaeoecology* 337-338: 72-87.

Badenhorst, S. & Plug, I. 2012. The faunal remains from the Middle Stone Age levels of Bushman Rock Shelter in South Africa. *The South African Archaeological Bulletin* 67 (195): 16-31.

Badenhorst, S., van Niekerk, K.L. & Henshilwood, C.S. 2016. Large mammal remains from the 100 ka Middle Stone Age layers of Blombos cave, South Africa. *The South African Archaeological Bulletin* 71 (203): 46-52.

Bartram, L.E. & Marean, C.W. 1999. Explaining the "Klasies Pattern": Kua etnoarchaeology, the Die Kelders Middle Stone Age archaeofauna, long bone fragmentation and carnivore ravaging. *Journal of Archaeological Science* 26: 9-29.

Beaumont, P.B. & Vogel, J.C. 2006. On a timescale for the past million years of human history in central South Africa. *South African Journal of Science* 102, 217-228.

Beaumont, P.B. 1999. Pniel 6 (The Bend). In: Beaumont, P.B. (Ed.), *Northern Cape: INQUA XV International Conference Field Guide*. Council of Geosciences, Pretoria, pp. 33-35.

Behrensmeyer, A.K. 1978. Taphonomic and ecological information from bone weathering. *Paleobiology* 4: 150-162.

Behrensmeyer, A.K., Gordon, K.D. & Yamagi, G.T. 1986. Trampling as a cause of bone surface damage and pseudo-cutmarks. *Nature* 319: 768-772.

Berger, L.R., Hawks, J., Dirks, P.H.G.M., Elliot, M. & Roberts, E.M. 2017. *Homo naledi* and Pleistocene hominin evolution in subequatorial Africa. eLife. https://doi.org/10.7554/eLife.24234.

Berna, F., Goldberg, P., Horwitz, L.K., Brink, J., Holt, S., Bamford, M., Chazan, M. 2012. Microstratigraphic evidence of in situ fire in the Acheulean strata of Wonderwerk cave, Northern Cape Province, South Africa. *Proceedings of National Academy of Science of the United States of America* 109 (20): E1215-E1220

Binford, L.R. 1981. *Bones. Ancient Men and Modern Myths*. New York, Academic Press.

Binford, L.R. 1984. *Faunal remains from Klasies River Mouth*. Academic Press: New York.

Brain, C.K. & Cooke, C.K. 1967. A Preliminary Account of the Redcliff Stone Age Cave Site in Rhodesia. *The South African Archaeological Bulletin* 21 (84): 171-182.

Brain, C.K. 1969. Faunal remains from the Bushman Rock Shelter, Eastern Transvaal. *The South African Archaeological Bulletin* 24 (94): 52-55.

Brain, C.K. 1974. Some suggested procedures in the analysis of bone accumulations from southern African Quaternary sites. *Annals of the Transvaal Museum* 29, 1-8.

Brain, C.K. 1981. *The Hunters or the Hunted? An Introduction to African Cave Taphonomy*. Chicago: University of Chicago Press.

Braun, K., Bar-Matthews, M., Ayalon, A., Zilberman, T. & Matthews, A. 2017. Rainfall isotopic variability at the intersection between the winter and summer rainfall regimes in coastal South Africa (Mossel Bay, Western Cape Province). *South African Journal of Geology* 120 (3): 323-340.

Brink, J.S. 1988. The taphonomy and palaeoecology of the Florisbad spring fauna. *Palaeoecology of Africa* 19: 169-179.

Brown, F.H., McDougall, I. & Fleagle, J.G. 2012. Correlation of the KHS Tuff of the Kibish Formation to volcanic ash layers at other sites, and the age of early Homo sapiens (Omo I and Omo II). *Journal of Human Evolution* 63 (4): 577-585.

Cain, C.R. 2005. Using burned animal bone to look at Middle Stone Age occupation and behavior. *Journal of Archaeological Science* 32: 873-884.

Cain, C.R. 2006. Human activity suggested by the taphonomy of 60 ka and 50 ka faunal remains from Sibudu Cave. *Southern African Humanities* 18 (1): 241-260.

Chase, B.M. & Meadows, M.E. 2007. Late Quaternary dynamics of Southern Africa's winter rainfall zone. *Earth-Science Reviews* 84: 103-138.

Chazan, M. 2015. Technological trends in the Acheulean of Wonderwerk Cave, South Africa. *African Archaeological Review* 32 (4): 701-728.

Chazan, M., Berna, F., Brink, J., Ecker, M., Holt, S., Porat, N., Lee-Thorp, J. & Horwitz, L.K. 2020. Archeology, environment, and chronology of the Early Middle Stone Age component of Wonderwerk Cave. *Journal of Paleolithic Archaeology* https://doi.org/10.1007/s41982-020-00051-8.

Chazan, M., Hagai, R., Matmon, A., Porat, N., Goldberg, P., Yates, R., Avery, M., Sumner, A. & Horwitz, L.K. 2008. Radiometric dating of the Earlier Stone Age sequence in Excavation I at Wonderwerk Cave, South Africa: preliminary results. *Journal of Human Evolution* 55 (1): 1-11.

Chazan, M., Horwitz, L.K., Ecker, M., Koopowitz, C., Rhodes, S.E., Morris, D. & Berna, F. 2017. Renewed excavations at Wonderwerk Cave, South Africa. *Evolutionary Anthropology* 26 (6): 258-260.

Clark, J. L. 2009. *Testing models on the emergence of modern human behavior: Middle Stone Age fauna from Sibudu cave (South Africa).* Unpublished DPhil Thesis: University of Michigan.

Clark, J.L. & Kandel, A.W. 2013. The evolutionary implications of variation in human hunting strategies and diet breadth during the Middle Stone Age of southern Africa. *Current Anthropology* 54 (suppl. 8): S269-S287.

Clark, J.L. & Plug, I. 2008. Animal exploitation strategies during the South African Middle Stone Age: Howiesons Poort and post-Howiesons Poort fauna from Sibudu Cave. *Journal of Human Evolution* 54: 886-898.

Clark, J.L. 2011. The evolution of human culture during the later Pleistocene: using fauna to test models on the emergence and nature of ‘‘modern’’ human behavior. *Journal of Anthropological Archaeology* 30:273-291.

