

UNIVERSITY OF THE WITWATERSRAND, SCHOOL OF GEOGRAPHY,
ARCHAEOLOGY AND ENVIRONMENTAL STUDIES

**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

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A thesis submitted to the Faculty of Science, University of the Witwatersrand,
Johannesburg, in fulfilment of the requirements for the degree of Doctor of
Philosophy

Declaration

I declare that this thesis is my own unaided work for submission for the degree of Doctor of Philosophy at the University of the Witwatersrand. The degree is by publication and my publications, submitted paper and contribution in co-authored papers are detailed in the text. The thesis has not been submitted before for any degree or examination at any other University.

A handwritten signature in black ink, appearing to read 'Jean Reynolds', written in a cursive style.

4 March 2016

Abstract

The analysis of faunal remains from archaeological sites can reveal much about past behaviour, palaeoenvironments and bone technology. This is especially pertinent for the Middle Stone Age (MSA): a period that corresponds to both the behavioural and anatomical development of *Homo sapiens*. In this thesis, I examine the faunal remains from Blombos Cave (BBC) and Klipdrift Shelter (KDS), two significant MSA sites about 45 km apart along the present-day southern Cape coast. The focus of the analyses is on the Still Bay (SB) layers (c. 75 – 68 thousand years ago [ka]) at BBC and the Howiesons Poort (HP) layers (c. 65 – 59 ka) at KDS. The aim of this thesis is to explore subsistence behaviour and environmental conditions during the SB and HP in the *fynbos* region of the southern Cape. I also investigate the effects of trampling on bone and whether trampling and other types of taphonomic modification can be used to infer occupational intensity in cave and rock shelter sites.

Taphonomic data indicate that significant differences exist between the SB and HP faunal assemblages at BBC and KDS, respectively. Carnivores and scavengers had a greater effect on the SB than on the KDS assemblage. Furthermore, subsistence activities at KDS focused on marrow extraction while filleting was probably an important strategy at BBC. Taxonomic analyses indicate that the representative fauna from both sites is generally consistent with what is expected in the *fynbos* biome but with some noticeable differences. Grazers, for example, are significantly more prevalent at KDS than BBC while seal is more common at BBC. Other zooarchaeological data also show differences in prey selection strategies. Diet breadth is more extensive at KDS than at BBC, although bovid mortality profiles at BBC are more juvenile-dominated. I propose that many of these contrasting patterns imply that subsistence intensification is more evident in the HP layers at KDS than in the SB at BBC. Moreover, the taphonomic data suggest that the SB at BBC was a low-intensity, sporadically occupied period in contrast to the high-intensity occupations, particularly during the middle layers of the HP at KDS. The results of the KDS analysis also indicate a shift in environmental conditions during the HP and show links between prey selection, the environment and occupational intensity during this period.

Trampling experiments indicate that trampling can generally be distinguished from butchery-marks, although bioturbation in shelly deposits can sometimes result in marks that mimic cut-

marks. More importantly, experiments show that pitting and abrasion are a more significant indicator of trampling than lines that resemble cut-marks. Based on these experiments, I argue that trampling modification can be used to infer occupational intensity at archaeological sites. Trampling marks in the KDS assemblage, for example, correspond well with the high occupational periods as indicated by other taphonomic data. Trampling and taphonomic data support the notion that BBC was a low-intensity, sporadically occupied site during the SB. By incorporating taxonomic, taphonomic and novel methods of skeletal-part analyses, this study contributes to our knowledge of human subsistence and palaeoenvironments during the SB and HP in the southern Cape. This thesis strengthens and adds to other research that has demonstrated variability in subsistence behaviour during the MSA.

Dedication

To my late parents: Barbara and William-John Reynard

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Conventions

Table 1.1: Terms used in this thesis

Terms	Definition	References
Zooarchaeology	Defined as using the analysis of faunal remains from archaeological sites to infer human behaviour or palaeoenvironmental conditions. This term is used instead of archaeozoology.	Reitz & Wing 2008 Plug 2014
Southern Cape	The area from the Cape Fold Mountain ranges in the north (c. 33°22') to the Agulhas Bank in the south, and from Pringle Bay in the west (c. 18°50') to Port Elizabeth (c. 25°35') in the east.	See figure 1
Modern human behaviour Behavioural modernity Complex cognition	These terms are used in this thesis to describe a suite of cognitive capabilities such as abstract thought, analogical reasoning, cognitive flexibility and multitasking that have developed in <i>Homo sapiens</i> .	Henshilwood & Marean 2003 Ambrose 2010 Wadley 2015: 156/157 Wynn & Coolidge 2011
Techno-complex	Designates a set of technological and/or cultural traits used to define an archaeological period in the Stone Age/Palaeolithic. In the literature review, I often retain the term 'Industry' with reference to older research.	Wurz et al. 2003
Late Pleistocene	The final phase of the Pleistocene Epoch from c. 126 ka to c. 10 ka.	Gibbard & van Kolschoten 2004
Fauna	'Fauna' here refers to all animal remains larger than ~ 750 g ('macrofauna'). This includes bone, teeth, horn and other osseous specimens. The remains of animals whose adult weight is smaller than ~ 750 g are referred to as 'micromammals' (if it includes only mammals) or 'microfauna' (if it includes	This thesis

	non-mammalian specimens such as reptiles and amphibians). Molluscan fauna is referred to as shellfish.	
Southern Coastal Plain Palaeo-coastal Plain	The currently submerged area of the Agulhas Bank of the southern Cape that would have been exposed during glacial periods when sea levels were lower.	Compton 2010 Faith & Behrensmeyer 2013
Bioturbation Pedoturbation	The disturbance of soil and sediment by animals and people (bioturbation) or any physical or chemical process (pedoturbation). In this thesis it is used to describe the effects of trampling on deposits in archaeological sites.	Reynard 2014 Olsen & Shipman 1988
The Klipdrift Shelter (KDS) sequence	The KDS Howiesons Poort sequence (c. 65- 59 ka) encompasses (from the bottom to the top of the sequence) layers PCA to PAY. I define the KDS period as follows: early Howiesons Poort – PCA & PBE; the middle Howiesons Poort – PBD, PBC & PBA/PBB; the later Howiesons Poort – PAZ & PAY	This thesis

CHAPTER 1 INTRODUCTION

The analysis of faunal remains from archaeological sites can inform on a range of issues regarding the past including subsistence behaviour (Klein 1975a; Blumenschine & Selvaggio 1988; Milo 1998; Dusseldorp 2012), palaeoenvironments (Klein 1972, 1980; Faith 2011a), demographic change (Stiner et al. 1999; Munro 2004; Steele & Klein 2009) and bone tool technology (Yellen *et al.* 1995; Henshilwood *et al.* 2001a; Backwell *et al.* 2008; d'Errico *et al.* 2012). These topics are particularly pertinent when examining the Middle Stone Age (MSA), the period from c. 300 thousand years ago (ka) to c. 25 ka (Wadley 2015: 159, 167). The association of the MSA with the biological and behavioural development of *Homo sapiens* makes this an especially significant era (Klein 2009; Wadley 2015). Zooarchaeology is an important element in unravelling past human behaviour and environments in the MSA.

The Still Bay (SB) and Howiesons Poort (HP) were significant periods in the MSA (Henshilwood 2012). The southern Cape of South Africa has a rich archaeological heritage and the discovery of SB sites such as Blombos Cave (BBC) (Henshilwood *et al.* 2001b) and the HP at sites such as Klasies River (Klein 1976; Singer & Wymer 1982; Deacon 1989, 1995; Wurz 2002), Boomplaas (Klein 1978; Deacon 1995; Faith 2013) and Klipdrift Shelter (Henshilwood *et al.* 2014) have enriched our knowledge of the behaviour of *Homo sapiens* in the region. BBC is the only SB site in the southern Cape with well-preserved, *in situ* and stratigraphically-associated fauna. There are five HP sites in the southern Cape (Henshilwood 2012) and of these Klasies River (Klein 1976), Boomplaas (Klein 1978; Faith 2013) and Klipdrift Shelter (KDS) (Henshilwood *et al.* 2014) have well-provenanced fauna.

1.1 Rationale, aims and hypotheses

In this thesis, I examine faunal remains from BBC and KDS, two MSA sites along the present southern Cape coast. The sites are relatively close to one another – about 45 km apart – in the *fynbos* biome of the Cape Floristic Region (CFR). The faunal remains that I have analysed are from the Still Bay layers at BBC and date to Marine Isotope Stage (MIS) 5a and those from the HP sequence at KDS date to MIS 4. The SB and HP are closely associated with modern complex behaviour (Wadley 2015). Indeed, artefacts such as shell beads, pressure-flaked bifacial foliate points made on heated silcrete, finely-worked bone tools and

engraved ochre from the SB layers of BBC (Henshilwood *et al.* 2001b, 2002, 2004, 2009; Mourre *et al.* 2010) indicate that this site is important to our understanding of the cognitive and behavioural development of modern humans. KDS, the other site investigated here, also provides important data on the development of complex behaviour as it has revealed a sophisticated stone tool technology and yielded significant quantities of engraved ostrich eggshell (Henshilwood *et al.* 2014). For both sites these important developments need to be integrated with the faunal data.

1.1.1 Rationale

Previous research involving the SB fauna at BBC has included foraging behaviour (Henshilwood *et al.* 2001b; Hillestad-Nel 2007; Lombard & Clark 2008; Thompson 2008; Thompson & Henshilwood 2011, 2014a, 2014b; McCall & Thomas 2012; Discamps & Henshilwood 2015) but very little faunal material from BBC has been taxonomically identified since 2000, even though regular excavations up to 2011 have continued to yield osseous remains. There is also a dearth of research on subsistence variability in the SB at BBC (but see Discamps & Henshilwood 2015). The fauna from the HP layers at KDS has not been fully assessed, apart from an introductory paper on the site which forms part of this thesis (Henshilwood *et al.* 2014). Furthermore, few studies have compared fauna from SB and HP periods since sites with both techno-complexes are rare. The close proximity of BBC to KDS in the same *fynbos* biome makes comparisons of these techno-complexes feasible. Faunal samples from these sites could potentially add significant information on MSA foraging strategies and palaeoecology in the southern Cape.

The palaeoecology of the Late Pleistocene in the southern Cape has been extensively studied (e.g., Klein 1972, 1974, 1975b; Henshilwood 2008a; Compton 2011; Faith 2011b, 2013; McCall & Thomas 2012; Faith & Behrensmeier 2013; Faith & Thompson 2013). However, faunal studies focusing primarily on the ecology in the SB are limited (e.g., Henshilwood *et al.* 2001b; Hillestad-Nel 2007; McCall & Thomas 2012; Steele & Klein 2013). In general, the environment of the SB in the southern Cape appears similar to some of the earlier periods of the MSA (e.g., McCall & Thomas 2012) and may have been comparable to modern conditions in the CFR (Hillestad-Nel 2013). The modern CFR encompasses vegetation dominated by *fynbos* and *renosterveld*, and shrub-based animals such as tortoise, small mammals and small, browsing bovids such as Cape grysbok (*Raphicerus melanotis*) and klipspringer (*Oreotragus oreotragus*) My research on BBC contributes new data and

perspectives on the palaeoenvironmental record of the SB of the southern Cape. The HP in the southern Cape has been characterised by palaeoenvironmental instability (Thackeray 1988; Van Pletzen 2000; Jacobs & Roberts 2008; Henshilwood 2008a; Chase 2010; Faith 2013) and the fauna from KDS adds to our understanding of the dynamics of environmental change in the HP.

Taphonomic modification is also an important consideration when assessing fauna from archaeological deposits (Brain 1981; Blumenschine 1986; Lyman 1994; Marean & Kim 1998). Much research has been conducted on the taphonomy of MSA faunal assemblages (e.g., Milo 1998; Marean *et al.* 2000; Thompson 2010; Thompson & Henshilwood 2011), but few studies have focused on the effects of trampling. Detailed studies on trampling modification in general – and in the southern Cape in particular – are lacking. This is especially problematic for the southern Cape since little is known about how the taphonomic history of bone is influenced by bioturbation in coastal rock-shelters, the repositories for most of the MSA occupations in the southern Cape. The ubiquity of evidence for shellfish exploitation at MSA sites along the southern Cape coast suggests that the trampling of bone associated with mollusc shell remains may affect the depositional history of faunal assemblages. In this thesis, experimental trampling data is employed to investigate occupational intensity throughout the sequences of BBC and KDS which may have significant implications for future research on palaeodemography.

Demographic issues such as occupational density probably had a significant influence on modern behaviour in the Late Pleistocene (Shennan 2001; Zilhão 2007; Powell *et al.* 2009; Richerson *et al.* 2009). Fluctuating population densities and changes in mobility patterns are also relevant to understanding the SB and HP in the southern Cape (Deacon 1989; Ambrose & Lorenz 1990; Powell *et al.* 2009; McCall & Thomas 2012; Mackay *et al.* 2014). The analysis of faunal remains may reveal links between subsistence patterns, environmental change and occupational density. Taxonomic and taphonomic data from BBC and KDS adds to our understanding of these processes, particularly in light of the limited information concerning occupational intensity in the SB.

1.1.2 *Aims and hypotheses*

The aims of this thesis are to:

1. Investigate subsistence behaviour during the SB and HP in the southern Cape

2. Explore the palaeoecology of BBC and KDS
3. Examine the effects of trampling on the taphonomic history of faunal remains in BBC
4. Understand whether these data relate to possible demographic changes in this time period in the southern Cape.

The hypotheses I develop in this thesis are:

1. Subsistence intensification is more evident in the HP than in the SB
2. Foraging strategies are linked to environmental change in MIS 5a/4
3. Trampling plays an important role in the taphonomic history of the KDS and BBC assemblages and can be used to infer occupation density
4. Occupational intensity is more pronounced in the HP than in the SB in the southern Cape.

1.2 Thesis structure

This thesis includes five papers: three published and two in press. Each paper is designated as a chapter. Other chapters provide information and background on specific perspectives and provide links between the various issues investigated. The bibliography presented at the end of the thesis includes only references for chapters 1, 2, 4, 8, 9 and the appendices and not references for the published or accepted articles.

Chapter 1: Introduction

Chapter 1 includes an introduction, the rationale, aims and the hypotheses. In addition, I explain the structure of the thesis, summarise the relevant papers and my contribution to each of them, and describe the interlinking chapters.

Chapter 2: Background

Chapter 2 contains the background of this study and lays the foundation for the scope of the study. It contains a literature review of the important topics relevant to this study such as the SB and HP periods and the role of zooarchaeology in MSA research. Background information is often repeated in the published papers due to the structural requirements of research articles. This chapter also describes the archaeological sites used in my analyses: BBC and KDS. I have included a published paper on the preliminary analysis of KDS as the 'site description' in this chapter. The paper details the archaeological finds, geology,

excavation procedure and dating methodology at KDS. It also includes a preliminary list of the faunal remains recovered there. The article is:

Henshilwood, C.S., van Niekerk, K.L., Wurz, S., Delagnes, A., Armitage, S., Rifkin, R., Douze, K., Keene, P., Haaland, M., Reynard, J., Discamps, E., Mienies, S. 2014. **Klipdrift Shelter, southern Cape, South Africa: preliminary report on the Howiesons Poort levels.** *Journal of Archaeological Science* 45: 284-303.

My contribution: I identified the terrestrial faunal remains, wrote the section on fauna, co-wrote the section on palaeoenvironments and contributed to the discussion.

Chapter 3: Subsistence behaviour at Klipdrift Shelter

This chapter consists of a paper describing subsistence behaviour at KDS. I use taphonomic analyses and skeletal-part and mortality profiles to explore subsistence strategies at KDS. The article is:

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

My contribution: I initiated the faunal research, identified the faunal remains, conducted ~ 80% of the analyses and wrote the manuscript. Co-authors commented and contributed to the writing of the paper.

Chapter 4: The Blombos Cave faunal analysis

In this chapter I present the results of my analysis of the BBC fauna that was not included in published papers. It includes the materials and methods used to assess the fauna.

Chapter 5: Subsistence behaviour at Blombos Cave

This chapter consists of a paper focusing on subsistence strategies at BBC. The paper uses a similar method to that employed in the analyses of faunal remains from KDS (Chapter 3) to investigate subsistence strategies at BBC. It also compares subsistence strategies at BBC with those of KDS. The article is:

Reynard, J.P. & Henshilwood, C.S. In press. **Subsistence strategies during the later Middle Stone Age in the southern Cape of South Africa: comparing the Still Bay of Blombos Cave with the Howiesons Poort of Klipdrift Shelter.** *Journal of Human Evolution*.

My contribution: I initiated the faunal research, identified the faunal remains, conducted the analyses and wrote the manuscript with comments by the co-author.

Chapter 6: Palaeoecology at Klipdrift Shelter

In this chapter I describe the palaeoecology of KDS in an article published in *Palaeo-3*. This paper deals with demographic changes and palaeoenvironments and also includes a background to occupational and demographic factors affecting the HP. The article is:

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

My contribution: I initiated the faunal research, identified the faunal remains, conducted ~ 80% of the analyses and wrote the majority of the manuscript. Co-authors commented and contributed to the writing of the paper.

Chapter 7: The effects of trampling in cave sites

Chapter 7 is a single-authored published paper on an experimental study describing the effects of trampling on bone in coastal sediment. This study fulfils two purposes: 1) it investigates whether trampling abrasion can mimic intentional use-wear and modifications, and; 2) it describes and defines the types of modification caused by trampling in coastal sediment. The article is:

Reynard, J.P. 2014. **Trampling in coastal sites: an experimental study on the effects of shell on bone in coastal sediment.** *Quaternary International* 330: 156-170.

Chapter 8: Taphonomic modification and occupational intensity

In this chapter I propose that trampling marks specifically – and taphonomic modification in general – can be used to measure occupational intensity in enclosed sites such as caves or rockshelters. Although not a published paper, this chapter includes an ‘introduction’

containing the aim and rationale, and ‘materials and methods’, ‘results’, and ‘discussion’ subdivisions. This chapter will be converted into a paper.

My contribution: I initiated the faunal research, identified the faunal remains, conducted the analyses and wrote the text.

Chapter 9: Discussion and conclusion

Here, I bring together the various results, arguments and outcomes of my papers, to discuss subsistence behaviour, palaeoecology, taphonomy, demographic changes and occupational density in the SB and HP. I also summarise the contents of this body of work and present future avenues for research. The bibliography of this thesis occurs after chapter 9 and contains all references not included in the published and in press papers.

Appendices

Appendices to some papers and chapters and supplementary information are presented after the references. The appendices include additional results and arguments that I was unable – through space or word limits – to include in some of my papers.

CHAPTER 2: BACKGROUND

In this chapter I discuss the background of key issues related to my thesis. This involves a literature review of the archaeological context of KDS and BBC and topics that are not reviewed in detail in any of the research articles presented in this thesis.

2.1 The palaeoenvironment of the southern Cape

The southern Cape is a region of climatic variability (Carr *et al.* 2007). The area near BBC and KDS forms part of the CFR and the vegetation consists mostly of *fynbos*, an evergreen sclerophyllous shrubland that dominates much of the southern coastal region of South Africa (Bergher *et al.* 2014). The region surrounding the *Breede* River – which runs between BBC and KDS – occurs at the boundary of the winter rainfall zone to the west and the summer rainfall zones further to the east. BBC and KDS generally have year-round precipitation but with much of the rain occurring in winter (Carr *et al.* 2007; Chase & Meadows 2007; Roberts *et al.* 2008). The region also situated near the convergence of the cold Benguela and warm Agulhas oceanographic systems (Barrable *et al.* 2002; Carr *et al.* 2007; Roberts *et al.* 2008).

Alternating glacial/interglacial Marine Isotope Stages (MIS) would have had significantly affected the environment along the southern Cape coast. Besides its influence on the climatic and oceanic systems, the gentle gradient off the now-submerged Agulhas Bank would have resulted in substantial marine regression periods (Compton 2011). These sea level fluctuations would have affected the availability of habitable land and foraging ranges for southern Cape populations (Fig. 2.1). MIS 4 was a particularly important period in the behavioural development of *Homo sapiens* (Table 1.1). MIS 4, a cool period, generally corresponds to the SB and HP periods (Chase 2010). The warmer MIS 5a, however, may also be linked to the early SB at BBC with the later SB associated with the beginning of MIS 4 (Thompson & Henshilwood 2011). MIS 4 was cool, possibly arid (Jacobs & Roberts 2008) and generally contemporaneous with the HP levels at KDS (Henshilwood *et al.* 2014). Chase (2010), however, has proposed that, rather than being dry, MIS 4 in the southern Cape was a moist period due to the interaction between temperate and tropical climatic systems. Speleothem data from Pinnacle Point suggests that ~72 to 63 ka was a period of climatic and

environmental instability and that summer-rainfall and C4 grasses may have been more abundant along the southern Cape coast than they are today (Bar-Matthews *et al.* 2010).

Table 2.1: Climatic change and technological/behavioural developments during the Middle Stone Age (adapted from Wadley 2015)

MIS Stage	Approximate start (ka)	Temperature	Techno-cultural events
2	29	Cold	Last Glacial Maximum; MSA disappears
3	57	Cool with warm oscillations	Possible <i>Homo sapiens</i> migration out of Africa; ostrich eggshell bead manufacture; Post-Howiesons Poort techno-complexes
4	71	Cool	Still Bay/Howiesons Poort techno-complexes; marine shell beads; engraved eggshell; diverse bone tool technology; possible bow-and-arrow technology
5a	82	Warm	Ground bone tools
5b	87	Cool	
5c	96	Warm	Ochre engraving; compound paint;
5d	109	Cool	
5e	123	Warm	Possible <i>Homo sapiens</i> migration out of Africa
6	191	Cool with warm oscillations	Heat treatment of rocks
7	243	Warm with cool oscillations	
8	300	Cool	MSA technology established; hafted points used as weapons

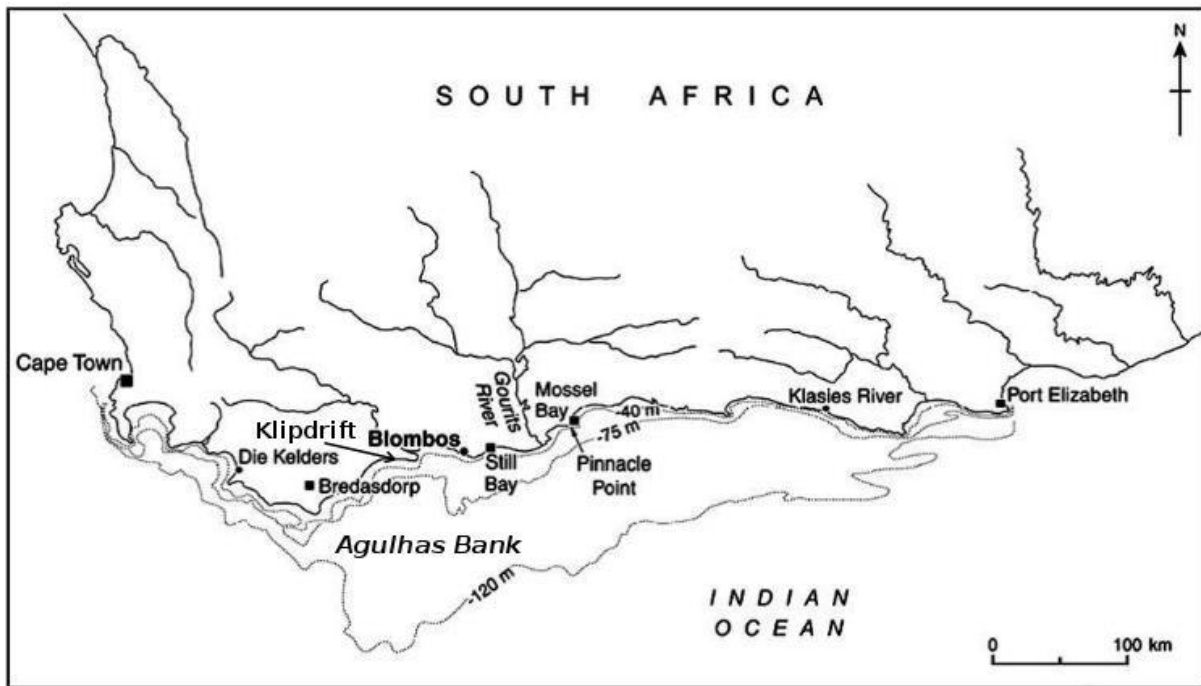


Figure 2.1: Map of the southern Cape showing the Agulhas Bank, Blombos Cave, Klipdrift Shelter and other significant sites (adapted from Jacobs *et al.* 2006)

2.2 The Still Bay

The SB techno-complex is generally associated with the archaeological finds from BBC, yet it has a long tradition related to the quest of uncovering and understanding South Africa's ancient archaeological heritage. Finely-worked, bifacial, foliate points were recovered from sites near Cape Town in the late 19th century (Henshilwood 2012). The term 'Still Bay' was named after a small town on the southern Cape coast after the recovery in the 1920s of bifacial points by Dr. C.H.T.D Heese in the dunes not far from the town and close to Blombos Cave (Henshilwood 2012). It was first suggested as the name of a Stone Age Industrial Complex by A.J.H Goodwin in a series of articles in the *Cape Times* newspaper (Goodwin 1933). Goodwin and van Riet Lowe (1929) also included 'oak-leafed' shaped 'spear points' in their terminology as the *fossile directeur* of the SB techno-complex (Henshilwood 2012). The term was later used to include other lithic industries such as the 'Mossel Bay' (Malan 1955). Goodwin noted that SB points involved a relatively sophisticated production sequence (Goodwin 1933: 521) and suggested they were similar to the Solutrean of Western Europe (Goodwin 1927).



Figure 2.2: Still Bay bifacial points from Blombos Cave (picture courtesy of Christopher Henshilwood & Magnus Haaland)

Despite the efforts by some researchers (e.g., Malan 1955, 1956), the term ‘Still Bay’ was only vaguely defined. By the 1960’s the term Still Bay fell progressively out of use in the archaeological lexicon and by the 1970’s, Sampson (1974) questioned the legitimacy of the Still Bay as a material culture. The term was then generally abandoned and was not included in Volman’s (1981, 1984) review of the southern African MSA. By the 1990’s, excavations at Hollow Rock Shelter in the Western Cape (Evans 1994) and at BBC (Henshilwood 1995) yielded lithics that conformed to the definition of the SB-type according to Goodwin and van Riet Lowe (1929). In their site report, Henshilwood *et al.* (2001a: 429) proposed that the SB be reintroduced as a “regional, cultural-stratigraphic term for assemblages with fully bifacially flaked, lanceolate shaped points.” Since the term was reinstated, SB lithics have also been recognised at Diepkloof (Texier *et al.* 2010), Soutfontein (Mackay *et al.* 2010), Spitzkloof Rockshelter (Dewar & Steward 2012) and Varsche Rivier (Steele *et al.* 2012) in the Western Cape, Sibudu (Wadley 2007) and Umhlatuzana Rock Shelter (Lombard *et al.* 2010) in KwaZulu- Natal and Apollo 11 in Namibia (Vogelsang *et al.* 2010).

The SB techno-complex is characterised by bifacial, foliate, lithic points (Fig. 2.2) (Goodwin & van Riet Lowe 1929; Goodwin 1933; Henshilwood *et al.* 2001a; Wadley 2007; Villa *et al.*

2009). Very likely – at BBC at least – complex pressure-flaking techniques combined with heat treatment of raw materials were employed to produce these distinctive lanceolate-shaped points (Mourre *et al.* 2010). At MSA sites such as BBC and Sibudu, SB points coincide with other expressions of cognitive complexity such as shell-beads and engraved ochre (Henshilwood *et al.* 2002, 2004). Moreover, fishing (van Niekerk 2011) and fowling (Val, in press) possibly developed into more systematic and efficient subsistence strategies during this period. Together with evidence of the demographic expansion of modern humans out of Africa between ~ 80 and 60 ka (Mellars 2006; Behar *et al.* 2008), this suggests that the SB is an important marker of behavioural modernity in the MSA (d’Errico *et al.* 2005; Henshilwood & Dubreuil 2011).

2.3 The Howiesons Poort

The HP is named after ‘Howiesons Poort’, a small cave near Grahamstown first excavated in the 1920’s by Stapelton and Hewitt (1927, 1928). The stone artefacts recovered from the name site – including burins, large segments and obliquely pointed blades – came to define this techno-complex although similar types of tools may have been recovered in the late 19th century from sites near Cape Town and in the Northern Cape (Henshilwood 2012). Originally the ‘Howiesons Poort series’ was incorporated in the SB techno-complex (Goodwin & van Riet Lowe 1929) but it was later removed by Malan and Goodwin (1938) to form a stand-alone Industry. Clark (1954) classified the HP as part of the Magosian, a LSA techno-complex considered transitional to the MSA. Given the microlithicisation that characterises HP artefacts, this fitted in perfectly with the accepted belief of the HP as a transitional Industry (Wurz 1999). The Pan-African Congress on Pre-history soon confirmed this assignment in 1955 by placing the HP and Magosian into the Second Intermediate Phase between the LSA and MSA (Clark 1959). By the 1960’s, however, similar artefact types were found at Klasies River (Singer & Wymer 1982), Montagu Cave (Keller 1970) and Apollo 11 (Wendt 1972) and it was then generally agreed that the HP was neither transitional, nor a final stage of the MSA and should be fully incorporated as a penultimate phase into the MSA (Deacon 1995). Currently, the HP is distributed widely across southern Africa from the Cave of Hearths in the north (Mason 1957), to Border Cave in the east (Beaumont *et al.* 1978) and to sites in Namibia such as Apollo 11 (Vogelsang *et al.* 2010) (see Henshilwood 2012 for a detailed list of HP sites). In the southern Cape, the important Howiesons Poort sites are

Klasies River (Wurz 1999), Nelson Bay Cave (Deacon 1978), Boomplaas (Deacon 1995) and Pinnacle Point (Brown *et al.* 2012).



Figure 2.3: Howiesons Poort tools from Umhlatuzana Rock Shelter (picture by Marlize Lombard)

HP lithics are traditionally defined by a prevalence of segments/crescents, trapezoids, and other backed/truncated artefacts and small blades/bladelets (Fig. 2.3) (Goodwin & van Riet Lowe 1929; Sampson 1974; Volman 1984). The description of the lithics is now more extensive and includes unifacial points, scrapers, *pièces esquillées* and partly bifacial points (Deacon 1995; Minichillo 2005; Wurz 1999; Wurz 2013). In terms of typology, the HP is viewed as notably different to preceding and later MSA assemblages (Ambrose & Lorenz 1990; Minichillo 2006) and much research has focused on this aspect of the Industry (e.g., Soriano *et al.* 2007; Villa *et al.* 2010; Lombard & Parsons 2011; Mackay 2011). Like the SB, the HP is also associated with complex cognition and innovative behaviours. Evidence of the possible use of bow-and-arrows (Lombard & Phillipson 2010), insecticides (Lennox & Bamford 2015) and bedding (Wadley *et al.* 2011) at Sibudu at ~ 64 ka suggest that this period is linked to technological innovation similar to that used in the Later Stone Age.

2.4 Dating of the Still Bay and Howiesons Poort

The complexity regarding the chronology of the SB and HP is linked to the early history of discovery of these techno-complexes. Excavations in and around the Cape Peninsula in the early 20th century often resulted in the recovery of artefacts assigned to both the SB and HP (Henshilwood 2012). At Peers Cave, for example, Jolly (1948: 106) was not certain of the chronology of SB and HP lithics relative to one another, although he noted that crescents – which were ‘slightly larger’ than Wilton implements – generally overlay Still Bay tools. Tunnel Cave and Skildergatkop Cave near Fish Hoek contained both SB and HP artefacts but their relative chronology was also uncertain (Malan 1955; Volman 1981). By the 1970’s, the consensus was that the HP was younger than assemblages with SB-like bifacials (although by now the term ‘Still Bay’ had fallen out of use) (Sampson 1974).

With the refinement of chronometric methods and environmental proxies, absolute dating became the focus of much MSA research in the 1970’s and 1980’s. Although Sampson (1974) placed the HP at > 20 ka, later palaeoenvironmental and sedimentological studies suggested that the HP occurred in either MIS 5 (Klein 1974, 1976, 1977; Avery 1982, 1987, 1992; Butzer *et al.* 1978; Butzer 1982, 1984) or on the MIS 5a/4 transition (Deacon & Geleijnse 1988; Deacon 1989, 1995). Although some researchers argued that the HP may have occurred in MIS 3 (Parkington 1990; Thackeray 1992), most studies indicated ages over 40 ka: beyond the range of radiocarbon dating (Beaumont *et al.* 1978; Volman 1984; Deacon 1992). By the time the SB assemblages uncovered in the 1990’s had been radiometrically dated (Vogel *et al.* 1999; Jones 2001; Henshilwood *et al.* 2002), most chronometric dates positioned the SB older than the HP (Henshilwood *et al.* 2001a; Tribolo *et al.* 2005: 498). Evans (1994) placed the SB layers at Hollow Rock Shelter at ~ 80 ka based on Volman’s (1984) chronology (MSA 2a/b) and later studies proposed an age of between 72 and 80 ka (Högberg & Larsson 2011). Initially it was suggested that the SB at BBC was between 60 and 50 ka (Henshilwood & Sealy 1997). Later, the chronology was amended to > 70 ka based on the belief that the SB layers at BBC were older than the HP which at that stage was thought to be between 70 and 65 ka (Henshilwood *et al.* 2001a).

Recent revised dates for the SB and HP have been of particular interest to MSA researchers. Until recently, chronometric studies have placed the HP within the 65 to 55 ka age range (Miller *et al.* 1999; Vogel 2001; Bird *et al.* 2003; Tribolo *et al.* 2005; Jacobs & Roberts 2008; Jacobs *et al.* 2008) with the SB slightly older at between 76 and 68 ka (Henshilwood *et al.*

2002; Jacobs *et al.* 2003a, b; Jacobs *et al.* 2008, 2012). Research by Jacobs and colleagues (Jacobs & Roberts 2008; Jacobs *et al.* 2008: 753, 2012) using single-grained optical stimulated luminescence (OSL) dating methods suggested that the SB and HP were relatively short-lived periods of ~ 900 and 5000 years or less, respectively, and that the HP represented an MSA 'horizon marker' (after Deacon 1992). The method used by Jacobs *et al.* (2008, 2012) to obtain these narrow age-ranges has been challenged by some researchers (Tribolo *et al.* 2013; Guerin *et al.* 2013) who claim that the mathematical formula that supports her model is incorrect. This challenge has recently been contested and Jacobs' method has been defended (Armitage *et al.* 2014; Gailbraith 2014; Jacobs & Roberts 2015). Jacobs *et al.* (2003a, b, 2006, 2008; Jacobs & Roberts 2015) and Tribolo *et al.* (2005, 2006, 2009, 2013) have often analysed the same sites and the age ranges of Tribolo have tended to be broader and older than those of Jacobs. For example, Jacobs *et al.* (2008) dates for the HP at Diepkloof range from 63 to 60 ka, while the OSL and thermoluminescence (TL) ages of Tribolo *et al.* (2013) span the period 105 to 52 ka. This may be because of the differences between OSL and the TL method used by Tribolo *et al.* (2005, 2009, 2013). The debate is still ongoing since the issues have not yet been resolved (Jacobs & Roberts 2015: 17). As Wadley (2015:167) observed, the controversy surrounding the dating dispute may signify the end of an 'Indian Summer' of refined, narrow-range, radiometric chronologies.

This dating debate may symbolise new interpretations of the SB and HP. The idea of these techno-complexes as homogenous entities has been re-assessed by some researchers (Soriano *et al.* 2007; Villa *et al.* 2009; Porraz *et al.* 2013; Wurz 2013; Soriano *et al.* 2015). Current studies highlight both regional and temporal variation within the SB (e.g., Archer *et al.* 2015). Bifacial points were shaped and used differently at various sites (Lombard *et al.* 2010; Soriano *et al.* 2015). HP lithics also vary temporally (Wurz 2013; de la Peña & Wadley 2014; de la Peña 2015) and between sites (Soriano *et al.* 2015) and research shows that there was a gradual technological shift from the HP to post-HP at many sites (Henshilwood *et al.* 2014; Soriano *et al.* 2010, 2015). Porraz *et al.* (2013) argue that the earlier SB and HP dates at Diepkloof imply that the relationship between the SB and HP needs to be re-examined (but see Wurz 2013). Indeed, they – along with other researchers such as Tribolo *et al.* (2009, 2013) – suggest that these techno-complexes may have coexisted in one form or another. Lithic technology such as that expressed in the SB and HP may be linked to subsistence behaviour (Clark & Lombard 2008; Kandel *et al.* 2015). Raw material procurement strategies and environmental conditions may also affect prey selection patterns and it is feasible that

both would influence mobility. My research explores whether such patterns exist and if temporal changes through the SB and HP could be related to subsistence variability.

2.5 Zooarchaeology and the Middle Stone Age

The recovery of fauna from sites in the southern Cape has significantly influenced our understanding of *Homo sapiens* behaviour in the MSA in general. Developments in chronometric dating techniques since the 1960's meant that sites could be relatively accurately dated. The result was that southern Cape sites such as Montagu Cave (Keller 1970), Hout Bay (Vogel 1970), Klasies River (Singer & Wymer 1968) and Die Kelders (Schweitzer 1970) were placed firmly in the context of the MSA at a time when the MSA sequence was being re-evaluated (Sampson 1974). From the 1970's onward, Klein conducted significant research on MSA fauna in the southern Cape (e.g., Klein 1972, 1974, 1975a, 1975b, 1976, 1977). On the basis of his analyses from sites such as Die Kelders and Klasies River, he argued that MSA people generally avoided larger carnivores and dangerous herbivores such as buffalo (Klein 1975b, 1977). His model proposed that MSA people were intrinsically less effective hunters than their Later Stone Age (LSA) successors because they lacked the neuro-cognitive ability for complex cognition and were not behaviourally 'modern' (Klein 1995, 2000, 2001).

By the time Volman (1984) published his revision of the MSA lithic sequence, the role of hunting as the dominant subsistence strategy began to be questioned. Studies by Binford (1978, 1981, 1984) and Brain (1967a, 1981) led to a new understanding of human foraging behaviour during the MSA. Both researchers emphasised the effects of preservation, taphonomy and uniformitarianism in the analysis of faunal remains. Since their seminal work, faunal assemblages are no longer considered the pristine remains of ancient hunters, left unaffected by scavenging animals or natural degradation. The interpretation of the Klasies River faunal assemblage has been a major point of controversy (Binford 1984; Deacon 1985; Marean 1986; Turner 1989; Thackeray 1990; Lupo 1994; Milo 1998; Bartram & Marean 1999; Klein *et al.* 1999; Outram 2000; Dominguez-Rodrigo 2002; Assefa 2006; Faith 2008, 2011a). Klein (1976) showed that smaller bovids were generally represented by upper limbs while the remains of larger bovids were mostly represented by skulls and lower limb bones. He interpreted these results as an example of the 'schlepp effect', first proposed by Perkins and Daly (1968). They found a similar faunal pattern at a Neolithic site in Turkey and proposed that meat was dragged (or 'schlepped') back to the site inside the hides, using the

feet as handles. Binford (1984) rejected Klein's hunting model and argued that scavenging was the prevailing subsistence pattern of the Klasies River people. In his taphonomic analysis of the Klasies fauna, however, Milo (1998) advocated that people at Klasies River were capable hunters who had prime access to large fauna. Using microscopy to assess bone surface markings, he found a portion of a stone projectile point embedded in the 100 ka cervical vertebra of an extinct giant buffalo, which, he argued, provided further evidence for the hunting of very large and dangerous bovids.

Marean and colleagues' research in the past twenty years has highlighted the important role ecological and taphonomic processes play in inferring subsistence behaviour (e.g. Marean 1985, 1986, 1997, 2005; Marean & Spencer 1991; Marean *et al.* 1992, 2000; Marean & Assefa 1999). His introduction of the 'completeness index' gave researchers an empirical means by which to test for the influence of non-human taphonomic processes on fragmented archaeofaunal assemblages (Marean 1991). He also noted that patterns of surface modification on long bone fragments were excluded from analyses when long fragments were not incorporated into the faunal analysis (Marean 1998). Bartram and Marean (1999) argued that the exclusion of long bone splinters biased interpretations of 'Klasies pattern' faunal assemblages (head-and-foot dominated assemblages). Significant sources of anthropogenic data were thus ignored resulting in either Binford's scavenging interpretation or Klein's 'schelpp effect' model. By re-fitting unidentifiable long bone fragments into identifiable elements, the sample sizes of MSA faunal assemblages could be increased (Bartram & Marean 1999), although this method has been argued to be too labour-intensive and time consuming (Klein *et al.* 1999).

C.K. Brain was a leading researcher in taphonomy. One of his most enduring contributions was the bovid size class classification scheme he devised (Brain 1974, 1981) that is still a standard in the field (Table 2.2). Brain (1967a, 1967b, 1981) also raised awareness of equifinality in presumed anthropogenic bone modifications. He noted that sand abrasion and human and animal trampling mimicked use-wear polish on bone, producing 'pseudo-tools' (Brain 1967b): bone fragments interpreted as artefacts by Dart (1949, 1958; Dart & Kitching 1958). Other researchers have also argued that bone modification caused by trampling was a significant cause of pseudo-tool production and anthropogenic-like markings (e.g., Myers *et al.* 1980; Haynes & Stanford 1984; Behrensmeier *et al.* 1986, Haynes 1988; Behrensmeier *et al.* 1989; Oliver 1989; Dominguez-Rodrigo *et al.* 2009, 2012). Observations of bone damage caused by modern herds of animals (e.g., Brain 1967b, 1981; Andrews & Cook 1985; Haynes

1986; Haynes 1988; Fiorillo 1989) and indigenous people (e.g., Brain 1967b; Gifford & Behrensmeier 1977; Gifford-Gonzalez 1989) have demonstrated that the effects of trampling can mimic anthropogenic modification.

Table 2.2: Bovid size classes devised by Brain (1974)

Weight range (kg)	Bovid size class*
0 -23	1
23 - 84	2
84 - 296	3
296 - 900	4
> 900	5

*Size class 5 is equivalent to Klein's (1976) very large mammal

By the turn of this century, many MSA zooarchaeological studies focused on evidence for modern human behaviour (Plug 2004; Cain 2005; Marean 2005; Clark & Plug 2008; Faith 2008, 2011c; Wadley *et al.* 2008; Thompson 2008; Steele & Klein 2009; Thompson 2010; Wadley 2010; Clark 2011; Thompson & Henshilwood 2011; Lombard 2015). Much of this centres on the increases in small game exploitation during the Late Pleistocene (Stiner *et al.* 1999; Stiner 2001; Munro 2004; Marean 2005; Steele & Klein 2009; Wadley 2010; Clark & Kandel 2013). Thompson's research on tortoise remains from BBC (Thompson & Henshilwood 2014a, b) emphasised the potential that small-game had in highlighting changing subsistence strategies in the southern Cape during the MSA (*cf.* Flannery 1969; Stiner *et al.* 1999). Her research on the Die Kelders (Thompson 2009), Pinnacle Point (Thompson 2010) and BBC fauna (Thompson & Henshilwood 2011) also explored the taphonomic history of sites in the southern Cape. Studies by Clark (2009, 2011) and colleagues have also contributed to our understanding of HP subsistence behaviour (Clark & Plug 2008; Lombard & Clark 2008; Clark & Ligouis 2010; Clark & Kandel 2013) and environments (Wadley *et al.* 2008; Clark 2013). Clark (2009, 2011) and colleagues (Clark & Plug 2008) study of the Sibudu fauna indicates that small fauna dominates the HP assemblage similar to that which occurs in the HP layers at Diepkloof (Steele & Klein 2013). Wadley (2010) argues that the prevalence of small, taxonomically-diverse fauna is one of several indicators that may suggest snaring or trapping.

Dusseldorp (2010, 2012a) and colleagues (Dusseldorp & Langejans 2013) have incorporated optimal foraging theory in their investigation of subsistence strategies in the later MSA with much of their research focusing on SB and HP assemblages (Dusseldorp 2012b, 2014; Dusseldorp & Langejans 2015). Dusseldorp (2012b) has also contributed to the debate on remote capture technology through the use of diversity indices, arguing that remote capture should increase dietary breadth. His analysis of diversity and evenness indices of faunal assemblages associated with the Still Bay and HP showed that diet breadth was narrowed rather than widened during the HP, with low diversity and evenness values. However, based on Wadley's (2010) suggestion that nocturnal animals could be easily caught with snaring or trapping, Dusseldorp and Langejans (2015) noted a significantly high number of these types of animals at BBC. Clark and Kandel (2013) also found that dietary breadth widened in seven MSA sites dated to MIS 4, which possibly implies the use of snares or traps. Thus the debate on the presence – or not – of remote capture technology during the SB and HP is still an on-going.

Faunal studies have been used to explore the environment of the CFR during the Late Pleistocene. The work of Klein (1972, 1974, 1975b, 1983, 1984; 1986) laid the foundation of what we know about large mammal communities in the southern Cape based on his faunal analyses of Nelson Bay Cave (Klein 1972), Klasies River (Klein 1976, 1989), Die Kelders (Klein 1974, 1975b; Klein & Cruz-Urbe 2000) and BBC (Henshilwood *et al.* 2001). Pinnacle Point has also contributed important data to southern Cape palaeoenvironmental proxies with research involving speleothems (Bar-Matthews *et al.* 2010), sedimentology (Karkanas & Goldberg 2010; Karkanas *et al.* 2015), marine regression modelling (Fisher *et al.* 2010) and fauna (Rector & Reed 2010; Rector & Verrelli 2010). More recent research by Faith (2011a, b, 2013a, b; Faith & Behrensmeyer 2013; Faith & Thompson 2013) has refined our understanding of the palaeoecology of the southern Cape. Much of Faith's research has incorporated statistical methods to assess transport strategies (Faith 2007; Faith & Gordon 2007) and diversity (Faith 2013a, b) in faunal assemblages. Using ungulate richness indices – devised by Thackeray (1980) – Faith (2013a) was able to use faunal assemblages to calculate precipitation levels at Late Pleistocene/Holocene sites. This has been shown to be a useful environmental proxy (Faith 2013b) and it is a method I apply in my analyses.

The studies described here have contributed significantly to our understanding of subsistence behaviour during the Late Pleistocene and many of the methods used by these researchers are incorporated in this thesis. For example, I use utility and diversity indices to explore foraging

strategies and the palaeoecological conditions that underlie those patterns. Taphonomic data based on the work of Marean and colleagues is also employed to infer the depositional history of the assemblages. Combining these methods is necessary to fully explore subsistence behaviour during the SB and HP.

2.6 Site Background

This section describes the two sites from which the fauna analysed in my thesis was excavated: BBC and KDS. BBC has been extensively described (e.g., Henshilwood *et al.* 2001a; Henshilwood 2005, 2008) and here the site background is a summary of the geological context, stratigraphy and relevant archaeological finds. KDS, on the other hand, has only recently been excavated and little about the site has been published. For that reason, I include the published preliminary report on the first excavation seasons in this chapter as a background to the site. The KDS paper details the archaeological finds, geology and excavation and dating methodology and also includes a list of the faunal remains recovered there. This paper therefore acts as a precursor to the analysis of the KDS fauna undertaken in the proceeding chapters.



Figure 2.4: Klipdrift Shelter and Blombos Cave in the southern Cape (picture by Christopher Henshilwood and Magnus Haaland)

2.6.1 *Blombos Cave*

BBC is ~ 300 km east of Cape Town and 25 km west of the town of Still Bay (Fig. 2.4). It is located at 34°25'S, 21°13'E ~ 100 m from the shore of the Indian Ocean and 34.5 m above sea level. The entrance to the cave occurs in a wave-cut cliff formed in calcified sediments of the Bredasdorp Group geological formation. Table Mountain Sandstone of the Cape Supergroup forms the basal layer of the caves about 4 – 6 m below the surface deposits under Bredasdorp Group sediments (Henshilwood *et al.* 2001a). These sediments consist of shelly conglomerate and marine sands of the De Hoopvlei Formation which is overlain by the aeolian sands of the Pliocene-aged Wankoe Formation that represents the volumetric bulk of the Bredasdorp Group (Malan 1989). Within the cave, sediments lie on large blocks of calcarenite rockfall that have caused the deposits to undulate from back to front. A 'wrapping effect' has occurred as sediments drape and slump in response to the basal rockfall (Henshilwood *et al.* 2001a). Ground waters rich in CaCO₃ (calcium carbonate) percolate through the cave roof and walls, creating an environment suited to the preservation of bone and shell, particularly near hearths and ash deposits (Henshilwood 2005). Compared to other MSA cave sites in the southern Cape such as Pinnacle Point and Klasies River, the interior of the cave is relatively small: the surface area of the cave floor is ~ 55 m² behind the drip line. The mouth of the cave was virtually sealed off by dune sand when excavations began.

Excavations started in 1991 with regular seasonal excavations continuing to the present. The stratum is defined by 'layers' that have accumulated through natural and /or human deposition. These layers differ from each other with regard to colour, texture, or composition (Henshilwood *et al.* 2001a). Layers are also grouped into phases defined as "a chronologically limited cultural unit within a local cultural sequence (Henshilwood *et al.* 2001a: 425). The surface area of BBC is divided into square metres and 0.5 m quadrates. The stratigraphic sequence consists of three LSA and four MSA occupation phases.

Approximately 20 cm of aeolian sand covered the surface of the LSA deposits when excavations began, which suggests that the contents of the cave had not been disturbed since the final LSA occupation at ~ 290 years ago (Henshilwood 2005). The LSA layers have been dated using accelerator mass spectrometry (AMS) radiocarbon methods to between 2000 and 290 years BP (Henshilwood 2008b). The LSA and MSA phases are separated by a layer of sterile dune sand between five and 50 cm thick named BBC Hiatus. Most likely this dune sand blew into the unoccupied cave during a sea level regression at ~ 70 ka. Thereafter, the

entrance to the cave was obstructed by dune sand and probably only re-opened when higher sea levels washed away this sand during the mid-Holocene (Henshilwood 2008b).

The MSA layers are divided into four phases: the M1 just below BBC Hiatus; the upper and lower M2; and the M3 at the bottom (Fig. 2.5). The M1 phase consist of medium brown sands containing lenses of shell, stone and bone, and many small, basin-shaped hearths (Henshilwood et al. 2001b; Henshilwood 2005). The M1 and upper M2 phases contain SB points, and end and side scrapers (Goodwin & van Riet Lowe 1929; Henshilwood *et al.* 2001a). These phases also contain engraved ochre plaques, perforated shell beads, formal bone tools and an engraved bone fragment (Henshilwood & Sealy 1997; Henshilwood *et al.* 2001a, 2001b, 2002, 2004; d'Errico *et al.* 2005, d'Errico & Henshilwood 2007). Three human teeth were also recovered there (Grine *et al.* 2000; Grine & Henshilwood 2002). These are the layers that encompass the SB period and that are analysed in this thesis. The lower M2 phase is generally less dense than the M1 or upper M2 and contains small amounts of flakes, blades and cores, a few pieces of ochre and hearths. No shell beads, SB points or bone tools were recovered from this phase (Henshilwood *et al.* 2001a).

The M1 phase consists of Layers CA, CB, CC, CCC, CD, CDA and CDB. The upper M2 phase consists of Layer CF, CFA, CFB/CFC and CFD. In this thesis, layers are sometimes combined for statistical purposes. Thus, Layer CFA and CFB/CFC and CFD are grouped into Layer CF while CDA and CDB are clustered in CD. With regard to the BBC sequence, I sometimes define the 'early' SB as Layer CF (upper M2 phase), the 'middle' SB as CD and CC (the middle M1 phase) and the 'later' SB as CB and CA (the upper M1 phase).

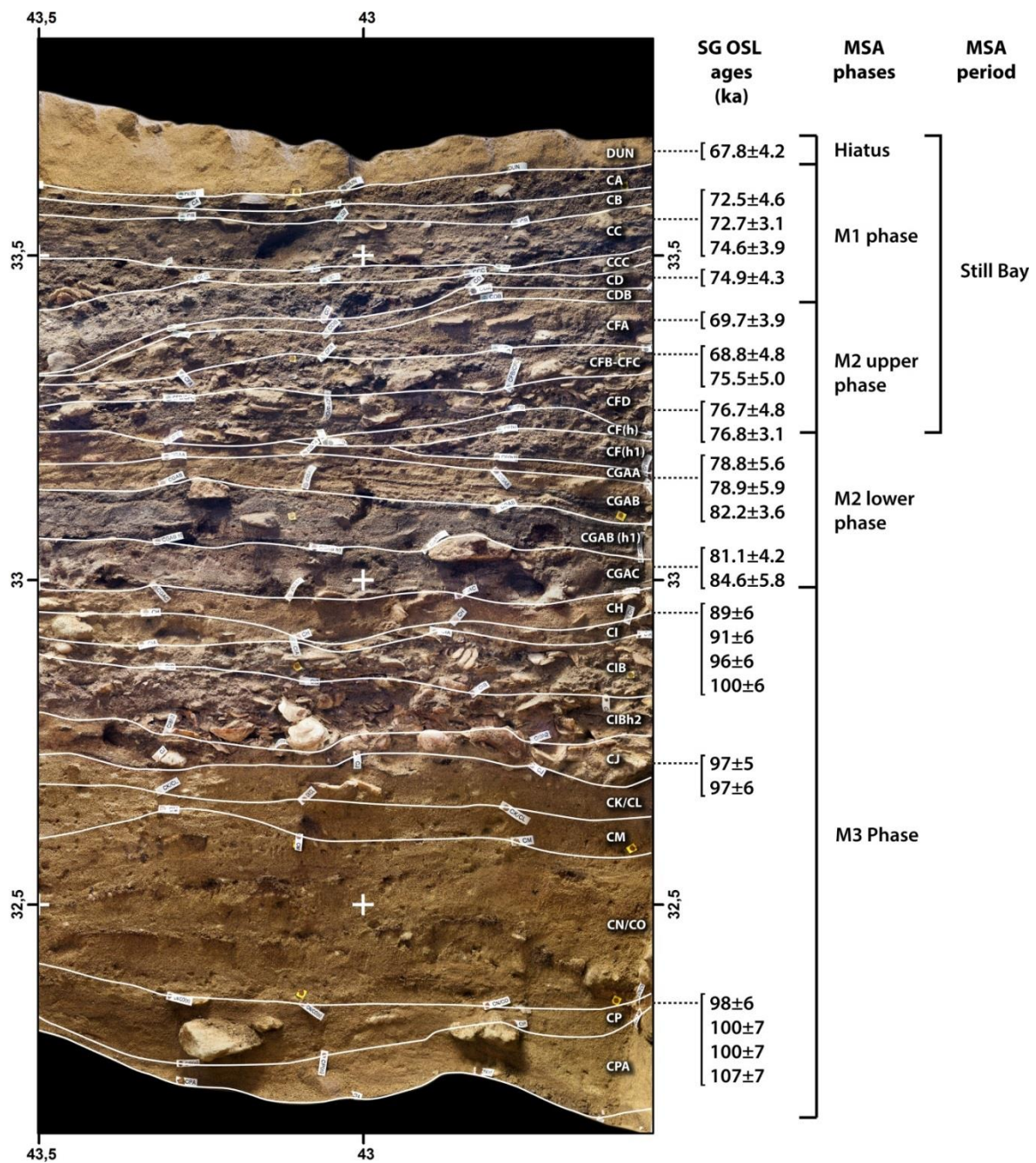


Figure 2.5: Stratigraphy and OSL dates for the MSA levels at Blombos Cave (from Henshilwood *et al.* 2011)

2.7 Site background for Klipdrift Shelter

Henshilwood *et al.* 2014

“Klipdrift Shelter, southern Cape, South Africa: preliminary report on the Howiesons Poort layers.”

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Klipdrift Shelter, southern Cape, South Africa: preliminary report on the Howiesons Poort layers



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ABSTRACT

Surveys for archaeological sites in the De Hoop Nature Reserve, southern Cape, South Africa resulted in the discovery of a cave complex comprising two locations, Klipdrift Cave and Klipdrift Shelter. Excavations commenced in 2010 with Later Stone Age deposits initially being recovered at the former site and Middle Stone Age deposits at the latter. The lithic component at Klipdrift Shelter is consistent with the Howiesons Poort, a technological complex recorded at a number of archaeological sites in southern Africa. The age for these deposits at Klipdrift Shelter, obtained by single grain optically stimulated luminescence, spans the period 65.5 ± 4.8 ka to 59.4 ± 4.6 ka. Controlled and accurate excavations of the discrete layers have resulted in the recovery of a hominin molar, marine shells, terrestrial fauna, floral remains, organic materials, hearths, lithics, ochre, and ostrich eggshell. More than 95 pieces of the latter, distributed across the layers, are engraved with diverse, abstract patterns. The preliminary results from Klipdrift Shelter presented in this report provide new insights into the Howiesons Poort in this sub-region and contribute further to ongoing knowledge about the complex behaviours of early *Homo sapiens* in southern Africa. Excavations at the Klipdrift Complex will continue in the future.

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1. Introduction

From 1998 to 2009 intermittent archaeological site surveys by two of the authors (CSH and KvN) along 60 km of coastline located in the De Hoop Nature Reserve, southern Cape, South Africa (Fig. 1) resulted in the detailed mapping of more than 160 archaeological sites. In 2010 two of the sites that comprise the Klipdrift Complex, Klipdrift Shelter (KDS) and Klipdrift Cave (KDC), were selected for test excavations (Figs. 1–3). The excavations form a part of the Tracsymbols project, funded by a European Research Council FP7 grant (2010–2015) (<http://tracsymbols.eu/>), with one key aim being to initiate new excavations at Late Pleistocene archaeological sites in southern Africa. The selection of the Klipdrift sites was

based on their visible, *in situ* Later Stone Age (LSA) and Middle Stone Age (MSA) deposits, the preserved fauna and their relative accessibility. In 2011 test excavations commenced at KDS (Figs. 2 and 3) revealing c. 1.6 m deep, well preserved, horizontal MSA deposits immediately below the steeply sloping, eroded surface (Fig. 4c). The clear separation of stratigraphic layers enabled the accurate recovery of materials from discrete depositional layers. The anthropogenic assemblage contained marine shells, terrestrial faunal remains, microfauna, a human tooth, organic materials, ash lenses and hearths, lithic artefacts, ochre and ostrich eggshell. In 2012 we initiated test excavations at a second MSA site within the complex, Klipdrift Cave Lower (KDCL) (Figs. 2 and 3).

Here we report on the preliminary analysis of the materials recovered from the KDS layers dated at 65.5 ± 4.8 ka to 59.4 ± 4.6 ka by single-grain optically stimulated luminescence (OSL) (Fig. 4). The lithics are typical of those attributed to the Howiesons Poort Industry (HP) in southern Africa. The research emanating from this site has the potential of contributing to current debates about the origins of modern human behaviour with a

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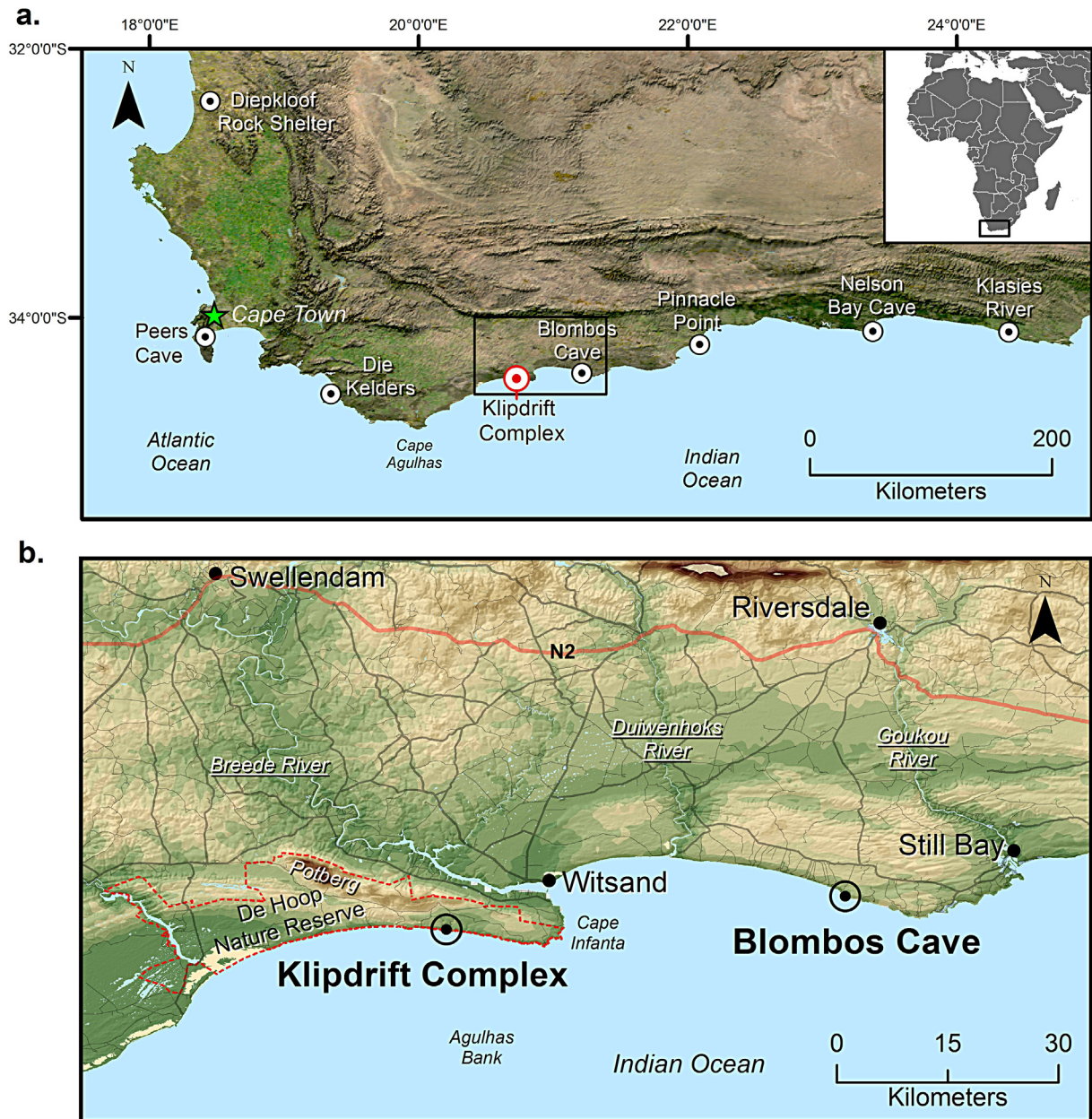


Fig. 1. Location of Klipdrift Complex and sites mentioned in the text.

specific focus on the *Homo sapiens* that inhabited the southern Cape during the MSA. Excavations at KDS and at other sites within the complex will continue in the future.

1.1. Site background

Evidence for human occupation of the De Hoop area from the Acheulean is confirmed by handaxes found near Potberg (Fig. 1) and the numerous LSA and fewer MSA sites distributed mainly along the coast. The Klipdrift Complex is a major depository for Late and Terminal Pleistocene sediments and archaeological deposits that are visible both on the surface and in eroded sections. The Complex is one of several caverns and overhangs along the southern Cape coast formed within the 500–440 Million year (Ma) Table Mountain Group (TMG) sandstones (Deacon and Geleijnse,

1988). Movement along the shear zones within the TMG forms fault breccias susceptible to erosion by high sea levels leading to the formation of caves within the near coastal cliffs (Pickering et al., 2013). KDC and KDS are formed in the TMG sandstones, presumably as a result of this process. In the eastern section of De Hoop, 5 Ma hard dune ridges of Bredasdorp Group limestone infill these TMG shear zones. The seaward extension of the limestone has been truncated by marine erosion and in these coastal cliffs a number of vadose caves have developed above the contact with the TMG (Marker and Craven, 2002).

The Klipdrift Complex (34° 27.0963'S, 20° 43.4582'E), is located in coastal cliffs 12–15 m from the Indian Ocean and c. 19 m above sea level. The larger western cave is c. 21 m deep and contains at least two sites, KDC and KDCL. KDS is a c. 7 m deep shelter, separated from KDC and KDCL by a quartzite promontory (Figs. 2–4). The complex is



Fig. 2. Klipdrift Cave and Klipdrift Shelter towards the north (upper) and west (lower).

located within the eastern section of the De Hoop Nature Reserve (Fig. 1b) on Portion 20 of farm 516, Swellendam district in the Overberg region of the southern Cape. Cape Town is c. 150 km to the west; the *Klipdriftfonteinspruit* stream (namesake of the cave complex) and Noetsie waterfall (Scott and Burgers, 1993), which are perennial sources of fresh water, lie about 200 m east of the Klipdrift Complex. The extensive Breede River estuary and Blombos Cave lie respectively 10 km and 45 km east/south-east (Fig. 1b).

In KDC archaeological deposits are concentrated behind the dripline and extend over 280 m² at a c. 25° slope. A c. 15 m talus slopes seawards at 31.5°. In KDS visible surface deposits extend c. 7 m² at a slope of c. 29° behind the dripline. The deposits are severely truncated and the talus lies at 38.5°. It is probable that the natural and archaeological deposits in the cave complex, especially those in KDS, were truncated by mid-Holocene +2–3 m sea levels (Bateman et al., 2004; Compton, 2001). A quartzite cobble beach lies directly below the complex with an extended rocky shoreline and few sandy beaches. Initial excavations in KDC in 2010 yielded Terminal Pleistocene deposits (Albany Industry) radiocarbon dated at c. 14–10 ka (report in prep.). In 2013 several tons of rockfall were removed in the area of the dripline in Klipdrift Cave (Fig. 3). A limited test excavation in the Klipdrift Cave Lower (KDCL) site revealed MSA deposits underlying the overburden. A provisional minimum OSL age of c. 70 ka was obtained for the base of the overburden. Further excavations of KDCL are planned.

KDS was first excavated in 2011 with subsequent seasons in 2012 and 2013. In total a volume of 2.3 m³ over an area of 6.75 m² has been excavated at KDS to depths from 30 cm to 100 cm (in individual quadrates) and more than 20 layers and lenses defined (Figs. 3 and 4). The uppermost dated layer yields an optically

stimulated luminescence (OSL) age of 51.7 ± 3.3 ka, the middle layers containing the HP range from 65.5 ± 4.8 ka to 59.4 ± 4.6 ka and the lowermost excavated, anthropogenically sterile layers give an age of 71.6 ± 5.1 ka (Fig. 4a).

1.2. Background: De Hoop Nature Reserve

De Hoop Nature Reserve covers 34 000 ha and extends for 60 km along the Indian Ocean coastline (Fig. 1b). The Potberg range, a 611 m high remnant of a syncline of the Cape Folded Belt composed of highly resistant TMG quartzite, lies to the north-west of Klipdrift. A major fault at the base of the range truncates it to the south. The TMG quartzites form sea cliffs where they are exposed beneath the Bredasdorp Group limestone. Sedimentary rocks of the TMG (sandstones), Bokkeveld Group (shales) and Uitenhage Group (mainly shale conglomerates) form the basement geology of the area. Marine transgressions have planed the softer shales and conglomerates into a gently southward sloping series of terraces. The Neogene limestones of the Bredasdorp Group, deposited as shallow marine environments (the Pliocene De Hoopvlei Formation and the Pleistocene Klein Brak Formation, both of which are shelly quartzose sand and conglomerate) and as coastal dunes (the Pliocene Wankoe Formation and the Pleistocene Waenhuiskrans Formation), underlie the greater part of the reserve (Marker and Craven, 2002) and cover most of the Bokkeveld and Uitenhage basement rocks. The Wankoe Formation forms the high-lying aeolianites into which the coastal plain was eroded during marine transgressions. More recent dune systems (Waenhuiskrans formation) were subsequently formed on the coastal plain. The Strandveld Formation, deposited as a strip of unconsolidated dunes during the Holocene is the most recent member of the Bredasdorp Group (Bateman et al., 2004; Malan, 1990; Roberts et al., 2006; Rogers, 1988).

The reserve is situated in the Cape Floristic Region, one of the six floral Kingdoms in the world. It falls within a winter rainfall area that has a Mediterranean climate. The current mean annual rainfall is approximately 380 mm with the maximum in August and the minimum in December and January. The warm Agulhas current results in temperate winters and warm summers with an average of 20.5 °C during the latter and an average of 13.2 °C during winter. The continental shelf, known as the Agulhas Bank (Fig. 1b), begins as a relatively shallow topographical feature south of Port Elizabeth and extends to the south and west beyond Cape Agulhas, 80 km west of the Klipdrift Complex. At its widest point, south of Cape Infanta (Fig. 1b), the Agulhas Bank extends more than 200 km (Bateman et al., 2004; Carr et al., 2007; Compton, 2011; Van Andel, 1989).

Three major vegetation types occur in the reserve, Limestone Fynbos, Mountain Fynbos, and Dune Fynbos/Thicket (Low and Rebelo, 1996). A diversity of plants and animals, both terrestrial and marine in a complex mosaic of different habitat types, is a result of these varied geological features and the close location of the reserve to Cape Agulhas, the meeting point of the west coast cold Benguela and warm east coast subtropical Agulhas currents. This diversity is illustrated by the 86 terrestrial mammal species that occur here, at least 250 species of fish in the marine protected area and the more than 260 resident and migratory bird species. Limestone Fynbos, which is characterized by low shrubs, is the predominant vegetation in the immediate vicinity of the Klipdrift Complex (Willis et al., 1996).

2. Excavation methodology

Two grid systems, oriented on a local north–south axis, were set up using a Trimble VX Spatial Station. The first is a three-

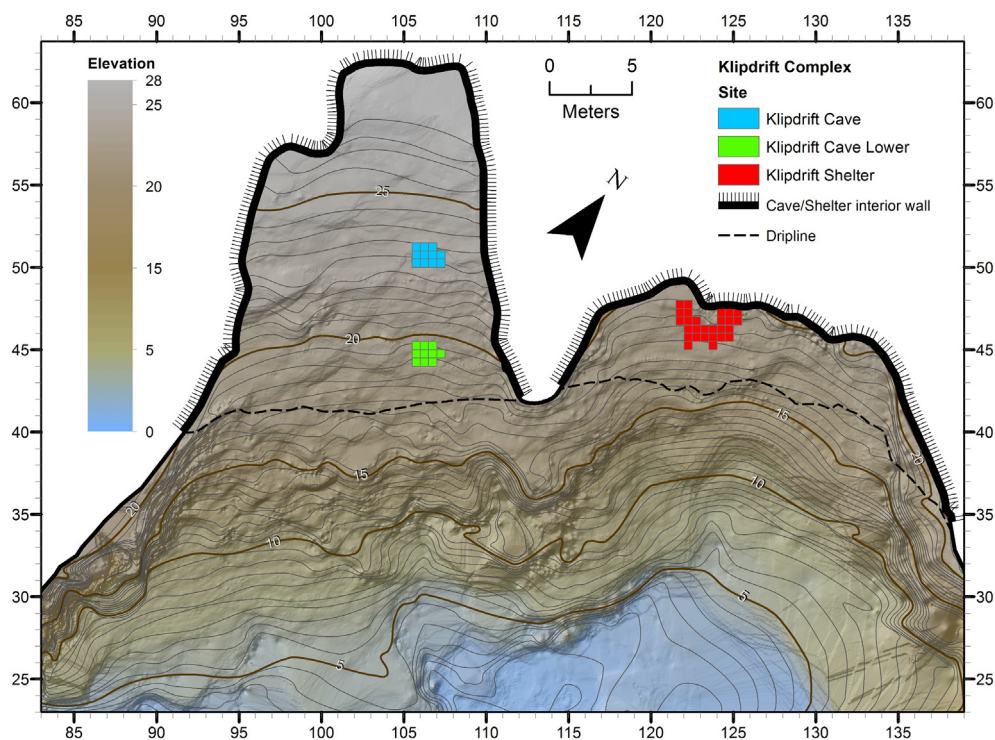


Fig. 3. Topographical features of Klipdrift Complex including layout of excavated archaeological sites, Klipdrift Cave, Klipdrift Cave Lower and Klipdrift Shelter.

dimensional, numerical coordinate system, where the X and Y axes are given arbitrary numerical values (50, 100), and the Z axis values refer to elevation above sea level. The second, an alpha-numerical system, consists of a continuous square metre grid starting from A1, in which each square is further subdivided into four 50×50 cm quadrates (named a, b, c and d) (see Fig. 4b).

Each quadrate was excavated individually by brush and trowel, following stratigraphic layers. The layers within each quadrate which contain sediments of several depositional events were principally identified and defined by their texture, composition, colour, thickness and content. The spatial extent of individual layers varies throughout the excavated area and layer depths range from c. 2–30 cm. The layers were given alphabetically ordered name codes (PAL, PBA, PCA etc.) (see Fig. 4). Name codes that share the two first letters (e.g. PA and subdivisions PAL, PAM etc.) were interpreted as having close contextual relationships. A micromorphological study of these layers is in progress. Spatial measurements taken during excavation refer to the numerical coordinate and were given a three-dimensional (XYZ) spatial reference. Lithics >20 mm, identifiable bones, ostrich eggshell, ochre and artefacts of special interest were individually recorded with high precision (1/1000 cm) and with an accuracy of ± 2 mm. Recovered finds or features were bagged in plastic, labelled with provenance data and given a unique specimen number. All plotted finds were classified on a primary entry form in the field by raw material, species, tool type and special characteristics. Non-plotted material (deposit/sediments) was sieved through a nested 3.0–1.5 mm sieve and retained for future analysis.

The topographic surface of a stratigraphic layer in a quadrate was recorded by c. 500 3D points (point cloud) using the 3D scanning function on the Trimble VX spatial station. The point cloud was later converted into a 3D model of the entire layer surface for remodelling of the original surface topography. The surface of each quadrate was also digitally photographed with a single lens reflex camera (Nikon D4) with surface markers, permitting the image to be geo-referenced and modelled in 3D. Similar photos

were taken of section walls, significant artefacts *in situ* and other relevant features.

All site maps, cross sections and illustrations of the KDS stratigraphic sequence are geo-referenced within the numerical coordinate system and made by combining photogrammetric methods with topographic data recorded by the total station. The Klipdrift Complex and surrounds were mapped by scanning the site in 3D. The point cloud that was generated (c. 250 000 points) was imported into Trimble RealWorks 6.5 and converted into a 3D mesh, from which planar maps, cross-section of surface topography and elevation models were produced. These were subsequently exported as CAD files and imported into ESRI ARCGIS 10.1 for further refinement, map making and for combining with geo-referenced images (Figs. 3 and 4). Materials recovered from the sites were primarily sorted and washed at the base laboratory situated at Potberg in the De Hoop Nature Reserve. On completion of the excavations, the material was moved to our laboratory in Cape Town for curation and further investigation. In the longer term the recovered assemblages will be curated at the Iziko South African Museum in Cape Town.

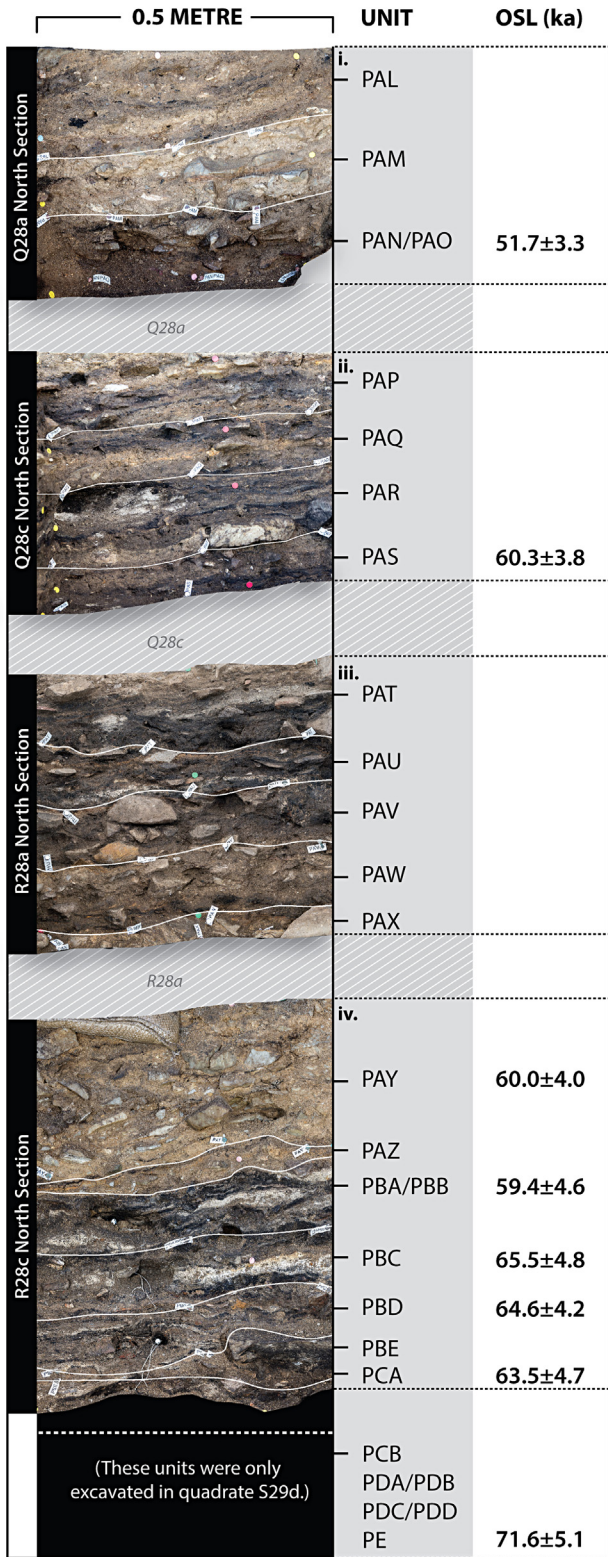
3. Optically stimulated luminescence dating

The MSA layers at KDS were dated using single-grain OSL. Single-grain measurements were performed since previous OSL dating studies conducted on southern African MSA sites demonstrate that multi-grain analyses are susceptible to a number of sources of inaccuracy (e.g. Jacobs et al., 2008). These inaccuracies may be avoided by measuring and analysing the OSL properties of a sample at the single-grain level (Jacobs and Roberts, 2007).

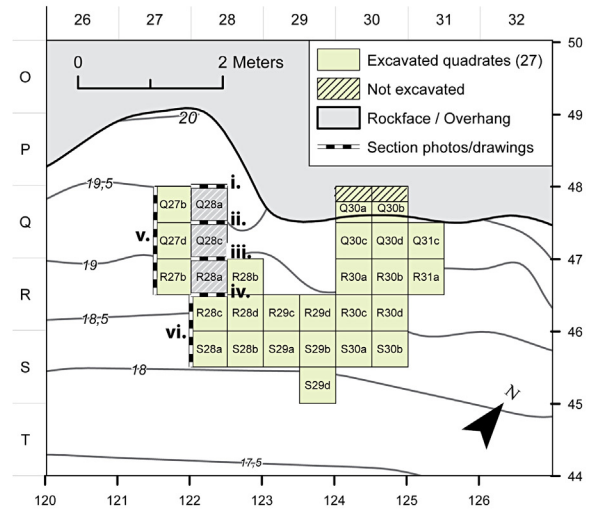
3.1. Sample collection, preparation and measurement

Samples were collected from cleaned sections by scraping material into opaque bags while under tarpaulin. Sample locations are listed in Table 1. Using the procedure outlined in Armitage et al.

a. Northern section walls



b. Klipdrift Shelter site map



c. Western section walls

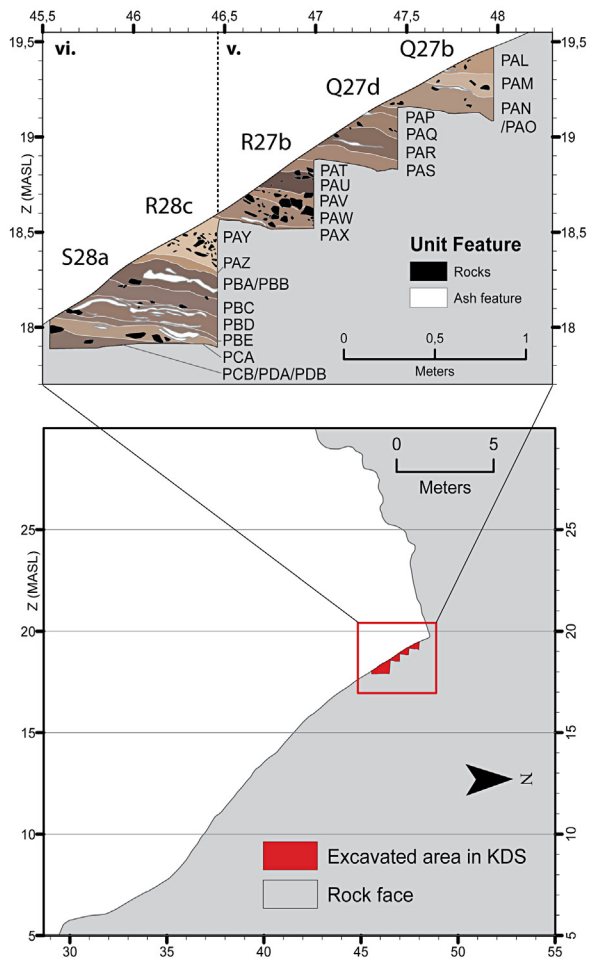


Fig. 4. a) Stratigraphy of Klipdrift Shelter showing layers and optically stimulated luminescence ages; b) Location of excavated quadrates within KDS; c) excavated layers in section showing the slope.

(2011) 212–180 μm diameter quartz grains were extracted from bulk samples. Beta and gamma dose rates were calculated for each sample using radioisotope concentrations measured by ICP-MS (U and Th) and ICP-AES (K). Dose rates were corrected using an assumed water content of $20 \pm 5\%$. This assumed value was preferred to measured values since the latter are strongly dependent upon the time elapsed since the section was excavated and the antecedent weather conditions. The assumed value is close to the mean measured water content ($19 \pm 6\%$) for a suite of 12 samples from KDS, which with the inclusion of the 5% uncertainty term, gives confidence that it approximates the true mean burial conditions. Gamma dose rates were corrected for a 20% volume of low-radioactivity clasts. Cosmic ray dose rates were calculated using site location and overburden density, accounting for shielding by the nearby rock face (Prescott and Hutton, 1994; Smith et al., 1997). An internal alpha dose rate of 0.03 ± 0.006 Gy/ka was assumed.

Equivalent doses were measured using the single-aliquot regenerative-dose technique (Murray and Wintle, 2000) using a Risø TL/OSL-DA-15 instrument (Bøtter-Jensen et al., 2003) fitted with a single-grain OSL attachment (Duller et al., 1999, 2000). Single-aliquot dose recovery tests (Roberts et al., 1999) were performed on every sample, and indicate inter-sample variability in the optimal preheating regime, a phenomenon also observed at Diepkloof Rock Shelter (Tribolo et al., 2013). Single-grain dose recovery tests, using the optimal measurement conditions identified by the single-aliquot data, were performed on four samples and yielded dose recovery ratios consistent with unity. Equivalent dose (D_e) measurements were performed using the optimal preheating regime identified for each sample. Data were screened using the grain rejection criteria of Armitage et al. (2011). In addition, grains were rejected where the sensitivity-corrected natural luminescence intensity exceeded twice the D_0 value of the saturating exponential fit to the growth curve (Wintle and Murray, 2006; Chapot et al., 2012). Equivalent doses were calculated for grains which passed these rejection criteria.

3.2. Estimation of the sample burial dose

All samples yielded sufficient data to calculate a meaningful D_e . Where the overdispersion (σ_d , the relative standard deviation of the true palaeodoses) of single-grain D_e values for a sample was 20% or less, all grains were assumed to belong to a single population (following Olley et al., 2004), and the Central Age Model (CAM, Galbraith et al., 1999) was used to calculate an equivalent dose for that sample. Where overdispersion exceeded 20%, it was assumed that more than one dose population was present, and the dataset was analysed using the Finite Mixture Model (FMM, Roberts et al., 2000). All datasets to which the FMM was applied were best fitted with two D_e populations, and in each case a single dominant

population ($\geq 87\%$ of accepted grains) was identified. The D_e calculated for this population was considered most appropriate for age determination. In samples KDS-DS7, 10 and 11, the remaining grains belong to a small (2–8%) lower dose population, which was interpreted to indicate the intrusion of lower dose grains from above by bioturbation, though it is noteworthy that samples overlying KDS-DS10 (KDS-DS1, 2 and 9) do not contain similar populations. The small (7–13%) higher dose population present in samples KDS-DS1, 2 and 9 was interpreted as indicating the presence of “partially bleached” grains.

Although 20% overdispersion has been widely used as a threshold above which the FMM should be used, it has been argued that this threshold is strictly only applicable to the Olley et al. (2004) dataset. In addition, samples which cannot contain more than one equivalent dose population occasionally yield overdispersion values above 20% (e.g. Armitage and King, 2013). However, inspection of radial plots for samples KDS-DS9 and 10 (Fig. 5a, b) indicates that both the minor high and low D_e populations identified by the FMM are clearly distinct from the population containing the majority of the grains. Conversely, radial plots for samples KDS-DS 3 and 12 (Fig. 5c, d), which were analysed using the CAM, appear to show a single population of grains. These results indicate that, for our dataset, the correct statistical model may accurately be chosen using the overdispersion parameter. Ages for the KDS samples are presented in Table 1.

4. Cultural artefacts

4.1. Lithics

This preliminary techno-cultural interpretation of the KDS sequence is based on the lithics recovered in 2010 and 2011. Layers PCA to PAY, ranging from 65.5 ± 4.8 ka to 59.4 ± 4.6 ka, provide highly significant samples for a first technological assessment, with 11,687 lithics >2 cm in the seven layers considered here (Table 2).