Clark, J.L. 2017. The Howieson's Poort fauna from Sibudu Cave: documenting continuity and change within Middle Stone Age industries. *Journal of Human Evolution* 107: 49-70.

Cohen, K.M., Finney, S.C., Gibbard, P.L. & Fan, J-X. 2013. The ICS international chronostratigraphic chart. *Episodes* 36: 199-204.

Collins, B.R. 2015. The taphonomy of the final Middle Stone Age from Sibudu Cave, South Africa. *International Journal of Osteoarchaeology* 25 (6): 805-815.

Collins, B.R. 2016. Foraging strategies in the final Middle Stone Age occupation at Sibudu cave, South Africa. *Journal of Archaeological Science: Reports* 5: 61-70.

Cooke, C.K. 1963. Report on excavations at Pomongwe and Tshangula Caves, Matopo Hills, Southern Rhodesia. *The South African Archaeological Bulletin* 18: 73-151.

Coolidge, F.L., Haidle, M.N., Lombard, M. & Wynn, T. 2016. Bridging theory and bow hunting: human cognitive evolution and archaeology. *Antiquity* 90 (349): 219-228.

Cooper, R.L. & Skinner, J.D. 1979. Importance of termites in the diet of the Aardwolf *Proteles Cristatus* in South Africa. *South African Journal of Zoology* 14 (1): 5-8.

Costamagno, S. 1999. Coudoulous II: taphonomie d'un aven-piège. Contribution des accumulations d'origine naturelle à l'interprétation des archéofaunes du Paléolithique moyen. *Anthropozoologica*, 29: 13-32.

Cruz-Uribe, K. 1983. The mammalian fauna from Redcliff cave, Zimbabwe. *The South African Archaeological Bulletin* 38 (137): 7-16.

Cruz-Uribe, K. 1991. Distinguishing hyena from hominid bone accumulations. *Journal of Field Archaeology* 18: 467-486.

d'Errico, F. & Backwell. L.R. 2016. Earliest evidence of personal ornaments associated with burial: the *Conus* shells from Border Cave. *Journal of Human Evolution* 93: 91-108.

d'Errico, F., Backwell, L.R., Villa, P., Degano, I., Lucejko, J., Bamford, M., Higham, T., Colombini, M.P. & Beaumont. P.B. 2012. Early evidence of San material culture represented by organic artifacts from Border Cave, South Africa. *Proceedings of the National Academy of Science of the United States of America* 109: 13214-13219.

David, B. 1990. How was this bone burnt? In S. Solomon, I. Davidson & D. Watson (eds) *Problem Solving in Taphonomy* vol. 2, pp. 65-79.

Dedekind, Z., Engelbrecht, F.A. & van der Merwe, J. 2016. Model simulations of rainfall over southern Africa and its eastern escarpment, *Water SA* 42: 129-143.

Dirks, P.H.G.M., et al 2017. The age of *Homo naledi* and associated sediments in the Rising Star Cave, South Africa. *eLife*. https://doi.org/10.7554/eLife.24231.

Discamps, E. & Henshilwood, C.S. 2015. Intra-Site Variability in the Still Bay Fauna at Blombos Cave: Implications for Explanatory Models of the Middle Stone Age Cultural and Technological Evolution. *PLOS ONE*. https://doi.org/10.1371/journal.pone.0144866

Domínguez-Rodrigo, M. 1999. Flesh availability and bone modifications in carcasses consumed by lions: palaeoecological relevance in hominid foraging patterns. *Palaeogeogreography, Palaeoclimatololgy, Palaeoecology* 149: 373-388.

Domínguez-Rodrigo, M. 2002. Hunting and scavenging by early humans: The state of the debate. *Journal of World Prehistory* 16:1-54.

Domínguez-Rodrigo, M., de Juana, S., Galán, A.B. & Rodríguez, M. 2009. A new protocol to differentiate trampling marks from butchery cut marks. *Journal of Archaeological Science* 36: 2643-2654.

Dusseldorp, G.L & Langejans, G.H.J. 2013. Carry that weight: Coastal foraging and transport of marine resources during the South African Middle Stone Age. *Southern African Humanities* 25:105-135.

Dusseldorp, G.L & Langejans, G.H.J. 2016. ‘Trapping the past’? Hunting for remote capture techniques and planned coastal exploitation during MIS 5 at Blombos Cave and Klasies River, South Africa. *Analecta Praehistorica Leidensia* 45: 15-27.

Dusseldorp, G.L. 2010. Prey choice during the South African Middle Stone Age: avoiding dangerous prey or maximising returns? *African Archaeological Review* 27: 107-133.

Dusseldorp, G.L. 2012. Studying prehistoric hunting proficiency: applying Optimal Foraging Theory to the Middle Palaeolithic and Middle Stone Age. *Quaternary International* 252: 3-15.

Ecker, M., Bank, C-G., Chazan, M., Chen, Y., Green, C., Morris, D., Stoikopoulos, N., Shadrach, K., Stratford, D. & Duke, H. 2021. Revisiting Pniel 6: The 2017-2019 excavations. *South African Archaeological Bulletin* 76 (214): 57-69.

Ecker, M., Brink, J., Horwitz, L.K., Scott, L. & Lee-Thorp, J.A. 2018. A 12,000-year record of changes in herbivore niche separation and palaeoclimate (Wonderwerk Cave, South Africa). *Quaternary Science Reviews* 180: 132-144.

Efremov, I.A. 1940. Taphonomy: a new branch of paleontology. *Pan-American Geologist* 74: 81-93.

Endicott, P., Ho, S.Y. & Stringer, C. 2010. Using genetic evidence to evaluate four palaeoanthropological hypotheses for the timing of Neanderthal and modern human origins. *Journal of Human Evolution* 59 (1): 87-95.

Engelbrecht, C.J. & Landman, W.A. 2016. Interannual variability of seasonal rainfall over the Cape south coast of South Africa and synoptic type association. *Climate Dynamics* 47 (1–2): 295-313.