Lithic raw materials are composed of five main groups: quartzite, quartz, silcrete, cryptocrystalline silicate (CCS) and calcrete. In all layers, a large portion of the stone found derives from the shelter's walls, and are mostly quartzite and to a lesser extent quartz. These coarse and poor quality raw materials were occasionally exploited by the knappers. Quartzite also includes fine-grained types derived from pebbles, while quartz is predominantly composed of good quality types, with very fine crystalline structure. Silcretes used by the KDS tool-makers are almost exclusively fine-grained types, frequently with internal cracks. Colour variations include grey, yellow-brown, brown, red and green. Primary sources of silcrete and calcrete are present in abundance along the Cape Fold Mountains (see Roberts, 2003) and near KDS they occur as outcrops in small rocky hills some 10 km north and

Table 1

Summary equivalent dose data and ages for the KDS samples. Samples are listed in stratigraphic order: σ_d denotes overdispersion, while n is the number of grains which pass the rejection criteria. The age models used are the Central Age Model (CAM) and the Finite Mixture Model (FMM). Uncertainties are based on the propagation, in quadrature, of errors associated with individual errors for all measured quantities. In addition to uncertainties calculated from counting statistics, errors due to 1) beta source calibration (3%, Armitage and Bailey, 2005), 2) ICP-MS/AES calibration (3%), 3) dose rate conversion factors (3%), 4) attenuation factors (2%, Murray and Olley, 2002) have been included.

Sample (KDS-...)	Square	Level	σ_d (%)	n	Age model	Grains in main component (%)	Equivalent dose (Gy)	Dose rate (Gy/ka)	Age (ka)
DS11	Q27B	PAN/PAO	25 ± 3	146	FMM	98 ± 1	45.4 ± 1.2	0.88 ± 0.04	51.7 ± 3.3
DS12	Q27B	PAS	18 ± 3	126	CAM	100	52.1 ± 1.4	0.86 ± 0.04	60.3 ± 3.8
DS3	R28C	PAY	19 ± 3	81	CAM	100	59.1 ± 1.9	0.98 ± 0.05	60.0 ± 4.0
DS2	R28C	PBA/PBB	27 ± 4	65	FMM	93 ± 6	54.8 ± 2.4	0.92 ± 0.05	59.4 ± 4.6
DS1	R28C	PBC	27 ± 3	113	FMM	87 ± 9	45.2 ± 1.9	0.69 ± 0.04	65.5 ± 4.8
DS9	R28C	PBD	21 ± 3	111	FMM	87 ± 5	58.5 ± 1.5	0.91 ± 0.05	64.6 ± 4.2
DS10	R28C	PCA	21 ± 3	60	FMM	95 ± 4	71.6 ± 3.0	1.13 ± 0.06	63.5 ± 4.7
DS7	S30A	PE	31 ± 4	91	FMM	92 ± 4	74.8 ± 2.9	1.05 ± 0.05	71.6 ± 5.1

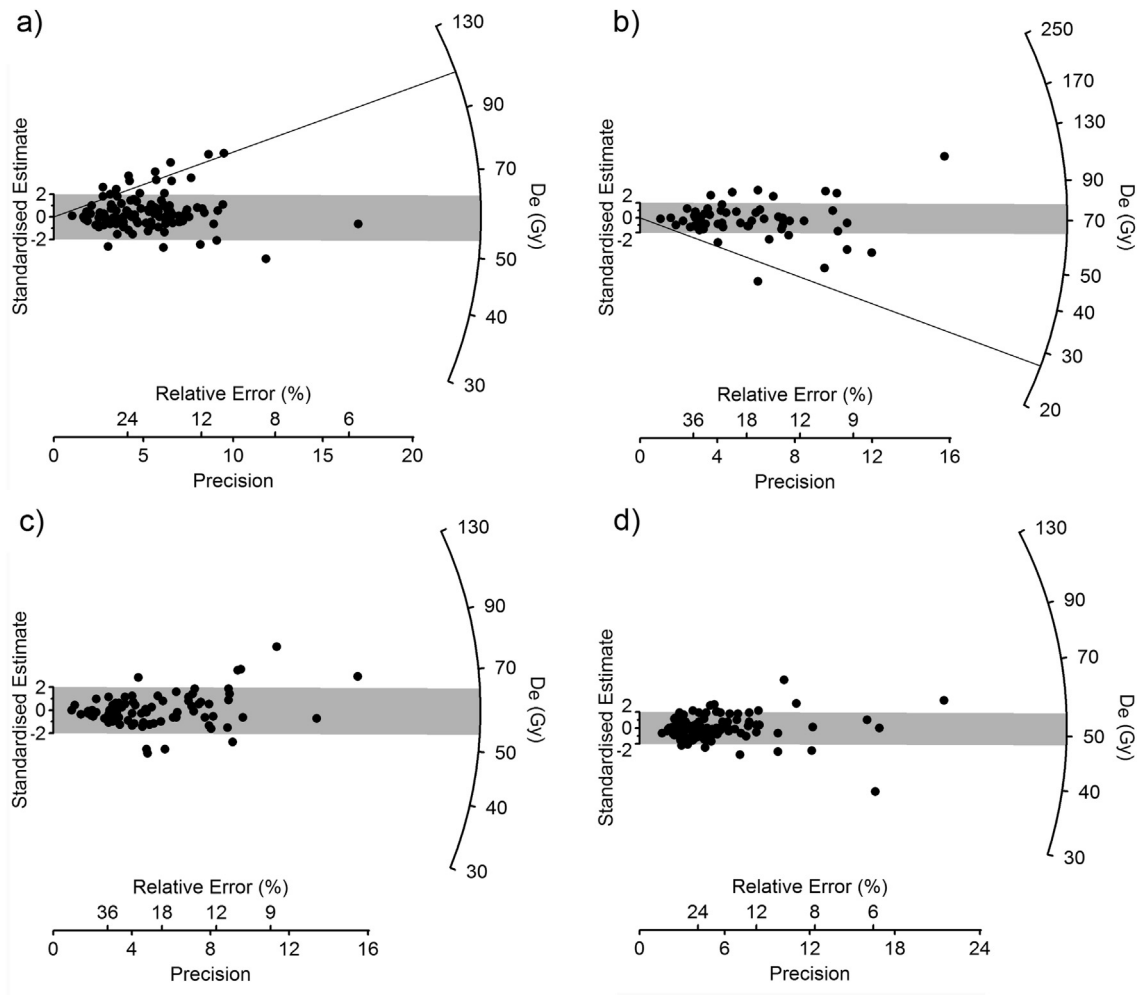


Fig. 5. Radial plots of equivalent doses for a) KDS-DS9, b) KDS-DS10, c) KDS-DS3 and d) KDS-DS12 of remaining deposits.

north-west of the site. Some of the knapped silcrete may originate from pebble sources that have not yet been identified.

Significant changes occur in the relative proportions of these raw material groups over time. Silcrete is dominant in the three lower layers (PCA, PBE, PBD), while quartz increases significantly in the two overlying layers (PBC, PBA/PBB), and quartzite as well as calcrete become more abundant in the uppermost PAZ and PAY layers (Table 2 and Fig. 6). These shifts in the sequence are even more pronounced when considering the raw material distribution of the blades and formal tools (backed tools and notched tools in particular) (Fig. 6).

The lithic *chaîne opératoire* performed on quartz, silcrete and CCS is almost entirely devoted to the production of blades, which is confirmed by the strong predominance of blade cores in all layers (PCA: 16/21 cores, PBE: 9/12, PBD: 35/47, PBC: 21/29, PBA/PBB: 26/43, PAZ: 11/18, PAY: 9/17). The flaking method applied to blade production is almost exclusively unidirectional and a number of technical attributes, e.g. platform edge abrasion, weakly developed bulbs and thin platforms, indicate the use of direct marginal percussion with a soft hammer, either mineral or vegetal. Core volume exploitation is varied and includes unifacial cores with prepared lateral convexities, semi-rotating cores, “narrow-face” cores and bipolar cores. The mean width of blades is quite homogeneous across raw materials and tends to be slightly higher in the four uppermost layers (from PBC to PAY: Fig. 6). The elongation of blades is high in all layers, with no significant pattern of change over time

(blades’ length/width in PCA: 2.7, PBE: 2.4, PBD: 2.5, PBC: 2.7, PBA/PBB: 2.3, PAZ: 2.4, PAY: 2.5). Blades (Fig. 7: 1–12) range from very small (length between 10 and 20 mm) to large (over 60 mm in length). Besides blade production, secondary flake production occurs on quartz, silcrete and calcrete. It consists mainly of discoidal and Levallois débitage. Discoidal cores occur in small quantities in the whole sequence, unlike the Levallois cores which are limited to the upper part of the sequence (layers PBC, PBA/PBB, PAZ, and PAY). The existence of a secondary Levallois reduction sequence is confirmed by the presence of Levallois flakes. These are very rare or absent from layers PCA to PBA/PBB and amount to 5 Levallois flakes in PAZ, and 24 in PAY. The top part of the sequence thus provides evidence for the emergence of an independent and structured flake reduction sequence. In contrast to other raw materials, quartzite was predominantly used for producing flakes (Table 2) from informal and unidirectional cores. Blade production on quartzite is weakly developed in all layers, except in PAY where quartzite blade production is relatively well represented. For both flake and blade production, quartzite exploitation was based on expedient and short reduction sequences performed with direct hard hammer percussion.

The tools (Fig. 7: 13–27) are typical of the HP; formal tools are composed of backed tools, notched tools, borers, retouched blades, *pièces esquillées* and points. Retouched tools account for less than 5% of the assemblages (PCA: 3.5%, PBE: 2.5%, PBD: 2.8%, PBC: 3.2%, PBA/PBB: 3.2%, PAZ: 5%, PAY: 2.6%). Some marked shifts occur in the

Table 2

Assemblage composition at KDS (the chunk category, which accounts for c. 40% of the total assemblage, has been eliminated from the quantitative analyses as it includes a number of ambiguous items – natural slabs or knapping debris – especially for quartzite).

	PAY		PAZ		PBA/PBB		PBC		PBD		PBE		PCA	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Flakes														
Quartz	67	8.9	178	33.9	631	40.9	152	23.6	145	7.9	81	10.2	104	13.9
Silcrete & CCS	97	12.9	60	11.4	71	4.6	44	6.8	250	13.6	79	10	97	12.9
Calcrete	34	4.5	15	2.9	59	3.8	1	0.2	0	0	6	0.8	0	0
Quartzite	318	42.3	136	25.9	316	20.5	265	41.1	560	30.4	204	25.8	220	29.3
Blades														
Quartz	22	2.9	35	6.7	312	20.2	66	10.2	150	8.1	117	14.8	66	8.8
Silcrete & CCS	69	9.2	32	6.1	29	1.9	44	6.8	556	30.2	238	30.1	186	24.8
Calcrete	15	2	9	1.7	17	1.1	0	0	3	0.2	0	0	1	0.1
Quartzite	88	11.7	16	3	29	1.9	27	4.2	80	4.3	36	4.5	36	4.8
Cores														
Quartz	10	1.3	8	1.5	41	2.7	17	2.6	14	0.8	6	0.8	9	1.2
Silcrete & CCS	7	0.9	10	1.9	4	0.3	9	1.4	34	1.8	6	0.8	7	0.9
Calcrete	5	0.7	0	0	1	0.1	0	0	0	0	0	0	0	0
Quartzite	4	0.5	1	0.2	0	0	4	0.6	8	0.4	0	0	0	0
Tools														
Quartz	0	0	6	1.1	23	1.5	10	1.6	7	0.4	0	0	2	0.3
Silcrete & CCS	9	1.2	12	2.3	6	0.4	4	0.6	32	1.7	15	1.9	20	2.7
Calcrete	2	0.3	3	0.6	0	0	0	0	0	0	0	0	0	0
Quartzite	3	0.4	2	0.4	4	0.3	0	0	4	0.2	1	0.1	0	0
Hammerstones														
	1	0.1	2	0.4	1	0.1	2	0.3	0	0	3	0.4	2	0.3
Subtotal	751	100	525	100	1544	100	645	100	1843	100	792	100	750	100
Chunks														
Quartz	141	–	135	–	308	–	83	–	114	–	127	–	89	–
Silcrete & CCS	10	–	22	–	19	–	12	–	48	–	22	–	35	–
Calcrete	25	–	8	–	19	–	5	–	0	–	0	–	0	–
Quartzite	936	–	288	–	548	–	382	–	492	–	522	–	358	–
Pebbles														
	14	–	12	–	11	–	11	–	8	–	17	–	16	–
Subtotal	1126	–	465	–	905	–	493	–	662	–	688	–	498	–
Total	1877	–	990	–	2449	–	1138	–	2505	–	1480	–	1248	–

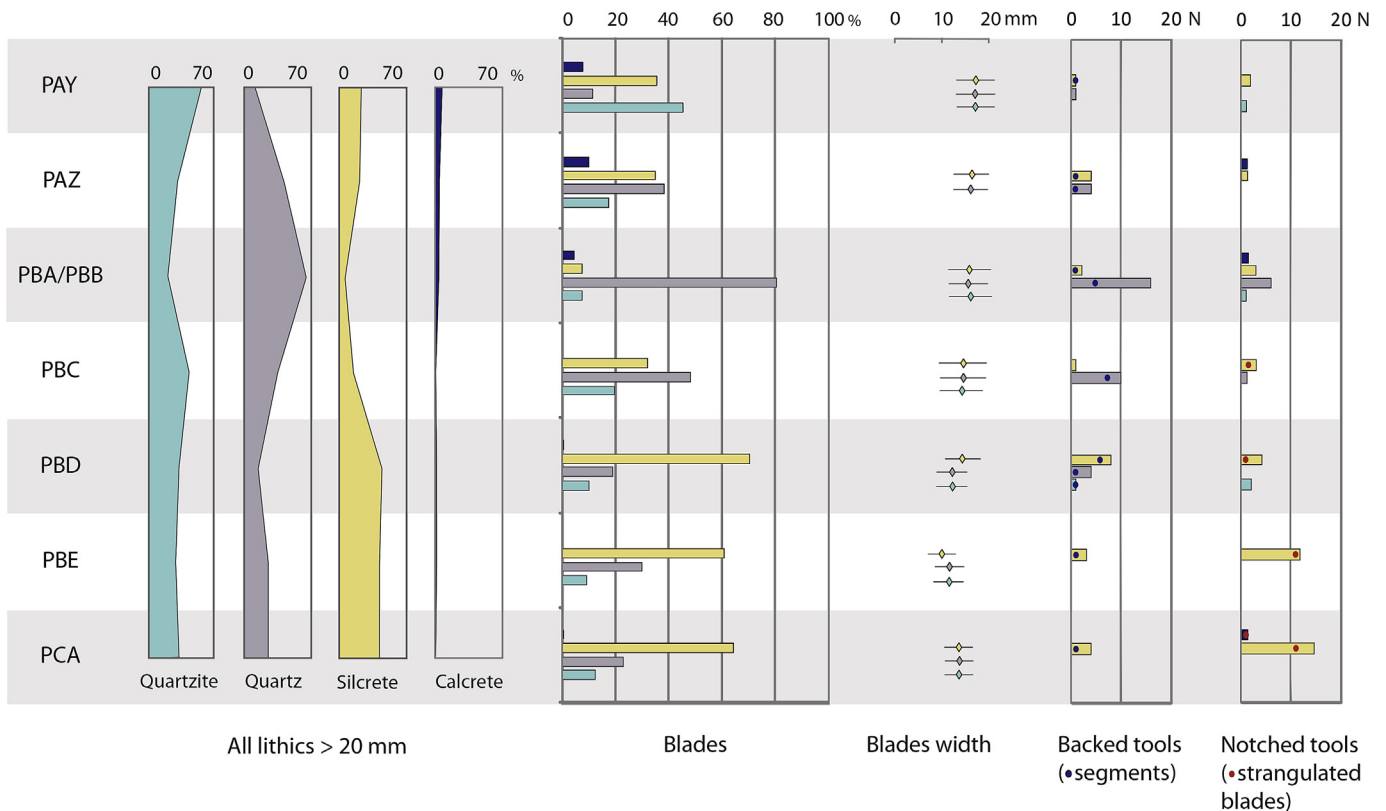


Fig. 6. Technological changes in lithics at KDS, layers PCA to PAY.

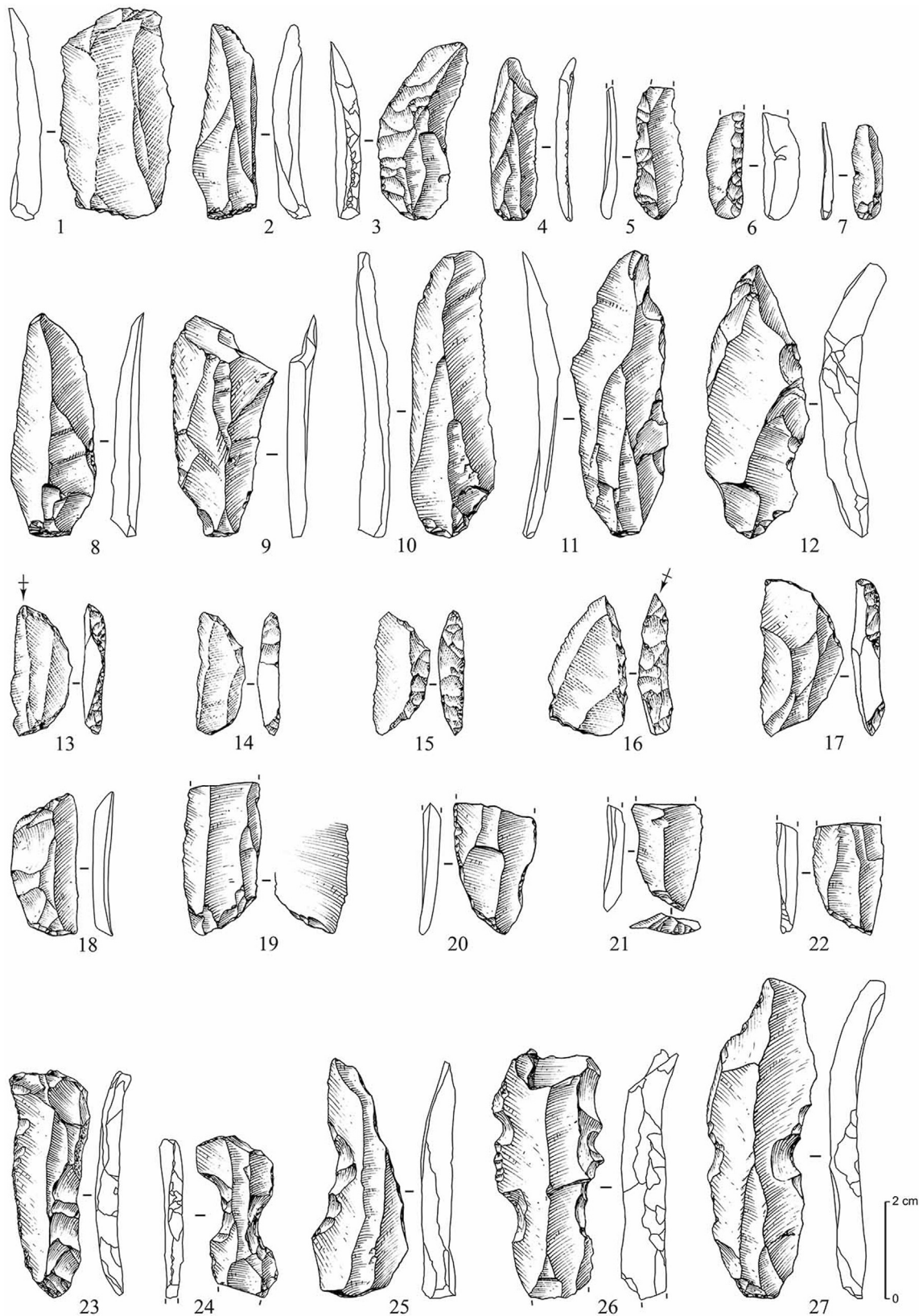


Fig. 7. Blades and formal tools: 1: quartz blade, layer PBA/PBB; 2, 3, 4, 5, 7, 8: silcrete blades, layer PBD; 6, 9: silcrete blades, layer PBC; 10, 11, 12: silcrete blades, layer PCA; 13, 14: quartz segments, layer PBC; 15: quartz segment, layer PBA/PBB; 16: quartz backed tool, layer PBA/PBB; 17: silcrete segment, layer PBD; 18: silcrete bi-truncated tool, layer PBD; 19, 20: silcrete truncated tools, layer PBE; 21, 22: silcrete truncated tools, layer PCA; 23, 26: silcrete strangulated notches, layer PBE; 24: silcrete retouched blade, layer PBD; 25: silcrete strangulated blade, layer PBD; 27: silcrete strangulated blade, layer PCA.

toolkit composition over time, both between and within tool groups (Table 3). Backed tools include different types (Fig. 7: 13–22), whose proportions vary consistently from one layer to another. Segments (Fig. 7: 13–15, 17) are best represented in the middle part of the sequence (layers PBD, PBC, PBA/PBB), with a peak in PBC (Fig. 6) where they correspond to a small set of quartz segments ($n = 7$) with standardized morpho-dimensional attributes. Truncated blades (*sensu* Igraja and Porraz, 2013) are present in almost all layers (PCA to PAZ). Within this category, a few highly standardized silcrete tools are characterized by a proximal oblique truncation opposite to a broken transverse distal part (Fig. 7: 19–22), which are only present in the lower layers (PCA – $n = 3$, PBE – $n = 2$, PBD – $n = 1$). Notched tools (Fig. 7: 23, 25–27) are also diagnostic with regard to patterns of change within the sequence (Fig. 6). They represent a large majority of the retouched tools in the lower layers (PCA and PBE with respectively 16/22 and 12/16 notched tools/total of tools). In these two layers, notched pieces include typical strangulated blades (Fig. 7: 23, 25–27) with multiple deep retouched notches on one or two lateral edges of large silcrete blades (PCA – $n = 7$ including 1 calcrete tool, PBE – $n = 6$). They also occur in lesser proportions in PBD ($n = 1$) and PBC ($n = 2$), but are totally absent in the uppermost layers. In all layers, notched tools are predominantly made on silcrete blanks.

The shift from a notched tool-dominated toolkit (in PCA, PBE) to a backed tool-dominated toolkit (in PBC, PBA/PBB) is closely correlated with the inversion of the relative proportions of silcrete to quartz in the same layers (Fig. 6). Few other categories of formal tools are specific to certain layers. PBD in particular contains borers in silcrete ($n = 2$), quartz ($n = 2$, including 1 crystal quartz) and CCS ($n = 1$). Silcrete blades with marginal continuous retouch on one lateral edge (Fig. 7: 24) are almost exclusively present in PBD ($n = 8$), and occur rarely in both PCA ($n = 1$) and PBC ($n = 1$). Unifacial points only occur in PAY ($n = 3$) and are typical of the “post-HP” period in southern Africa (see for instance Conard et al., 2012; Lombard et al., 2012; Soriano et al., 2007; Villa et al., 2005).

Technological variations through time from PCA to PAY relate to three main phases that can be included within the HP complex. The lowermost phase (PCA, PBE) is characterized by the predominant exploitation of silcrete for blade production, the prevalence of notched tools, the presence of strangulated blades and of highly standardized truncated blades. The following phase (PBC, PBA/PBB) is marked by an increase in quartz exploitation which becomes the most common raw material, while backed tools, including typical segments, constitute the main tool group. The third and uppermost phase (PAY) is defined by the predominance of quartzite, an

increase in the size of blades, the emergence of an independent and structured flake production based on a Levallois concept, a decrease in the proportions of backed tools and the presence of a few unifacial points. PAY could be interpreted as a transitional layer towards the post-HP. In between these phases, layers PBD and PAZ appear as transitional layers, thus pointing to a process of gradual change over time.

4.2. Ochre

Mineral pigments recovered from archaeological contexts are generally termed ‘ochre’ and refer to rocks which derive their colour from haematite ($\alpha - \text{Fe}$) and goethite ($\alpha - \text{FeO}(\text{OH})$) (Eastaugh et al., 2008). The term describes earthy materials which consist of anhydrous iron (III – ferric or Fe^{3+}) oxide such as red ochre (unhydrated haematite or Fe_2O_3), partly hydrated iron (III) oxide-hydroxide such as brown goethite ($\text{FeO}(\text{OH})$) or hydrated iron (III) oxide-hydroxide such as yellow limonite ($\text{Fe}_2\text{O}_3(\text{OH}) \cdot n\text{H}_2\text{O}$) (Cornell and Schwertmann, 2003).

An identified total of 356 pieces or 1756 g of ochreous material was extracted during the 2011–2013 excavation seasons at KDS. Ochreous deposits do not occur within the shelter and no sources have been identified in the immediate vicinity of the complex. Besides a ferricrete source 400 m to the east several ochreous outcrops occur within 5–10 km of the site. Ochre sources are more frequent within a 30 km radius of KDS, the most conspicuous being the Bokkeveld Group deposits of the Cape Supergroup (Vorster, 2003). These comprise red ferruginous shales, siltstones, mudstones and haematized shales. The lowering of sea levels, for example during MIS 5e, would likely have exposed Bokkeveld shales within 0.5–1 km from the site.

All identified specimens heavier than 0.1 g were analysed and are described in terms of weight and size, colour, geology and processing technique employed. The analysed pieces comprise both complete (such as hard ferruginous) and fragmentary (softer shales and mudstones) specimens.

4.2.1. Stratigraphic frequency

The bulk of the assemblage derives from layers PBA/PBB followed by PCA and PBD (Table 4). By mass, layer PBE has the highest concentration of red ochre (847.6 g) in the assemblage (48.3%). It should be noted that by weight just over 90% of the ochre in layer PBE consists of coarse to finely processed pieces weighing less than 0.1 g each. In terms of average mass the highest mean weights are recorded in PBC (4.3 g) and PCA (3.2 g). The high standard

Table 3

Retouched tool composition at KDS (Q: quartz, S: silcrete, C: calcrete, Qi: quartzite) (backed tools may include localized or marginal retouch and oblique truncations may also be proximal).

	PAY				PAZ				PBA/PBB				PBC				PBD				PBE				PCA			
	Q	S	C	Qi	Q	S	C	Qi	Q	S	C	Qi	Q	S	C	Qi	Q	S	C	Qi	Q	S	C	Qi	Q	S	C	Qi
Segments	1	–	–	–	1	1	–	–	4	1	–	–	7	–	–	–	1	3	–	1	–	1	–	–	–	1	–	–
Backed tools	–	1	–	–	2	4	–	–	17	1	–	–	1	1	–	–	3	4	–	–	3	–	–	–	–	–	–	–
Oblique truncations	–	–	–	–	1	–	–	–	1	–	–	–	2	1	–	–	1	–	–	–	2	–	–	–	–	3	–	–
Single notches	–	2	–	–	–	1	1	–	3	2	–	–	1	1	–	–	–	–	–	–	6	–	–	–	8	–	–	–
Denticulates	–	–	–	1	–	–	–	–	3	1	2	1	–	–	–	–	2	–	2	–	–	–	–	–	–	1	–	–
Strangulated blades	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	1	–	–	6	–	–	–	6	1	–	–
Borers	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	3	–	–	–	–	–	–	–	–	–	–
Retouched blades	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	8	–	–	–	–	–	–	–	1	–	–
Unifacial points	–	2	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Burins	–	1	–	–	–	2	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Pièces esquillées	–	–	–	–	–	–	1	–	–	1	–	1	1	–	–	–	1	5	–	–	–	–	–	–	–	–	–	–
Scrapers	–	–	–	1	–	1	1	1	2	2	1	1	1	–	–	–	1	–	1	–	–	–	–	–	1	–	–	–
Miscellaneous	–	5	4	1	4	5	–	1	1	3	–	2	1	–	–	–	12	–	–	–	1	–	1	2	3	–	–	–
Total	1	11	4	4	8	14	3	2	31	11	3	5	15	6	0	0	7	41	0	4	0	19	0	1	2	24	1	0

Table 4
Ochre frequency by weight, size and stratigraphic layer.

Layer	Total (n)	Total (g)	Mean (g)	Std. dev.	Mean (mm)	Std. dev.
PAY	17	13.4	0.8	1.6	16.4	5.7
PAZ	12	21.2	1.8	3.2	16.8	10.4
PBA/PBB	113	248.7	2.2	5.4	15.4	8.3
PBC	19	126.7	4.3	11.5	23.5	14.4
PBD	59	182.2	1.7	5.1	17.4	9.1
PBE	39	847.6	1.6	7.5	12.9	8.8
PCA	97	316.3	3.2	8.9	19.1	10.5
	356	1756.1	2.2	–	17.3	–

deviations in weight for layer PBC and also PCA indicate that specimens range substantially in terms of weight and therefore size, and possibly also in terms of intensity of processing. The lowest average weights occur in layers PAY (0.78 g) and PBE (1.6 g). The heaviest individual pieces derive from layer PCA (79.5 g), followed by PBE (38.5 g), PBC (35.7 g), PBA/PBB (29.2 g) and PBD (17.3 g). The least heavy examples originate from layers PBD, with 41 pieces weighing <0.5 g, and PCA with 36 pieces <0.5 g.

In terms of average size, the largest grouping is that from layers PBC (23.5 mm) and PCA (19.1 mm), followed by PBD, PAZ and PAY at 17.4 mm, 16.8 mm and 16.4 mm respectively (Table 4). Layers PBA/PBB (12.3 mm) and PBE (12.9 mm) contain the smallest mean sizes of ochre pieces. The largest pieces are from layer PCA (74.6 mm) and the smallest from PBA/PBB (1.0 mm). Note the high standard deviations in size for layers PAZ, PBC and PCA.

4.2.2. Geological profiles and colour categories

Six raw material categories are discerned, namely fissile shale, indurated shale, mudstone, ferricrete, haematite and sandstone. Fine-grained and soft (2–3 on Moh's hardness scale) sedimentary forms including fissile shale (53%), indurated shale (22.9%) and mudstone (14.5%) accounts for 90.3% of the raw material assemblage (Fig. 8a). Harder (>4 on Moh's scale) and essentially coarse-grained forms such as ferricrete (2.4%), haematite (2.4%) and sandstone (4.8%) constitute the remainder (9.7%) of the assemblage. Layers PAY to PCA display marked geological variability, with all six geological categories occurring in layers PBC, PBD and PCA. Layer PBC exhibits the highest frequencies of ferricrete (5.3%) and

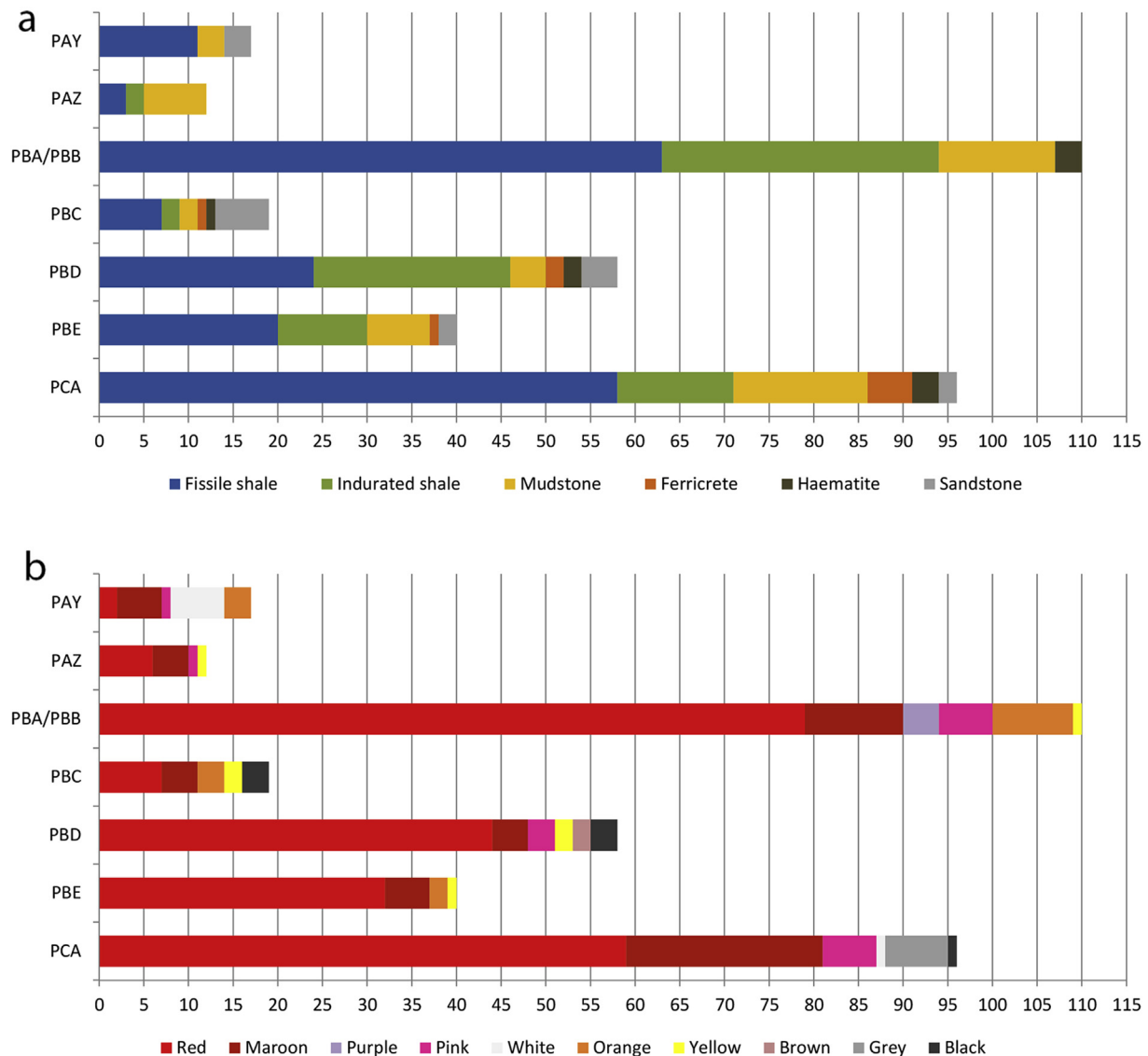


Fig. 8. Ochre recovered from KDS indicated stratigraphically and according to a) raw material frequencies and b) colour. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

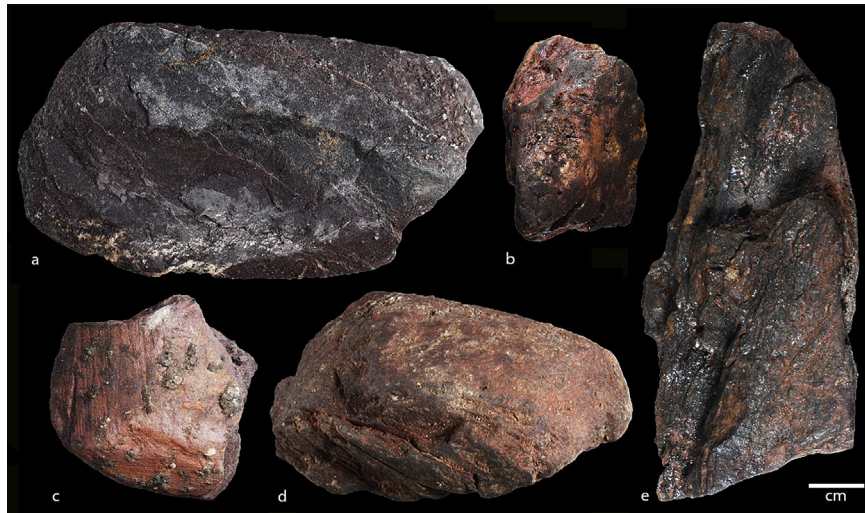


Fig. 9. Examples of processed ochre pieces from KDS: a) coarse-grained ground purple shale cobble (PCA), b) ground and polished shale-derived crayon-like piece (PBC), c) ground and scraped soft shale-derived specimen (PCA), d) ground hard shale chunk (PBE) e) knapped and ground haematite-rich shale fragment (PBC). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

sandstone (31.6%). PBE displays the greatest proportion (91.3%) of red ochre derived from fissile and indurated shales.

Colour was collapsed into ten groups including red, maroon, purple, pink, white, orange, yellow, brown, grey and black (Fig. 8b). Geological and colorimetric relationships could not be objectively ascertained, principally because destructive analytical methods are required to determine such variables (Dayet et al., 2013). Basic visual classification and comparison with the Natural Colour System (NCS) Digital Atlas (<http://www.ncscolour.com>, 2013) was therefore used for colour classification in this study. Although visible spectroscopy can provide the absorbance spectra and colour parameters of the ochre assemblage, this method will only provide information concerning the colorimetric properties of the external surfaces of the specimens. Red (62%) is the predominant colour, followed by maroon (15.3%), orange (4.5%) and pink (4.5%). The remainder of the assemblage (13.7%) includes lighter (yellow and white) and darker (brown and black) categories. The majority (77%) of red pieces are derived from fissile shales.

4.2.3. Utilization strategies

Ochre at KDS occurs in the form of residual powder, nodules, and fragments or as inclusions in larger pieces of rock (Fig. 9). Some examples show signs of grinding on hard abrasive surfaces or scraping with sharp-edged implements. Indications of ochre processing by grinding or scraping ($n = 20$) or by deliberate knapping ($n = 31$) have been identified at KDS.

The proportion of modified pieces (17.5%) is well within the range of other MSA sites (~14%) (Watts, 2002, 2009, 2010; Hodgskiss, 2010; Dayet et al., 2013) (Table 5). Similar to the MSA

at Diepkloof (Dayet et al., 2013) Sibudu (Hodgskiss, 2010), Blombos (Watts, 2009) and Pinnacle Point (Watts, 2010), grinding is the primary processing technique. Of the ground pieces including crayons, 67.7% comprise fissile shale, 12.9% indurated shale, 6.5% mudstone and sandstone respectively and 3.2% haematite and ferricrete respectively. Fissile and indurated shales appear to have been preferentially processed by grinding (80.6%). In addition, 81.8% of ochre crayons comprise soft to hard red fissile shales. At Diepkloof and Sibudu scraping is not a primary processing technique and the presence of only a single scraped piece at KDS (layer PBD) is therefore not unusual. Clear indications of knapping occur on 31 pieces from layers PBA/PBB ($n = 20$), PBD ($n = 5$), PBE ($n = 1$) and PCA ($n = 5$), suggesting that knapping may have formed part of the chaîne opératoire of ochre processing in these layers (Fig. 9e).

4.3. Ostrich eggshell

We have identified 95 fragments of clearly and deliberately engraved ostrich eggshell (EOES) recovered from layers PAY to PCA (3.8% of the total number of OES fragments). The majority of the EOES pieces derive from PBC (27%) and PBD (25%) (Table 6). An additional 6 engraved pieces were recovered from layer PAX (not reported here), and no EOES fragments were recovered from any of the layers above PAX. The EOES is spatially distributed across the area where HP layers were excavated (4.75 m²) and up to 50 cm below the surface. There are no LSA deposits in KDS and during excavation there was no sign of disturbance to the deposits that might have resulted from the intrusive burial of engraved eggs at the site by LSA people. The EOES fragments are under study but preliminary observations can be made. The designs entail variations of cross-hatched or sub-parallel line themes, and most are similar to those reported from Diepkloof in the HP and pre-HP layers (Texier et al., 2010, 2013) and from the HP layers at Apollo 11 (Vogelsang et al., 2010). All the designs identified at Diepkloof (Texier et al., 2013, Table 4: 3423) are present at KDS, except for the “sub-parallel intersecting lines motif”. One design present in the upper layers at KDS, not reported from Diepkloof, consists of a finely carved diamond shaped cross-hatched pattern (Fig. 10a,b), distinctly different to those from layers below, and from the “crosshatched grid motif” reported from Diepkloof (Texier et al., 2013: 3420). This diamond shaped pattern is present only in layers PAX, PAY and PAZ. In PAX and PAY this is the only engraved

Table 5

The prevalence of processed ochre pieces per layer.

Layer	<i>n</i>	Ground	%	Crayons	%	Flakes	%
PAY	17	1	5.9	—	—	—	—
PAZ	12	1	8.3	—	—	—	—
PBA/PBB	113	6	3.9	3	3.9	20	19.6
PBC	19	4	21.1	2	10.5	—	—
PBD	59	1	3.4	2	3.4	5	8.5
PBE	39	1	2.6	1	2.6	1	2.6
PCA	97	5	6.2	3	2.1	5	5.2
	356	19	6.2	11	3.0	31	8.3

Table 6
Frequency of engraved and unmodified OES throughout the sequence.

Layer	EOES (n)	OES (n)	% EOES
PAY	5	106	4.7
PAZ	15	187	8.0
PBA/PBB	22	1274	1.7
PBC	23	349	6.6
PBD	25	202	12.4
PBE	4	90	4.4
PCA	1	282	0.4
Total	95	2490	3.8

motif present. The “sub-parallel rectilinear or curved lines” design at Diepkloof (Texier et al., 2013: 3423) is the most commonly occurring motif in layers PBC to PAZ at KDS. Our study of the EOES is ongoing but initial observations suggest similarities with many of the EOES motifs found at Diepkloof, with some differences.

5. Fauna

5.1. Macrofauna

A preliminary analysis of the macrofaunal remains from the PAY to PCA layers was conducted following Driver (2005) and Klein and Cruz-Urbe (1984). The comparative faunal collections of the Ditsong Museum of Natural History in Pretoria were used to identify bone remains. Micromammals, defined as species where adults weigh less than 750 g, are not included in this analysis. Because of the difficulty in differentiating bovids, many remains were assigned only to size classes based on Brain (1974). Size class 1 includes small bovids such as Cape grysbok (*Raphicerus melanotis*), size 2 includes southern reedbuck (*Redunca arundinum*), size 3 includes red hartebeest (*Alcelaphus buselaphus*), and size 4 are large bovids such as eland (*Tragelaphus oryx*) and African buffalo (*Syncerus caffer*). Although eland is sometimes identified as *Taurotragus oryx*, we follow the classification scheme of Skinner and Chimimba (2005) – based on genetic studies (e.g., Essop et al., 1997) – and classify eland as *Tragelaphus oryx*. We also use the size 5 class for very large bovids, such as the extinct long-horned buffalo (*Syncerus antiquus*). Long-horned or giant buffalo are also known as *Pelorovis antiquus* but we follow more recent studies that assign them to the genus *Syncerus* (Gentry, 2010; Rector and Reed, 2010; Faith, 2013). Due to the fragmentary nature of the assemblage, many mammal remains

such as rib, cranial or vertebral fragments could not be identified beyond class. These specimens are classified as ‘small’, ‘medium’, ‘large’ or ‘very large mammal’ based on size. Small mammals are defined as indeterminate specimens ranging in size from the Cape dune molerat (*Bathyergus suillus*) up to and including size 1 bovids, medium mammals up to size 2 bovids, and large mammals are size 3 bovids and larger (Brain, 1974). ‘Very large mammal’ includes a specimen that could not be confidently identified to order and may be black rhinoceros (*Diceros bicornis*) or long-horned buffalo. Small carnivores range in size to that of the African wild cat (*Felis silvestris*), medium carnivores to the size of the African civet (*Civettictis civetta*) and large carnivores as larger than *C. civetta*. A few fish remains were recovered at KDS, mainly vertebrae and jaw bones, but these have not been studied.

5.1.1. Assemblage

Of the 28,128 fragments of bone, weighing 11,758 g, 2129 (7.6%) could be identified to at least the class level, while 292 (1.0%) could be identified to genus/species. Bone from KDS is extensively fragmented: the majority of identified fragments ($n = 1343$; 63.1%) are less than 2 cm in length and 19.7% of identified bone ($n = 419$) is less than 1 cm long. This extensive fragmentation is likely the reason why the Minimum Numbers of Individuals (MNI) in all layers is lower than expected (Marshall and Pilgram, 1993). Fragmentation is probably a result of burning with evidence present on 1761 fragments (82.7% of identified bone). Although burning was not recorded for unidentified bone, the proportion of unidentified burnt specimens appears much the same as in the identified sample. The elevated proportion of burnt bone is likely due to the high numbers of hearths and hearth-like structures occurring at KDS. Most of the faunal material was recovered from within, or close to, these hearths suggesting that most of the burnt bone can be associated with cooking events. This, and the relative lack of carnivores, is a strong indicator that humans were the main accumulators of the faunal assemblage.

5.1.2. Identified fauna

Tortoise remains are common and constitute 31% of the identified fauna (Table 7). The majority of identified tortoise bones are carapace or plastron but due to their small size it was not possible to differentiate tortoise taxa based on shell fragments. Most of these are likely angulate tortoise (*Chersina angulata*), although some may be the Cape tortoise (*Homopus* sp.). Rock hyrax (*Procapra capensis*) is the most prevalent identified macromammal. Layers

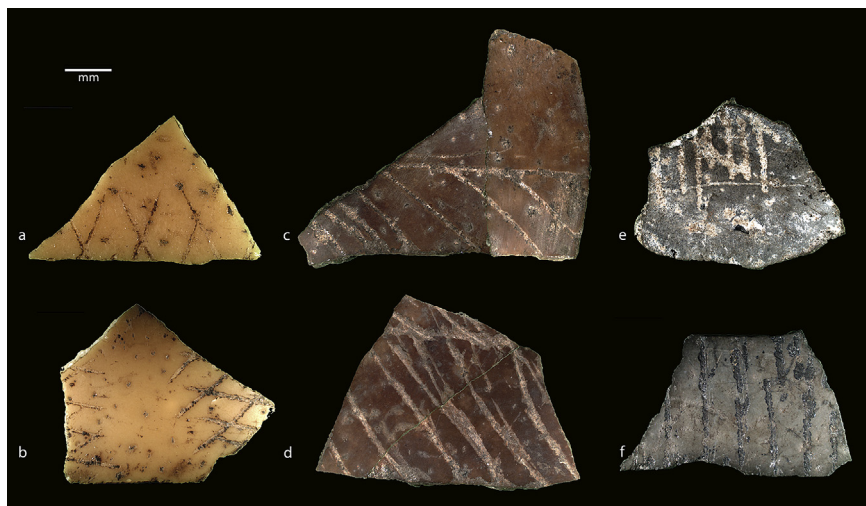


Fig. 10. Engraved OES pieces from PAZ (a and b), PBC (c and d) and PBD (e and f). Note that both c and d consist of two refitted parts.

Table 7

The Number of Identified Specimens (NISP) and the Minimum Number of Individuals (MNI) for macromammal and tortoise remains. Bovid size classes exclude specimens that could be identified to genus/species. Small, medium, large and very large mammals include specimens such as cranial, rib and vertebral fragments that could not be confidently identified beyond class. Linnaean classification based on Skinner and Chimimba (2005) except *Syncerus antiquus* (Gentry, 2010).

Taxa	Common name	PAY		PAZ		PBA/PBB		PBC		PBD		PBE		PCA	
		MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP
Testudinidae	Tortoise	2	59	1	23	2	71	2	51	3	251	2	105	1	24
<i>Chersina angulata</i>	Angulate tortoise	2	10	2	4	2	8	2	11	2	21	2	8	1	3
cf. Pelomedusidae	Turtle	–	–	–	–	–	–	–	–	1	1	–	–	–	–
<i>Lagomorpha</i>	Hare/Rabbit	1	1	–	–	–	–	2	4	1	3	–	–	1	3
<i>Lepus saxatilis</i>	Scrub hare	–	–	–	–	–	–	–	–	–	–	–	–	1	1
<i>Lepus</i> sp.	Hare	–	–	–	–	–	–	1	1	1	1	–	–	–	–
<i>Bathyergus suillus</i>	Cape dune moleerat	2	8	1	1	–	–	–	–	–	–	–	–	–	–
<i>Procavia capensis</i>	Rock hyrax	3	22	2	11	1	1	3	27	2	30	1	1	1	6
	Small mammal	3	41	2	8	3	33	3	78	3	78	2	8	2	31
Herpestidae sp.	Mongoose	–	–	–	–	–	–	–	–	1	1	–	–	–	–
	Small carnivore	–	–	–	–	1	1	1	2	–	–	1	1	–	–
<i>Felis</i> cf. <i>caracal</i> / <i>serval</i>	Caracal/Serval	–	–	1	1	–	–	1	1	–	–	–	–	–	–
<i>Arctocephalus</i> cf. <i>pusillus</i>	Cape fur seal	–	–	–	–	–	–	–	–	1	2	–	–	–	–
	Medium carnivore	–	–	1	2	–	–	1	1	–	–	–	–	–	–
	Medium mammal	2	16	2	8	3	134	3	80	2	64	2	17	3	30
<i>Parahyaena brunnea</i>	Brown hyena	–	–	–	–	1	1	–	–	–	–	–	–	–	–
<i>Diceros bicornis</i>	Black rhinoceros	–	–	–	–	–	–	1	2	–	–	–	–	–	–
<i>Equus</i> sp.	Zebra	–	–	–	–	2	10	3	25	1	2	–	–	1	2
<i>Raphicerus</i> sp.	Steenbok/Grysbok	1	1	1	1	1	1	2	6	1	7	1	5	–	–
<i>Sylvicapra grimmia</i>	Grey duiker	–	–	–	–	1	2	–	–	1	2	–	–	–	–
<i>Oreotragus oreotragus</i>	Klipspringer	–	–	–	–	–	–	–	–	1	4	–	–	–	–
<i>Ourebia ourebi</i>	Oribi	–	–	–	–	1	1	–	–	–	–	–	–	–	–
<i>Pelea capreolus</i>	Grey (Vaal) rhebok	–	1	1	1	1	3	–	–	–	–	–	–	1	2
<i>Redunca</i> sp.	Reedbuck	–	–	–	–	1	3	–	–	1	1	–	–	–	–
<i>Redunca fulvorufula</i>	Mountain reedbuck	–	–	–	–	1	1	–	–	–	–	–	–	–	–
<i>Redunca arundinum</i>	Southern reedbuck	–	–	–	–	–	–	1	1	–	–	–	–	–	–
<i>Alcelaphini</i> sp.	Hartebeest/Wilderbeest	–	–	–	–	1	3	1	2	1	1	–	–	1	1
<i>Connochaetes gnou</i>	Black wildebeest	–	–	–	–	–	–	1	1	1	1	1	1	–	–
<i>Alcelaphus buselaphus</i>	Red hartebeest	–	–	–	–	1	1	1	1	1	2	–	–	1	1
<i>Damaliscus</i> sp.	Bles or bontebok/? <i>D. niro</i>	–	–	–	–	1	3	–	–	–	–	–	–	–	–
<i>Damaliscus pygargus</i>	Bontebok/Blesbok	–	–	1	1	1	1	1	2	–	–	–	–	1	1
<i>Tragelaphus oryx</i>	Eland	–	–	–	–	–	–	–	–	–	–	1	1	1	4
cf. <i>Syncerus antiquus</i>	Giant buffalo	–	–	–	–	1	1	–	–	–	–	–	–	–	–
	Bovid 1	2	9	1	1	2	18	2	15	3	62	2	7	1	4
	Bovid 1/2	–	–	–	–	–	–	–	–	–	–	–	–	1	1
	Bovid 2	3	13	1	4	3	42	2	31	3	30	1	14	2	40
	Bovid 2/3	–	–	–	–	1	2	1	7	1	3	–	–	1	4
	Bovid 3	1	6	2	10	3	20	2	29	2	45	1	2	1	40
	Bovid 3/4	–	–	–	–	2	7	–	–	1	7	1	1	1	6
	Bovid 4	1	1	1	2	1	3	–	–	1	4	1	3	1	19
	Large mammal	2	5	1	3	2	25	3	45	2	23	2	6	1	7
	Very large mammal	–	–	–	–	1	1	–	–	–	–	–	–	–	–
Total		25	192	21	81	41	397	40	423	38	646	21	180	25	230

PAY and PAZ are dominated by micromammal remains, and small mammals such as hyrax and Cape dune moleerat with a few identified bovid bones. Lagomorph remains were recovered from PAY, PBC, PBD and PCA with one specimen identified as scrub hare (*Lepus saxatilis*). Equids (*Equus* sp.) are common in layers PBA/PBB and PBC and many of the 'large mammal' rib and vertebral fragments in these layers are probably equid remains. Based on variation in long bone and metapodia sizes, it is likely that the quagga (*Equus quagga quagga*) or plains zebra (*Equus quagga burchellii*) and mountain zebra (*Equus zebra*) may be present but the fragmented nature of the bones prevents positive identification. It is unclear whether the Cape zebra (*Equus capensis*) is present.

Cape grysbok or steenbok (*Raphicerus* sp.) occur in most layers and are most common in PBC, PBD and PBE. A single oribi (*Ourebia ourebia*) phalange was identified in PBA/PBB with sufficient morphological traits to distinguish this specimen from grey duiker (*Sylvicapra grimmia*), klipspringer (*Oreotragus oreotragus*) or the more common *Raphicerus*. Larger bovids are relatively more common in PBA/PBB, PBC and PCA. Blesbok or bontebok (*Damaliscus pygargus*) remains were recovered from these layers. One

Damaliscus tooth fragment was noticeably larger than *D. pygargus* but smaller than tsessebe (*Damaliscus lunatus*) and may be the extinct blesbok (*Damaliscus niro*). Reedbuck (*Redunca* sp.) occurs in PBA/PBB and PBD. The vertebral fragment assigned to 'very large mammal' likely belongs to long-horned buffalo. Regarding alcelaphines, hartebeest was distinguishable from black wildebeest (*Connochaetes gnou*) by tooth morphology. For example, enamel infolds, particularly on the mesial region of the buccal surfaces of molars, are more pronounced in hartebeest than wildebeest. The relatively high number of 'large mammal' rib and vertebral specimens in layers PBA/PBB and PBC is probably related to the alcelaphines recovered from those layers. Eland remains are relatively more common in PCA and suggest that the other unidentified size 4 bovid specimens from that layer are also most likely eland since no African buffalo have been identified.

5.1.3. Comparisons with other sites

As is the case at KDS, small mammals (particularly dune moleerat and hyrax), small bovids and tortoise are common in the pre-70 ka MSA layers at Blombos (Henshilwood et al., 2001; Thompson and

Henshilwood, 2014), in the HP layers at Diepkloof (Steele and Klein, 2013) and at Die Kelders (Klein and Cruz-Urbe, 2000). Of the large bovids recovered, eland is relatively common at Blombos, Die Kelders and Diepkloof but rare at KDS. In contrast, equid, quite common at Diepkloof and KDS, is only present in the earlier (~100 ka) M3 phase at Blombos and rare at Die Kelders. The prevalence of equids at KDS and within the HP layers at Diepkloof suggests a grassier environment during this period. *Damaliscus* does not occur at either Diepkloof or Blombos but is present at Die Kelders and KDS. While African buffalo occur at Blombos and Die Kelders, remains have not been recovered from KDS. Future studies of KDS fauna will include assessment of skeletal profiles and surface modification patterns.

5.2. Shellfish

The shellfish data presented are a sample of the material retained in the 3 mm sieve from a number of quadrates (between four and six per layer) spanning the sequence from PCA to PAY. This data represents 32.4% of the total volume excavated from these layers. Just over 29 kg of shellfish has been analysed from a volume of 0.51 m³ and 7 layers. Shells were weighed and quantified by determining the minimum number of individuals (MNI) per layer, based on counting the apices of gastropods, the left and right umbos of bivalves with the most common side taken as the MNI, and the highest number of either front, back or middle valves (middle valve counts were divided by 6) of chitons was taken as the MNI. Both apices and opercula of the giant periwinkle *Turbo sarmaticus* were counted and the highest count taken as the MNI. The greatest dimensions of intact limpets and opercula were measured with digital callipers to the nearest millimetre. Shells that were <2 cm (whole) were not considered to be food items and were recorded as incidental shells or juvenile limpets.

In total, excluding the incidental and juvenile shells, 14 species of shellfish were identified (Table 8). Note that although two periwinkle species, *Diloma sinensis* and *Diloma tigrina*, are present, their data have been combined as the countable apices are not identifiable to species level when the shells are broken. Overall, the most common species, in terms of MNI (absolute, per m³ and in terms of relative frequency), is the giant chiton, *Dinoplax gigas*, followed by the brown mussel, *Perna perna*, and *T. sarmaticus*. By weight, the most common species is the abalone, *Haliotis midae*, followed by *D. gigas*, and *T. sarmaticus*.

H. midae, *D. gigas* and *T. sarmaticus* are consistently the most common by weight relative to other species within layers, although frequencies differ between layers. As they are all relatively large animals with heavy shells, their dominance by weight is not that surprising, although they tend to dominate the assemblage in terms of MNI as well. Only in PAY is the Argenville's limpet, *Scutellastra argenvillei*, which is rare or absent in other layers, the second most common in terms of weight (38%). This could be a function of the smaller sample size in PAY. In terms of MNI, the range of the most common species is more varied between layers, but in most instances *D. gigas* and *T. sarmaticus* are most common, but the relative percentage of *P. perna* increases in most layers. Four species, the black mussel *Choromytilus meridionalis*, sand mussel *Donax serra*, kelp limpet *Cymbula compressa* and bearded limpet *Scutellastra barbara* are present in such small quantities that their contribution to the diet of the KDS occupants would have been minimal.

There is a shift in the relative percentage by weight of the three most common species – at the base of the sequence, PCA, *T. sarmaticus* is the most common, in PBE and PBD *H. midae* is the most common, in PBC *D. gigas* is only slightly more common than *H. midae*, and in all the layers above *D. gigas* is the most frequently

occurring species by weight (Fig. 11). The same shift is evident from the density data (g/m³) of these species.

5.2.1. Densities by layer

There is little or no shellfish present in layers below PCA. That which has been recorded is thought to derive from PCA above, where PCA and PCB could not be separated. Densities are considerably higher in layers PBC and PBD, with 183 kg/m³ and 181 kg/m³ respectively, than in any other layers (Table 8), and gradually decreases towards the top of the sequence, with less than 3 kg/m³ in PAY. Shellfish volumes decrease drastically above PAY (<1 kg/m³), and only increase again in layers PAQ (1.4 kg/m³) and above (up to 12.2 kg/m³ in PAL). Notwithstanding the effects of volume reduction over time and geomorphological processes that cannot be accounted for, PBC and PBD are very dense shell layers, both relative to other layers within this site, as well as to other MSA sites with shellfish remains and published volumes. At Klasies River, the highest recorded density of shellfish is in the MSA II, at 162 kg/m³ (Thackeray, 1988). The HP layers at Klasies River show a gradual decline in shellfish volumes through time, starting at 8.7 kg/m³ in the lower layers, and ending in 0.8 kg/m³ in the uppermost HP layers. At Blombos, shellfish volumes are highest in layer CI in the M3 phase, c. 100 ka, at 163.8 kg/m³ (Henshilwood et al., 2001), and lower in the M2 (c. 80 ka) and M1 (c. 75 ka, Still Bay) phases, with 31.8 kg/m³ and 17.5 kg/m³ respectively. At Pinnacle Point Cave PP13B, in layers dating between 90 and 164 ka, shell densities are relatively low, ranging from 0.01 kg/m³ to 8.7 kg/m³ (Jerardino and Marean, 2010). Shellfish data have not been provided for the HP layers at Pinnacle Point Site PP5–6, but densities appear to be low (Brown et al., 2012).

Although the density of shellfish declines with time, the species composition does not indicate a change in the distance from the shore significant enough to result in changes in collection strategies, for example an increase in *P. perna*, which can be transported over greater distances, or a decrease in large high yield species when distances exceed 5 km (Langejans et al., 2012).

5.2.2. Shellfish size

It has been argued that reductions in shellfish size can be used as a proxy for intensification of shellfish gathering and increased group size (e.g. Klein and Steele, 2013), although some suggest that the role of environmental factors on shellfish growth rates might be more significant than previously considered (Sealy and Galimberti, 2011). The number of measurable shells from the current sample is small, but has been included here for completeness. Very few of the *Cymbula granatina* shells were intact enough for measurement, and all are from PBD and PBC. From the small measurable sample ($n = 10$), the median is 67.5 mm, mean 67.4 mm, minimum 57 mm and maximum 79 mm. These sizes are smaller than the average of modern *C. granatina* from unexploited areas on the Cape west coast (Parkington et al., 2013), and somewhat smaller than those reported from MSA contexts on the west coast, except for Boegoeberg 2, where sizes are similar (Steele and Klein, 2008; exact measurements are not provided).

The current measurable *Cymbula oculus* sample is also small (median 72.5 mm, mean 71.2 mm, minimum 55 mm, maximum 84 mm, $n = 16$). These sizes are somewhat smaller than that of *C. oculus* from the HP at Klasies River, but bigger than any published LSA data (Klein and Steele, 2013).

All measurements ($n = 63$) of *T. sarmaticus* opercula are from layers PCA to PBA/PBB. The median length is 38 mm, mean 36.9 mm, minimum 14 mm and maximum 50 mm. This is smaller than those from the HP at Klasies River, larger than any published LSA opercula sizes, and most similar in size to those from the MSA I and II from Klasies River (Klein and Steele, 2013).

Table 8Minimum number of individuals (MNI), weight (g) and density (MNI/m³ and kg/m³) of shellfish from layers PCA to PAY.

Species	PAY		PAZ		PBA/PBB		PBC		PBD		PBE		PCA	
	MNI	g	MNI	g	MNI	g	MNI	g	MNI	g	MNI	g	MNI	g
<i>Choromytilus meridionalis</i>	–	–	1	<1	–	–	1	<1	–	–	–	–	–	–
<i>Perna perna</i>	1	5	8	26	14	49	68	123	22	54	32	59	18	23
<i>Donax serra</i>	1	1	–	–	–	–	–	–	–	–	–	–	–	–
<i>Burnupena cincta</i>	2	2	2	10	4	94	56	323	8	46	4	9	1	4
<i>Haliotis midae</i>	1	2	1	47	2	334	18	3445	27	5739	12	2052	1	284
<i>Cymbula compressa</i>	–	–	1	3	1	2	1	3	1	20	2	5	–	–
<i>Cymbula granatina</i>	1	1	1	3	1	26	20	417	8	328	1	63	1	43
<i>Cymbula oculus</i>	1	1	1	10	13	119	16	220	21	380	10	210	5	59
<i>Scutellastra argenvillei</i>	1	48	1	3	1	<1	1	1	1	59	1	3	1	42
<i>Scutellastra barbara</i>	–	–	–	–	–	–	–	–	–	–	1	5	1	1
<i>Patella</i> spp.	–	3	1	12	–	29	–	36	–	65	–	49	–	89
<i>Diloma</i> sp.	–	–	1	5	1	24	17	54	3	3	6	3	1	30
<i>Turbo sarmaticus</i>	1	13	3	165	17	572	19	707	25	1265	30	1263	45	1290
<i>Dinoplax gigas</i>	6	54	25	742	114	1877	206	3612	25	1193	27	546	6	233
Shell fragments	–	7	–	19	–	155	–	121	–	47	–	54	–	19
Total MNI and g	15	135	46	1046	168	3281	423	9061	141	9197	126	4322	80	2118
Density MNI/m ³ and kg/m ³	294	3	703	16	1660	32	8526	183	2771	181	1159	40	931	25
Non-food species	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Incidental shells	–	2	–	1	–	1	–	5	–	3	–	14	–	31
Juvenile <i>Patella</i> sp.	–	–	–	0	–	3	–	8	–	7	–	5	–	1

5.2.3. Collection strategies

The abundance of *D. gigas*, *H. midae* and *T. sarmaticus* indicates that the inhabitants were targeting species with high meat yield rates (Langejans et al., 2012). These three species contributed the highest average meat weight per m³ in every layer (cf. Avery, 1976). They are usually only collectible at low tides and in the instance of *H. midae*, the kelp limpet *C. compressa* and *S. barbara*, spring low tides. Thus it appears that the majority of shellfish collection was scheduled to coincide with low tides.

5.3. Human remains

A nearly complete crown of an isolated human left mandibular deciduous second molar (Ldm2) was recovered from quadrat S29b, layer PBE dated at c. 64 ka (Fig. 4, PBE lies between layers dated to 64.6 ± 4.2 and 63.5 ± 4.7 ka). A description of the molar is in preparation by Havarti et al.

6. Palaeoenvironment

6.1. Fauna

The high densities of shellfish at KDS suggest that it was located close to the shore during most of the HP occupation. The cold water endemic shellfish species, *C. granatina*, or granite limpet, which does not occur on the south coast today, is present in relatively small quantities throughout the sequence, and most common in terms of weight (8.4 kg/m³) in PBC. Their presence suggests that sea surface temperatures (SST) were cooler than present, although the abundant presence of warmer water species such as *T. sarmaticus* and *D. gigas* mitigates against extreme differences in temperature. The few fragments of *C. meridionalis*, a species most abundant on the colder west coast today, could also support cooler conditions, although it is probably only a good indicator of cooler conditions when it outnumbers its warmer water counterpart, *P. perna*, which is not the case here.

The species composition indicates rocky shores, with the exception of a few fragments of *D. serra* in PAY, which is a sandy beach inhabitant. The steady increase in *D. gigas* at the expense of *H. midae* and *T. sarmaticus* in the upper layers could indicate an increase in sandy conditions, as *D. gigas* is more tolerant of sandy environments than the other two species (Kilburn and Rippey, 1982; Wood, 1993; Yssel, 1989).

The terrestrial fauna from KDS consists largely of species that occurred in the area historically (Skead, 1980). The abundance of rock hyraxes indicates rocky hillsides associated with shrubs, consistent with the fynbos and rocky crevices surrounding KDS today. The presence of terrapin and reedback implies a nearby fresh-water source such as a wetland or riverbed. Southern reedback (*R. arundinum*) prefer tall grass or reed beds for cover and are typically found in grasslands adjacent to wetlands or vleis.

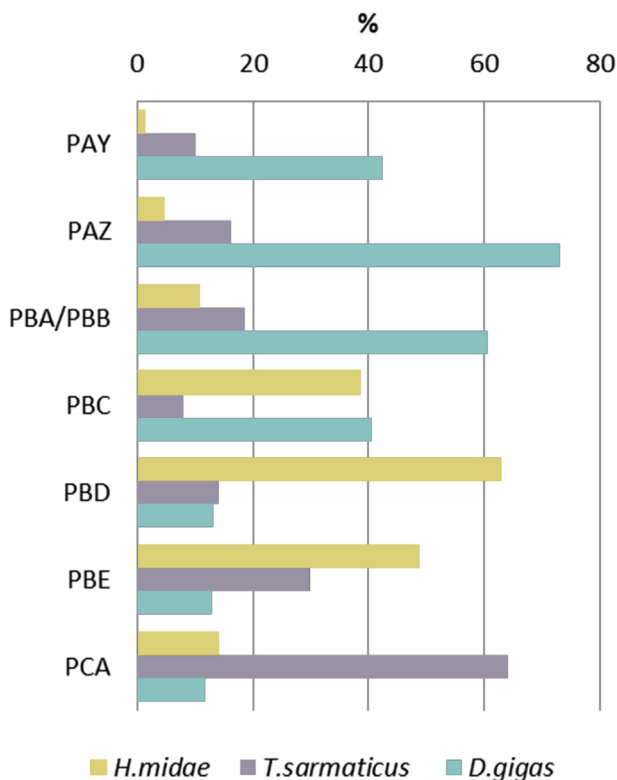


Fig. 11. Relative frequency (%) per layer of the three most common shellfish species based on weight.

Presence/absence data by main habitats (with n taxa)

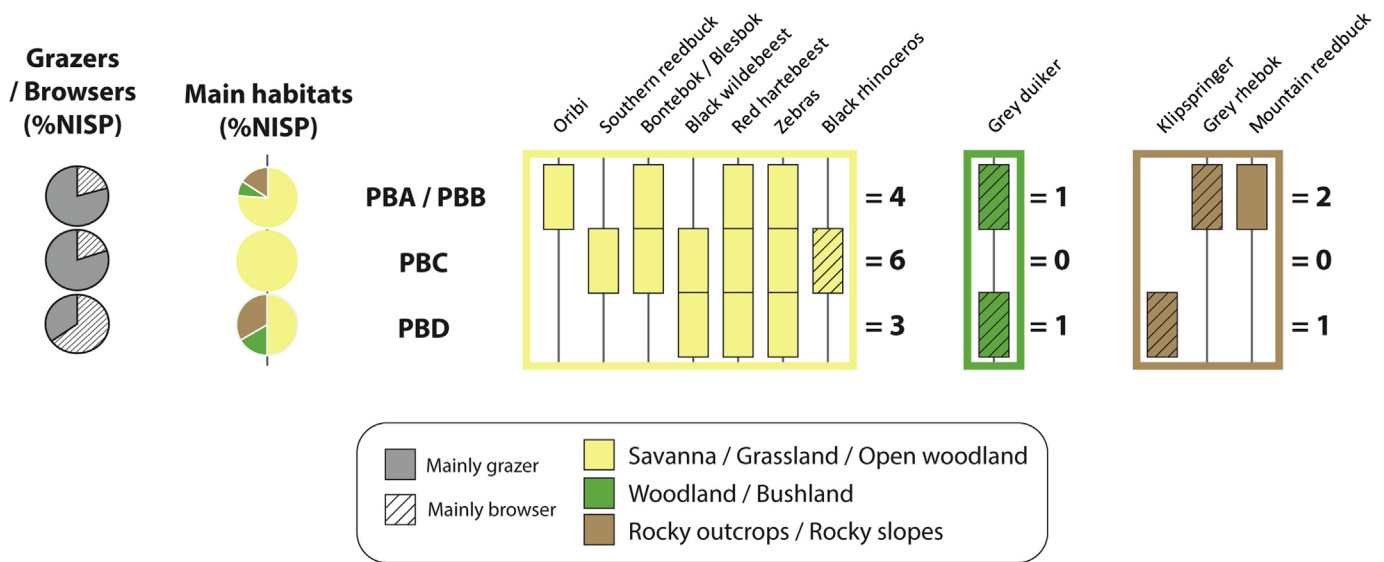


Fig. 12. Palaeoenvironmental analyses of large herbivore communities (grazer/browser ratios and data on main habitat preferences expressed as NISP proportions and presence/absence of each taxa).

Mountain reedbuck favour dry, grass-covered mountain slopes but also require the availability of fresh water (Skinner and Chimimba, 2005). The Klipdriftfontein stream lies close to KDS and could have been the source of this fresh water. Southern reedbuck is not known to occur in fynbos historically and its presence could indicate moister than present or historical conditions (Skead, 1980).

The presence of dune mole-rats in PAZ and PAY and the absence of this species in all other layers could indicate a change in the local environment to more sandy conditions. Dune mole-rats are associated with mesic coastal, sandy, environments (Bennett et al., 2009). Increase in size is thought to correlate with increased moisture (Klein, 1991). Unfortunately mole-rat remains from KDS were too fragmented for measurement. The lack of dune mole-rat remains in other layers may also be due to the small sample size or changes in taphonomic conditions across the sequence that have yet to be identified. Likewise the absence of Cape fur seal at KDS could be due to taphonomic and preservational issues, or the relatively small sample size. Conversely, seals may have been butchered close to the shore with little osteological material transported back to the site.

Palaeoenvironmental analyses of large herbivore communities are still tentative for KDS, as identified remains are rare. The sample sizes for layers PCA, PBE, PAZ and PAY are too small (total NISP <10) to allow for a secure interpretation. We thus focus here on layers PBD (total NISP = 20), PBC (40) and PBA/PBB (29). Although evidence for temporal changes should be treated with caution due to the current small sample size, some observations can be made.

Some patterns are apparent when large mammal data is interpreted in terms of grazer/browser ratios and main habitat preferences (Fig. 12, interpretations based on modern data cf. Rector and Reed, 2010; Skinner and Chimimba, 2005; Sponheimer et al., 2003). While 65% of identified bones in PBD correspond to ungulates that are mainly browsers (steenbok/grysbok, grey duiker and klipspringer), the upper HP layers indicate a considerable increase in ungulates that are mainly grazers (equids, red hartebeest, southern reedbuck, mountain reedbuck, black wildebeest, bontebok/blesbok and oribi). In layers PBC and PBA/PBB they represent 80% and 79% of identified ungulates respectively (Fig. 12).

This sharp increase in presence of grazers is paralleled by data relating to main habitat preferences. There appears to be a change from slightly more bushy terrain in PBD to an environment dominated by grasslands in PBC, potentially interspersed with woodlands and shrubs (as indicated by the presence of black rhinoceros). PBC documents the development of a full suite of ungulates that are preferentially found in open grassland/savannah ecosystems (6 out of the 6 taxa identified in the layer), with equids representing 63% of identified ungulates. The environment in PBA/PBB is somewhat intermediate between PBD and PBC.

The development of a grassland-dominated ecosystem in PBC around 66 ka may correspond to an increased frequency of C4 plants following an increase in summer rain. Isotopic studies of the nearby Crevice Cave speleothems (Bar-Matthews et al., 2010) support this hypothesis: in these records, increases in $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ around 68 ka have been interpreted as indicative of correlated increases in C4 plants and in summer rain respectively.

7. Discussion

The comprehensive data collection strategy adopted at KDS during the 2011–2013 excavations of the HP layers, and the subsequent and on-going analysis of this assemblage, allows for preliminary observations to be made and provide a sound basis for future excavations at the site. The small assemblage recovered from the upper layers of KDS (PAL – PAN/PAO) with an age of 51.7 ± 3.3 ka provides a tentative glimpse of the post-HP layers and will be one focus of future excavations.

The HP layers at KDS have been dated by OSL to 65.5 ± 4.8 ka to 59.4 ± 4.6 ka. Similar OSL dates have been attained for a number of other HP assemblages in southern Africa, suggesting that the HP is a relatively short-lived industry (Jacobs et al., 2008). However, the chronology produced by Jacobs et al. (2008) has recently been questioned by Guérin et al. (2013), who claim that the HP ages are erroneously precise, and that the “adjusted dose rate” model used by Jacobs et al. (2008) is incorrect. It is beyond the scope of this paper to attempt to adjudicate either criticism, but we note that the

“adjusted dose rate” model was not applied to KDS samples, and individual ages presented here have relative uncertainties which are consistent with the expectations of Guérin et al. (2013). New OSL and thermoluminescence ages from Diepkloof (Tribolo et al., 2013) also contradict the findings of Jacobs et al. (2008), indicating a much longer HP chronology, with an early HP at c. 109 ka and a final HP at c. 52 ka. The full range of these latter ages for the HP is not evident at KDS.

The lithic assemblages from PCA to PAY correlate with the HP complex. They evidence a number of changes, involving raw material composition, frequencies and types of retouched tools, which relate to three main phases occurring during a gradual process of change. Similar patterns of change through time are documented at Klasies River (Villa et al., 2010; Wurz, 2000) and at Diepkloof in the intermediate and late HP layers (Porráz et al., 2013a, 2013b). The lower KDS layers (PCA, PBE) share a number of similarities with the lower phase at Klasies River and the Intermediate HP phase at Diepkloof, while the middle KDS layers (PBC, PBA/PBB) correspond to the upper part of the sequence at Klasies River and to the late HP at Diepkloof. This diagnosis for KDS is based on the layers which are currently available for analysis. Further research on the underlying and overlying layers will undoubtedly complete and refine this preliminary assessment.

In terms of ochre processing strategies and geological diversity, the KDS assemblage appears to exhibit four distinctive phases. Whereas the lowest layer (PCA) resembles PBD and PBC in terms of displaying the standard range of processing techniques and geological varieties, layer PBE consists of a dense concentration of thoroughly processed shale-derived red ochre. PBE contains the highest concentration of red ochre derived from fissile shales, and the range of geological types are limited relative to other layers in the sequence. Layer PBE therefore represents a break in standard pigment selection and processing strategies displayed by the samples recovered from layers PAY to PBD. As powdered ochre may have been used for various purposes (Bonneau et al., 2012; d’Errico et al., 2012; Henshilwood et al., 2009, 2011; Rifkin, 2011; Soriano et al., 2009; Wadley et al., 2009), such high volumes may be indicative of the deliberate processing of large amounts of ochre for very specific purposes. Following this emphasis on processing ochre into fine powder, layer PBC exhibits the largest assembly of ochre crayons and the widest geological variability. In layer PBA/PBB, the raw material composition remains largely unchanged but there is increased evidence for flaking as a primary processing strategy. The upper layers (PAY and PAZ) display the least variability in terms of raw material selection and processing technique employed.

The prevalence of small mammals and tortoise at KDS is similar to that found at many other MSA sites in the southern and western Cape. Larger mammal data from KDS – particularly alcelaphines and equids – suggests an environment where grasses feature more prominently than they did historically, as has been noted for the HP layers at Diepkloof (Steele and Klein, 2013). In other reports significant faunal changes during the HP period are not emphasized. At KDS, while most layers (PAZ, PBA/PBB, PBC and PCA) are dominated by remains of medium and large mammals (mainly bovinds and equids), others are dominated by tortoise remains (PBD and PBE) and layer PAY by small mammals (particularly rock hyrax and Cape dune mole-rat). The KDS sequence also documents changes in the relative proportion of small bovinds (e.g. Cape grysbok/steenbok, klipspringer, grey duiker; more common in layers such as PBD) and of equids and larger bovinds (e.g. red hartebeest, black wildebeest, bontebok/blesbok, eland – more common in layers such as PBC). Further studies of the KDS fauna will include taphonomical analyses to decipher how these patterns correlate with environmental and/or subsistence changes. The significant extent of these faunal

changes might imply that HP hunter-gatherers changed their subsistence strategies and adapted to varying environments, while not necessarily modifying the main characteristics of their technical and cultural behaviours. KDS can play a role in future research focused on understanding the interplay between cultural changes, especially in lithic technology (see 4.1 above), and subsistence strategies during the HP.

The shellfish data here complement that from other known HP locations with shellfish such as Klasies River and Diepkloof. As at Klasies River, the density of shellfish declines with time through the HP (Thackeray, 1988), whereas the opposite is true at Diepkloof (Steele and Klein, 2013). The high density of shellfish, particularly in layers PBC and PBD, suggests that the coastline was nearby, and lower densities in the younger layers could reflect a retreat of the coast due to lowering sea levels. Conversely, the presence of dune mole-rat remains only in the upper layers PAY and PAZ, where shellfish densities are lowest, implies the presence of dune sand and a nearby coastline. More data are needed to address these conflicting signals. The low incidence of fish bones could be due to taphonomic processes as bone is generally poorly preserved and fragmented, and fish bone is even more susceptible to degradation than mammalian bone (Szpak, 2011).

Ostrich eggshell is abundant throughout the site. The presence of at least 95 OES pieces engraved with abstract patterns, similar to that reported from only two other HP contexts, Diepkloof and Apollo 11, extends the geographic extent of this cultural tradition.

8. Conclusion

KDS is a newly discovered coastal site in the southern Cape containing lithics typical of the HP. It is the first known typical HP site (see Henshilwood, 2012) located on the c. 600 km of coastline between Nelson Bay Cave, Plettenberg Bay and Peers Cave (Skildegat) on the Cape Peninsula (Fig. 1). No anthropogenic deposits were recovered at KDS that predate 65.5 ± 4.8 suggesting that the c. 71 ka early HP-like technology reported at Pinnacle Point (Brown et al., 2012) and the $>c. 72$ ka Still Bay phases from nearby Blombos Cave (Henshilwood, 2012) are technocomplexes that predate the KDS HP deposits. Nevertheless, the KDS assemblage provides a useful corollary with the earlier Blombos and Pinnacle Point data on coastal subsistence patterns during the MSA in this region. Future excavations at the adjacent KDCL site with MSA deposits that predate c. 70 ka, and of the post-HP layers (for which a single age of 51.7 ± 3.3 ka is currently available) at KDS, will add to this knowledge. The apparent absence of shellfish at this site is worth noting.

The current faunal sample from KDS is too small for definitive statements regarding environmental conditions during the HP in this region, although tentatively, the macromammal and shellfish data point to some changes in rainfall regimes and local environments within the sequence. Additional data from microfauna, isotopic analysis and larger macrofaunal samples will contribute to refining these observations and to the greater picture of environmental conditions during this period. It is worth noting that the environmental change that is evident in layer PBC apparently corresponds to a change in lithic raw materials, from a predominant exploitation of silcrete to an increased importance of quartz exploitation and also a marked decrease in pigment exploitation. Future research on the KDS HP will focus on understanding the role played by environmental changes in the evolution of raw material and food procurement strategies by MSA hunter-gatherers. The development of an open landscape might have influenced general mobility strategies, affecting both hunted species and access to raw materials.

Whether the engraved OES from KDS indicates continuity in the practice of marking or decoration of material culture in the

southern Cape, as is evidenced at Blombos (Henshilwood et al., 2009) in the Still Bay and pre-Still Bay layers, is not clear at this stage. This is especially so as there is an anthropogenically sterile sand layer above the terminal MSA deposits at Blombos and below the first MSA deposits at KDS. However, the planned detailed studies of the KDS engraved OES may provide further evidence on likely cultural links with other Western Cape sites.

The recent discovery and excavation of KDS helps reinforce the notion that *H. sapiens* using HP technology were fairly widely spread in South Africa between 66 and 59 ka, were able to adapt to a range of environmental conditions and yet produced a technology that is fairly standardized. The latter suggests a deliberate continuity in material culture styles probably reinforced by frequent contact among and between the groups that ranged across this region. Some of the cultural traditions, such as the engraving of OES, appear infrequently, but their presence in sites on the west coast and now the southern Cape reinforces this notion of contact within a far reaching social network.

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CHAPTER 3: SUBSISTENCE BEHAVIOUR AT KLIPDRIFT SHELTER

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Subsistence strategies in the southern Cape during the Howiesons Poort: Taphonomic and zooarchaeological analyses of Klipdrift Shelter, South Africa

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Late Pleistocene

ABSTRACT

The Howiesons Poort techno-complex of southern Africa was a particularly significant phase in the development of complex cognition in *Homo sapiens* and new sites are crucial to our understanding of this period. Here, we present the results of a taphonomic and zooarchaeological analysis of Klipdrift Shelter to investigate subsistence strategies during the Late Pleistocene. In particular, we focus on the taphonomic history of the assemblage. Our analysis shows that the Klipdrift Shelter faunal assemblage is extensively fragmented; probably as a result of anthropogenic processing and post-depositional alteration. As a result, little significant information can be extrapolated from the analysis of skeletal-part abundance per layer. Human involvement in the accumulation of ungulate, small mammal, carnivore and tortoise remains is apparent in all layers. We show evidence of disarticulation, marrow extraction, skinning, filleting and carnivore consumption and document the processing of low-ranked game and elements. We also discuss the possibility of remote-capture technology at Klipdrift during the Howiesons Poort.

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1. Introduction

The newly excavated Klipdrift Shelter (KDS) – with its recovered engraved ostrich eggshell from the Howiesons Poort (HP) layers – promises to be an important site in exploring behavioural complexity during the Late Pleistocene. The development of complex or cognitively ‘advanced’ behaviour in African hominins in the Middle Stone Age (MSA), from ca. 300 ka to 30 ka, is particularly prevalent in the HP techno-complex of southern Africa during MIS 4 (Ambrose and Lorenz, 1990; Deacon and Shuurman, 1992; Wadley, 2001; Jacobs et al., 2008; Henshilwood and Dubreuil, 2011; Hodgskiss, 2014). Sophisticated lithic reduction techniques and

evidence of innovative behaviour (such as possible bow-and-arrow use) during the HP suggests that humans then were as cognitively modern as those in the Upper Palaeolithic/Later Stone Age (Mellars, 2006; Lombard and Phillipson, 2010; Lombard and Haidle, 2012; Wurz, 2013). Zooarchaeological studies have made significant contributions to our understanding of hominin behaviour in the Late Pleistocene (Bunn and Kroll, 1986; Stiner et al., 1999; Klein and Cruz-Urbe, 2000; Clark, 2011; McCall and Thomas, 2012) and taphonomic analyses are a crucial step in unravelling subsistence strategies at African Pleistocene sites (Klein, 1975; Brain, 1981; Blumenshine, 1986; Marean et al., 1992; Marean and Kim, 1998; Milo, 1998; Marean et al., 2000; Thompson and Henshilwood, 2011). Yet, except for Sibudu (e.g., Clark and Ligouis, 2010), relatively few HP sites – especially in the southern Cape – have faunal remains from well-stratified contexts that have been taphonomically analysed (but see Faith (2013)). In this study, we focus on the

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taphonomic history of KDS and describe and analyse the fauna recovered from the MSA in general, and HP layers in particular.

1.1. Background

In recent years HP subsistence strategies have been extensively studied (e.g., McCall, 2007; Lombard and Clark, 2008; McCall and Thomas, 2012; Dusseldorp, 2014). Some of these analyses interrogate the role that resource intensification plays in subsistence behaviour (McCall, 2007; Clark, 2011; McCall and Thomas, 2012). Subsistence intensification has been defined as the extraction of increased amounts of energy from a given area at the expense of foraging efficiency (Schoener, 1974; Munro, 2009: 141). Initial research on foraging intensity focused on its effect on pre-agropastoralist subsistence economies (Binford, 1968; Flannery, 1969) but more recent studies have looked for evidence of intensive foraging in the Late Pleistocene (Stiner et al., 2000; Stiner, 2001; Munro and Bar-Oz, 2005; Speth and Clark, 2006; Bar-Oz and Munro, 2007; Steele and Klein, 2009; Clark, 2011; Speth, 2013). Research suggests that population pressure may play a role in intensive foraging (Stiner et al., 2000; Jerardino, 2010; Clark, 2013). Jerardino (2010) argues that increasing population sizes during the Holocene resulted in the shell 'megamiddens' located along the western Cape. She sees evidence of over-harvesting of molluscs and an increase in smaller bovids and tortoises at Elands Bay Cave and surrounding sites as indicative of intensive subsistence exploitation during that period. Henshilwood and Marean (2003) argue that benign environmental conditions were likely to encourage population expansions, ultimately resulting in a reduction of exploitable land and resources. This, they contend, was particularly relevant during the shift from interglacial to glacial periods. McCall and Thomas (2012) see evidence of longer-term residential occupation at HP sites and suggest that this would have resulted in increased demographic pressure and the rapid depletion, and thus intensification, of available resources. Yet Dusseldorp (2014: 27) maintains that there is no evidence of a 'southern Africa-wide demographic crisis' through MIS 4 and MIS 3. Faith (2013) argues that the contrast between low-occupational intensity at Boomplaas Cave and higher-density occupation at coastal sites likely reflects a shift in populations to the coast during the HP. Certainly, environmental conditions are probably associated with changing subsistence patterns in the Late Pleistocene in southern Africa (Deacon, 1989; Ambrose and Lorenz, 1990; Deacon and Shurman, 1992; Henshilwood, 2008; Ziegler et al., 2013). McCall (2007), for example, proposes that a reduction in food resources correlates to environmental changes at the Marine Isotope Stage 5a/4 transition which, in turn, is linked to increased mobility patterns and innovative economic strategies. Clark's (2009, 2011) study of the fauna from the HP at Sibudu shows more evidence of resource stress in the HP than in the post-HP period at Sibudu. In the HP, she found that diet breadth (as measured by evenness) is broader and small game and bushpig (a relatively dangerous prey) are more common which, she suggests, may be linked to human adaptations to environmental productivity.