Eriksson, P.G., Simpson, E.L., Eriksson, K.A., Bumby, A.J., Steyn, G.L. & Sarkar, S. 2000. Muddy roll-up structures in siliciclastic interdune beds of the c. 1.8 Ga Waterberg Group, South Africa. *Palaios* 15:177-183.

Faith, J.T. 2007. Sources of variation in carnivore tooth-mark frequencies in a modern spotted hyena (*Crocuta crocuta*) den assemblage, Amboseli Park, Kenya. *Journal of Archaeological Science* 34: 1601-1609.

Faith, J.T. 2008. Eland, buffalo, and wild pigs: were Middle Stone Age humans ineffective hunters? *Journal of Human Evolution* 55: 24-36.

Fernández-Jalvo, Y. & Andrews, P. 2003. Experimental effects of water abrasion on bone fragments. *Journal of Taphonomy* 3:147-163.

Fernández-Jalvo, Y. & Andrews, P. 2016. *Atlas of taphonomic identifications: 1001 + images of fossil and recent mammal bone modification*. New York: Springer Dordrecht Heidelberg.

Finch, J. M. & Meadows, M.E. 2019. South African Biomes and their changes over time. In J. Knight, & C. Rogerson, (eds) *The geography of South Africa*. Cham: Springer, pp 57-69.

Fisher, J.W. 1995. Bone Surface Modifications in Zooarchaeology. *Journal of Archaeological Method and Theory* 2 (1): 7-68.

Gagnon, M & Chew, A.E. 2000. Dietary preferences in extant African bovidae. *Journal of Mammalogy* 81 (2): 490-511.

García-Morato, S., Marin-Monfort, M.D. & Fernández-Jalvo, Y. 2019. Rolling bones: a preliminary study of micromammal abrasion on different initial taphonomic stages. *Palaeontologia Electronica* 22.2.pvc-2 1-16. https://doi.org/10.26879/974.

Gifford, D.P & Crader, D.C. 1977. A computer coding system for archaeological remains. *American Antiquity* 42 (2): 225-238.

Gifford-Gonzalez, D. 2018. *An introduction to zooarchaeology*. Cham: Springer International Publishing.

Grant, A. 1982. The use of tooth wear as a guide to the age of domestic ungulates. In B. Wilson, C. Grigson, & S. Payne (eds.), *Ageing and sexing animal bones from archaeological sites*. Oxford: British Archaeological Reports, British Series, Vol 109, pp 91-108.

Grayson, D.K. & Frey, C.J. 2004. Measuring Skeletal Part Representation in Archaeological Faunas. *Journal of Taphonomy* 2 (1): 27-42.

Greenfield, H.J. & Arnold, E.R. 2008. Absolute age and tooth eruption and wear sequences in sheep and goat: determining age-at-death in zooarchaeology using a modern control sample. *Journal of Archaeological Science* 35: 836-849.

Grine, F.E., Bailey, R.M., Harvati, K., Nathan, R.P., Morris, A.G., Henderson, G.M., Ribot, I. & Pike, A.W.G. 2007. Late Pleistocene human skull from Hofmeyr, South Africa, and modern human origins. *Science* 315:226-229.

Grody, E. 2016. *A critical zooarchaeological examination of animal use and processing at the Early Iron Age sites LE6 and LE7 in the Kruger National Park*. MA Thesis: University of Pretoria.

Grün, R. 2006. Direct dating of human fossils. *American Journal of Physical Anthropology* 49: 2-48.

Grün, R., Brink, J.S., Spooner, N.A., Taylor, L., Stringer, C.B., Franciscus, R.G. & Murray, A.S. 1996. Direct dating of Florisbad hominid. *Nature* 382 (500-501): 6591

Henn, B.M., et al. 2011. Hunter-gatherer genomic diversity suggests a southern African origin for modern humans. *Proceedings of the National Academy of Sciences of the United States of America* 108 (13): 5154-5162.

Henn, B.M., Steele, T.E. & Weaver, T.D. 2018. Clarifying distinct models of modern human origins in Africa. *Current Opinion in Genetics and Development* 53: 148-156.

Hoffman, M.T. 1996. Bushmanland Nama-Karoo. In Low, A.B & Robelo, A.G (eds), *Vegetation of South Africa, Lesotho and Swaziland*. Pretoria: Department of Environmental Affairs and Tourism, pp 160-204.

Hublin, J.J. 2009. The origin of Neandertals. *Proceedings of the National Academy of Sciences* 106 (38): 16022-16027.

Hublin, J.J., et al. 2017. New fossils from Jebel Irhoud, Morocco and the pan-African origin of *Homo sapiens*. *Nature* 546: 289-292.

Hutson, J.M. 2012. *A Comparative Study of Life and Death at Middle Stone Age Open-air sites within the Southern African Interior*. Unpublished PhD Thesis: University of Nevada.

Hutson, J.M. 2018. The faunal remains from Bundu Farm and Pniel 6: examining the problematic Middle Stone Age archaeological record within the southern African interior. *Quaternary International* 466: 178-193.

Jacobs, Z. 2010. An OSL chronology for the sedimentary deposits from Pinnacle Point Cave 13B-a punctuated presence. *Journal of Human Evolution* 59 (3-4): 289-305.

Jones, G.G. 2006. Tooth eruption and wear observed in live sheep from Butser Hill, the Cotswold Farm Park and five farms in the Pentland Hills, UK. In D. Ruscillo (ed) *Recent advances in ageing and sexing animal bones*. Oxford: Oxbow Books, pp 155-178.

Kiberd, P. 2001. Bundu Farm. A Middle and Later Stone Age pan site, Northern Cape, South Africa. Preliminary results of fieldwork 1998-2000. *Nyame Akuma* 55: 51-55.

Kiberd, P. 2006. Bundu Farm: a report on archaeological and palaeoenvironmental assemblages from a pan site in Bushmanland, Northern Cape, South Africa. *South African Archaeological Bulletin* 61: 189-201.

Kibii, J.M. 2009. Taphonomic aspects of African porcupines (*Hystrix cristata*) in the Kenyan Highlands. *Journal of Taphonomy* **7** (1): 21-27.

Klein, R.G. & Cruz-Uribe, K. 1984. *The analysis of animal bones from archaeological sites*. Chicago: University of Chicago Press.

Klein, R.G. & Cruz-Uribe, K. 1996. Exploitation of large bovids and seals at Middle and Later Stone Age sites in South Africa. *Journal of Human Evolution* 31: 315-334.

Klein, R.G. & Cruz-Uribe, K. 2000. Middle and Later Stone Age large mammal and tortoise remains from Die Kelders Cave 1, Western Cape Province, South Africa. *Journal of Human Evolution* 38: 169-195.

Klein, R.G. 1972. The late Quaternary mammalian fauna of Nelson Bay Cave (Cape Province, South Africa): its implications for megafaunal extinctions and environmental and cultural change. *Quaternary Research* 2: 135-142.

Klein, R.G. 1974. Environment and subsistence of pre-historic man in the southern Cape Province, South Africa. *World Archaeology* 5 (3): 249-284.

Klein, R.G. 1975. Middle Stone Age man-animal relationships in southern Africa: Evidence from Die Kelders and Klasies River Mouth. *Science*: 265-267.

Klein, R.G. 1976. The mammalian fauna of the Klasies River Mouth sites, southern Cape Province, South Africa. *The South African Archaeological Bulletin* 32: 14-27.

Klein, R.G. 1977. The mammalian fauna from the Middle and Later Stone Age (Later Pleistocene) levels of Border Cave, Natal Province, South Africa. *South African Archaeological Bulletin* 32: 14-27.

Klein, R.G. 1978. Preliminary analysis of the mammalian fauna from the Redcliff Stone Age Cave site, Rhodesia. *Occasional Papers of the National Museums and Monuments of Rhodesia, Series A Human Sciences* 4: 43-80.

Klein, R.G. 1979. Stone Age exploitation of animals in southern Africa: Middle Stone Age people living in southern Africa more than 30,000 years ago exploited local animals less effectively than the Later Stone Age people who succeeded them. *American Scientist* 67 (2): 151-160.

Klein, R.G. 1983. Palaeoenvironmental implications of Quaternary large mammals in the fynbos region. In Deacon, H.J., Hendey, Q.B. & Lambrechts, J.J.N (eds) *Fynbos Palaeoecology: A preliminary synthesis*. South African National Scientific Programmes: Pretoria, 75: 116-138.

Klein, R.G. 1989a. Biological and behavioral perspectives on modern human origins in southern Africa. In P. Mellars & C. B. Stringer (Eds) *The Human Revolution: behavioral and biological perspectives on the origins of modern humans*. Edinburgh: Edinburgh University Press, pp. 529-546.

Klein, R.G. 1989b. Why does skeletal part representation differ between smaller and larger bovids at Klasies River Mouth and other archeological sites? *Journal of Archaeological Science* 16 (4): 363-381.

Klein, R.G. 1995. Anatomy, Behaviour and Modern Human Origins. *Journal of World Prehistory* 9: 167-198.

Klein, R.G. 2000. Archeology and the Evolution of Human Behavior. *Evolutionary Anthropology* 9:17-36.

Klein, R.G. 2001. Southern Africa and modern human origins. *Journal of Anthropological Research* 57:1-16.

Klein, R.G. 2003. Comment on "The Origins of Modern Human Behavior: Critique of the Models and Their Test Implications". *Current Anthropology* 45: 640-641.

Klein, R.G. 2008. Out of Africa and the Evolution of Human Behavior. *Evolutionary Anthropology* 17:267-281.

Kuhn, B.F., Berger, L.R. & Skinner, J.D. 2010. Examining criteria for identifying and differentiating fossil faunal assemblages accumulated by hyenas and hominins using extant hyenid accumulations. *International Journal of Osteoarchaeology* 20: 15-35.

Kuman, K. & Clarke, R.J. 2000. Stratigraphy, artefact industries and hominid associations for Sterkfontein, Member 5. *Journal of Human Evolution* 38 (6): 827-847.

Kuman, K. & Field, A.S. 2009. The Oldowan Industry from Sterkfontein Caves, South Africa. In: Schick, K. & Toth, N. (eds), *The Cutting Edge: New Approaches to the Archaeology of Human Origin*s. Stone Age Institute Press: Gosport, pp 151-170.

Kuman, K. 1989. *Florisbad and ≠Gi: the contribution of open-*air *sites to study of the Middle Stone Age in southern Africa*. Unpublished PhD Thesis: University of Pennsylvania.

Kuman, K. 2014. Acheulean industrial complex. In: C, Smith (ed.), *Encyclopedia of Global Archaeology*. Springer: Dordrecht, pp 7-19.

Kuman, K., Sutton, M.B., Pickering, T.R. & Heaton, J.L. 2018. The Oldowan industry from Swartkrans cave, South Africa, and its relevance for the African Oldowan. *Journal of Human Evolution* 123: 52-69.

Kyriacou, K., Parkington, J.E., Will, M., Kandel, A.W. & Conard, N.J. 2015. Middle and Later Stone Age shellfish exploitation strategies and coastal foraging at Hoedjiespunt and Lynch Point, Saldanha Bay, South Africa. *Journal of Archaeological Science* 57: 197-206.

Lam, Y.M., Xingbin, C. & Pearson, O.M. 1999. Intertaxonomic variability in patterns of bone density and the differential representation of Bovid, Cervid, and Equid elements in the archaeological record. *American Antiquity* 64 (2): 343-362.

Landt, M.J. 2007. Tooth marks and human consumption: ethnoarchaeological mastication research among foragers of the Central African Republic. *Journal of Archaeological Science* 34 (10): 1629-1640.

Larsson, L. 2007. The Middle Stone Age of northern Zimbabwe: excavations at Zombampata and Ruchera caves. *Zimbabwean Prehistory* 27: 18-30.

Lombard, M. & Gärdenfors, P. 2021. Causal cognition and theory of mind in evolutionary cognitive archaeology. *Biological Theory* 1-19.

Lombard, M., Wadley, L., Deacon, J., Wurz, S., Parsons, I., Mohapi, M., Swart, J. & Mitchell, P. 2012. South African and Lesotho Stone Age sequence updated. *South African Archaeological Bulletin* 67 (195): 123-144.