Technological innovation may have also influenced subsistence strategies during the HP. Lombard (2011) and colleagues (Lombard and Phillipson, 2010; Lombard and Haidle, 2012) argue for evidence of bow-and-arrow technology at Sibudu during the HP. Research by Clark (2009, 2011) and colleagues (Clark and Plug, 2008; Lombard and Clark, 2008) indicate that small fauna dominates the HP assemblage at Sibudu. While they concede that this may be a result of environmental conditions (given that smaller, more solitary fauna favour the closed, bushy habitat prevalent during the HP), they also suggest it may be associated with remote-capture hunting strategies. Indeed, Steele and Klein (2013) show a similar

predominance of small fauna in the HP layers at Diepkloof. Wadley (2010) posits that the prevalence of small, taxonomically-diverse fauna is one of several indicators that may suggest snaring or trapping. This, she argues, implies people with enhanced working memory that were, for all intents and purposes, modern.

1.2. Analytical framework

Here, we use taphonomic, skeletal-abundance and mortality data to investigate subsistence strategies of southern Cape populations during the HP. Under the assumption that fauna was foraged optimally, it should be expected that foragers would have chosen higher-valued skeletal-parts such as prime meat-bearing or marrow-rich long-bones over low-valued elements to transport back from kill-sites (Jochim, 1979; Winterhalder, 2001). This is especially true if prey was procured at great distance from the shelter where the economic cost of transporting complete carcasses outweighed the benefits (Metcalfe and Barlowe, 1992; Faith, 2007; cf. Clark, 2011: 277). Skeletal-part patterns are therefore assessed with transport distances in mind. Due to a lack of comparative data from pre- and post-HP periods, we are unable to assess if subsistence strategies were comparatively more or less intensive in the HP at KDS. Nonetheless, we record evidence of the processing of low-ranked game (e.g., rodents and hyrax) and low-utility elements such as phalanges (Munro, 2004; but see Jin and Mills (2011)), pelvis and calcanei (Binford, 1978; Morin, 2007). These data could be used in future research on subsistence behaviour in the southern Cape. Our study was conducted in an analytical framework comparable to the methods employed by previous researchers (e.g., Stiner et al., 2000; Munro, 2004; Steele and Klein, 2009; Clark, 2011). In particular, we look for: 1) evidence of the exploitation of low-ranked prey and low-utility elements; 2) variable foraging ranges; and 3) mortality patterns in the faunal assemblage.

1.3. Site background

The Klipdrift Complex (34°27.0963'S, 20°43.4582'E) is situated in the De Hoop Nature Reserve on the coast of the southern Cape of South Africa, about 10 km west of the mouth of the Breede River (Fig. 1a). It consists of two known sites – Klipdrift Cave and Klipdrift Shelter – within a wave-cut cliff ca. 17 m above sea level (Fig. 1b). Deposit layers in KDS are defined by texture, composition, colour, thickness and content and named with the top layers alphabetically preceding the lower layers (e.g., PBC above PBD) (Fig. 2a). Sediment in KDS is generally fine-grained and varies from loose and powdery to consolidated and 'sticky' with numerous, small inclusions of quartzite and calcrete resulting from spalling of the roof and walls. Many of these consolidated and sticky patches are likely caused by dripline water mixed with ashy sediment and organic material. The deposits from PCA to PBA/PBB are generally black and grey layers with a relatively high number of hearths or ash features. PAZ and PAY are lighter and grittier while the upper deposits (PAW – PAU) are also characterised by black and grey layers with some red or orange/brown patches.

Excavations were conducted following a grid system established with a Trimble VX Spatial Station (Fig. 2b). The site floor was divided into 50 × 50 cm squares. Identifiable bone and bone tools were individually plotted and all remaining excavated material was sieved through 3 mm and 1.5 mm mesh screens. At KDS about 7 m² of severely truncated deposits lie behind the dripline at about 39° to the horizontal (Fig. 2c). The truncation was likely the result of raised sea levels which probably washed out sediment during the Holocene from the front of a more expansive Klipdrift Complex. The deposits in KDS are from Layers PE to PAL. Using single-grain optically stimulated luminescence (OSL), the MSA layers at KDS

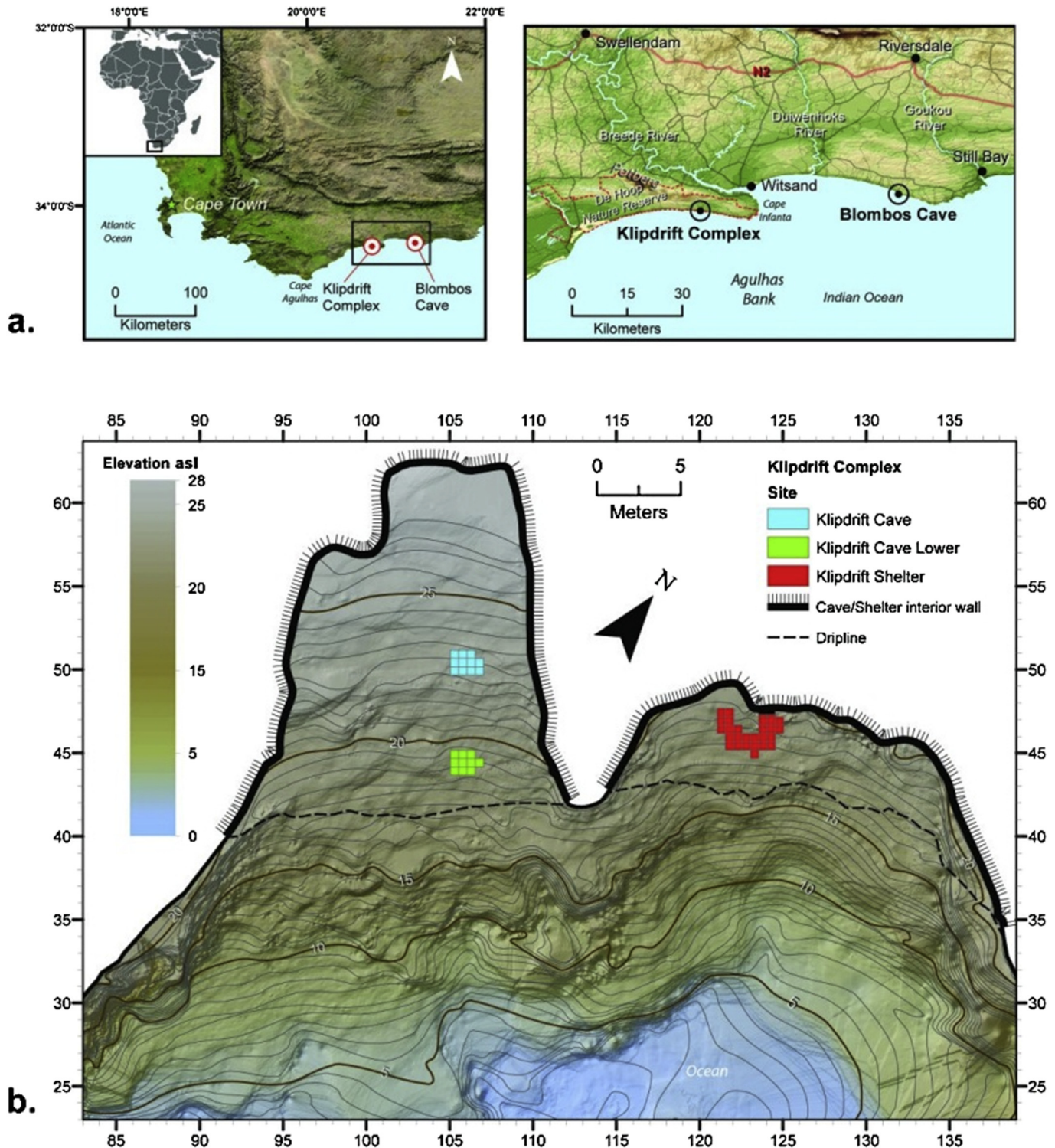


Fig. 1. a) Location of Klipdrift Complex and Blombos Cave in the southern Cape; b) topography of Klipdrift Cave and Klipdrift Shelter.

were dated to between c. 71.6 ± 5.1 ka (PE) and 51.7 ± 3.3 ka (PAN/PAO) and the HP layers (PCA – PAY) were dated to between c. 65.5 ± 4.8 ka and 59.4 ± 4.6 ka. All lithic industries from PCA – PAY are attributed to the HP techno-complex although PAY is possible transitional to the post-HP. Engraved ostrich egg shell was recovered from layers PCA – PAY with most of these occurring in PBD. Shellfish remains occur in most layers but with little or no shell below PCA. For more detailed descriptions of the local geology,

excavation methods and the OSL dating method, see Henshilwood et al. (2014).

2. Materials and methods

Terrestrial fauna from the 2011 and 2012 excavation seasons was examined. We analysed all piece plotted specimens and faunal remains recovered from coarse fraction screened through 3 mm

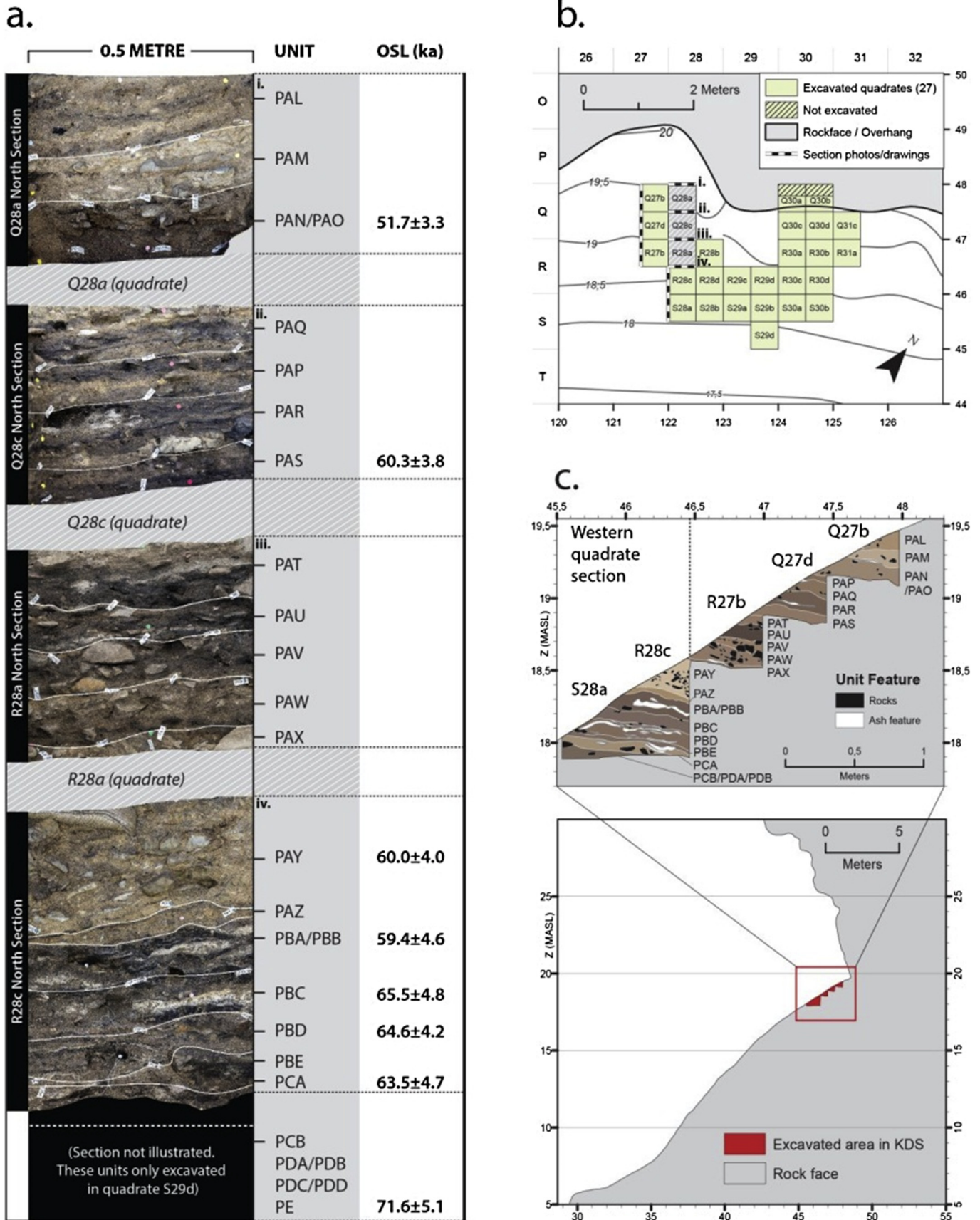


Fig. 2. a) Stratigraphy of Klipdrift Shelter with optimal stimulated luminescence dates; b) excavated quadrates; c) excavated layers in section showing the slope of deposits.

sieves from Layers PDC to PAU. No lithic analysis was conducted on the layers below PCA so it is unclear whether these are from a pre-HP period. PAW to PAU are post-HP material but the extremely small sample size also makes it problematic to compare this sample with the HP material in any statistically meaningful way. While we assessed all the faunal remains recovered from KDS (PDC to PAU), we focus on the HP layers, PCA to PAY, in this study. The remains were analysed following Driver (2005) and Klein and Cruz-Urbe (1984) using the comparative faunal collections of the Ditsong National Museum of Natural History (formerly the Transvaal Museum) in Pretoria. The post-cranials of bovidae ('bovid') remains that could not be identified beyond Linnaean family were assigned to size classes based on Brain (1974) (Table 1). Many faunal remains, such as cranial, rib and vertebral fragments, could not be identified beyond class and were categorised in small, medium or large indeterminate mammal size classes (Table 1). Small mammals are defined as species ranging in size from the Cape dune molarat (*Bathergus suillus*) up to and including size 1 bovids, medium mammals are equivalent to size 2 bovids, large mammals are size 3 and 4 bovids and very large mammal equal size 5 bovids. We often combine larger ungulate (equids, size 3 and above) due to the relatively small sample size (cf. Bunn and Kroll, 1986; Thompson and Henshilwood, 2011).

Table 1
Size classes for identified fauna.

Weight range (kg)	Bovoid size class ^a	Indeterminate ungulate size class	Indeterminate mammal size class
0–23	1	Small bovid	Small mammal
23–84	2	Medium bovid	Medium mammal
84–296	3	Larger ungulate ^b	Medium/Large mammal
296–900	4		Large mammal
>900	5		Very large mammal

^a From Brain (1974). Size class 5 is equivalent to Klein's (1976) very large mammal.

^b Equids are included in 'Larger ungulate'.

Of the 35,864 specimens, 12.68 kg in total, 2266 (6.3%) could be identified to at least the class level. For identifiable remains, we recorded the element, skeletal portion, side, state of epiphyseal fusion, types of surface modification, fracture patterns, length and – where possible – long-bone cortical thickness. The lengths of identified specimens were classed as code 1 (0–0.9 cm), code 2 (1–1.9 cm), code 3 (2–2.9 cm), etc. We used the method of Driver (2005) to record fracture patterns but follow Villa and Mahieu (1991) in defining spiral and transverse breakage. Surface modification was recorded using a 10× and 20× hand lens and based on standard criteria (Behrensmeyer, 1978; Behrensmeyer et al., 1986; Blumenschine and Selvaggio, 1988; Olsen and Shipman, 1988; Blumenschine et al., 1996; Dominguez-Rodrigo et al., 2009). We also noted evidence of bone abrasion based on experimental studies (Brain, 1967; d'Errico et al., 1984; Reynard, 2014). No attempt was made to tally the number of marks per bone fragment. We defined burning using a four-stage colour method (dark brown, black, grey and white) and 'localised' or partial burning based on previous research (e.g., Brain, 1981; Shipman et al., 1984; Nicholson, 1993; Stiner et al., 1995; Driver, 2005). Age at death was estimated based on tooth wear/eruption, epiphyseal plate fusion and the presence of degenerative joint pathology. Our analysis includes identified specimens (n = 2266) in addition to

unidentified long-bone fragments (n = 764) which often display modification and fracture patterns that inform on subsistence behaviour (Enloe, 1993; Marean and Kim, 1998; Pickering et al., 2003; Marean et al., 2004). For long-bone fragments, we recorded fracture patterns, incidence of surface modification, lengths and cortical thickness.

We report the number of identified specimens (NISP) and adjust for the expected frequency that a particular skeletal element should occur in a complete ungulate skeleton by using 'normed' NISP (cf. Hesse and Perkins, 1974; Grayson, 1984; Grayson and Fey, 2004; Faith, 2007; Clark, 2011). Normed NISP (nNISP) values are the number of elements divided by the amount of times those elements occur in a complete carcass. To assess the frequency of skeletal-groups in larger mammals, we add the nNISPs for elements within a skeletal-group and divide that figure by the number of elements that comprise a skeletal-group for a single skeleton. For example, we define the forelimb as scapulae, humeri, radii and ulnae. We therefore add the nNISP values for those four elements and divide it by four: the expected value for each skeletal-group will therefore be one. Because of sample size constraints, we generally compare the layers with the highest NISP, namely PCA, PBD, PBC and PBA/PBB. Although small, PAZ and PAY are included in the analysis due to their role as a possibly transitional phase between the HP and post-HP (Henshilwood et al., 2014). These two layers are also often combined because of similar sediment texture, colour and taxonomic composition.

3. Results

3.1. Bone accumulators

3.1.1. Surface modification and breakage

Faunal specimens from KDS are generally small and the assemblage is extensively fragmented, particularly in PBE, PBD and PBC. The majority of identified fragments are between 1 and 2 cm long (n = 1049; 46.5%) and 25% of identified specimens (n = 565) are less than 1 cm in length. Despite this, bone preservation is reasonably good. Relatively few specimens display evidence of acid etching and only three identified specimens exhibit gypsum (calcium sulphate dehydrate) deposition.

Discolouration through burning is the most common form of bone modification (n = 1939; 86.6% of all specimens) (Table 2). Generally burning is more common in the lower layers (e.g., PDC – PCA; 94.1%) than the upper layers (PAZ – PAU; 62%). Manganese staining was noted on only four specimens. However it was not possible to distinguish manganese staining on completely blackened specimens and manganese discolouration is likely more prevalent than reported here. Nonetheless, burning appears extensive on the KDS fauna. This is probably because most of the faunal material was recovered from within, or close to, ashy sediment and hearth-like areas. The large amount of burnt bone and its association with hearths suggest burning through human activities and not as a result of natural processes such as brush fires. The fragmented condition of the fauna is similar to that of other Howiesons Poort sites such as Klasies River (Deacon and Geleijnse, 1988), Sibudu (Clark and Ligouis, 2010; Wadley, 2012) and Diepkloof (Miller et al., 2013; Steele and Klein, 2013) as are the deposits from which the fauna was recovered. At these sites hearths are common and the stratigraphy often consists of alternating black and grey layers.

Table 2
Surface modification of identified fauna and unidentified long-bone fragments per layer.

Modification	PAU-PAX		PAY		PAZ		PBA/PBB		PBC	
	n	%*	n	%*	n	%*	n	%*	n	%*
Burn (L)	2	5.4	50	18.5	20	16.5	156	23.7	102	17.6
Burn (Br)	11	29.7	78	28.8	54	44.6	271	41.2	228	39.4
Burn (Bl)	0	0	25	9.2	19	15.7	112	17	90	15.5
Burn (Gr)	0	0	0	0	1	0.8	10	1.5	25	4.3
Burn (W)	0	0	4	1.5	2	1.7	25	3.8	63	10.9
Burn (total)	13	35.1	157	57.9	96	79.3	571	86.8	506	87.4
Percussion mark	5	13.5	69	25.5	53	43.8	270	41	214	37
Cut mark	0	0	8	3	7	5.8	33	5	43	7.4
Tooth mark	0	0	1	0.4	1	0.8	2	0.3	2	0.4
Gnaw mark	1	2.7	3	1.1	0	0	2	0.3	0	0
Root etching	5	13.5	43	15.9	17	14.1	110	16.7	65	11.2
Abrasion/Sheen	0	0	24	8.9	15	12.4	219	33.3	132	22.8
Weathering	0	0	0	0	0	0	5	0.8	1	0.2
Acid etching	0	0	10	3.7	10	8.3	33	5	25	4.3
Encrustation	3	8.1	43	15.9	22	18.2	26	4	34	5.9
Total specimens per layer	37		271		121		658		579	

Modification	PBD		PBE		PCA		PCB		PDA-PDC		Total	
	n	%*	n	%*	n	%*	n	%*	n	%*	n	%**
Burn (L)	129	18.2	23	11.6	86	26.5	14	22.2	6	8.8	588	19.4
Burn (Br)	361	50.9	143	71.9	172	52.9	33	52.4	46	67.7	1397	46.1
Burn (Bl)	92	13	6	3	36	11.1	7	11.1	5	7.4	392	12.9
Burn (Gr)	61	8.6	3	1.5	22	6.8	0	0	2	2.9	124	4.1
Burn (W)	25	3.5	1	0.5	1	0.3	0	0	1	1.5	122	4
Burn (total)	668	94.2	173	86.9	315	96.9	54	85.7	60	88.2	2623	86.6
Percussion mark	117	16.5	20	10.1	100	30.8	25	39.7	28	41.2	901	29.8
Cut mark	34	4.8	3	1.5	15	4.6	1	1.6	4	5.9	148	4.9
Tooth mark	1	0.1	0	0	3	0.9	3	4.8	0	0	13	0.4
Gnaw mark	0	0	0	0	0	0	0	0	0	0	6	0.2
Root etching	57	8	7	3.5	31	9.5	0	0	6	8.8	341	11.3
Abrasion/Sheen	74	10.4	13	6.5	79	24.3	27	42.9	21	30.9	604	20
Weathering	1	0.1	1	0.5	0	0	0	0	0	0	8	0.3
Acid etching	14	2	2	1	3	0.9	3	4.8	3	4.4	103	3.4
Encrustation	20	2.8	14	7	10	3.1	1	1.6	6	8.8	179	5.9
Total specimens per layer	709		199		325		63		68		3030	

L = localised, Br = brown, Bl = black, Gr = grey, W = white. *Percentage per layer; **Percentage of all specimens.

The prevalence of spiral fractures indicates that ungulate long-bones were generally fractured while fresh, except in PBD (Fig 3). Percussion marks on identified bone and long-bone fragments are relatively common ($n = 901$; 29.8%) while cut marks occur on 5% of this sample ($n = 148$) and are present on a wide range of taxa including small mammals, ungulates, tortoise and carnivores. PCB, PBA/PBB and PAZ have the highest proportion of percussion-

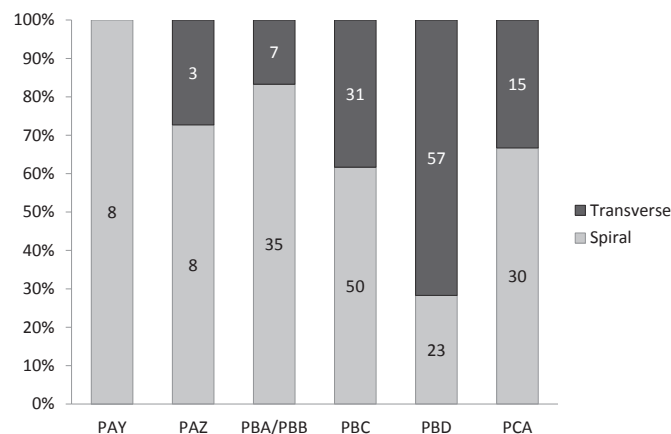


Fig. 3. Ungulate long-bone breakage patterns per layer. N = number of fractured ends.

marked bone. Tooth and gnaw marks are rare, being present on less than 1% of the remains in most layers. PCB has relatively higher frequencies of tooth marks ($n = 3$; 4.8%) and acid-etching and gnaw marks are more common in PAU – PAX.

Generally, burning and percussion marks are common on ungulate bone except in PAY (Table 4). Butchery marks on ungulate bone (NISP = 42; 6.7%) are relatively rare. As in spiral fractures, there is also a decrease in percussion-marked fauna in PBD. Only 0.6% of identified specimens (NISP = 14) are categorised as carnivores (Table 3). Carnivores appear to have had little influence on fauna with few incidences of tooth marks and little acid-etched bone. Few specimens of large carnivores were recovered and most are the remains of smaller predators such as mongoose and genet. Hyena and feline specimen's (all phalanges) exhibit cut marks and previous research suggests this type of modification on carnivore distal limbs indicates skinning (Binford, 1981; Lyman, 1987; Val and Mallye, 2011). Three carnivore bones, including a percussion-marked mandible, display percussion marks that may be related to marrow extraction. Localised burning is also prevalent on the carnivore specimens ($n = 11$; 78.6%). Burnt and percussion-marked carnivore bone occurs throughout the sequence. Surface modification patterns, ungulate long-bone breakage and the scarcity of carnivore activity at KDS show that faunal remains of ungulates and carnivores were overwhelmingly accumulated through human activities. This is further supported by the relative abundance of cultural artefacts, hearths and evidence of lithic tool manufacture in the HP layers (Henshilwood et al., 2014).

Table 3Number of identified specimens (NISP) of taxa per layer. Linnaean classification based on Skinner and Chimimba (2005) except *Syncerus antiquus* (Gentry, 2010).

Order	Taxa	Common name	PAU – PAW	PAY	PAZ	PBA/PBB	PBC	PBD	PBE	PCA	PCA/PCB	PCB	PDA–PDC	Total
Chelonii	Testudinidae	Tortoise	4	59	23	71	51	251	105	24	4	1	2	595
	<i>Chersina angulata</i>	Angulate tortoise	2	10	4	8	11	21	8	3	0	0	0	67
	cf. Pelomedusidae	Turtle	0	0	0	0	0	1	0	0	0	0	0	1
Lagomorpha	<i>Lagomorpha</i>	Hare/Rabbit	0	1	0	0	4	3	0	3	1	0	0	12
	<i>Lepus</i> sp.	Hare	1	0	0	0	1	1	0	0	0	0	0	3
	<i>Lepus saxatilis</i>	Scrub hare	0	0	0	0	0	0	0	1	0	0	0	1
Rodentia	<i>Bathyergerus suillus</i>	Cape dune molerat	0	8	1	0	0	0	0	0	0	0	0	9
Carnivora	<i>Herpestes</i> sp.	Mongoose	0	0	0	0	0	1	0	0	0	0	0	1
	<i>Arctocephalus</i>	Cape fur seal	0	0	0	0	0	2	0	0	0	0	0	2
	cf. <i>pusillus</i>													
	<i>Felis caracal/serval</i>	Caracal/Serval	0	0	1	0	1	0	0	0	0	0	0	2
	<i>Parahyena brunnea</i>	Brown hyena	0	0	0	1	0	0	0	0	0	0	0	1
Hyracoidea	<i>Procavia capensis</i>	Rock hyrax	5	22	11	1	31	30	1	6	0	1	3	111
Perrisodactyla	<i>Diceros bicornis</i>	Black rhinoceros	0	0	0	0	2	0	0	0	0	0	0	2
Artiodactyla	<i>Equus</i> sp.	Zebra	0	0	0	10	25	2	0	2	0	0	1	40
	<i>Redunca fulvorufula</i>	Mountain reedbuck	0	0	0	1	0	0	0	0	0	0	0	1
	<i>Redunca arundinum</i>	Southern reedbuck	0	0	0	0	1	0	0	0	0	0	0	1
	<i>Redunca</i> sp.	Reedbuck	0	0	0	3	0	1	0	0	0	0	0	4
	<i>Tragelaphus oryx</i>	Eland	0	0	0	0	0	1	4	0	0	0	0	5
	<i>Syncerus antiquus</i>	Giant buffalo	0	0	0	1	0	0	0	0	0	0	0	1
	<i>Pelea capreolus</i>	Grey (Vaal) rhebok	0	0	1	3	0	0	0	2	0	0	0	6
	<i>Raphicerus</i> sp.	Steenbok/Grysbok	0	1	1	1	8	7	5	0	0	0	0	23
	<i>Ourebia ourebi</i>	Oribi	0	0	0	1	0	0	0	0	0	0	0	1
	<i>Oreotragus oreotragus</i>	Klipspringer	0	0	0	0	0	4	0	0	0	0	0	4
	<i>Antidorcas</i>	Springbok	3	0	0	0	0	0	0	0	0	0	0	3
	cf. <i>marsupialis</i>													
	<i>Sylvicapra grimmia</i>	Grey duiker	0	0	0	2	0	2	0	0	0	0	0	4
	<i>Damaliscus pygargus</i>	Bontebok/Blesbok	0	0	1	1	2	0	0	1	0	0	0	5
	<i>Damaliscus</i> indet.	Bles or bontebok/?D. niro	0	0	0	3	0	0	0	0	0	0	0	3
	<i>Alcelaphus buselaphus</i>	Red hartebeest	0	0	0	1	1	2	0	1	0	0	0	5
	<i>Connochaetes gnou</i>	Black wildebeest	0	0	0	0	1	1	1	0	0	0	0	3
	<i>Alcelaphini</i> indet.	Hartebeest or Wildebeest	0	0	0	6	2	1	0	1	0	0	0	10
	Bovidae indet.	Bov I	0	9	1	18	15	62	7	4	0	0	3	119
		Bov I/II	0	0	0	0	0	0	1	0	2	0	0	3
		Bov II	1	13	4	42	31	30	14	40	0	3	2	180
		Bov II/III	0	0	0	2	7	3	0	4	0	0	7	23
		Bov III	1	6	10	20	29	45	2	40	0	1	3	157
		Bov III/IV	0	0	0	7	0	7	1	6	0	2	0	23
		Bov IV	0	1	2	3	0	4	3	19	0	1	0	33
		Carnivora indet.	Small carnivore	0	0	0	1	2	0	1	0	0	1	0
	Mammal indet.	Medium carnivore	0	0	2	0	1	0	0	0	0	0	0	3
		Small mammal	1	41	8	33	78	78	8	31	0	7	12	297
		Medium mammal	1	16	8	134	80	64	17	30	5	5	9	369
		Large mammal	0	5	3	25	45	23	6	7	0	12	1	127
		Very large mammal	0	0	0	1	0	0	0	0	0	0	0	1
	Total ID		19	192	81	400	429	646	180	230	10	36	43	2266
	Total ULBF ^a		18	79	40	258	150	63	19	83	2	27	25	764
Total Non-ID		2	1660	969	4863	9367	6791	4011	2155	207	1068	1741	32,834	
Grand Total		39	1931	1090	5521	9946	7500	4210	2468	219	1131	1809	35,864	
% ULBF		46.2	4.1	3.7	4.7	1.5	0.8	0.5	3.4	0.9	2.4	1.4	2.1	
% identifiable		4.9	9.9	7.4	7.2	4.3	8.6	4.3	9.3	4.6	3.2	2.4	6.3	

^a Unidentified long-bone fragments.

Table 4
Mammal modification patterns per layer.

Taxa	Modification	PAY N = 30	PAZ N = 21	PBA/PBB N = 120	PBC N = 114	PBE N = 30	PBD N = 166	PCA N = 122
Ungulate	B	4	15	107	102	21	162	120
	PM	3	10	38	62	8	50	22
	CM	0	2	7	12	2	15	4
	T & GM	0	0	2	0	0	0	0
	AE	4	1	4	2	0	8	1
Small mammal		N = 34	N = 11	N = 7	N = 31	N = 1	N = 42	N = 15
	B	5	9	6	25	1	40	14
	PM	2	0	0	7	0	1	2
	CM	0	0	0	3	0	2	1
	T & GM	0	0	0	1	0	0	0
Carnivore	AE	1	1	2	4	0	0	1
			N = 3	N = 2	N = 4	N = 1	N = 3	
	B		3	1	3	1	3	
	PM		1	0	1	0	0	
	CM		1	1	1	0	0	
	T & GM		0	0	0	0		

B = burning; PM = percussion mark; CM = cut mark; AE = acid etching. T & GM = tooth and gnaw marks. Small mammal is Cape dune mole rat, hyrax and lagomorph.

3.1.2. Small fauna accumulators

The presence of tortoise and small mammals such as hyrax in MSA sites are often the result of carnivore and raptor predation even when larger mammals were accumulated through human activities (Cruz-Urbe and Klein, 1998; Klein and Cruz-Urbe, 2000; Badenhorst et al., 2014; Thompson and Henshilwood, 2014). At KDS, modification patterns on tortoise and small mammal specimens indicate that they are most likely the result of human accumulation. Burning is extensive on tortoise remains ($n = 632$; 95.5%) (Table 5). We also note that 262 tortoise shell fragments (46% of all burnt shell) are only burnt – or more burnt – on the outside of the shell while 7 specimens (1.2%) are more burnt on the inside. This type of burning pattern indicates that tortoise shell was mostly heated on the outside and suggests that tortoises were cooked on their backs (cf. Thompson and Henshilwood, 2014). Other forms of surface modification are rare. Percussion marks are not common ($n = 74$; 11.2% of all tortoise specimens), with most occurring on tortoise shell fragments ($n = 71$). Even fewer specimens show signs of carnivore or raptor processing: no specimens display teeth marks, one specimen exhibits acid-etching and gnaw marks occur on only two tortoise shell fragments.

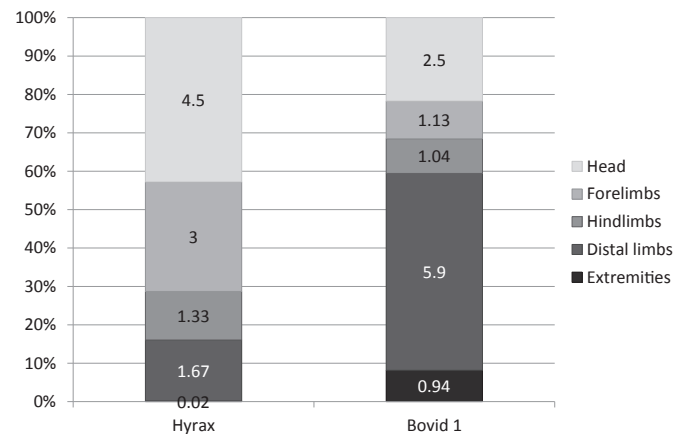


Fig. 4. Normed NISP of skeletal groups for hyrax and size 1 bovid. Values in columns equal Σ nNISP for each element within a skeletal group divided by the number of elements within that group. Expected values for a complete skeleton are one (1) for each skeletal group. Head = crania, mandibles; Forelimbs = scapula, humeri, radii, ulna; Hindlimbs = pelvis, femora, tibiae, patellas; Distal limbs = carpals, tarsals, metapodia; Extremities = phalanges, sesamoids.

Table 5
Surface modification of tortoise bone and shell per layer.

Skeletal-part	Modification	PAY N = 59	PAZ N = 23	PBA/PBB N = 72	PBC N = 51	PBD N = 252	PBE N = 105	PCA N = 28
Shell	B	48	18	56	50	251	105	28
	PM	17	9	23	9	7	1	1
	CM	2	0	1	0	1	0	0
	AE	4	6	3	0	0	0	0
Bone		N = 10	N = 4	N = 8	N = 11	N = 21	N = 8	N = 3
	B	6	4	8	9	21	7	3
	PM	0	1	0	1	0	1	0
	CM	0	1	0	0	2	1	0
	AE	0	0	1	0	0	0	0

B = burning; PM = percussion mark; CM = cut mark; AE = acid etching. Tooth and gnaw marks excluded because of low occurrence.

Burning is prevalent on small mammal remains throughout most of the sequence except PAY (Table 4). Anthropogenic marks are more common than carnivore marks although both are relatively rare. Most hyrax specimens are also burnt ($n = 78$; 70.3%) and although percussion marks are few ($n = 9$; 8.1%), they occur on a wide range of elements. Cut marks are not common but are more

prevalent than tooth or gnaw marks and acid-etching. Scrape marks occur on at least two hyrax mandibular specimens. One neonate mandibular fragment displays scrape marks on the outside region. Moreover, three mandibular fragments are more burnt on the anterior and buccal (incisor) portion than on the posterior or lingual (molar) region. This pattern of burning has been shown in

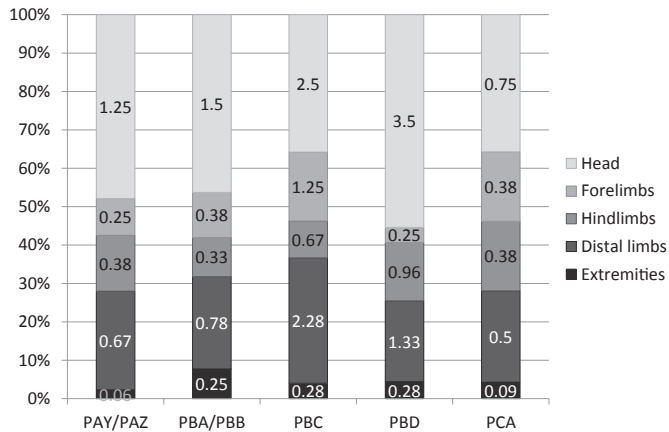


Fig. 5. Normed NISP for skeletal groups of combined larger mammals per layer. Values in columns equal $\Sigma nNISP$ for each element within a skeletal group divided by the number of elements within that group. Expected values for a complete skeleton are one (1) for each skeletal group. Head = crania, mandibles; Forelimbs = scapula, humeri, radii, ulna; Hindlimbs = pelvis, femora, tibiae, patellas; Distal limbs = carpals, tarsals, metapodia; Extremities = phalanges, sesamoids.

Cape dune molerats to indicate human consumption (Henshilwood, 1997) and has been noted on human-consumed hyraxes from Blombos Cave (Badenhorst et al., 2014). Surface modification and breakage patterns suggest that hyrax and other small mammal remains at KDS are a result of human consumption and not raptors or carnivores.

3.2. Skeletal-part profiles

The analysis of ungulate skeletal-part profiles can provide a window on the transport and processing decisions of MSA hunters. At KDS, smaller ungulates are generally represented by a wider range of elements than larger ungulates (Supplementary Table S1). There is a significant difference between size 1 and size 2 bovid NISP skeletal-part profiles ($\chi^2 = 21.820$; $p < 0.0001$) (Supple-

mentary Fig. S1a). Skeletal-part distribution is also significantly different between hyrax and size 1 bovids ($\chi^2 = 61.115$; $p < 0.0001$) (Fig. 4).

To examine variation in larger ungulate skeletal profiles, we often included 'indeterminate large mammal' specimens (Table 3) with larger ungulate data (see Supplementary Fig. S1b). We did this to increase our sample size and because the prevalence of ungulate bone and the lack of carnivore remains, tooth marks, and acid-etching at KDS suggest that the indeterminate large mammal specimens are all large ungulates. Hereafter, 'larger ungulate' are only those specimens that could be identified as \geq size 3 bovids or perrisodactyla. Large mammal specimens that could not be identified to taxa are referred to as 'indeterminate large mammal', while the combined 'larger ungulate' and 'indeterminate large mammal' data is referred to as 'larger mammal'.

The normed skeletal-group values for larger mammals indicate no significant differences in skeletal-parts between layers (Fig. 5). The proportions of skeletal-groups are distributed more evenly in PCA than in other layers. Radii and metapodia are more common in PBC while skulls are proportionally more prevalent in PBD, PBA/PBB and PAY/PAZ. Larger mammal NISP skeletal-parts profiles are generally not significantly different, except between PBC and PBD ($\chi^2 = 9.72$; $p = 0.045$) (Supplementary Fig. S1b). Normed NISP profiles for larger mammals suggest that proximal limbs and foot bones are generally under-represented in contrast to skulls (Fig. 6). Combined ungulate profiles are characterised by a dominance of cranial remains with relatively few foot bones. (Supplementary Fig. S2).

3.3. Fragmentation

Post-depositional destruction can bias skeletal patterns (Lyman, 1984) and severe fragmentation very likely affects element representation at KDS. Table 6 shows a significant, but weak, correlation between bone density and ungulate skeletal abundance at KDS suggesting the effects of density-mediated destruction. Marean and Cleghorn (2003) argue that where density-mediated attrition is a major influence, researchers should limit their analyses to 'high

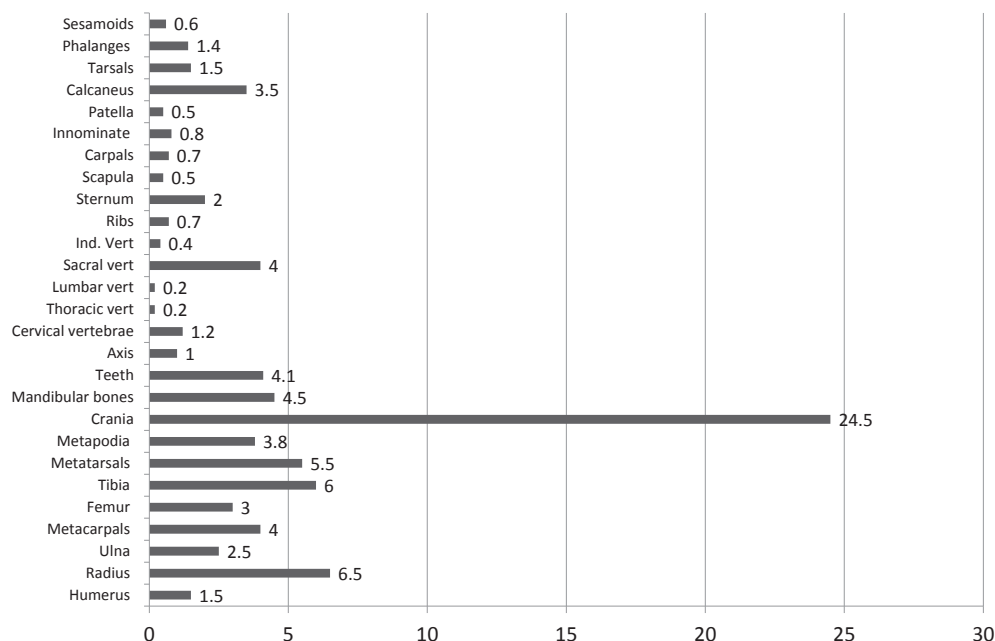


Fig. 6. Normed NISP for combined larger mammals (Size 3, 4 & 5 bovids, perrisodactyla and indeterminate 'large mammal').

survival' elements such as skulls and long-bones which are less likely to be affected by taphonomic destruction. Yet even high survival elements are affected by bone destruction (Table 6). At KDS, larger mammals also appear more influenced by density-mediated attrition than smaller bovids.