Lombard, M., Wadley, L., Jacobs, Z., Mohapi, M. & Roberts, R.G. 2010. Still Bay and serrated points from Umhlatuzana Rock Shelter, KwaZulu-Natal, South Africa. *Journal of Archaeological Science* 37: 1773-1784.

Lotter, M.G. & Kuman, K. 2018. The Acheulean in South Africa, with announcement of a new site (Penhill Farm) in the lower Sundays River Valley, Eastern Cape Province, South Africa. *Quaternary International* 480: 43-65. https://doi:10.1016/j.quaint.2017.08.06.

Lutjeharms, J.R.E., Monteiro, P.M.S., Tyson, P.D. & Obura, D. 2001. The oceans around southern Africa and regional effects of global change. *South African Journal of Science* 97: 119-120.

Lyman, R.L. & Fox, G.L. 1989. A critical evaluation of bone weathering as an indication of bone assemblage formation. *Journal of Archaeological Science* 16: 293-317.

Lyman, R.L. 1994a. Quantitative units and terminology in zooarchaeology. *American Antiquity* 59 (1): 36-71.

Lyman, R.L. 1994b. *Vertebrate Taphonomy*. Cambridge: Cambridge University Press.

Lyman, R.L. 2008. *Quantitative Paleozoology*. Cambridge: Cambridge University Press.

Maguire, J.M. 1976. *A taxonomic and ecological study of the living and fossil Hystricidae with particular reference to southern Africa*. Unpublished PhD. Thesis. University of the Witwatersrand.

Maguire, J.M., Pemberton, D. & Collett, M.H. 1980. The Makapansgat limeworks grey breccia: hominids, hyaenas, hystricids or hillwash? *Palaeontologica Africana* 23: 75-98.

Marean, C.W. 1998. A critique of the evidence for scavenging by Neandertals and Early Modern Humans: new data from Kobeh Cave (Zagros Mountains, Iran) and Die Kelders Cave 1 Layer 10 (South Africa). *Journal of Human. Evolution* 35: 111-136.

Marean, C.W. 2010a. When the sea saved humanity. *Scientific American* 303: 54-61.

Marean, C.W. 2010b. Pinnacle Point Cave 13B (Western Cape Province, South Africa) in context: The Cape Floral kingdom, shellfish, and modern human origins. *Journal of Human Evolution* 59 (3-4): 425-443.

Marean, C.W., Abe, Y., Frey, C.J. & Randall, R.C. 2000. Zooarchaeological and taphonomic analysis of the Die Kelders cave 1 Layers 10 and 11 Middle Stone Age larger mammal fauna. *Journal of Human Evolution* 38: 197-233.

Marean, C.W., Bar-Matthews, M., Fisher, E., Goldberg, P., Herries, A., Karkanas, P., Nilssen, P.J. & Thompson, E. 2010. The stratigraphy of the Middle Stone Age sediments at Pinnacle Point Cave 13B (Mossel Bay, Western Cape Province, South Africa). *Journal of Human Evolution* 59 (3-4): 234-235.

Marean, C.W., et al. 2007. Early human use of marine resources and pigment in South Africa during the Middle Pleistocene. *Nature* 449: 905-909.

Marean, C.W., Spencer, L.M., Blumenschine, R.J. & Capaldo, S.D. 1992. Captive hyaena bone choice and destruction, the schlepp effect and Olduvai archaeofaunas. *Journal of Archaeological Science* 19: 101-121.

Marshall, L.G. 1989. Bone Modification and "The Laws of Burial." In R. Bonnichsen & M. H Sorg (eds) *Bone Modification*. Thompson-Shore Inc. USA, pp 7-23.

Mason, R. 1957. The Transvaal Middle Stone Ag and statistical analysis. *South African Archaeological Bulletin* 12 (48), 119-137.

Mason, R. 1962. *Prehistory of the Transvaal*. Johannesburg: Witwatersrand University Press.

Matmon A., Ron H., Chazan M., Porat N. & Horwitz L.K. 2012. Reconstructing the history of sediment deposition in caves: a case study from Wonderwerk Cave, South Africa. *Geological Society of America Bulletin* 124 (3-4): 611-625

McBrearty, S. & Brooks, A.S. 2000. The revolution that wasn't: a new interpretation of the origin of modern human behavior. *Journal of Human Evolution* 39: 453-563.

McCarthy, T.S., Ellery, W.N., Backwell, L.R., Marren, P., de Klerk, B., Tooth, S., Brandt, D. & Woodborne, S. 2010. The character, origin and palaeoenvironmental significance of the Wonderkrater spring mound, South Africa. *Journal of African Erath Science* 58 (1): 115-126.

Mellars, P.A. & Stringer, C.B. (Eds). 1989. *The Human Revolution: behavioral and biological perspectives on the origins of modern humans*. Edinburgh: Edinburgh University Press.

Meyer M., et al. 2012. A high-coverage genome sequence from an Archaic Denisovan individual. *Science* 338:222-226.

Miller, C., Finch, J., Hill, T., Peterse, F., Humphries, M., Zabel, M. & Schefuß, E. 2019. Late Quaternary climate variability at Mfabeni peatland, eastern South Africa. *Climate of the Past* 15: 1153-1170.

Milo, R.G. 1998. Evidence for hominid predation at Klasies River Mouth and its implications for behaviour of early modern humans. *Journal of Archaeological Science* 25: 99-133.

Mucina, L. & Rutherford, M.C. 2006. *The vegetation of South Africa, Lesotho and Swaziland*. Strelitzia 19. Pretoria: National Biodiversity Institute.

Nielsen, R., Akey, J.M., Jakobsson, M., Pritchard, J.K., Tishkoff, S. & Willerslev, E. 2017. Tracing the peopling of the world through genomics. *Nature* 541: 302-310.

Palmer, A.R. & Hoffman, M.T. 1997. Nama Karoo. In: Cowling, R.M., Richardson, D.M. & Pierce, S.M. (eds), *Vegetation of Southern Africa*. Cambridge: Cambridge University Press, pp 167-186.