Table 6

Spearman's rank-order correlation between skeletal element abundance (normed NISP) of all ungulates and 'high survival' element bone densities (Caribou data in Lam et al., 1999), and Standardised Food Utility Indices (SFUI) (Metcalf and Jones, 1988) at KDS. Significant values embolden.

Sample	Bone density		SFUI		N
	r_s	p-value	r_s	p-value	
PAY/PAZ ^a	0.701	0.053	-0.404	0.282	25
PBA/PBB ^a	0.338	0.169	-0.445	0.23	40
PBC ^a	0.146	0.54	-0.164	0.676	56
PBD ^a	0.455	0.051	-0.28	0.456	59
PCA ^a	0.178	0.6	0.468	0.204	34
All ungulate (high survival)	0.537	0.005	-0.268	0.486	443
All ungulate (all elements)	0.390	0.006	-0.121	0.582	860
Size 2 & medium mammal (all elements) ^b	0.127	0.436	-0.044	0.846	414
Size 2 & medium mammal (high survival) ^b	0.323	0.166	-0.418	0.262	217
Larger mammal (all elements) ^c	0.354	0.021	-0.147	0.526	257
Larger mammal (high survival) ^c	0.575	0.004	-0.385	0.306	130

High survival elements are the cranium, mandible, humerus, radius, ulna, metacarpal, femur, tibia and metatarsal.

^a Data from high survival elements of all ungulates per layer.

^b Size 2 bovids and indeterminate 'medium mammal' remains.

^c Larger mammal equals size 3, 4 & 5 bovids, perrisodactyla and indeterminate 'large mammal'.

Evidence of the effects of fragmentation occurs in the identified and unidentified datasets. Food utility indices have been devised to quantify the subsistence value of elements (Binford, 1978). Larger meat and marrow-bearing bones have high utility values and

≥ 6 mm are relatively common throughout all layers, except PAY, (Table 7) implying that proximal long-bones of larger ungulates are probably more common than the identified specimens indicate. The above data show that the distribution of skeletal-parts per layer at KDS is affected by fragmentation and density-mediated

attrition. For these reasons, skeletal-part patterns per layer cannot be interpreted in a meaningful way in terms of temporal trends in transport decisions or distances from kill-sites (Marean and Frey, 1998).

Table 7

Evidence of fragmentation per layer.

Layer	PAY/PAZ	PBA/PBB	PBC	PBD	PCA
% Proximal limbs (large ungulate)	0	3.9	2.3	0	15.4
% Code 1 ^a fragments per layer	28.1	15.5	19.3	27.7	7.9
% Skulls (large ungulate)	35.3	30.0	12.5	25.4	20.7
% ULB ^b with cortical thickness > 6 mm	15.1	28.7	22	27	22.4
Average length code for ID specimens	2.3	2.5	2.6	2.1	3.1
Average weight of faunal specimens (g)	0.347	0.484	0.328	0.338	0.672

Large ungulate equals size 3, 4 & 5 bovids and perrisodactyla.

^a Percentage of identified specimens < 1 cm in length.

^b Unidentified long-bone.

nutritional utility should correlate positively with skeletal-abundance (Metcalf and Jones, 1988). At KDS, however, most layers have negative trends between nNISP and food utility indices. We note that the layer (PCA) with the most positive SFUI curve (Table 6) has the largest faunal specimens and the least amount of identified fragments < 1 cm long (length code 1) (Table 7). Table 7 shows that layers with greater proportions of small (code 1) faunal specimens have significantly less identifiable large ungulate proximal long-bones ($r_s = -0.975$; $p < 0.05$). Thus layers with the largest faunal specimens are more likely to preserve identifiable proximal long-bone (i.e., elements with higher utility values) and display more positive utility trends. Furthermore, over half the dense, compact bones recovered from KDS are fragmented ($n = 44$; 51.8%) (cf. Marean, 1991) suggesting fragmentation influenced skeletal-part profiles by affecting the identifiability of long-bone elements. Other evidence lies in the cortical thicknesses of unidentified long-bone fragments. Measurements from identified fauna indicate that larger ungulate proximal long-bones are all ≥ 6 mm thick, with only six smaller ungulate long-bones < 6 mm. Unidentified long-bone fragments with cortical thicknesses of

3.4. Processing activities

Despite the difficulty in interpreting skeletal-part patterns in terms of transport choices, information on human behaviour can still be inferred through the analysis of processing decisions. Bone processing was intense at KDS, as is attested by the high fragmentation and the abundance of burnt elements. Generally, larger ungulates display more percussion and cut marks than smaller bovids (Fig. 7). There is a significant difference between percussion marks on size 1 and size 2 bovids ($\chi^2 = 19.63$; $p < 0.05$) but not between equids and size 3 bovids ($\chi^2 = 2.81$; $p = 0.093$) or size 4/5 bovids ($\chi^2 = 2.97$; $p = 0.084$). Cut marks are relatively more common on the fore and hindlimbs of larger than size 2/medium-size mammals (Fig. 8a and b). Evidence for various processing activities includes:

3.4.1. Skinning

A substantial proportion of cut marks ($n = 17$; 40.5%) occur on ungulate distal limb extremities such as phalanges, sesamoids, and the distal ends of metapodia. These anatomical regions yield little

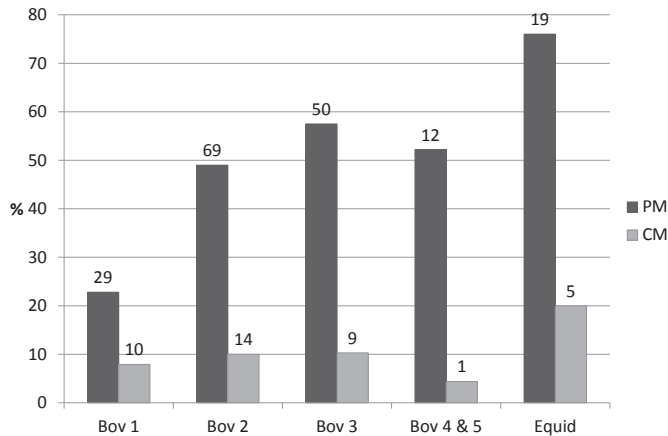


Fig. 7. Butchery mark frequencies per ungulate size class. PM = percussion marks; CM = cut marks, NISP above columns.

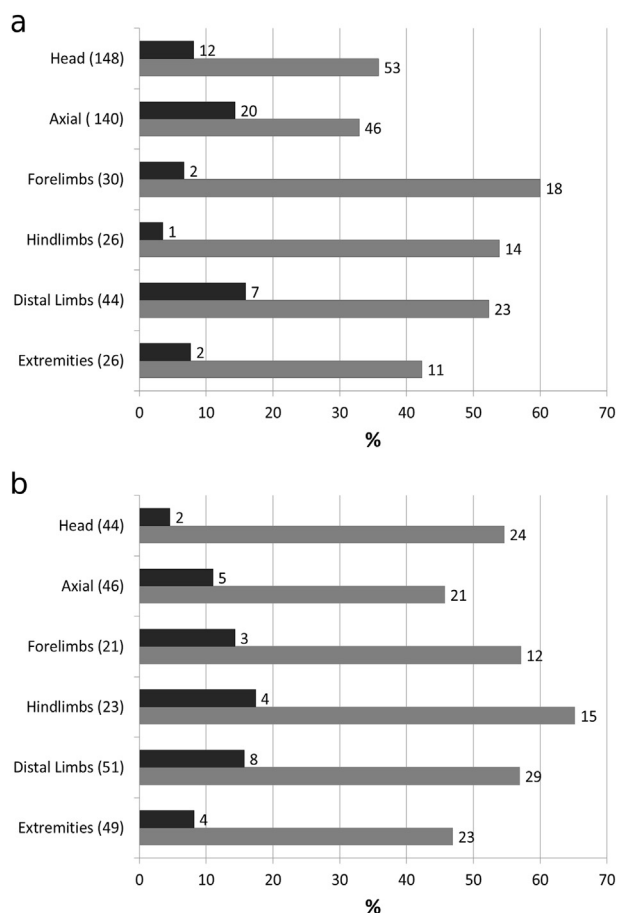


Fig. 8. a) Butchery mark frequency on skeletal-groups of medium mammal (Bovid 2 and indeterminate 'medium mammal' remains). NISP in brackets. Axial consist of ribs and vertebrae. PM = percussion marks; CM = cut marks. Head = crania, mandibles; Forelimbs = scapula, humeri, radii, ulna; Hindlimbs = pelves, femora, tibiae, patellas; Distal limbs = carpals, tarsals, metapodia; Extremities = phalanges, sesamoids. b) Butchery mark frequency on skeletal-groups of larger mammal (Bovid 3, 4, and 5, perrisodactyla and indeterminate 'large mammal' remains). NISP in brackets.

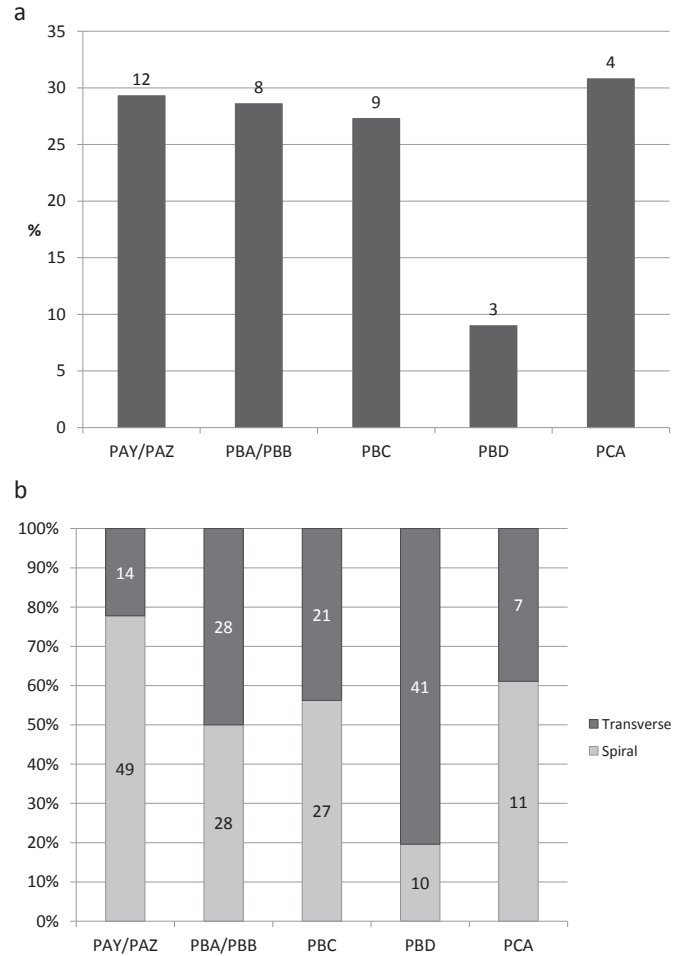


Fig. 9. a) Proportion of percussion marked small mammal long-bone per layer including unidentified long-bone with a cortical thickness ≤ 2 mm. NISP above columns. b) Fracture patterns of small mammal long-bone per layer including unidentified long-bone with a cortical thickness ≤ 2 mm. N = number of fractured ends.

meat. While some of these may be related to disarticulation (see below), cut marks there are also likely to be related to skinning (Binford, 1981; Val and Mallye, 2011; Walshe, 2014). As mentioned earlier, cut marks on carnivore phalanges also suggest the skinning of hyena and felids. The lack of cut-marked small mammal bone makes it problematic to infer skinning activities from small mammal remains.

3.4.2. Disarticulation

Two ungulate tarsal bones displaying chop marks appear to have been split in half suggesting lower-limb dismemberment. Cut marks often occur near articular processes on mandibles, pelves and long-bones. Three mandibular specimens exhibit severe cut marks near their mandibular foramen which is probably associated with mandibular disarticulation or the removal of the tongue. Some metapodia display cut marks near the distal or proximal articular surfaces. (11.84%; $n = 11$) which may indicate disarticulation but could also reflect skinning.

3.4.3. Filleting

Cut marks on shafts are often interpreted as evidence for filleting (Domínguez-Rodrigo, 1999; Galán and Domínguez-Rodrigo, 2013). Cut marks are generally more prevalent on the epiphyses of smaller bovids and medium mammals (Proximal ends: $n = 10$; 17.2%. Shaft: $n = 6$; 13.3%. Distal ends: $n = 6$; 13.3%). Larger

mammals display more cut marks on shaft regions ($n = 8$; 22.9%) which may suggest that the meat of larger mammals were more likely to be filleted.

3.4.4. Bone marrow exploitation

The prevalence of long bone fragments with spiral fractures and percussion marks suggest that marrow extraction was a common strategy at KDS. Low-utility elements also exhibit evidence of marrow extraction. Ungulate phalanges, for example, are generally fragmented (NISP = 81; 83.5%) and 13 'split' phalanges (13.4% of all phalanges) with either percussion or chop marks indicate they were split in half longitudinally. Proportionally more ungulate phalanges with percussion marks occur in PBC ($n = 10/17$; 58.8%) and PBD ($n = 9/18$; 50%). Jin and Mills (2011), however, demonstrate that split phalanges need not imply nutritional stress. Yet percussion marks on other low-ranked elements such as pelves, calcanei, mandibles and scapula (Binford, 1978; Morin, 2007) also suggest intensive marrow extraction throughout the sequence, particularly in PBD (Table 8). Small mammal elements are not expected to be exploited for marrow and the low rate of percussion marks on hyrax, Cape dune molarat and lagomorph long-bones seem to support this (NISP = 6; 11.7%). However, fragmented long bones of small mammals were common at KDS and are difficult to assign to taxa. The cortical thicknesses of hyrax, lagomorph and Cape dune molarat long-bone in the KDS assemblage were all <2 mm thick. Unidentified long bone that could not be assigned to element with cortical thicknesses <2 mm is therefore assumed to be from these small mammals. If these unidentified specimens are included with the identified small mammal sample, the proportion of percussive marked long bone increases to 24.3% (NISP = 36) (Fig. 9a). The fracture patterns of that sample also suggest that marrow extraction in small mammals was relatively common in most layers except PBD (Fig 9b). Percussion mark and fracture patterns, therefore, indicates that marrow extraction encompassed small and large fauna and high and low-ranked elements.

Table 8

Percussion marks on ungulate phalanges, innominates, calcanea, mandibles and scapula per layer.

Layer	N	Percussion marks	%
PAY/PAZ	14	6	42.9
PBA/PBB	36	17	47.2
PBC	28	16	57.1
PBD	38	23	60.5
PCA	13	4	30.8

3.4.5. Burning

Most KDS bones (86.6%) show evidence of burning but only 21.1% of these burnt bones are carbonised/calced (black, grey or white). Cancellous elements (e.g., ribs, vertebrae and innominates) are slightly more carbonised/calced ($n = 125$; 24.3%). PAY/PAZ ($n = 3$; 5.1%) has significantly less severely burnt cancellous bone than PBA/PBB ($\chi^2 = 6.78$; $p = 0.0092$). In PCA, PBC and PBA/PBB, epiphyses of long bones are more severely burnt than shaft fragments (24% of epiphyses and 12% of shafts) but these differences are not statistically significant. Generally, severely burnt bones are relatively rare, cancellous portions are not intensely burnt, while light/localized burning is prevalent. This suggests that most of the bones were burned either accidentally (through proximity with hearths) or through roasting. The use of bone as fuel cannot be demonstrated at KDS (cf. Costamagno et al., 2005).

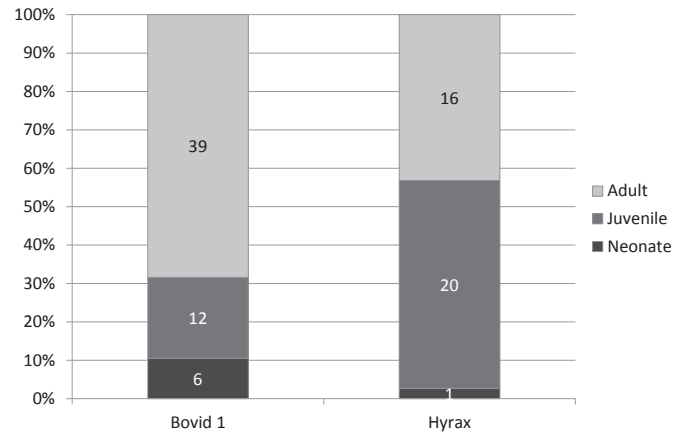


Fig. 10. Bovid 1 vs. hyrax mortality profiles based on epiphyseal fusion. NISP in columns.

3.5. Age profiles

We classified fused long-bone epiphyses as adult and unfused or just-fused long-bone as juvenile. Due to the extensive fragmentation, only 411 vertebral, phalangeal and long bone specimens had at least one end that could be examined for epiphyseal fusion. While some ends could not be examined due to breakage, the majority of ends ($n = 276$; 56.6% of epiphyseal ends) are fused but a large proportion are either unfused or just-fused ($n = 181$; 37.1%). Most teeth are very fragmented and because few tooth-rows were recovered, it was difficult to assess wear patterns. Some elements displayed evidence of degenerative joint pathology (osteophytosis) which suggest they were old individuals. Three ribs with severe osteophytosis probably belong to large ungulates. Generally, medium and large mammals' profiles are dominated by adults indicating that these animals were foraged in their prime. Mortality profiles are often characterised as 'attritional' or 'catastrophic' (Klein, 1982). Attritional patterns generally reflect natural death assemblages and are dominated by very young and very old individuals with fewer prime-aged specimens. Catastrophic patterns, on the other hand, occur when 'successive age classes contain progressively fewer individuals' (Klein, 1982: 153). In other words, catastrophic patterns tend to contain relatively younger remains. The high proportion of heavily-worn equid teeth suggests that most were older individuals. Heavily-worn teeth imply that a more attritional pattern may be evident among equids (Table 9). Although severely fragmented teeth were excluded from the tooth-wear analysis, many of these were larger bovid teeth with evidence of extensive wear.

There is a significant difference between hyrax and size 1 bovid mortality profiles ($\chi^2 = 11.453$; $p = 0.0033$) (Fig. 10). Small mammals such as hyrax are mostly juveniles. Hyrax can be relatively accurately aged based on tooth-eruption sequences and tooth-wear (Steyn and Hanks, 1983; Fisher and Parkington, 2014). Although long-bone epiphyseal fusion data implies as many juveniles as adults in the hyrax remains, the number of deciduous teeth suggests a more youthful sample (Table 9). Tooth-row data therefore demonstrates a mortality profile dominated by juveniles. Fig. 11 compares epiphyseal fusion of dominant taxa through time. Variations in mortality patterns through the sequence, however, are difficult to assess due to small sample sizes and mortality profiles between layers are not significantly different.

Table 9
Tooth-row wear patterns.

Teeth	H	R	D	Al	E	Eq	Bov 2	Bov 3	Indet. large mammal	Total
Deciduous	14	2				1			1	18
No/little wear	2		2		1		2	1		8
Heavily worn	1		1	1		6	2	2		13
Total	17	2	3	1	1	7	4	3	1	39

H = Hyrax; R = *Raphicerus*; D = *Damaliscus*; Al = *Alcelaphini*; E = Eland; Eq = Equid.

4. Discussion

4.1. Fragmentation and site-formation

Sediment compaction is often cited as a significant factor in the taphonomic history of archaeological assemblages (e.g., Klein and Cruz-Urbe, 1984; Kidwell, 1986) and bone affected by diagenesis is particularly liable to fragment under sediment weight (Lyman, 1994). Research suggests that if soil compaction is a factor then fragmentation would intensify with increasing stratigraphic depth (Shipman, 1981; Kidwell, 1986; Kos, 2003). However, there is no apparent increase in fragmentation with depth at KDS (Table 7) ($r_s = -0.6$; $p > 0.05$) and few specimens display evidence of chemical modification (Table 2).

Given the attrition of the KDS fauna, it seems reasonable to consider the effects of trampling – a major cause of faunal fragmentation (Gifford and Behrensmeyer, 1977; Myers et al., 1980; Blasco et al., 2008; Reynard, 2014). Few specimens at KDS ($n = 4$) display trampling marks but a large proportion of bone display bone abrasion ($n = 604$; 20% of identified specimens). It is important to note that abrasion or polish defines the condition of the bone and not the cause. Bone often exhibits a glossy sheen that resembles polish when heated at relatively low temperatures (~300 °C) and is susceptible to fragmentation since it becomes ceramic-like both in texture and brittleness after heating (Nicholson, 1993; Stiner et al., 1995). Abrasion, therefore, may be

the result of burning or possibly anthropogenic use-wear. However, there is no significant correlation between abrasion and burning through the sequence ($r_s = 0.429$; $p = 0.397$). This suggests that trampling may have contributed to the relatively high proportion of abraded specimens. Equifinality between burning, use-wear and trampling makes it difficult to infer trampling intensity per layer but the data suggest that abrasion is most common in PBD, PBC and PBA/PBB (Table 2).

4.2. Fragmentation and skeletal-parts

The skeletal-part data raise the question as to why cranial fragments are relatively abundant and proximal long-bones (humeri and femora) are less prevalent than distal limbs. Site function might explain this pattern, but evidence of a wide range of activities at KDS implies that it was likely used as a home-base. The high utility-values for bovid proximal long-bone suggest that more of these elements should have been transported back to the cave-site, especially for smaller ungulates (O'Connell et al., 1990; Monahan, 1998). Analysts sometimes fail to incorporate long-bone shaft fragments when measuring skeletal abundance and this can contribute to head-and-foot dominated patterns apparent in many Stone Age faunal assemblages (Bartram and Marean, 1999). At KDS, however, 40.1% ($n = 18$) of size 1 and size 2 bovids, and 45.2% ($n = 28$) of larger ungulate long-bone elements were identified by shaft fragments (Supplementary Fig. S2).

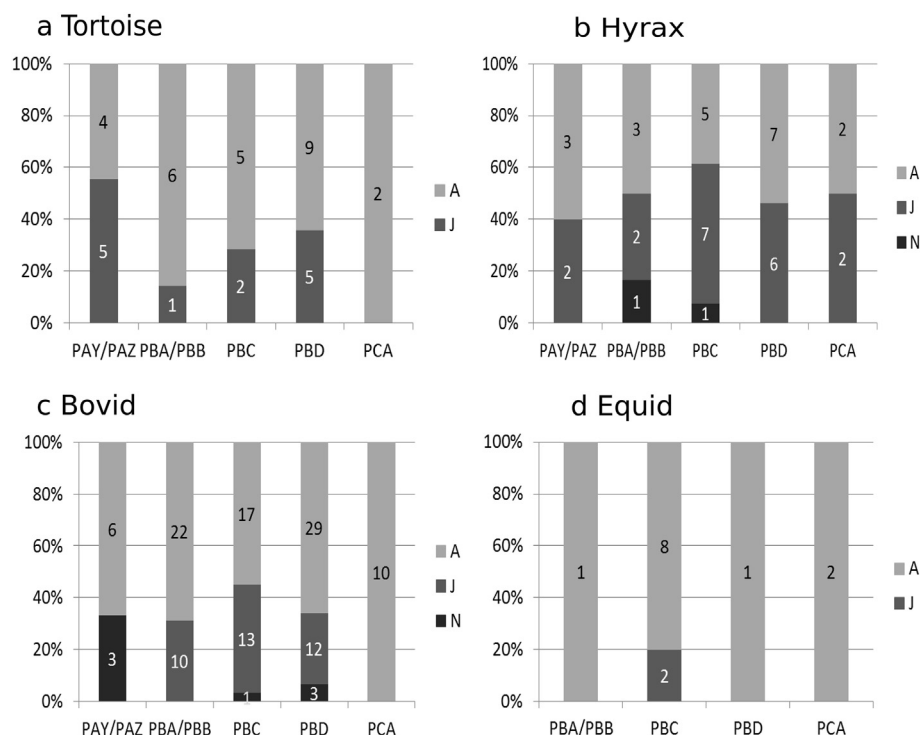


Fig. 11. a) Tortoise; b) Hyrax; c) Bovid and; d) Equid age-profiles per layer. A = Adult; J = Juvenile; N = Neonate. Data based on epiphyseal fusion. NISP in columns.

One factor affecting skeletal-part patterns may be the identifiability of small samples of severely fragmented fauna. Severe fragmentation decreases the numbers of identified elements by reducing the area of bone on which diagnostic features occur (Lyman and O'Brien, 1987; Grayson and Fey, 2004). Furthermore, metapodia have a particular morphology that makes even small fragments of shafts easier to identify than proximal long-bone. Smaller elements, such as those from hyrax, are less likely to fragment because of their smaller surface area and are therefore more likely to be identified (Johnson, 1985; Marean, 1991). The prevalence of cranial elements at KDS could be explained by two factors: 1) cranial fragments can easily be identified even when highly fragmented; 2) the use of nNISP values for skeletal-part profiles necessarily implies large skull counts in the case of highly fragmented assemblages. Thus, intense fragmentation at this site may well explain the skeletal-part patterns identified.

4.3. Evidence for remote-capture technology?

Hyrax and size 1 bovid skeletal-part and mortality patterns are significantly different. Hyraxes generally have a more equitable representation of skeletal parts than size 1 bovids while small bovids are represented by more distal limbs and phalanges (Fig. 4). Small bovids are mostly adult and are dominated by *Raphicerus*. Hyraxes on the other hand are generally juveniles. Differences in skeletal-part profiles between hyraxes and small bovids are unlikely to be due to taphonomic factors or transport decisions since both taxa are equally small but could be influenced by the identifiability issues discussed previously. More than likely, this discrepancy reflects processing activities since, compared to hyraxes, more meat occurs on bovid limbs. Variation between hyrax and small bovid mortality profiles could indicate differences in ecology or acquisition methods. Both steenbok (*Raphicerus campestris*) and Cape grysbok (*Raphicerus melanotis*) lamb throughout the year although grysbok birthing periods can peak in spring and early summer (Skinner and Ciumba, 2005). Birthing periods for hyrax varies and, in the De Hoop Nature Reserve, generally peak from September to November (Millar, 1971; Badenhorst et al., 2014). Differences in mortality profiles between hyraxes and small bovids may point to seasonality and this will be discussed in more detail in a future study. Yet these differences could also imply that bovids were selectively hunted while hyrax remains may have been collected by predators or be the result of natural death assemblages (Badenhorst et al., 2014). A prevalence of immature hyrax remains are often the result of raptor predation (Cruz-Urbe and Klein, 1998). However, as discussed previously, bone modification and fracture patterns indicate that hyrax remains are the result of human accumulation. Cruz-Urbe and Klein (1998) argue that the prevalence of immature hyrax in the Later Stone Age deposits at Die Kelders may imply the use of remote-capture technology such as bow-and-arrow or nets. Contemporary groups often use snares and traps to collect hyrax (Kundaali, 1976) and remote-capture technology probably existed during the HP (Lombard and Phillipson, 2010; Lombard and Haidle, 2012). It is feasible then that the prevalence of young, immature hyrax at KDS may therefore point to the use of nets, snares or traps in obtaining small mammals (cf. Yellen, 1991; Stiner et al., 2000; Wadley, 2010).

The presence of dangerous carnivore remains such as caracal and hyena could suggest remote-capture technology or highly-efficient projectile weaponry (Charles, 1997) as well as incidences of scavenging. Most carnivore remains show evidence of anthropogenic modification. These raise interesting questions about the extent of carnivore consumption in the Late Pleistocene. The processing of carnivores for food is more common in the Mesolithic (Crezzini et al., 2014) but there is evidence for the consumption of carnivores in the Late Pleistocene (Charles, 1997).

Unfortunately, the small sample size makes it difficult to examine the scope of carnivore consumption at KDS and how extensive they were consumed during the HP. Whether carnivores at KDS were exploited for food or fur, these prey were very likely dangerous to hunt and it is reasonable to propose that some type of mechanism could have been introduced to reduce the risk to hunters. Hand-thrown spears, for example, have been shown to only be effective between 5 and 8 m (Churchill and Rhodes, 2009). However, it is also possible that the carnivores at KDS were not hunted and their remains could reflect episodic scavenging. The differential bovid 1 and small mammal mortality profiles, the relatively large percentage of small mammal remains and evidence for carnivore processing pose interesting questions concerning the potential use of snares, traps or long-distance projectile weaponry such as bow-and-arrow in the hunting of game at KDS.

4.4. Subsistence patterns

Various processing activities such as disarticulation, marrow extraction, skinning and filleting are evident on a range of fauna (Table 10). Burning, however, is by far the most common surface modification. The prevalence of localised, partial burning suggests that this burning was the result of roasting activities. Bone marrow has been well documented as a significant resource in both contemporary foraging (e.g., O'Connell et al., 1988; Lupo, 2006) and Stone Age subsistence studies (e.g., Blumenschine, 1986; Brink, 1997; Munro and Bar-Oz, 2005). In some cases, especially during the Early Pleistocene, marrow utility is incidental to the overall economic benefits of carcass processing and other variables such as carcass-size, prey-type and transport decisions are at least as important (Blumenschine et al., 1994; Lupo, 2006: 27). In contrast, the evidence shows that KDS may have had a marrow-based economy where marrow was a specific consideration in the selection of bones for transport. Morin and Ready's (2013: 259) suggest that a 'marrow-based' subsistence strategy is one where marrow was a key factor in the selection of bones for transport. This may also explain the difference in skeletal-part profiles between hyrax and size 1 bovids discussed earlier. There is a significant relationship at KDS between nNISP values and marrow utility indices for both smaller and medium-sized bovids (Table 11). This suggests that despite the effects of density-mediated attrition on the KDS assemblage, a marrow-based subsistence strategy for ungulates is likely. Table 11 also shows a significant negative correlation between nNISP and meat drying indices for larger mammals but not for smaller ungulates. However, as a result of equifinality, significant correlations with marrow utility are often associated with negative correlations with meat drying indices for larger mammals (Morin and Ready, 2013). Indeed, while marrow and meat-drying indexes are not correlated for caribou ($r_s = 0.176$; $p = 0.627$) and sheep ($r_s = 0.584$; $p = 0.077$), they are significantly and negatively correlated for bison ($r_s = -0.794$; $p = 0.0061$) (Table 11). Bone destruction and equifinality in the utility of large ungulates complicate the interpretation of skeletal-part patterns. However, considering the significant relationships above as well as other evidence for large bovid marrow processing (percussion marks and spiral fractures), it is most likely that the correlations observed are the sole result of the exploitation of small and large bovid bones for their marrow. This focus on marrow extraction may have been a reaction to nutritionally-stressed environments where fat reserves are scarce. Morin and Ready (2013: 253) note that marrow-focused patterns are especially prevalent during the Late Pleistocene in Western Europe (MIS 4 onwards) and suggest that this may reflect an increased focus on marrow and fat consumption during cooler isotopic periods.

Table 10
Summary of general characteristics.

	Tortoise	Small mammals	Carnivores	Bovids	Equids
Bone destruction	Burning prevalent on all taxa. Probable density-mediated attrition.				
Taphonomy	Shell mostly burnt on the outside	Spiral fractures dominate. Cut and percussion marks present	Evidence of skinning and consumption	Evidence of butchery, skinning and marrow extraction	Evidence of butchery and marrow extraction
Skeletal profile	Mostly shell.	Hyrax profiles significantly different to size 1 bovids	Mostly phalanges	Head-and-foot pattern dominates.	Mostly distal limbs and phalanges
Age profile	Mostly juvenile in PAY/PAZ	Mostly juvenile	Mostly adult	Mostly adult	Mostly senile

Table 11
Spearman's rank-order correlation between skeletal-abundance (nNISP) and Unsaturated Marrow Indices (UMI), and Meat Drying Indices (MDI) for all elements and high-survival elements only

All elements ^a	UMI			MDI		
	r _s	p-value	Significance	r _s	p-value	Significance
Larger mammal (Bison data)	0.527	0.117	No	-0.678	0.003	Yes
Size 2 mammal (sheep data)	0.725	0.012	Yes	-0.266	0.287	No
All ungulate (caribou data)	0.851	0.0001	Yes	-0.391	0.129	No
High-survival elements only						
Larger mammal (Bison data)	-0.714	0.111	No	0.314	0.544	No
Size 2 mammal (sheep data)	-0.314	0.544	No	-0.262	0.531	No
All ungulate (caribou data)	0.086	0.872	No	-0.829	0.042	No

^a Including 'low survival' elements. Larger mammal includes perrisodactyla, indeterminate 'large mammal' and bovids \geq size 3. Size 2 mammal includes indeterminate 'medium mammal' and size 2 bovids. Bison, caribou and sheep data from [Morin and Ready \(2013\)](#). High survival elements are the cranium, mandible, humerus, radius, ulna, metacarpal, femur, tibia and metatarsal.

Taphonomic and faunal evidence may point to the role of intense subsistence strategies at KDS. A wide range of prey including small fauna and shellfish were systematically exploited ([Henshilwood et al., 2014](#)). Percussion marks on small mammal long bones and very thin unidentified long bone fragments also indicate regular marrow extraction from low-ranked prey. Percussion marks and localised burning on carnivore bones suggest that they may also have been consumed which suggests a broad diet at KDS ([Stiner et al., 2000](#); [Munro, 2009](#)). Percussion marks on low-ranked elements such as calcanei suggest intensive processing of prey. Evidence of intensive processing occur throughout most layers but is not linked to particular layers or periods within the HP at KDS. Despite the evidence above, the lack of comparative data from KDS and other southern Cape sites makes it problematic to view the comprehensive processing of low-ranked game and elements as 'intensification' as documented by other researchers (e.g., [Stiner et al., 2000](#); [Munro, 2004, 2009](#)). Very little data documenting intensive processing is available from southern Cape sites so, as yet, we are unable to tell whether the intensive processing noted is unique to KDS or is characteristic of other southern Cape MSA or HP sites. Intensified subsistence may be the result of palaeoecological or nutritional stress, innovative technology associated with the development of complex behaviour during the MSA, or other factors such as ritual or belief systems. Increasing dietary breadth, for example, has been shown to be the result of a number of causes ([Clark and Kandel, 2013](#)). It would therefore be of interest for future studies to compare the HP with post-HP fauna at KDS. Comparisons between the HP fauna from KDS with fauna in the Still Bay layers from nearby Blombos Cave would also be valuable. By doing so, we could possibly better understand if intensification was a factor in the southern Cape during the Late Pleistocene.

5. Conclusion

Evidence of a wide range of activities at KDS (e.g., subsistence activities, fire making, lithic and bone debitage, ochre processing) as well as its location in a rockshelter imply that KDS was likely used as a home-base that included butchery activities. Burning is by far the most common modification with almost 90% of faunal remains showing evidence of thermal alteration. Percussion marks are also relatively common (~30%) and spiral fractures dominate breakage patterns. Surface modification and breakage patterns demonstrate that hyrax, other small mammals and tortoise were almost exclusively accumulated by humans. Percussion and cut marks and burning suggest that carnivores were skinned as well as processed for food. In general, a range of processing activities such as skinning, filleting and dismemberment are evident at KDS.

Bone fragmentation is extensive at KDS and is likely a result of post-depositional factors (e.g., trampling) and intensive processing. Fragmentation and the relatively small sample sizes make it difficult to assess the significance of skeletal-part variability (and its implication for transport decisions) through the sequence. Evidence of intensive marrow extraction may have also contributed to the severe fragmentation at KDS. Marrow exploitation may have been an important criterion in the transportation of elements to KDS and our data suggests a systematic marrow-based subsistence strategy for ungulates. Extensive processing suggests an efficient utilisation of faunal resources by southern Cape people at ~60 ka: a critical period in the expansion of humans out of Africa. Differences in hyrax and size 1 bovid age and skeletal-profiles imply that these taxa were procured and processed differently. This, and the evidence of dangerous carnivore exploitation, raises questions about the potential use of remote-capture technology such as snares, traps or highly-efficient projectile weaponry in the hunting of prey but definitive proofs of their existence at KDS is still lacking. The

exploitation of low-ranked prey and low-utility elements occur throughout the KDS sequence. However, the context of this behaviour remains unclear. Small sample sizes and a lack of comparative data make the interpretation of the KDS data in relation to subsistence intensification problematic. More data from post and pre-HP layers at KDS and nearby sites such as Blombos Cave could help clarify these and other subsistence strategies during the Late Pleistocene in the southern Cape.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at <http://dx.doi.org/10.1016/j.quaint.2015.07.041>.

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CHAPTER 4: THE BLOMBOS CAVE FAUNAL ANALYSIS

This chapter contains the results of my analysis of the BBC fauna. I begin by presenting the materials and methods used in the analysis of the faunal remains. The results list taphonomic variation, taxonomic composition, and skeletal-part and mortality profiles throughout the SB sequence at BBC. The implication and discussions with regard to these results are considered in the next chapter and chapter 9.

4.1 Materials and methods

AS with the KDS assemblage, faunal remains from BBC were assessed following Driver (2005) and Klein and Cruz-Uribe (1984) using the comparative faunal collections of the Ditsong National Museum of Natural History (formerly the Transvaal Museum) in Pretoria. I analysed identified faunal remains and long-bone fragments not identified to element recovered from the 2011 and 2013 excavation seasons. Out of the 6665 mammalian and tortoise specimens identified, a total of 648 specimens (9.7%) could be assigned at least to the class level. Taxa, element, skeletal portion, side, state of epiphyseal fusion, types of surface modification, fracture patterns, length and – if possible – long-bone cortical thickness were recorded for all specimens. Bovid post-cranial remains are categorised to size class based on Brain (1974). Remains that could only be consigned to element (e.g., cranial and vertebral fragments) are assigned to ‘very small’, ‘small’, ‘medium’ or ‘large’ indeterminate mammal size classes. Very small mammal are species smaller than the Cape dune mole rat (*Bathyergus suillus*), small mammals ranging in size from the Cape dune mole rat up to and including size 1 bovids, medium mammals correspond to size 2 bovids, large mammals to size 3 and 4 bovids and very large mammal are equivalent to size 5 bovids.

Microfauna (fauna with an adult weight < 700 g) and tortoise remains were tallied but not included in our analysis. Because of the relatively small sample sizes (cf. Thompson & Henshilwood 2011), ‘large’ and ‘very large’ indeterminate mammal remains are pooled with large ungulates (perrisodactyls and bovids \geq size 3) and referred to as ‘large mammal’. I also frequently combine size 2 bovids and indeterminate medium mammal remains and refer to these

as ‘size 2 mammal’. Because of the lack of large carnivore remains in our sample (cf. Henshilwood et al. 2001a), most ‘medium mammal’ specimens probably belong to ungulates.

4.1.2 *Methodology*

I use the same methodology as with the KDS fauna to determine specimen length (Driver 2005), fracture patterns (Villa and Mahieu 1990) and to record long-bone cortical thickness. Faunal specimens were examined with a Nikon binocular light microscope (10 – 40x magnification) under oblique, unidirectional, incandescent lighting. Surface modification was assessed following standard criteria (Behrensmeier 1978; Blumenschine & Selvaggio 1988; Blumenschine et al., 1996). Burning was defined using a three-stage colour method (black, grey or white) and ‘localised’ or partial burning based on standard references (e.g., Brain, 1981; Nicholson, 1993; Stiner et al., 1995; Driver, 2005).

I ‘normalise’ the number of identified specimens (NISP) to adjust for the expected frequency that a particular skeletal element should occur in the complete carcass of an ungulate (see Reynard et al., in press). Skeletal-parts of ungulates are categorised into five skeletal groups: the head, forelimb, hindlimb, distal limbs and extremities (Table 4.1). To measure the frequency of skeletal-groups in ungulates, I add the normalised NISPs (nNISP) for elements in skeletal-group and divide that figure by the number of elements that make up a skeletal-group for a single individual. For example, the hindlimb is defined as the innominate, femur, patella and tibia. I therefore add the nNISP values for those four elements and divide it by four: the expected value for each skeletal-group will thus be one. Where density mediated attrition has affected element representation, I use only high-survival elements (skulls and long-bones) in our classification of skeletal-groups (cf. Marean & Cleghorn 2003). In this regard, the hindlimb then consists of the femur and tibia only.

Due to a lack of assessable teeth (and to compare data from BBC with KDS), specimens with epiphyseal plates such as phalanges, long-bones and vertebrae fragments were examined for indicators of age. Bone with fused epiphyses are categorised as adult, while those that were ‘unfused’ or ‘recently-fused’ are classed as juvenile. For a specimen to be examined, at least one end should have an epiphysis. I was able to assess 205 specimens for epiphyseal fusion.

Table 4.1: Classification of skeletal-groups

Skeletal group	All elements	High survival only
Head*	Cranium, mandible, hyoid, horncores	Cranium, mandible, horncores
Forelimb	Scapula, humerus, radius, ulna	Humerus, radius, ulna
Hindlimb	Innominate, femur, patella, tibia	Femur, tibia
Distal limb	Carpals, tarsals, metapodia	Metapodia
Extremities	Phalanges, sesamoids	-----

4.2 Results

In this section, I present the results of my analysis of the faunal data from BBC. I first assess the taphonomic history of the assemblage to establish the dominant bone collectors, and then investigate skeletal-part profiles, taxonomic composition and mortality profiles. Although critical in the evaluation of taphonomy, bone density-mediated attrition is not measured in this chapter because those analyses were conducted for a published paper presented in the next chapter (Reynard & Henshilwood, in press).

4.2.1 Taphonomic history

Discolouration due to burning is the most common surface modification (50%; n = 667) with most specimens partially burnt (31.6%; n = 422) (Table 4.2). Layer CDA has the highest proportion of burnt specimens (n = 15; 83.3%) with the least occurring in CF/CFA (n = 35; 33.3%). Less than 9% (n = 114) of specimens display percussion marks which are generally more common in Layer CB and CC (Table 4.3). Tooth marks (6.1%; n = 82) are slightly more widespread than cut marks (5.7%; n = 76) and gnaw marks are rare (0.4%; n = 5). Cut marks are proportionally more common in CDA (n = 4; 22.2%) while percussion marks are relatively more

prevalent in CB (n = 21; 11.8%) and CC (n = 26; 11.2%). What is termed ‘encrustation’ is the most common form of surface modification. This is a sediment-like, consolidated material fixed to the surface of bone specimens. It is likely alkaline-based and associated with calcium carbonate-rich sediment and some of it may be gypsum sulphate (cf. Thompson 2008).