Parkington, J.E., Poggenpoel, C., Rigaud, J-P. & Texier, P-J. 2005. From tool to symbol: the behavioural context of intentionally marked ostrich eggshell from Diepkloof, Western Cape. In: F, d'Errico, & L, Backwell (eds) *From Tools to Symbols: From Early Hominids to Modern Humans*. Witwatersrand University Press: Johannesburg, pp. 475-492.

Parkinson, A.H. 2016. Traces of Insect Activity at Cooper's D Fossil Site (Cradle of Humankind, South Africa), *Ichnos* 23 (3-4): 322-339.

Payne, S. 1973. Kill-off patterns in sheep and goats: the mandibles from Asvan Kale. *Anatolian Studies* 23: 281-303.

Pearson, P.N. 2012. Oxygen isotopes in foraminifera: overview and historical review. *The Paleontological Society Papers* 18: 1-38.

Perkins, D. & Daly, P. 1968. A hunters' village in Neolithic Turkey. *Scientific American* 219 (5): 96-109.

Pickering, T.R. 2002. Reconsideration of criteria for differentiating faunal assemblages accumulated by hyenas and hominids. *International Journal of Osteoarchaeology* 12: 127-141.

Pickering, T.R., Sutton, M.B., Heaton, J.L., Clarke, R.J., Brain, C.K. & Kuman, K. 2012. New hominid fossils from Member 1 of the Swartkrans formation, South Africa. *Journal of Human Evolution* 62: 618-628.

Plug, C. & Plug, I. 1990. MNI Counts as Estimates of Species Abundance. *The South African Archaeological Bulletin* 45 (151): 53-57.

Plug, I. 2004. Resource exploitation: animal use during the Middle Stone Age at Sibudu Cave, KwaZulu-Natal. *South African Journal of Science* 100: 151-158.

Plug, I. 2006. Aquatic animals and their associates from the Middle Stone Age levels at Sibudu. *Southern African Humanities* 18 (1): 289-299.

Pobiner, B.L., DeSilva, J., Sanders, W. J. & Mitani, J.C. 2007. Taphonomic analysis of skeletal remains from chimpanzee hunts at Ngogo, Kibale National Park, Uganda. *Journal of Human Evolution* 52 (6): 614-636.

Porraz, G. et al. 2015. Bushman Rock shelter (Limpopo, South Africa): a perspective from the edge of the highveld. *South African Archaeological Bulletin* 70 (202): 166-179.

Porraz, G.,Val, A., Tribolo, C., Mercier, N., de la Peña, P., Haaland, M., Igreja, M., Miller, C.E. & Schmid, V.C. 2018. The MIS5 Pietersburg at '28' Bushman Rock Shelter, Limpopo Province, South Africa. *PLOS ONE* https://doi.org/10.1371/journal.pone.0202853.

Potts, R. & Shipman, P. 1981. Cutmarks made by stone tools on bones from the Olduvai Gorge, Tanzania. *Nature* 291, 577-580.

Ramsay, P.J. & Cooper, J.A.G. 2002. Late quaternary sea-level change in South Africa. *Quaternary Research* 57: 82-90.

Rebelo, A.G., et al. 2006. Fynbos Biome. In L. Mucina, & M. C. Rutherford (eds) *The vegetation of South Africa, Lesotho and Swaziland*. Sterlitzia; No. 19: Pretoria, pp 52-219.

Reitz, E.J. & Wing, E.S. 2008. *Zooarchaeology*. 2nd Edition. Cambridge: Cambridge University Press.

Reynard, J.P. & Wurz, S. 2020. The palaeoecology of Klasies River, South Africa: An analysis of the large mammal remains from the 1984-1995 excavations of Cave 1 and 1A. *Quaternary Science Reviews* https://doi.org/10.1016/j.quascirev.2020.106301.

Reynard, J.P. 2011. *The unidentified long bone fragments from the Middle Stone Age Still Bay layers at Blombos Cave, Southern Cape, South Africa*. Unpublished Msc Thesis: University of the Witwatersrand.

Reynard, J.P. 2016. *Macro-faunal exploitation in the Cape Floral Region (Fynbos Biome) of the southern Cape, South Africa c. 75-60 ka: Case studies from Blombos Cave and Klipdrift Shelter*. PhD Thesis: University of the Witwatersrand.

Reynard, J.P., Discamps, E., Badenhorst, S., van Niekerk, K.L. & Henshilwood, C.S. 2015. Subsistence strategies in the southern Cape during the Howiesons Poort: taphonomy and zooarchaeology of Klipdrift Shelter, South Africa. *Quaternary International* http://dx.doi.org/10.1016/j.quaint.2015.07.041.

Reynard, J.P., Discamps, E., Wurz, S., van Niekerk, K.L., Badenhorst, S. & Henshilwood, C.S. 2016. Occupational intensity and environmental changes during the Howiesons Poort at Klipdrift Shelter, southern Cape, South Africa. *Palaeogeography, Palaeoclimatology, Palaeoecology* 449: 349-364.

Rhodes, S.E., Goldberg, P., Ecker, M., Horwitz, L.K., Boaretto, E., Chazan, M. 2022. Exploring the Later Stone Age at a micro-scale: new high-resolution excavations at Wonderwerk Cave. *Quaternary International*, 614: 126-145.

Richardson, P.R.K & Levitan, C.D. 1994. Tolerance of Aardwolves to defense secretions of *Trinervitermes trinervoides*. *Journal of Mammalogy* 75 (1): 84-91.

Richter, D., Grün, R., Joannes-Boyau, R., Steele T.E., Amani, F., Rue´ M., Fernandes, P., Raynal J-P., Geraads, D., Ben-Ncer, A., Hublin, J-J. & McPheron, S.P. 2017. The age of the hominin fossils from Jebel Irhoud, Morocco, and the origins of the Middle Stone Age. *Nature* 546: 293-296.

Roffe, S.J., Fitchett, J.M. & Curtis, C.J. 2019. Classifying and mapping rainfall seasonality in South Africa: a review. *South African Geographical Journal* 101 (2): 158-174.

Schlebusch, C.M., et al. 2017. Southern African ancient genomes estimate modern human divergence to 350,000 to 260,000 years ago. *Science* 358: 652-655.

Schlebusch, C.M., et al. 2020. Khoe-San Genomes Reveal Unique Variation and Confirm the Deepest Population Divergence in *Homo sapiens*. *Molecular Biology and Evolution* 37 (10): 2944-2954.

Scott, L. & Neumann, F.H. 2018. Pollen-interpreted palaeoenvironments associated with the Middle and Late Pleistocene peopling of southern Africa. *Quaternary International* 495: 169-184.

Semaw, S., Rogers, M.J., Simpson, S.W., Levin, N.E., Quade, J., Dunbar, N., McIntosh, W.C., Cáceres, I., Stinchcomb, G.E., Holloway, R.L., Brown, F.H., Butler, R.F., Stout, D. & Everett, M. 2020. Co-occurrence of Acheulian and Oldowan artifacts with *Homo erectus* cranial fossils from Gona, Afar, Ethiopia. *Science Advances* 6 (10) https://doi.org/10.1126/sciadv.aaw4694.

Shipman, R. & Rose, J.J. 1983. Early hominid hunting, butchering and carcass processing behavior: approaches to the fossil record. *Journal of Anthropological Archaeology* 2 (1): 57-98.

Skinner, J.D. & Chimimba, C.T. 2005. *The mammals of the Southern African sub-region*. Cambridge: Cambridge University Press.

Soulier, M.C. & Morin, E. 2016. Cutmark data and their implications for the planning depth of Late Pleistocene societies. *Journal of Human Evolution* 97: 37-57.

Speth, J.D. & Clark, J.L. 2006. Hunting and overhunting in the Levantine late Middle Paleolithic. *Before Farming* 3:1-42.

Steele, T.E & Klein, R.G. 2008. Intertidal shellfish use during the Middle and Later Stone Age of South Africa. *Archaeofauna* 17: 63-76.

Steele, T.E. & Klein, R.G. 2013. The Middle and Later Stone Age faunal remains from Diepkloof Rock Shelter, Western Cape, South Africa. *Journal of Archaeological Science* 40: 3453-3462.

Stiner, M.C. 1993. The place of hominids among predators: Interspecific comparisons of food procurement and transport. In J. Hudson (ed) *From Bones to Behavior: Ethnoarchaeological and Experimental Contributions to the Interpretation of Faunal Remains*. Occasional Paper 21. Carbondale: Southern Illinois University Press, pp 38-61.

Stiner, M.C., Kuhn, S.L., Weiner, S. & Bar-Yosef, O. 1995. Differential burning, recrystallization, and fragmentation of archaeological bone. *Journal of Archaeological Science* 22: 223-237.

Stokes, S., Thomas, D.S.G. & Washington, R. 1997. Multiple episodes of aridity in southern Africa since the last interglacial period. *Natur*e 388: 154-158.

Stringer, C. & Galway-Witham, J. 2017. On the origin of our species. *Nature* 546: 212-214.

Stringer, C. 2012. The status of *Homo heidelbergensis* (Schoetensack 1908). *Evolutionary Anthropology* 21: 101-107.

Stuut, J-B.W., Prins, M.A., Schneider, R.R., Weltje, G.J., Jansen, J.F.H. & Postma, G. 2002. A 300 kya record of aridity and wind strength in southwestern Africa: inferences from grain-size distributions of sediments on Walvis Ridge, SE Atlantic. *Marine Geology* 180: 221-233.

Sutton, M.B. 2012. *The archaeology of Swartkrans Cave, Gauteng, South Africa: New excavations of Members 1 and 4*. Unpublished PhD Thesis: University of the Witwatersrand.

Tappen, M. 1994. Bone weathering in the tropical rain forest. *Journal of Archaeological Science* 21: 667-673.

Thackeray, J.F. 1990. Carnivore activity at Klasies River Mouth: a response to Binford. *Palaeontologia Africana* 27: 101-109.

Thackeray, J.F. 2016. The possibility of lichen growth on bones of *Homo naledi*: were they exposed to light? *South African Journal of Science* 112 (7/8): 1-5.

Thomas, D.S.G., Stokes, S. & Shaw, P.A. 1997. Holocene aeolian activity in the southwest Kalahari Desert, southern Africa: significance and relationships to Late Pleistocene dune-building events. *The Holocene* 7 (3): 273-281.

Thompson, C.E.L., Ball, S., Thompson, T.J.U. & Gowland, R. 2011. The abrasion of modern and archaeological bones by mobile sediments: the importance of transport modes. *Journal of Archaeological Science* 38:784-793.

Thompson, E., Williams, H.M. & Minichillo, T. 2010. Middle and late Pleistocene Middle Stone Age lithic technology from Pinnacle Point 13B (Mossel Bay, Western Cape Province, South Africa). *Journal of Human Evolution* 59: (3-4), 358-377.

Thompson, J.C. & Henshilwood, C.S. 2014. Tortoise taphonomy and tortoise butchery patterns at Blombos cave, South Africa. *Journal of Archaeological Science* 41: 214-229.

Thompson, J.C. 2010. Taphonomic analysis of the Middle Stone Age faunal assemblage from Pinnacle Point Cave 13B, Western Cape, South Africa. *Journal of Human Evolution* 59: 321-339.

Val, A. & Mallye, J. B. 2011. Small carnivore skinning by professionals: skeletal modifications and implications for the European Upper Palaeolithic. *Journal of Taphonomy* 9: 221-243.

Val, A. & Stratford, D. 2015. The macrovertebrate fossil assemblage from the Name Chamber, Sterkfontein: taxonomy, taphonomy and implications for site formation processes. *Palaeontologia africana* 50: 1-17.

Val, A. 2016. New data on the avifauna from the Middle Stone Age layers of Sibudu Cave, South Africa: taphonomic and palaeoenvironmental implications. *Quaternary International* 421: 173-189.

Val, A., de la Pena, P. & Wadley, L. 2016. Direct evidence for human exploitation of birds in the Middle Stone Age of South Africa: the example of Sibudu cave, KwaZulu-Natal. *Journal of Human Evolution* 99: 1-17.