Table 4.2: Burnt fauna at Blombos Cave

Layer	N	Localised		Black		Grey		White		Total	
		n	%	n	%	n	%	n	%	n	%
CA	196	49	25.0	22	11.2	4	2.0	0	0	75	38.3
CB	178	53	29.8	24	13.5	16	9.0	2	1.1	95	53.4
CC	232	78	33.6	29	12.5	13	5.6	4	1.7	124	53.5
CCC	136	40	29.4	20	14.7	5	3.7	0	0	65	47.8
CD	144	48	33.3	14	9.7	20	13.9	16	11.1	98	68.1
CDA	18	7	38.9	2	11.1	5	27.8	1	5.6	15	83.3
CDB	43	7	16.3	3	7.0	2	4.7	3	7.0	15	34.9
CF/CFA	105	19	18.1	14	13.3	0	0	2	1.9	35	33.3
CFB/CFC	115	43	37.4	13	11.3	1	0.9	1	0.9	58	50.4
CFD	169	78	46.2	8	4.7	0	0	1	0.6	87	51.5
BBC Total	1336	422	31.6	149	11.2	66	4.9	30	2.2	667	50.0

Table 4.3: Surface modification at Blombos Cave

Layers	N	Percussion Marks		Cut Marks		Tooth Marks		Gnaw Marks		Acid-etching		Root etching		Weathering		Encrustation	
		n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
CA	196	12	6.1	16	8.2	20	10.2	1	0.5	3	1.5	8	4.1	0	0	38	19.4
CB	178	21	11.8	16	9.0	10	5.6	0	0	0	0	11	6.2	0	0	20	11.2
CC	232	26	11.2	14	6.0	11	4.7	0	0	2	0.9	16	6.9	0	0	16	6.9
CCC	136	9	6.6	8	5.9	8	5.9	1	0.7	1	0.7	13	9.6	0	0	6	4.4
CD	144	13	9.0	5	3.5	1	0.7	0	0	2	1.4	9	6.3	1	0.7	7	4.9
CDA	18	1	5.6	4	22.2	0	0	0	0	0	0	1	5.6	0	0	0	0
CDB	43	1	2.3	3	7.0	1	2.3	0	0	1	2.3	4	9.3	0	0	1	2.3
CF/CFA	105	4	3.8	2	1.9	11	10.5	3	2.9	6	5.7	3	2.9	0	0	18	17.1
CFB/CFC	115	10	8.7	4	3.5	7	6.1	0	0	6	5.2	7	6.1	0	0	22	19.1
CFD	169	17	10.1	4	2.4	13	7.7	0	0	1	0.6	8	4.7	2	1.2	40	23.7
BBC Total	1336	114	8.5	76	5.7	82	6.1	5	0.4	22	1.7	80	6	3	0.2	168	12.6

Table 4.4: Fracture patterns at Blombos Cave (BBC). Percentages with numbers of fractured ends in brackets

Samples	Spiral	Transverse	Irregular
CA	69.6 (80)	21.7 (25)	8.7 (10)
CB	51.5 (34)	34.8(23)	13.6 (9)
CC	65.0 (76)	32.5 (38)	2.6 (3)
CD	58.3 (35)	28.3 (17)	13.3 (8)
CF	53.5 (62)	36.2 (42)	10.3 (12)
Total BBC	60.6 (287)	30.6 (145)	8.9 (42)

Fracture patterns are calculated for unburnt, identified ungulate long-bone and are dominated by spiral fractures (Table 4.4). Spiral fractures are particularly prevalent in CA (n = 80; 69.6%) and CC (n = 76; 65.0%). Transverse fractures are generally slightly more common in CB (n = 9; 13.6%) and CD (n = 8; 13.3%). Irregular fractures occur are on average on less than 10% (n = 42; 8.9%) of bones.

4.2.2 Skeletal-part profiles

To assess skeletal-part profiles, I use high-survival elements only since analyses presented in the next chapter show that ungulates from BBC are affected by density-mediated attrition. The data presented in figures 4.4 and 4.5 are raw NISP values because the focus of this examination is change over time and all high-survival elements – including crania and mandibles – are paired (see Reynard et al., in press).

Generally, crania are very rare in large mammal skeletal profiles (Fig. 4.1). Large mammal long-bones are relatively more common than most other elements and there are also a proportionally high number of calcanei. Size 2 mammals are dominated by skull remains (Fig. 4.2). Skull from size 2 mammals are significantly more common than those from large mammals ($\chi^2 = 27.94$; df = 1; $p < 0.0001$ for skulls and high-survival post-cranial elements between size 2 bovids and large mammals). Both crania and long-bones are prevalent in the size 1 bovid profiles (Fig. 4.3). In fact, skeletal-part profiles of size 1 bovids are generally relatively equitably distributed. Skulls are significantly more common than long-bones in the size 2 mammal element profile when compared to size 1 bovids ($\chi^2 = 14.83$; df = 1; $p = 0.00012$). The proportion of crania and

mandibles is also significantly different between size 2 bovids and large mammals ($\chi^2 = 18.910$; $df = 1$; $p < 0.0001$).

On the whole, fewer elements of size 2 mammals were recovered than either large mammals or size 1 bovids at BBC. At BBC there are proportionally more skull remains of size 2 than size 1 bovids. This may be the result of identification bias: skull fragments were easier to categorise as size 2 than size 1 bovids due to the difficulty in discerning hyrax and other small mammals from small bovids. Size 1 skull specimens may therefore be under-estimated.

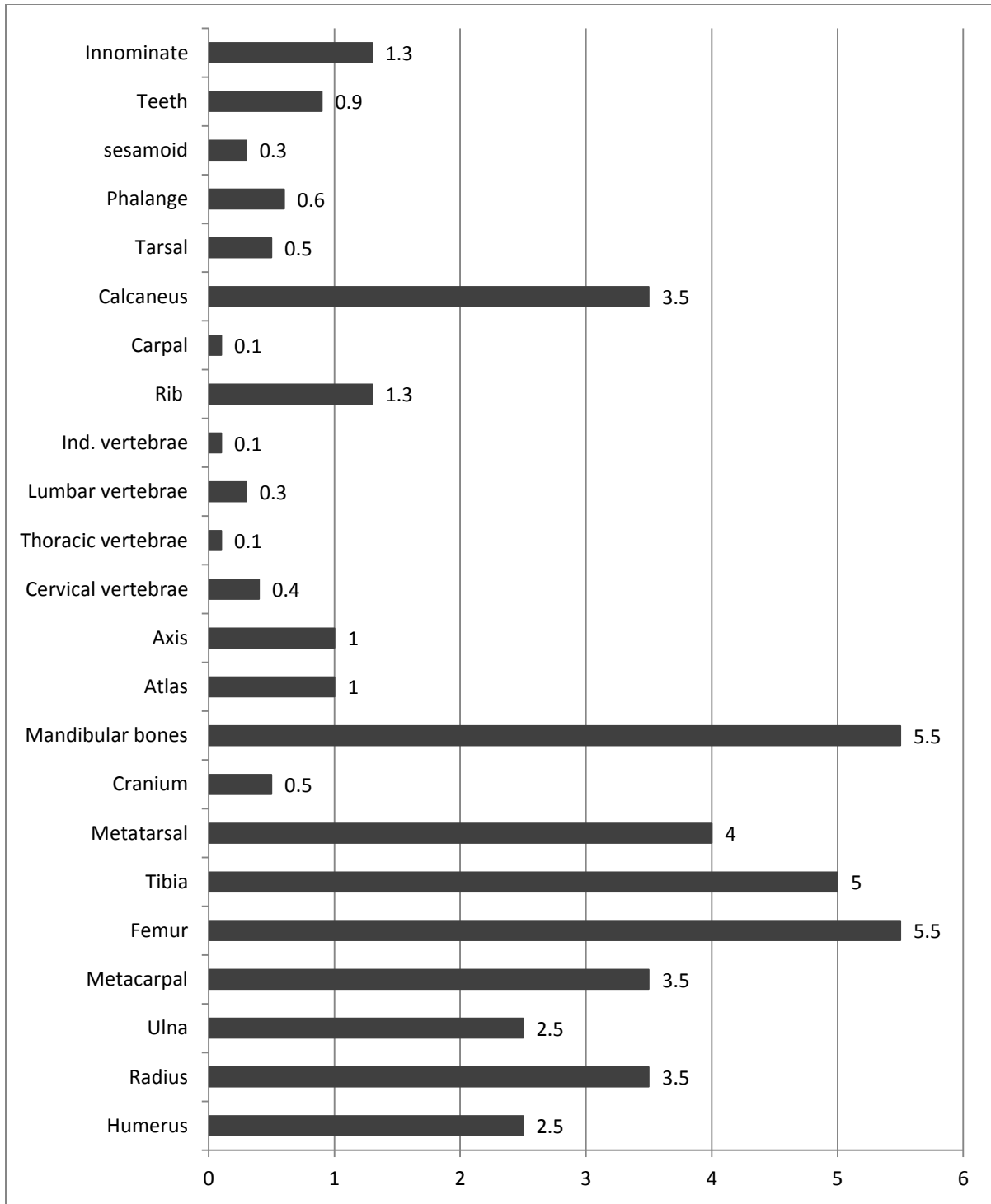


Fig. 4.1: Large mammal normed NISP (nNISP) skeletal profile

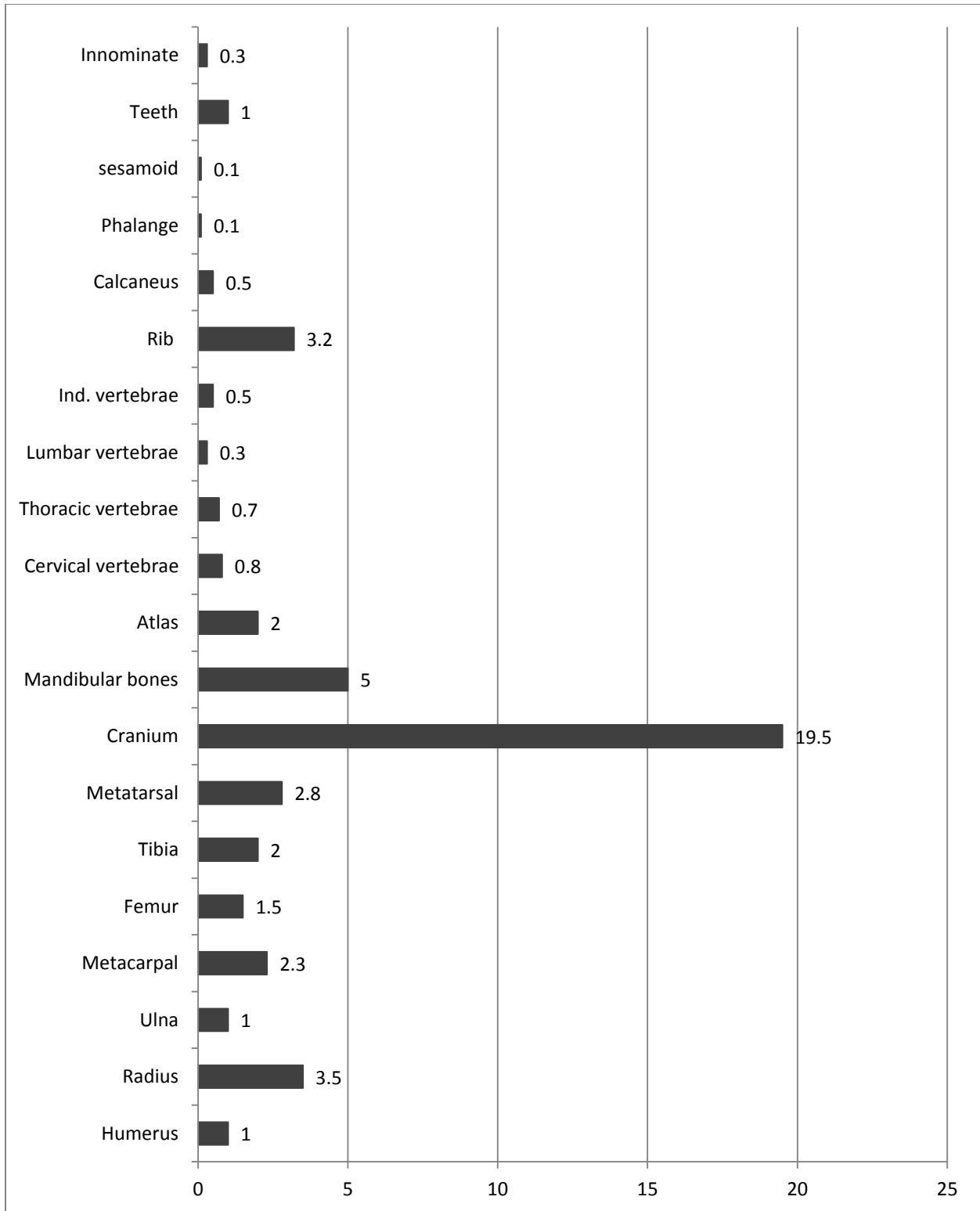


Fig. 4.2: Size 2 bovid and medium mammal nNISP skeletal profile

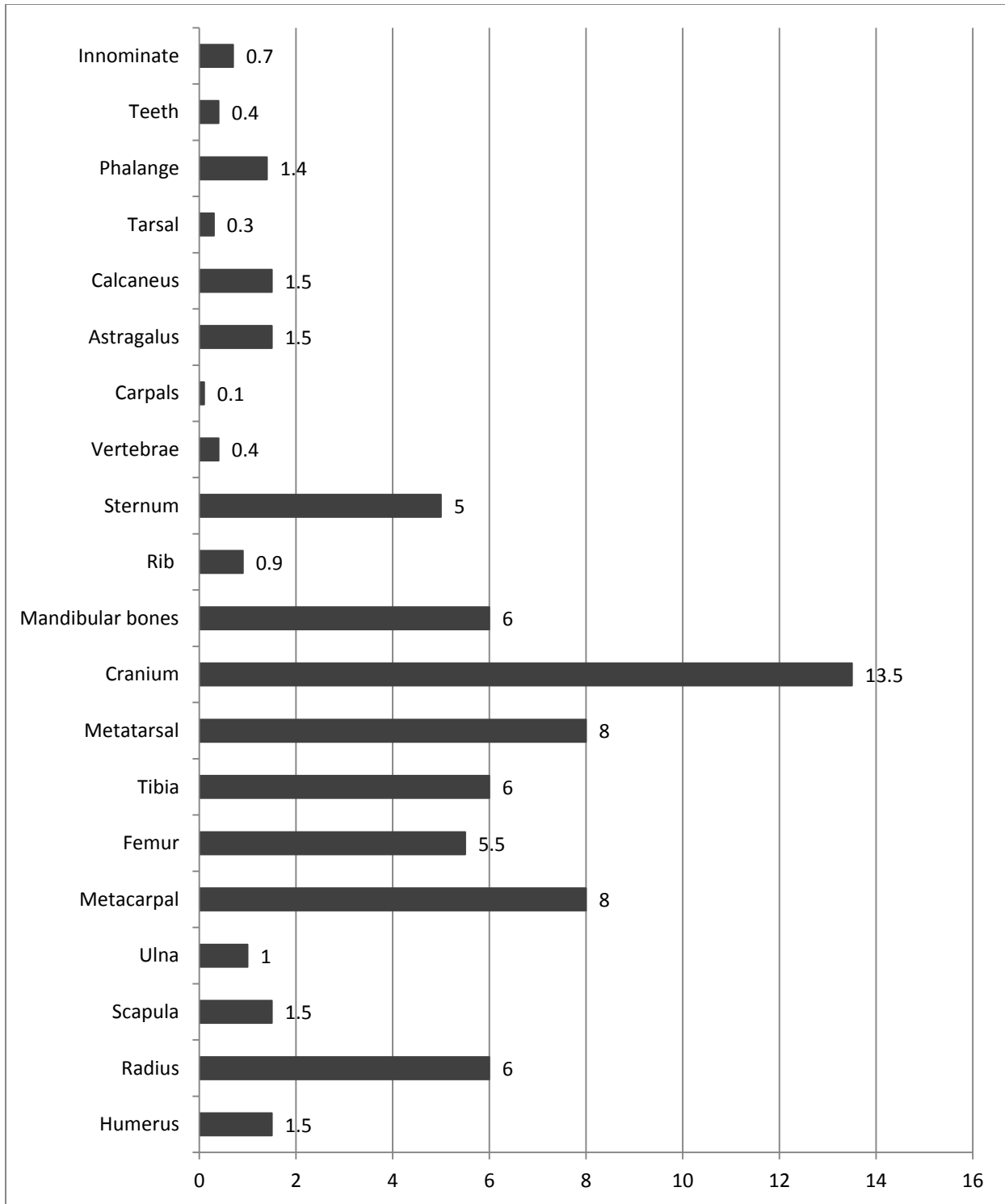


Fig. 4.3: Size 1 bovid nNISP skeletal profile

For size 2 mammals, skull remains are proportionally more common than post-cranial remains (Fig. 4.4). Layer CD generally has few post-cranial remains relative to the other layers. Because of the variable abundance of post-cranial elements, I could not conduct chi-squared or Fisher’s exact tests for the skeletal-profiles of size 2 mammals. I did, however, measure variability between skulls and post-cranials (Table 4.5). The results show no significant differences between skulls and long-bones through the layers. The variability in skeletal-parts may be the result of the general lack of size 2 mammal remains mentioned earlier. The dearth of size 2 elements is particularly noticeable in CA and CB.

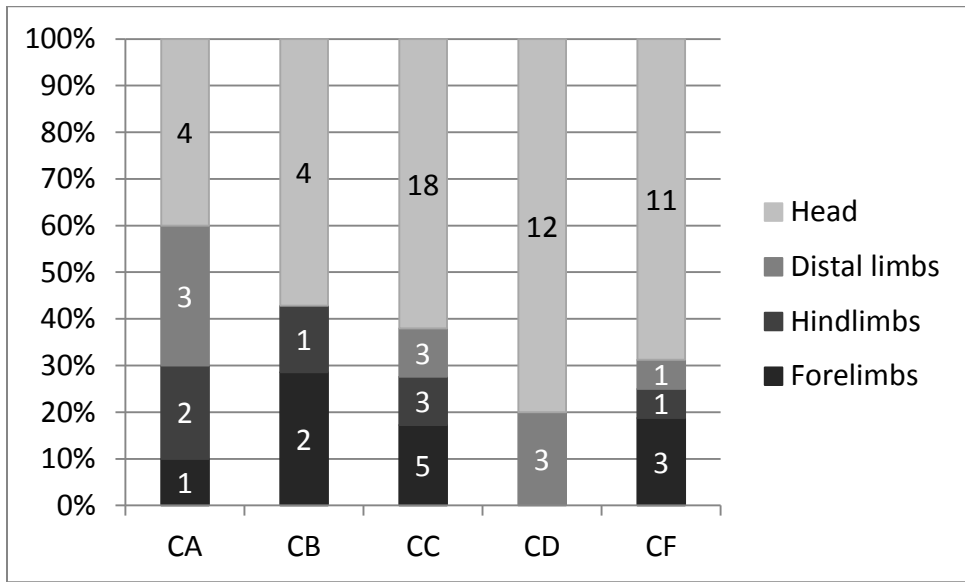


Figure 4.4: Distribution of size 2 mammal skeletal-parts throughout the Still Bay at Blombos Cave.

Table 4.5: Chi-squared and Fisher’s exact tests for cranial versus post-cranial elements for size 2 mammals

Layer	Size 2 mammals	
	Chi-squared/Fishers exact	Probability
CA & CB	0.637	> 0.0500
CB & CC	1	> 0.0500
CC & CD	1.465	0.2261
CD & CF	0.512	0.4745

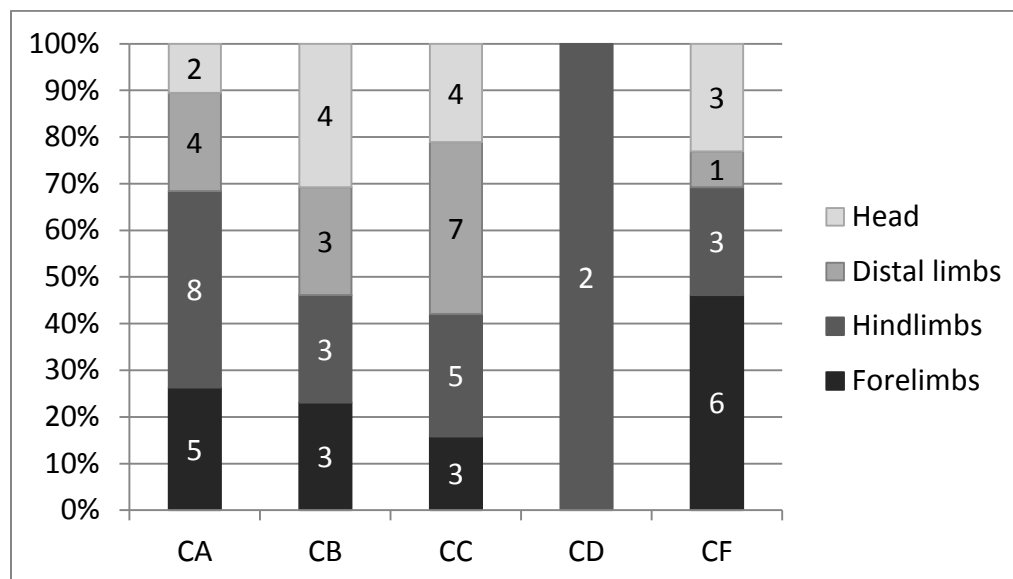


Figure 4.5: Distribution of large mammal skeletal-parts throughout the Still Bay at Blombos Cave.

For large mammals, skull remains are generally lacking throughout the SB sequence and post-cranial are proportionally more prevalent (Fig. 4.5). Proximal limbs are more common than distal limbs for large mammals (Fig. 4.1 & 4.5) probably because these are more meat and marrow-bearing elements than the extremities. As with size 2 mammals, few large mammal remains occur in CD. Chi-squared tests were conducted to test variability in skeletal-part representation throughout the SB sequence (Table 4.6). There are no significant differences between skeletal regions of large mammals between most layers (layer CD is excluded because of the presence of zero cell values).

Table 4.6: Chi-squared for skeletal-part profile distribution for large mammals

Layer	Large mammal	
	Chi-squared	Probability
CA & CB	2.547	0.4669
CB & CC	1.011	0.7987
CC & CF	5.201	0.1577

4.2.3 Taxonomic composition

Table 4.7 documents the taxa identified in the fauna assessed from the 2011 and 2013 excavation seasons. Despite the small sample size, a range of species was recovered from that collection. Tortoise is the most prevalent taxon (cf. Thompson & Henshilwood 2014b) but small mammals are also relatively common at (NISP = 79; 46.8% of taxa identified to genus). Hyrax and Cape dune mole rats, for example, occur relatively frequently in the sample and carnivores are quite rare. With regards to ungulates, size 1 bovids such as steenbok/Cape grysbok (*Raphicerus* sp.) and klipspringer (*Oreotragus oreotragus*) are the most common. Large ungulates such as eland (*Tragelaphus oryx*) and the long-horned buffalo (*Syncerus antiquus*) were also identified.

Due to the relatively small sample size identified, I also present the mammalian fauna identified by Klein and Cruz-Urbe in Henshilwood et al. (2001a) (Table 4.7). Their collection shows a predominance of small mammals such as dune molerats and hyraxes, as well as *Raphicerus*. Cape fur seal (*Arctopcephalus* cf. *pusillus*) are noticeably more common in their assemblage, as are eland and rhinoceros. Although the taxa identified generally concur, my analysis and Klein and Cruz-Urbe's sometimes differ. For example, I found caracal/serval (*Felis caracal/serval*) and Cape fox (*Vulpes chama*) in my assemblage whereas they did not. Other taxa not represented in Table 4.7 identified by Klein and Cruz-Urbe include Hippopotamus (*Hippopotamus amphibious*) and bluebuck (*Hippotragus leucophaeus*) (see Henshilwood et al. 2001a for a detail list of fauna identified). My sample is too small to infer environmental conditions. However, in Klein and Cruz-Urbe's sample, the prevalence of *Raphicerus* – a browser – and eland – a mixed-feeder – from the M1 phase suggest a more mixed/browse-dominated habitat during the SB (Henshilwood et al. 2001a).

Table 4.7: Number of identified specimens (NISP) at Blombos Cave (BBC). ‘Total Identified’ include tortoise. ULBF = unidentified long-bone fragments

Order	Taxa	Common Name	CA	CB	CC	CD	CF	Total	KC M1*	KC M2*
Chelonii	<i>Testudinidae</i>	Tortoise	1397	539	899	756	1665	5256		
	<i>Chersina angulata</i>	Angulate tortoise	97	65	127	63	127	479		
Lagomorpha	<i>Lepus sp.</i>	Hare	2	-	-	-	1	3	25	15
	<i>Lepus capensis</i>	Cape hare	-	-	-	1	-	1	11	4
Rodentia	<i>Bathyergus suillus</i>	Cape dune mole rat	3	-	8	6	3	20	419	303
	<i>Hystrix sp.</i>	Porcupine	-	1	-	-	-	1	1	-
Carnivora	<i>Herpestes sp.</i>	Mongoose	-	-	1	-	1	2	3	4
	<i>Arctocephalus cf. pusillus</i>	Cape fur seal	2	-	13	1	5	21	126	32
	<i>Felis lybica</i>	African wildcat	1	-	-	-	-	1	16	1
	<i>Felis caracal/serval</i>	Caracal/Serval	-	-	1	1	1	3	-	-
	<i>Vulpes chama</i>	Cape fox	-	-	-	-	5	5	-	-
Hyracoidea	<i>Procavia capensis</i>	Rock hyrax	1	4	7	11	25	48	169	190
Perissodactyla	<i>Rhinicerotidae</i> ind.	Rhinoceros	1	1	-	-	-	2	13	-
	<i>Equus sp.</i>	Zebra	1	-	-	-	-	-	-	-
Artiodactyla	<i>Tragelaphus oryx</i>	Eland	-	3	1	-	-	4	48	8
	<i>Syncerus caffer</i>	African buffalo	-	-	-	-	1	1	2	-
	<i>Syncerus antiquus</i>	Giant buffalo	-	-	1	1	-	2	-	-
	<i>Pelea capreolus</i>	Grey (Vaal) rhebok	-	-	1	-	1	2	6	2
	<i>Raphicerus sp.</i>	Steenbok/Grysbok	8	2	5	3	18	36	111	51
	<i>Oreotragus oreotragus</i>	Klipspringer	1	-	2	-	18	21	-	-
	<i>Sylvicapra grimmia</i>	Grey duiker	1	-	1	-	-	2	-	2
	<i>Alcelaphini</i> indet.	Hartebeest or Wilderbeest	-	-	-	-	1	1	5	190

Table 4.7 continued

Taxa	Common Name	CA	CB	CC	CD	CF	Total	KC M1*	KC M2*
Bovidae indet.	Bov I	12	8	26	13	62	121	382	360
	Bov I/II	-	-	1	1	4	6		
	Bov II	12	5	17	17	13	64	74	51
	Bov II/III	2	-	2	1	-	5		
	Bov III	8	5	10	2	11	36	91	50
	Bov III/IV	5	7	9	4	7	32		
	Bov IV	5	5	6	2	10	28	193	58
	Bov IV/V	1	-	-	3	-	4		
	Bov V	-	2	2	-	-	4		
	Large ungulate	-	2	2	-	4	8		
Carnivora indet.	Small carnivore	-	-	1	-	3	4		
	Medium carnivore	2	-	-	2	2	6		
Mammal indet.	Very small mammal	3	6	19	8	21	57		
	Small mammal	17	18	47	23	57	162		
	Medium mammal	27	21	75	16	30	169		
	Large mammal	4	16	16	3	14	53		
	Very large mammal	-	1	1	-	-	2		
Total Identified		1516	646	1174	875	1983	6194	1729	1167
Total ULBF		76	70	88	85	71	390		
Total Unidentified		4350	3541	8887	3516	5703	25997		
Grand Total		5942	4257	10149	4476	7757	32581		

*KC M1 & KC M2 = BBC M1 & M2 layers analysed by Klein & Cruz-Urbe (Henshilwood *et al.* 2001a)

In terms of taxonomic groups, size 1 bovids are the most numerous taxa followed by small mammals. Large ungulates dominate CB while size 1 bovids are more common in CF (Fig. 4.6). The spike in carnivores in CC in Figure 4.6 is due to the relatively high number of seal remains there. Small mammals are quite common in CD. There are significant difference in the proportion of taxa between CC and CD ($\chi^2 = 16.818$; $df = 4$; $p = 0.0021$) and between CD and CF ($\chi^2 = 28.710$; $df = 4$; $p < 0.00001$) which probably relate to the substantial decrease in size 1 bovids from CF to CD and the increase in large ungulates from CD to CC.

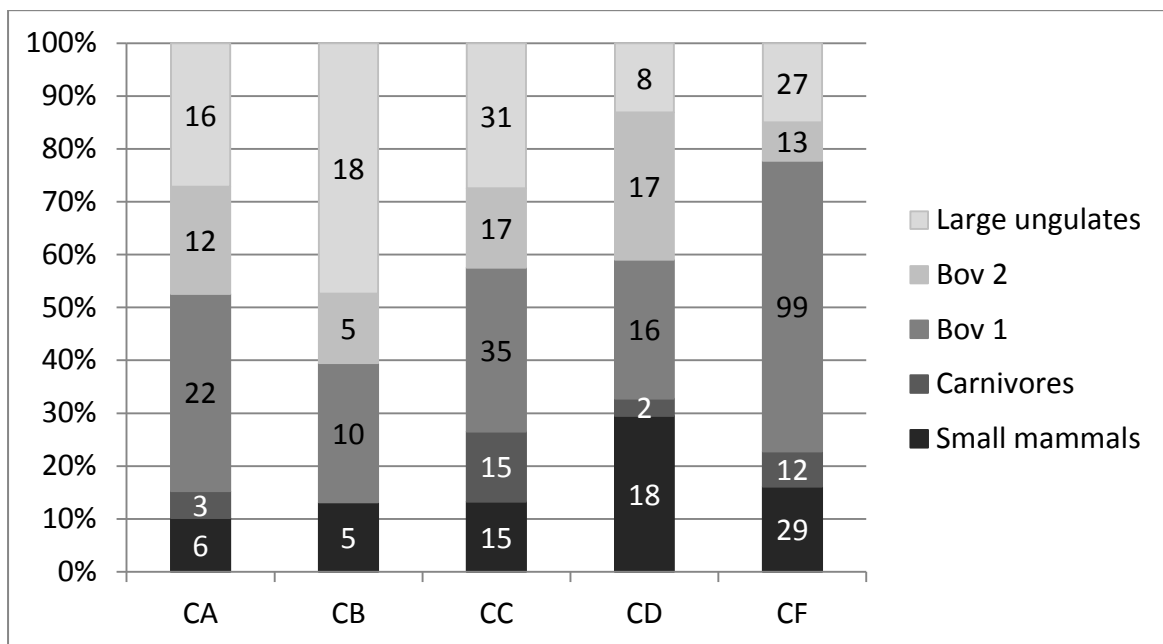


Figure 4.6: Distribution of taxonomic groups throughout the Still Bay sequence. Large ungulates comprise identified size 3, 4 & 5 bovids, and perrisodactyls. Small mammal comprised of identified lagomorphs, Cape dune mole rat and hyrax remains

Figure 4.7 shows the proportions of mammal size classes in the SB. CF ($n = 78$; 63.9%) and CD ($n = 31$; 62%) have the highest proportion of small and very small mammal size classes. Only 6% ($n = 3$) of size classes are large mammal in CD. In contrast, 27.4% ($n = 17$) of specimens in CB are large mammal. There is a progressive decrease in the proportion of small and very small mammals from CF to CA with a significant drop in small/very small mammals from CD to CC (Large/medium vs very small/small: $\chi^2 = 6.245$; $df = 1$; $p = 0.013$).

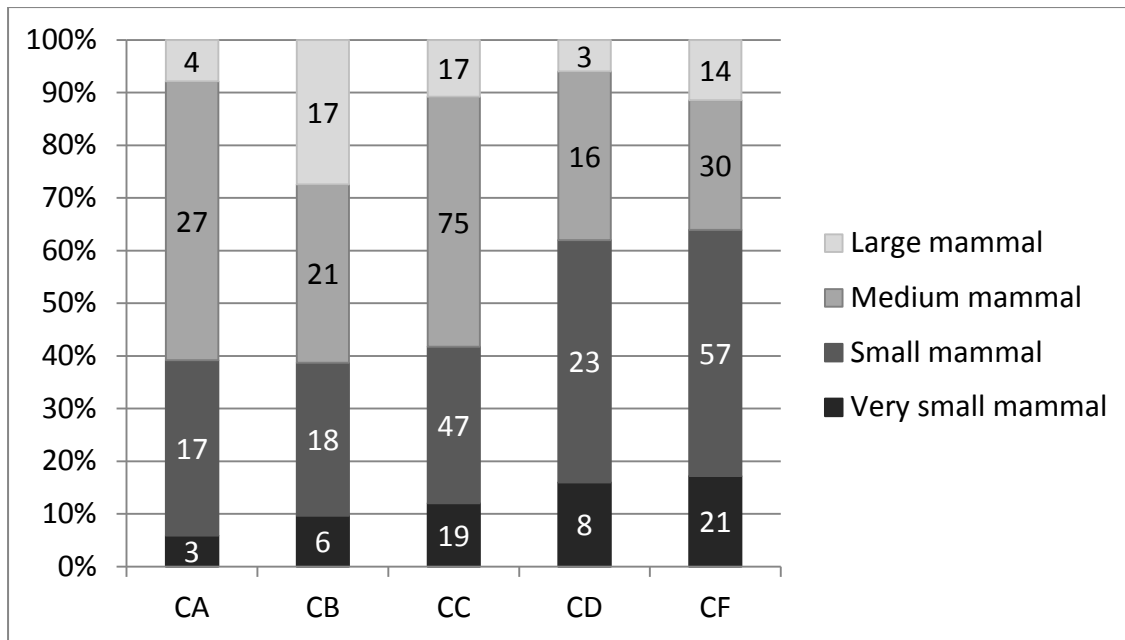


Figure 4.7: Proportions of mammal size classes in the Still Bay at Blombos Cave.

Tortoise remains are prevalent throughout the assemblage (Table 4.7). While they are very common in CF and CD, tortoise abundance drops in CC (Fig. 4.8). From CC, there is a progressive increase in the proportion of tortoise until they peak in CA. The role of tortoise in intensification is discussed in the next chapter (Reynard & Henshilwood, in press) as well as in chapter 8.

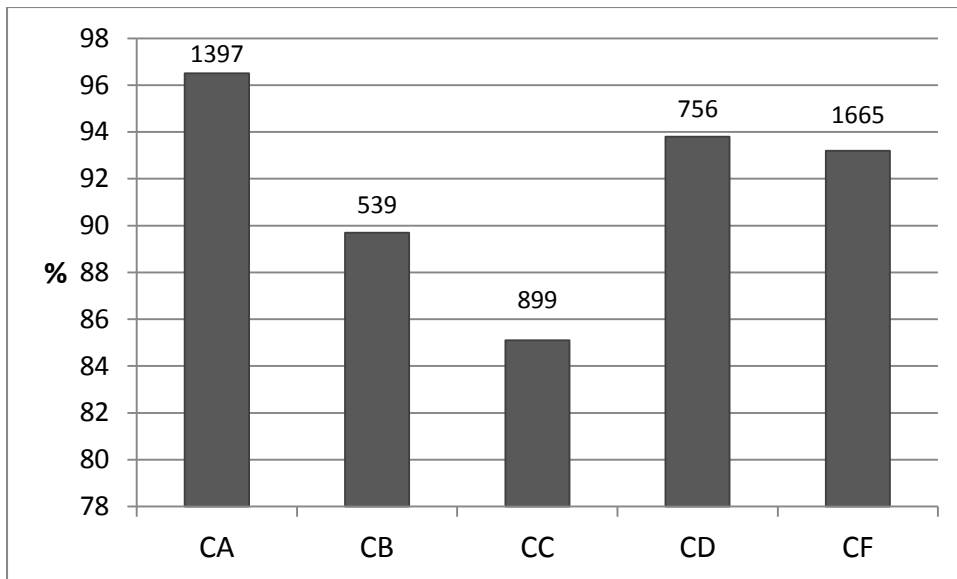


Figure 4.8: Proportions of tortoise remains in the Still Bay layers at Blombos Cave. The data here include all specimens identified as tortoise including shell fragment > 1 cm.

4.2.4 Age profiles

Slightly more specimens at BBC were noted as juveniles (number of unfused/recently-fused ends [n] = 125; 30.5%) compared to fragments with fused ends or adults (n = 122; 29.8%) (Fig. 4.9). There is no significant difference between small mammals and bovid (for adult vs. juvenile: $\chi^2 = 0.0192$; df = 1; p = 0.8898). Carnivores are significantly more juvenile-dominated at BBC compared to bovids ($\chi^2 = 6.353$; df = 2; p = 0.0417) or small mammals ($\chi^2 = 5.211$; df = 2; p = 0.0224).

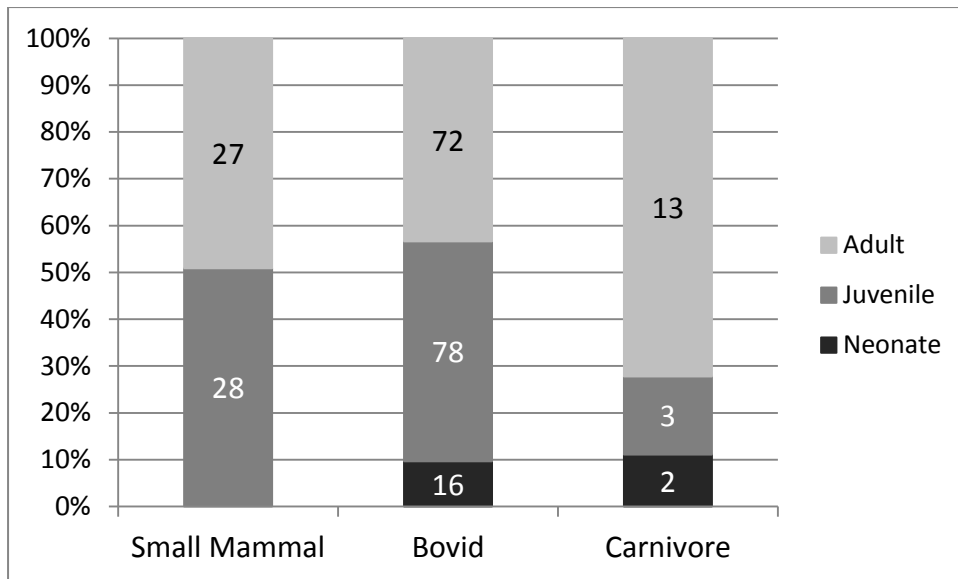


Figure 4.9: Mortality profiles for taxonomic groups. Number of assessed ends in columns

With regard to bovids, size 2 mammals have the highest proportion of juveniles ($n = 23$; 56.1%) while size 1 bovids have the most adults ($n = 50$; 53.2%) (Fig.4.10). There are significant differences in neonates, juveniles and adults between size 1 and 2 bovids ($\chi^2 = 17.749$; $df = 2$; $p = 0.00014$). Large mammals have equal proportions of juveniles and adults (for both: $n = 13$; 40.6%) and there is no significant difference in age classes between size 2 and large mammals ($\chi^2 = 2.381$; $df = 2$; $p = 0.304$). There is a slightly significant decrease in juveniles from the upper M2 through the M1 phase ($\chi^2 = 8.579$; $df = 2$; $p = 0.0137$)

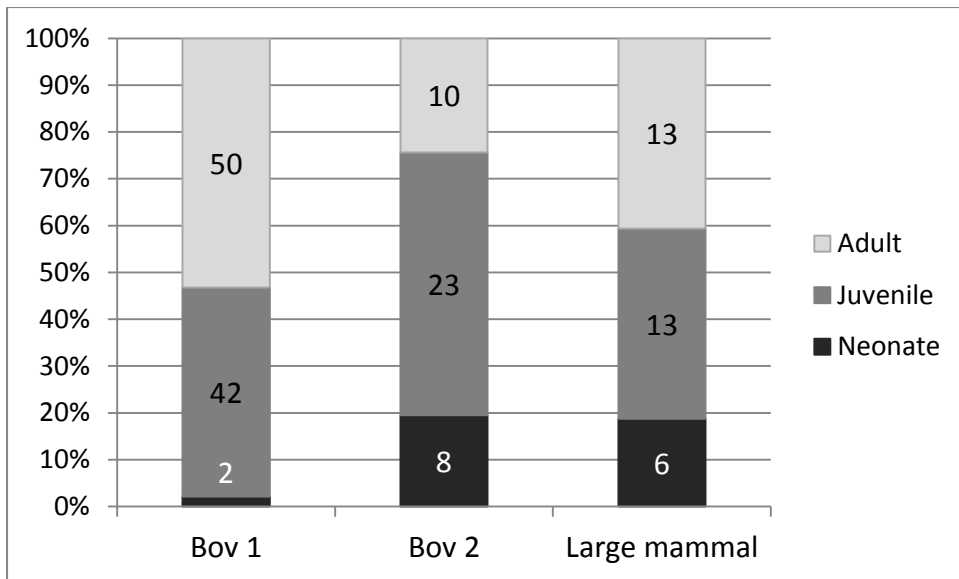


Figure 4.10: Age profiles for bovid size classes

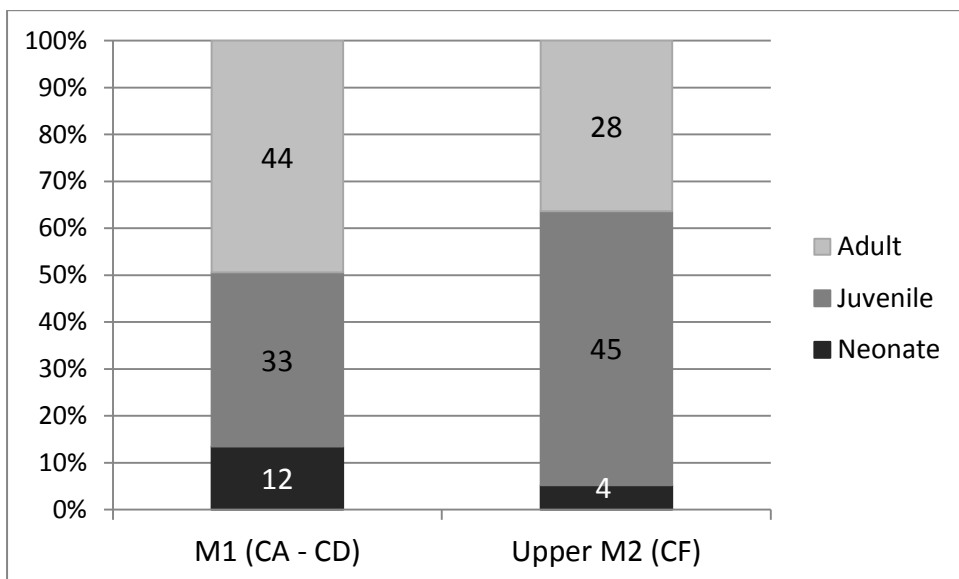


Figure 4.11: Age profiles through the Still Bay

Inferring age through epiphyseal fusion is limited to those fragments where the epiphyses are visible. If we extend our analysis of mortality at BBC to include the surface texture of bone then the sample increases significantly. We noted all specimens with a distinctive porous surface as juvenile while the rest were classes as adult. Chi-squared tests indicate that the results of surface analysis are not significantly different from using epiphyseal fusion in

determining age ($\chi^2 = 2.325$; $df = 1$; $p = 0.1273$). Based on surface texture, we are able to trace trends in the proportion of juvenile exploitation through the Still Bay at BBC (Fig. S3). Surface texture shows a drop in juveniles from the CF to CA. CF/CFA yielded the most juvenile specimens (CF/CFA significantly more than CFB/CFC: $\chi^2 = 10.389$; $df = 1$; $p = 0.013$) according to surface analysis with a spike also visible in CCC (CD vs CCC: $\chi^2 = 5.763$; $df = 1$; $p = 0.016$; CCC vs CC: $\chi^2 = 10.671$; $df = 1$; $p = 0.0012$).