Val, A., de la Peña, P., Bansal, S., Colino, F., Culey, J., Duval, M., Hodgskiss, T., Morrissey, P., Murray, A., Murungi, M., Neumann, F.H., Shadrach, K., Thomsen, K.J., van der Ryst, M.M., Witelson, D., Zhao, J. & Stratford, D. 2021. The place beyond the trees: renewed excavations of the Middle Stone Age deposits at Olieboomspoort in the Waterberg Mountains of the South African Savanna Biome. *Archaeological and Anthropological Sciences* https://doi.org/10.1007/s12520-021-01302-7

Val, A., Porraz, G., Texier, P.J., Fisher, J.W. & Parkington, J. 2020. Human exploitation of nocturnal felines at Diepkloof Rock Shelter provides further evidence for symbolic behaviours during the Middle Stone Age. *Scientific Reports* 10, 6424, https://doi.org/10.1038/s41598-020-63250-x van der Ryst, M.M. 2007. *Seeking shelter: Later Stone Age hunters, gatherers and fishers of Olieboomspoort in the Western Waterberg, South of the Limpopo*. PhD Thesis: University of the Witwatersrand.

van Niekerk, K.L. 2011. *Marine fish exploitation during the Middle and Later Stone Age of South Africa*. PhD Thesis: University of Cape Town.

van Pletzen, L. 2000. *The large mammal fauna from Klasies River*. MA Thesis: University of Stellenbosch.

Villa, P. & Mahieu, E. 1991. Breakage patterns of human long bones. *Journal of Human Evolution* 21: 27-48.

Villa, P., Soriano, S., Tsanova, T., Higham, T., d'Errico, F., Backwell, L.R., Lucejko, J. & Beaumont, P.B. 2012. Border Cave and the beginning of the Later Stone Age in South Africa. *Proceedings of the National Academy of Science of the United States of America* 109: 13208-13213.

Voorhies, M.R. 1966. *Taphonomy and Population Dynamics of an Early Pliocene Vertebrate Fauna, Knox County, Nebraska*. Unpublished Ph.D. Thesis: University of Wyoming.

Wadley, L. 2001. What is cultural modernity? A general view and a South African perspective from Rose Cottage Cave. *Cambridge Archaeological Journal* 11 (2): 201-221.

Wadley, L. 2010. Were snares and traps used in the Middle Stone Age and does it matter? A review and a case study from Sibudu, South Africa. *Journal of Human Evolution* 58 (2): 179-192.

Wadley, L. 2015. Those marvellous millennia: the Middle Stone Age of southern Africa. *Azania: Archaeological Research in Africa* 50 (2): 155-226.

Wadley, L., Esteban, I., de la Peña, P., Wojcieszak, M., Stratford, D., Lennox, S., d'Errico, F., Rosso, D.E., Orange, F., Backwell, L.R. & Sievers, C. 2020. Fire and grass-bedding construction 200 thousand years ago at Border Cave, South Africa. *Science* 369: 863-866.

Wadley, L., Hodgskiss, T. & Grant, M. 2009. Implications for complex cognition from the hafting of tools with compound adhesives in the Middle Stone Age, South Africa. *Proceedings of the National Academy of Sciences of the United States of America* 106 (24): 9590-9594.

Wadley, L., Mauran, G., Sievers, C., van Deventer, H., Biemond, W., Seanego, K., Li, B. & Jacobs, Z. 2021. Red Balloon Rock Shelter: Iron Age and Middle Stone Age occupations on the Waterberg Plateau in Limpopo, South Africa. *Southern African Humanities* 34: 19-58.

Wadley, L., Plug, I. & Clark, J.L. 2008. The contribution of Sibudu fauna to an understanding of KwaZulu-Natal environments at ~60 ka, ~50 ka and ~37 ka. In S, Badenhorst, P, Mitchell & J. C. Driver (eds) *Animals and people: archaeozoological papers in honour of Ina Plug*. Oxford: Archaeopress, pp 34-45.

Watts, I. 2002. Ochre in the Middle Stone Age of southern Africa: ritualized display or hide preservative? *The South African Archaeological Bulletin* 57:64-74.

Wenban-Smith, F., Bates, M., Bridgland, D., Harp, P., Pope, M. & Roberts, M. 2010. *South-East Region Research Frameworks: The Early Palaeolithic: Resource Assessment and Research Agenda*. Kent County Council.

Wilkins, J., Schoville, B.J., Brown, K.S. & Chazan, M. 2012. Evidence for early hafted hunting technology. *Science* 338:942-946.

Wilkins, J., Schoville, B.J., Brown, K.S., Gliganic, L., Meyer, M.C., Loftus, E., Pickering, R., Collins, B., Blackwood, A.F., Makalima, S., Hatton, A. & Maape, S. 2020. Fabric analysis and chronology at Ga-Mohana Hill North Rockshelter, Southern Kalahari Basin: evidence for in situ, stratified Middle and Later Stone Age deposits. *Journal of Paleolithic Archaeology* https://doi.org/10.1007/s41982-020-00050-9.

Wurz, S. 1999. The Howiesons Poort at Klasies River- an argument for symbolic behaviour. *The South African Archaeological Bulletin* 54: 38-50.

Wurz, S. 2008. Modern human behaviour at Klasies River. S*outh African Archaeological Society Godwin Series* 10: 150-156.

Wurz, S. 2013. Technological trends in the Middle Stone Age of South Africa between MIS 7 and MIS 3. *Current Anthropology* 54 (Sup 8): S305-319.

Wurz, S. 2014. Southern and east African Middle Stone Age: Geography and climate. In C Smith (ed) *Encyclopedia of global archaeology*. New York: SpringerScience, pp 6890-6912.

Wynn, T. & Coolidge, F.L. 2011. The implications of the working memory model for the evolution of modern cognition. *International Journal of Evolutionary Biology* 2011: 741357. https://dx.doi.org/10.4061/2011/741357.

Wynn, T. 2009. Hafted spears and the archaeology of mind. *Proceedings of the National Academy of Sciences of the United States of America* 106 (24): 9544-9545.

Zeder, M. A. 2006. Reconciling rate of long bone fusion and tooth eruption and wear in sheep (*Ovis*) and goat (*Capra*). In D. Ruscillo (ed.) *Recent advances in ageing and sexing animal bones.* Oxford: Oxbow Books, pp 87-118.