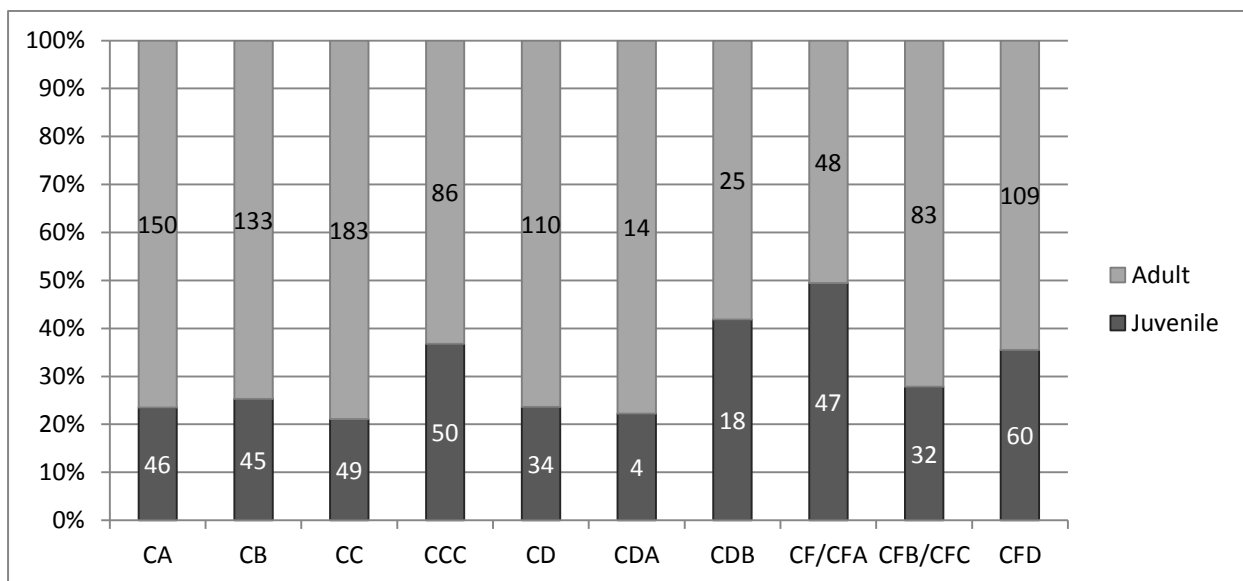


Figure 4.9: Mortality patterns based on surface texture throughout the Still Bay layers at Blombos Cave. Number of assessed specimens in columns

The results of this analysis will be discussed further in the next chapter. There, I will compare this assessment of the BBC fauna with the analysis of the KDS fauna presented in Reynard et al., in press. I also discuss the results of the BBC analysis and its implication in detail in chapter 9.

CHAPTER 4: SUBSISTENCE BEHAVIOUR AT BLOMBOS CAVE

Reynard & Henshilwood. In press

“Subsistence strategies during the later Middle Stone Age in the southern Cape of South Africa: comparing the Still Bay of Blombos Cave with the Howiesons Poort of Klipdrift Shelter.”

Journal of Human Evolution

Figures, tables and captions are attached to the end of manuscripts submitted to JHE. In this chapter, I have embedded the tables and figures within the manuscript.



(Picture by Magnus Haaland)

Subsistence strategies during the Late Pleistocene in the southern Cape of South Africa: comparing the Still Bay of Blombos Cave with the Howiesons Poort of Klipdrift Shelter

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Abstract

The Still Bay (SB) and Howiesons Poort (HP) were two significant techno-complexes in the Middle Stone Age and key periods in the expression of behavioural complexity. In this study, we compare the recently excavated fauna from the SB layers at Blombos Cave (BBC) with faunal analyses from the HP levels at Klipdrift Shelter (KDS). We consider our findings in the framework of recent models for early human subsistence behaviour. In particular, we link our study with models involving resource intensification to examine whether foraging strategies in the HP were more or less intensive than those in the SB. Our results suggest that carnivores had a greater influence on the SB than the KDS assemblage. Processing activities were also significantly different between BBC and KDS – filleting was likely an important strategy at BBC while subsistence activities at KDS may have focused on marrow extraction. Diet breadth is also more extensive at KDS than at BBC, although bovid mortality profiles at BBC are more juvenile-dominated. Taphonomic data suggests that the SB at BBC was a low-intensity, sporadically occupied period in contrast to the high-intensity occupations during the HP at KDS. We argue that this may be related to differences in mobility and residential patterns between these techno-complexes.

KEYWORDS: Middle Stone Age; Zooarchaeology; Still Bay; Howiesons Poort; Intensification; Subsistence strategies

Introduction

From approximately 300 thousand years ago (ka) to 30 ka, the Middle Stone Age (MSA) was a key era in both the anatomical and behavioural development of *Homo sapiens* (Foley and Lahr, 1997; Klein, 2009; Wadley, 2015). The period between 80 ka and 60 ka – roughly occurring during Marine Isotope Stages (MIS) 5a and 4 – incorporates two techno-complexes, the Still Bay (SB) and Howiesons Poort (HP), which represent significant periods in the development of behavioural and cognitive complexity (Henshilwood and Dubreuil, 2011; Henshilwood, 2012; Wurz 2013; Henshilwood et al., 2014). Data from SB and HP sites could therefore be useful in exploring aspects of human behaviour during an era associated with the geographic expansion of people out of Africa (Henn et al., 2012). Comparing these techno-complexes may reveal links between technology and behaviour that in turn could help us understand how *H. sapiens* adapted to their environment.

Taphonomic studies of faunal assemblages are crucial in assessing the subsistence strategies and demographic factors that frame behavioural modernity. Studies of the fauna from HP sites such as Sibudu (Plug, 2004; Clark and Plug, 2008; Clark, 2011), Diepkloof (Steele and Klein, 2013) and Boomplaas (Klein, 1978; Faith, 2013a) in South Africa have revealed significant information on palaeoenvironments and subsistence behaviour during this period. Subsistence data from SB sites, however, are scarce since very few SB sites have well-stratified, *in situ* and well-preserved fauna. Blombos Cave (BBC) is the only site in the southern Cape of South Africa that meets these criteria (Henshilwood et al., 2001a; Thompson and Henshilwood, 2011). Equally rare are MSA sites with well-provenanced fauna that contain both SB and HP sequences (Sibudu [Clark, 2014, although the SB data are not yet published] and Diepkloof [Steele and Klein, 2013], although published taphonomic analyses have not yet been presented). Sequences like these are critical in investigating relationships between these techno-complexes and subsistence variability in the later MSA. In lieu of a single site in the southern Cape that contains both the SB and HP, we examine the faunal assemblages from these time periods at two sites in close proximity to one another.

Here, we compare faunal remains from the SB layers (c. 77 – 68 ka) of the 2011 and 2013 excavation seasons at BBC, with those from the HP sequence (c. 66 – 59 ka) at Klipdrift Shelter (KDS) (Henshilwood et al., 2014; Reynard et al., in press). In our faunal analysis, we incorporate models to investigate whether subsistence intensification was evident at either site. KDS is

located close to BBC (~ 45 km away) and contains an extensive HP sequence. BBC and KDS both occur in the Cape Floral Region (CFR) in the southern Cape of South Africa (Henshilwood et al., 2001a, 2014). Because similar techniques and methods were used to analyse the fauna from both sites, the results are comparable and differences in the bone assemblages between these sites are likely due to environmental change through time, differences in human behaviour and/or taphonomic history.



Figure 1: Blombos Cave, Klipdrift Shelter and Pinnacle Point in the southern Cape of the Western Cape Province of South Africa

Site descriptions

Palaeoenvironment

BBC and KDS are on the southern Cape coast of South Africa (Fig. 1), with the mouth of the *Breede* River located between the two sites. The surrounding habitat is dominated by *fynbos* vegetation – evergreen, sclerophyllous shrubland – that thrives in winter-rainfall/dry summer environments in the CFR (Bergh et al., 2014). Modern-day faunal communities in the *fynbos*

biome consists mostly of animals adapted to shrubland environments such as small mammals (e.g., hyrax [*Procavia capensis*] and Cape dune mole rat [*Bathyergus suillus*], tortoise and small, browsing bovids (e.g., Cape grysbok [*Raphicerus melanotus*] and klipspringer [*Oreotragus oreotragus*]) (Skinner and Chimimba, 2005; Radloff, 2008). Although still present in the CFR, large ungulates such as rhinoceros (*Diceros/Ceratotherium* sp.), alcelaphines, hippopotamus (*Hippopotamus amphibius*) and African buffalo (*Syncerus caffer*) were more prevalent in the Holocene and Pleistocene (Skead, 1987; Faith, 2011). The transition from MIS 5a to 4 involved significant decreases in temperatures and probable climatic instability (Bar-Matthews et al., 2010). Palaeoenvironmental conditions would likely have been influenced by the broad, shallow continental shelf known as the Agulhas Bank off the present-day coast of the southern Cape, resulting in fluctuating shorelines between glacial and interglacial periods. Marine regressions would therefore have significantly affected the availability of habitable land and foraging ranges for Late Pleistocene southern Cape populations.

Blombos Cave

BBC (34°24'51"S, 21°13'04"E) is located ~ 25 km west of the town of Still Bay and 300 km east of Cape Town. It is approximately 100 m from the Indian Ocean and 34.5 m above sea level (Henshilwood et al., 2001a; Henshilwood, 2008). The BBC MSA sequence occurs below a layer of sterile, yellowish dune sand named 'BBC Hiatus' and consists – in sequence from top to bottom – of four MSA occupational phases: a M1 phase; an upper and lower M2 phase; and a M3 phase (Henshilwood et al., 2001a) (Fig. 2). The fauna analysed for this paper was recovered from the SB period which encompasses the M1 and upper M2 phases. The M1 deposit contains numerous basin-shaped hearths and is characterised by bifacial, foliate lithic points, the *fossile directeur* of the SB techno-complex (Henshilwood et al., 2001a). The upper M2 contains large hearths, shellfish, fewer bifacial points and a formal bone tool industry (Henshilwood et al. 2001b). Engraved ochre plaques (Henshilwood et al., 2002, 2009), perforated shell beads (Henshilwood et al., 2004; Vanhaeren et al., 2013), bone tools and engraved bone (Henshilwood and Sealy, 1997; Henshilwood et al., 2001b; d'Errico and Henshilwood, 2007) have also been recovered from these phases, in addition to three human teeth (Grine et al., 2000).

The Still Bay levels at Blombos Cave have been dated using a number of methods, including thermoluminescence (TL), optically stimulated luminescence (OSL) and electron spin resonance

(ESR) (Jones, 2001; Henshilwood et al., 2002; Jacobs et al., 2003a, b; Tribolo, 2003; Jacobs et al., 2006a, b; Tribolo et al., 2006). BBC hiatus above the M1 phase is dated by OSL to 69 ± 5 and 70 ± 5 ka (Henshilwood et al., 2002; Jacobs et al., 2003a, b, 2006a, b). An OSL age of 72.7 ± 3.1 ka was obtained for the upper part of the M1 phase (Jacobs et al., 2003a, b). TL ages for the M1 phase are 74 ± 5 and 78 ± 6 ka (Tribolo et al., 2006). The OSL age for the upper M2 layers that contain bifacial points is 76.8 ± 3.1 ka (Jacobs et al., 2006a). In 2010 the Still Bay levels were resampled for OSL dating and the new ages for the Still Bay at Blombos Cave are 75–72 ka (Jacobs et al. 2012). Taking into account earlier dating results and those obtained using the TL method, we suggest that 75 ka should be regarded as the *terminus post quem* for the SB levels at BBC.

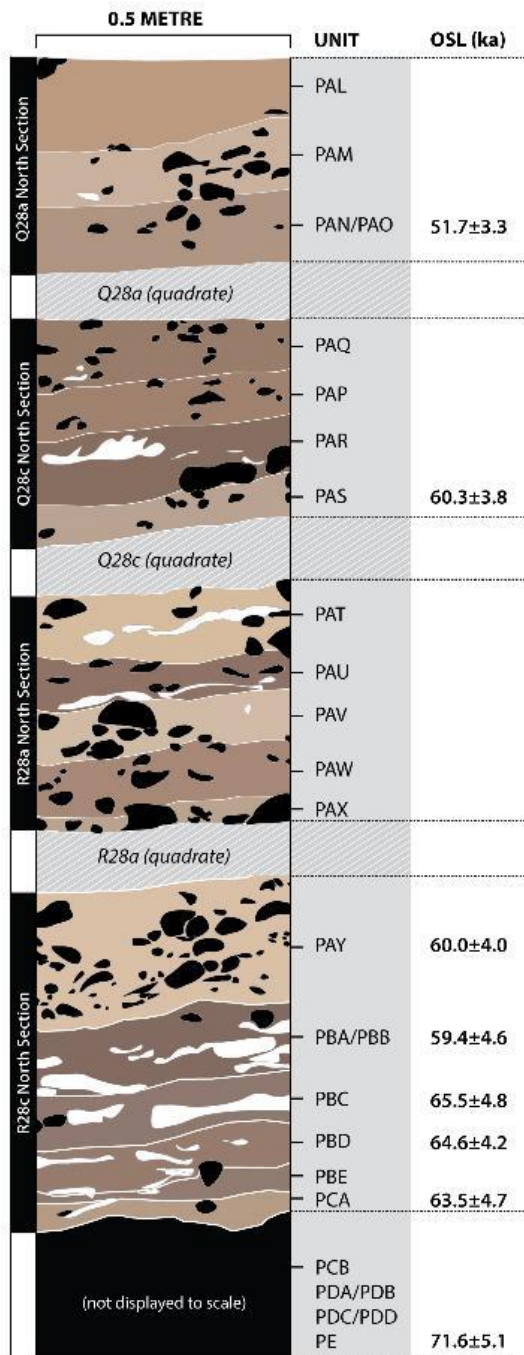
Previous research on the fauna from BBC focused on palaeoenvironments (Henshilwood et al., 2001a; Henshilwood, 2008; Hillestad-Nel, 2008), the relationship between the SB and Pre-SB layers (Thompson, 2008; Thompson and Henshilwood, 2011), the role of tortoises in subsistence strategies (Thompson, 2014a, 2014b) and spatial variability in the SB (Discamps and Henshilwood, 2015). Significant research on the BBC fauna has been undertaken by Thompson (2008; Thompson and Henshilwood, 2011). Her analyses suggest that people were the primary bone accumulators although carnivore scavenging is also noted. However, there was little evidence that carnivores accumulated prey and brought bone into the cave; carnivore involvement was mainly through scavenging of human-collected bone. The assemblage displayed a moderate amount of bone density-mediated attrition. She found variability in subsistence behaviour through the entire BBC sequence and suggests that the M1 phase was probably more intensely occupied than the M2 or M3 phases.

Klipdrift Shelter

KDS is part of the Klipdrift Complex ($34^{\circ}27.0963'S$, $20^{\circ}43.4582'E$), a vadose cave situated in the De Hoop Nature Reserve, about 150 km east of Cape Town. It is ~ 17 m above sea level within a limestone cliff underlain by Table Mountain Groups sandstones (Malan, 1989). Over $7m^2$ of deposits form a talus with a slope of $\sim 38^{\circ}$. The truncated deposits are probably the result of marine erosion from raised sea levels during the mid-Holocene.

MSA layers at KDS have been dated to between *c.* 71.6 ± 5.1 ka (Layer PE) and 51.7 ± 3.3 ka (Layer PAN/PAO) using single-grain OSL methods (Fig. 2). Lithics recovered from layers PCA to PAY have been assigned to the HP techno-complex and PAY may be transitional to the post-HP (Henshilwood et al., 2014). The HP layers (PCA to PAY) have been dated to between 65.5 ± 4.8 ka and 59.4 ± 4.6 ka. Shellfish remains occur in most layers with little or no shell below PCA. Engraved ostrich egg shell was recovered from layers PCA to PAY with most pieces in PBD. At both BBC and KDS, the site floors were divided into 50 x 50cm squares and all excavated material was sieved through 3mm and 1.5mm mesh screens. Previous research on the KDS fauna involved a taphonomic analysis (Reynard et al., in press). This analysis suggests that KDS was an intensively occupied site where marrow-processing was common, even on low-ranked elements (Reynard et al., in press). A recent palaeoecological study of KDS shows that occupational intensity was focused in the middle layers of the HP sequence and may have been linked to environmental change in the southern Cape coast (Reynard et al., 2016). The analysis in this study is based on data contained in those studies.

a Klipdrift Shelter



b Blombos Cave

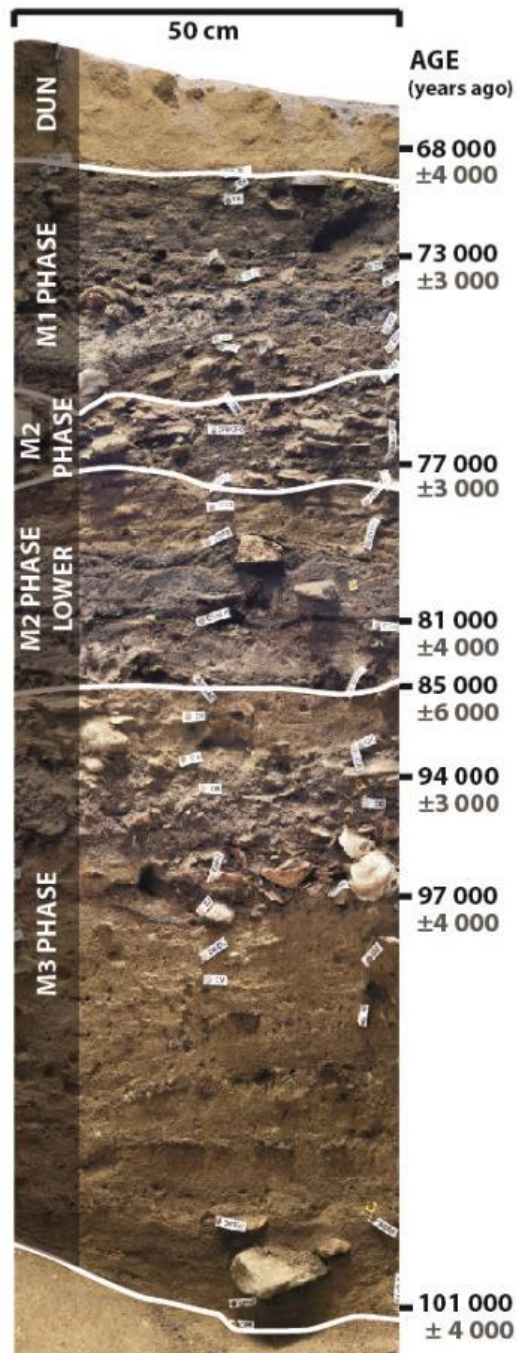


Figure 2: Stratigraphy and optically stimulated luminescence (OSL) dates for (a) Klipdrift Shelter and (b) Blombos Cave (images courtesy of Magnus Haaland and Christopher Henshilwood)

Subsistence strategies during the Middle Stone Age

Various models explaining subsistence behaviour in the Late Pleistocene have been suggested by archaeologists. Binford's (1984) hypothesis on the dominance of scavenging in the MSA based on faunal remains from Klasies River has, on the whole, been rejected based on re-analyses (Milo, 1998; Klein, 1989; Turner, 1989) and evidence from newly excavated sites (Marean 1998; Bartram and Marean, 1999; Marean and Assefa, 1999). Klein's (1974, 1975, 1981; Klein and Cruz-Uribe, 1996) argument for 'less competent' hunters in the MSA based on cognitive abilities has also been criticised (Marean and Assefa, 1999; Faith, 2008, 2011; Dusseldorp, 2010).

Optimal foraging theory (OFT) models predict that people hunt and gather as efficiently as possible and attempt to forage the most 'profitable' subsistence resources within certain constraints (Dusseldorp, 2012; Winterhalden, 2001). These constraints are addressed by various models. The diet breadth or prey choice model, for example, assumes that prey can be ranked according to their caloric value – generally measured as body size (MacArthur and Pianka, 1966; Hames and Vickers, 2009) – while patch choice models assume that resources are distributed heterogeneously in 'patches' across a terrain (Kelley, 1995). A variation of the patch choice model, the marginal value theorem, factors in certain time-constraints involved in patch foraging (Burgher et al., 2005). Other models, such as the central-place foraging model, define how foragers maximize net returns while traveling to and from concentrated resource 'patches' (Bettinger and Malhi, 1997). Simply put, the net profitability of prey is defined by its caloric value (body size or quantity), the number of carriers involved and the distance needed to procure it, and its handling cost. Given that most of these factors are archaeologically invisible, applying the various models is often challenging and ethnographic studies have been useful in trying to link theory with empirical data (Monahan, 1998; Lupo, 2006; Schoville and Otárola-Castillo, 2014). Recent studies have, however, successfully utilised OFT in MSA/Middle Paleolithic faunal analyses (Clark 2011; Dusseldorp 2010; 2012; Langejans et al. 2012; Thompson and Henshilwood, 2014a) and our study incorporates much of this reasoning.

Resource and subsistence intensification can be contextualized within the framework of OFT (e.g., Binford, 1968; Schoener, 1974). Subsistence intensification is seen as reflecting socio-ecological stress and has been defined as the extraction of increased amounts of energy from a given area at the expense of foraging efficiency (Schoener, 1974; Munro, 2009: 141). First put

forward by Flannery (1968) to explain the rise of agriculture, the premises linked to intensification are that, as resources are depleted through increasing populations/population pressure (Stiner et al., 1999; Stiner, 2001; Stiner and Kuhn, 2006; Munro, 2009; Jerardino, 2010) or environmental degradation (Henshilwood and Marean, 2003; McCall, 2007), more labour-intensive strategies are employed that produce lower rates of returns (O'Connell and Hawks, 1981; Bird and O'Connell, 2006; Minichillo, 2006). Intensification has also been suggested to have occurred in the SB. McCall (2007) and colleagues (McCall and Thomas, 2012) argue SB technology was multi-functional and a response to environmental instability during MIS 4. They also suggest that HP lithics were task-specific tools associated with the targeting of localised, seasonal resources. Both techno-complexes, they propose, can be linked to environmental or demographically induced intensive strategies. At Sibudu, increased dietary breadth during the HP may also signify resource stress, although changing environments may also have played a role (Clark, 2011). Recent studies focusing on the small fauna from BBC (Badenhorst et al., 2014; Thompson and Henshilwood, 2014a, 2014b) indicate that a broad diet breadth was evident in the SB and pre-SB layers there but the question remains as to whether this is related to environmental or ecological factors, or had intensive subsistence strategies played a role.

Increased dietary breadth is frequently associated with intensification but is also linked to technological capabilities. Research suggests that there were significant increases in the exploitation of low-ranked fauna such as shellfish and small mammals during the Late Pleistocene in Eurasia (Stiner et al., 1999, 2000; Marean, 2005; Munro and Atici, 2009) and Africa (Steele and Klein, 2009; Wadley, 2010; Clark and Kandel, 2013). This was most likely as a result of the geographic expansion of modern humans (Stiner et al., 2000; Clark and Kandel 2013; Kandel et al., 2015). Tortoise and shellfish, prevalent at many MSA sites along the southern Cape, are generally smaller during the Later Stone Age (LSA) and some researchers have argued that this was due to their over-exploitation during the LSA as a result of increased population pressure (Steele and Klein, 2009). Increased dietary breadth may also be linked to the development of flexible, adaptable subsistence strategies facilitated by technology (Kandel et al., 2015). In addition to the technological capacity of people in the Late Pleistocene (McBrearty, 2012; Coolidge et al., 2016), a predominance of small, taxonomically-diverse, hard-to-catch fauna may be one of several indicators for the use of nets, snares or traps in the procurement of prey (Wadley 2010). An example is the common occurrence of birds and fish in LSA faunal

collection and the relative scarcity of this type of low-ranked fauna at MSA sites (Plug and Clark, 2008; Van Niekerk, 2011; but see Val, in press). Indeed, technological innovation can result in the exploitation of previously ‘unprofitable’ prey with returns surpassing those from exploiting prey that is generally considered more highly ranked (Ugan, 2005; Dusseldorp, 2010). This may be the case for the appearance of ‘more competent’ hunters in the LSA. It has been argued intensification in the LSA may be a consequence of the successes of MSA foragers who depleted their environments (McBrearty and Brooks, 2000; Faith, 2008) or it may be linked to natural glacial/interglacial cycles with poorer environments in the Holocene contrasting with more diverse Pleistocene habitats (Faith, 2011).

Materials and methods

Analytical Framework

We build on the models discussed above by proposing that intensification is more evident in the HP than the SB. Our hypothesis is based on previous research that suggests that subsistence strategies may have been more intensive in HP faunal assemblages (cf. Clark, 2011; Reynard et al., in press). Earlier taphonomic studies on BBC show that SB occupations were probably relatively ephemeral given the evidence of carnivore involvement at BBC (Thompson and Henshilwood, 2011). Based on this, we would expect that SB fauna display less signs of intensification. In the context of our paper, subsistence intensification includes the processing of low-ranked game (e.g., rodents and hyraxes), low-utility elements (phalanges, pelves and calcanei) and an increase in the abundance of juvenile prey (cf. Stiner et al., 2000; Munro, 2004; Steele and Klein, 2009; Clark, 2011). In particular, we examine and compare:

1. The exploitation of low-ranked prey

The diet breadth model predicts that ‘high-ranked’ taxa such as calorie-rich, prime-aged bovids and/or easy-to-catch fauna would more likely be pursued when encountered. Within productive environments, high-ranked prey should therefore dominate bone assemblages since the effort taken to hunt smaller, more nutritionally-depleted fauna such as juveniles should generally outweigh the caloric benefits (Munro 2004; Clark 2011). Intensification occurs when the subsistence base is broadened to include ‘low-ranked’ fauna such as small, difficult-to-catch and low-calorie game (rodents and birds) and juvenile individuals.

2. The exploitation of low-utility elements

During periods of resource stress it is expected that processing intensity would increase. Phalanges, calcanei and mandibles have little marrow reserves (Binford, 1978; Morin, 2007) so the low rate of return for processing these elements may be construed as intensification (Clark 2011; but see Jin and Mills, 2011 for an alternative explanation for phalange processing). A higher proportion of nutritionally-depleted elements such as these in an assemblage therefore imply more subsistence intensive strategies.

3. Variations in transport distances

Under OFT models, prey is more likely to be procured closer to home-bases within certain ecological constraints such as those defined by the productivity of local patches. As foraging distances increase, transporting game becomes calorically costly and at increasing distances, the skeletal-parts transported back are more likely to be meat or marrow-rich elements such as upper limbs (femora or humeri) (Jochim, 1979; Winterhalder, 2001). Increasing foraging ranges may suggest intensification when the costs of transporting carcass remains begin to exceed the caloric benefits of the prey (Metcalf and Barlow, 1992; Faith, 2007; cf. Clark, 2011: 277). To investigate transport distances, we examine the proportions of skulls to post-cranial remains of ungulates. Research on modern foragers suggests that the proportion of skulls to post-cranials for large prey decline as foraging distances increases (O'Connell et al., 1988; Monahan, 1998). Similarly, the ratio of crania to mandibles can also depend on transport distances (Speth and Clark, 2006). Mandibles – which contain some marrow and the tongue – are more likely to be removed from the skull at the kill-site with increasing foraging distances while the heavier cranium is left behind.

Our hypothesis is that intensification would result in: 1) an increase in small ground game (e.g., hyrax [*Procavia capensis*] and Cape dune mole rat [*Bathyergus suillus*]) above and beyond what would be expected by environmental change alone; 2) a greater reliance on marrow exploitation of low-ranked elements as diet breadth increases, and; 3) the procurement of more immature individuals. Because only two seasons of faunal remains have been analysed from BBC, the dataset is relatively small but we feel that comparisons between BBC and KDS are nevertheless appropriate. An important aspect of this study is the methodological similarity between the BBC

and KDS faunal analyses. However, as a result of this, our data could not be combined or compared with Thompson and Henshilwood's (2011) taphonomic analyses of BBC since different methods were used to assess the assemblages. For example, in examining percussion marks, we look at the proportion of all percussive marked specimens while Thompson and Henshilwood (2011: 16) present the relative proportion of midshaft long-bone fragments within bovid size classes. It is important to note this study involves only mammalian fauna. Because of that and the relatively small sample sizes, this analysis should be viewed as a preliminary investigation into subsistence intensification in the Late Pleistocene in South Africa.

The Blombos Cave and Klipdrift Shelter fauna

Faunal remains from BBC and KDS were assessed following Driver (2005) and Klein and Cruz-Uribe (1984) using the comparative faunal collections of the Ditsong National Museum of Natural History (formerly the Transvaal Museum) in Pretoria. In this study, we examined identified faunal remains and long-bone fragments not identified to element recovered from the 2011 and 2013 excavation seasons at BBC (Fig. 3) and compare it to the 2011 and 2012 excavations at KDS. At BBC, of the 6665 identified mammalian and tortoise specimens, a total of 648 specimens (9.7%) could be identified at least to the class level. At KDS, 35 864 specimens were examined and 2 266 (6.3%) could be identified to at least the class level. The original analysis of the KDS fauna is in Reynard et al., (in press). To compare BBC with the KDS dataset, we restrict our analysis to the macro-mammalian fauna. Taxa, element, skeletal portion, side, state of epiphyseal fusion, types of surface modification, fracture patterns, length and – where possible – long-bone cortical thickness were recorded for all specimens. Post-cranial remains of bovids are consigned to size classes based on Brain (1974). Remains that could only be identified to element and not categorised beyond class (e.g., cranial and vertebral fragments) are assigned to 'small', 'medium' or 'large' indeterminate mammal size classes. At BBC, an additional category: 'very small mammal' was included. Very small mammal are species smaller than the Cape dune molerat (*Bathyergus suillus*), small mammals ranging in size from the Cape dune molerat up to and including size 1 bovids, medium mammals correspond to size 2 bovids, large mammals to size 3 and 4 bovids and very large mammal are equivalent to size 5 bovids. Unless otherwise noted, Cape fur seals (*Arctocephalus pusillus*) are excluded in our discussions

on carnivores because they would not have contributed to the faunal assemblage as bone collectors.

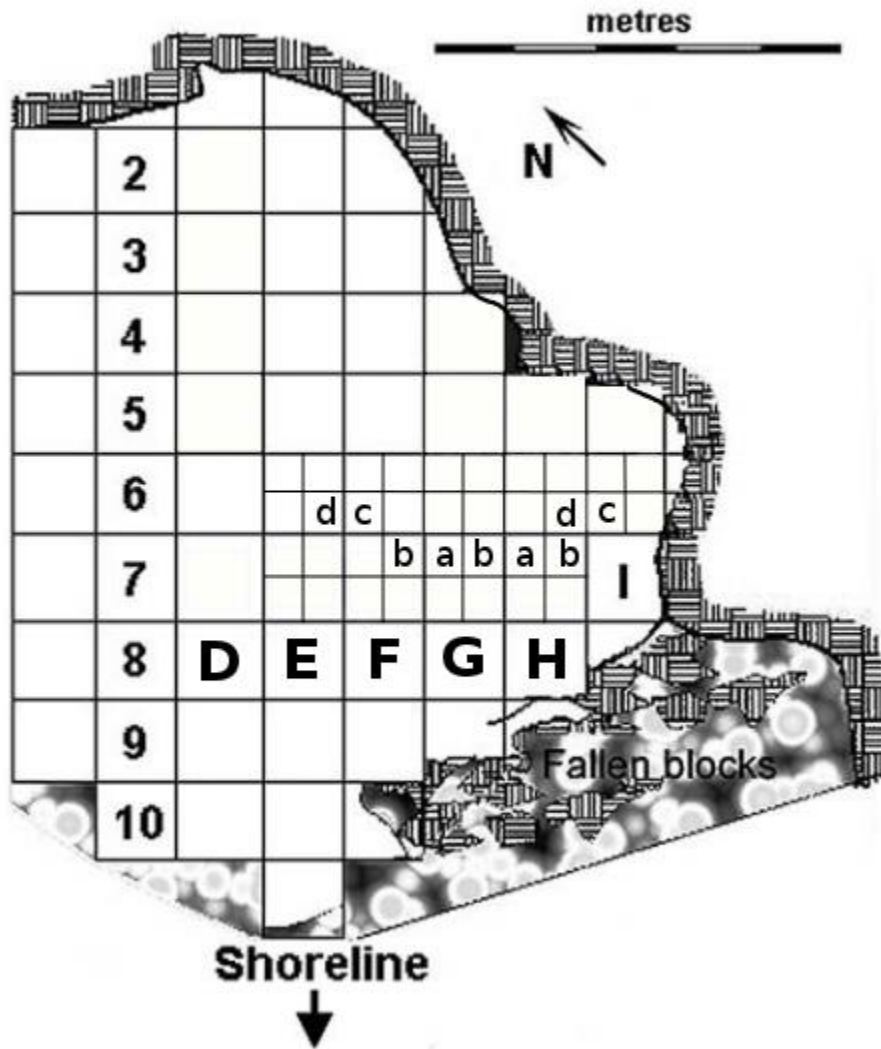


Figure 3: Site map of Blombos Cave. Lowercase letters represent squares examined in this study

Since the focus of this study is the macro-mammal collection, microfauna (fauna with an adult weight < 700 g) and tortoise remains were counted but not included in our analysis. At KDS, very small mammals were incorporated into either the ‘small mammal’ or ‘microfauna’ category. ‘Large’ and ‘very large’ indeterminate mammal remains are combined with large ungulates

(perrisodactyls and bovids \geq size 3) and referred to as ‘large mammal’ due to the relatively small sample sizes (cf. Thompson and Henshilwood, 2011). Similarly, we often combine size 2 bovids with indeterminate medium mammal remains when analysing bone density-mediated attrition or utility indices. The lack of large carnivore remains in our sample (cf. Henshilwood et al., 2001a; Reynard et al., in press) suggests that most ‘medium mammal’ specimens belong to ungulates. The combined size 2 bovid and medium mammal sample is referred to as ‘size 2 mammals’. Taxa denoted as ‘cf.’ are included in the analysis.

Methodology

All specimens were measured and fracture and modification statuses recorded. Specimen length is classified as either code 1 (0 – 0.9 cm), code 2 (1 – 1.9 cm), code 3 (2 – 2.9 cm), etc. Fracture patterns are based on Villa and Mahieu (1990) and categorised as spiral, transverse and irregular. For long-bone fragments, cortical thickness is recorded. Faunal specimens were examined with a Nikon binocular light microscope (10 – 40x magnification) under oblique, unidirectional, incandescent lighting. Pre- and post-depositional surface modification was assessed following standard criteria (Behrensmeyer, 1978; Blumenschine and Selvaggio, 1988; Blumenschine et al., 1996). Burning was defined using a three-stage colour method (black, grey or white) and ‘localised’ or partial burning based on previous research (e.g., Brain, 1981; Nicholson, 1993; Stiner et al., 1995; Driver, 2005). To assess subsistence strategies related to burning at BBC, we also examined all unidentified bone fragments > 2 cm ($n = 1052$) from that site and divided them into ‘spongy’ or cancellous specimens ($n = 123$), cortical or compact fragments ($n = 719$) and cortical fragments with spongy bone attached ($n = 210$). These unidentified bone data from BBC were only used to measure burnt bone as refuse or possible fuel and not included in other analyses or tables.

Skeletal-part profiles can be used to explore the handling and transport decisions of forager-based societies (O’Connell et al., 1990; Metcalfe and Barlow, 1992; Bird and O’Connell, 2006; Faith, 2007). We adjust for the expected frequency that a particular skeletal element should occur in the complete carcass of an ungulate by ‘normalising’ the NISP (cf. Hesse and Perkins, 1974; Grayson, 1984; Grayson and Frey, 2004; Faith, 2007; Clark, 2011). The normed NISP (nNISP) is the number of elements documented divided by the amount of times those elements should occur in a complete skeleton. Following previous research (Clark, 2011; Reynard et al., in press),

skeletal-parts of ungulates are categorised into five skeletal groups: the head, forelimb, hindlimb, distal limbs and extremities (Table 1). To measure the frequency of skeletal-groups in ungulates, we add the nNISPs for elements in skeletal-group and divide that figure by the number of elements that make up a skeletal-group for a single individual. For example, we define the hindlimb as the innominate, femur, patella and tibia. We therefore add the nNISP values for those four elements and divide it by four: the expected value for each skeletal-group will thus be one. In size classes where density mediated attrition has affected element representation, we use only high-survival elements (skulls and long-bones) in our classification of skeletal-groups (cf. Marean and Cleghorn, 2003). In this regard, the hindlimb then consists of the femur and tibia only.

Table 1: Definition and classification of skeletal groups

Skeletal group	All elements	High survival only
Head*	Cranium, mandible, hyoid, horncores	Cranium, mandible, hyoid, horncores
Forelimb	Scapula, humerus, radius, ulna	Humerus, radius, ulna
Hindlimb	Innominate, femur, patella, tibia	Femur, tibia
Distal limb	Carpals, tarsals, metapodia	Metapodia
Extremities	Phalanges, sesamoids	-----

**Teeth are excluded*

Food utility indices are often used to measure the economic value of elements (Binford, 1978; Brink, 1997; Frieson, 2001; Morin, 2007; Morin and Ready, 2013). We measure Standardised Food Utility Indices (SFUI), Meat Utility Indices (MUI), Unsaturated Marrow Indices (UMI) and Meat Drying Indices (MDI) for all elements and high-survival elements (Metcalf and Jones, 1988; Frieson, 2001; Morin and Ready, 2013). Nutritional value – whether meat, marrow or dried-meat utility – should correlate positively with skeletal-abundance (as measured by nNISP) if meat (MUI), marrow (UMI), dried meat (MDI) or a combination of these (SFUI) was the desired subsistence goal (Metcalf and Jones, 1988).

Skeletal element evenness for size 1 and size 2 bovids and large mammals were also calculated based on Faith and Gordon (2007). This index uses the proportion of long-bones in an assemblage to infer foraging strategies. Faith and Gordon (2007) propose that skeletal evenness can be modeled on the utility strategies suggested by Binford (1978), namely: 1) *bulk strategy*, where the maximum number of anatomical parts (high quantity) are transported back to base-camp from a kill-site; 2) *gourmet strategy*, where elements are transported back to base-camp based on the selected desirability of the anatomical parts (high quality); 3) *unbiased*, where skeletal parts are transported proportional to their economic utility. Faith and Gordon (2007: 874) also include an ‘*unconstrained*’ strategy in which skeletal parts are transported based on their abundance in a complete carcass and not on economic utility. Evenness indices also link element abundance with utility (in the form of SFUI). Only if these conditions are met can element evenness be categorised into one of the above utility transport strategies.

An important criterion in this study is diet breadth. One measure of diet breadth is taxonomic richness which can be defined as the number of taxa (NTAXA) within an assemblage (Lyman 2008). We examine general mammalian taxonomic richness to explore the range of all mammalian taxa in the assemblages and calculate NTAXA to the level of genera. Taxonomic richness is affected by sample sizes because larger samples are likely to produce higher NTAXA (Grayson, 1984; Lyman, 2008). Since the relationship between sample size and NTAXA is logarithmic (Wolff, 1975), we use a *richness index* ($\text{NTAXA}/\log \text{NISP}$) calculated by dividing NTAXA by the log of the number of specimens in the taxa under consideration (Lyman, 2008). To further compensate for sample size differences, *residual analyses* (where residuals above or below regression lines are measured) were conducted. These are then compared to *Fisher’s α* – a simple measure of diversity – since these measurements are reasonably insensitive to sample size discrepancies (Magurran, 2004; cf. Faith, 2013b).

Due to a lack of assessable teeth (and to compare data from BBC with KDS), specimens with epiphyseal plates such as phalanges, long-bones and vertebrae fragments were examined for indicators of age. Bone with fused epiphyses are categorised as adult, while those that were ‘unfused’ or ‘recently-fused’ are classed as juvenile. For a specimen to be examined, at least one end should have an epiphysis. We were able to assess 205 specimens from BBC and 411 specimens from KDS for epiphyseal fusion.

Results

In this section, we compare the data from BBC to KDS. The primary KDS data is published in Reynard et al. (in press). We first assess the taphonomy of the assemblages to establish occupational history, and then compare skeletal-profiles, diet breadth and mortality profiles.

Taphonomic history

Table 2: Burnt fauna at Blombos Cave

Modification	Blombos Cave		Klipdrift Shelter	
	n	%	n	%
Burn (L)	422	31.6	588	19.4
Burn (Bl)	149	11.2	392	12.9
Burn (Gr)	66	4.9	124	4.1
Burn (W)	30	2.2	122	4.0
Burn (Total)	667	50.0	1226	40.5
Percussion mark	114	8.5	901	29.8
Cut mark	76	5.7	148	4.9
Tooth mark	82	6.1	13	0.4
Gnaw mark	5	0.4	6	0.2
Root etching	80	6.0	341	11.3
Weathering	3	0.2	8	0.3
Acid etching	22	1.7	103	3.4
Encrustation	168	12.6	179	5.9
Total specimens	1336		3030	

Bone accumulators Half of the BBC sample exhibit evidence of burning (50%; n = 667) with most specimens partially burnt (31.6%; n = 422) (Table 2). Less than 9% (n = 114) of specimens display percussion marks (Table 3). Tooth marks (6.1%; n = 82) are more prevalent than cut marks (5.7%; n = 76) and gnaw marks are rare (0.4%; n = 5). Besides burning, the most common form of surface modification is ‘encrustation’: a sediment-like, consolidated material on the surface of bone specimens. It is likely alkaline-based and associated with calcium carbonate-rich sediment and some of it may be gypsum sulphate (cf. Thompson 2008). At KDS, bone preservation is generally better than at BBC with less encrusted surfaces. There, burning is the most common form of bone modification (n = 1226; 40.5%) followed by percussion marks (n = 901; 29.8%). Tooth (n = 13; .4%) and gnaw marks (n = 6; 0.2%) are proportionally less common than at BBC. Encrustation was less common on the KDS specimens (n = 179; 5.9%) than at BBC.

Compared to KDS (Reynard et al., in press), fauna from BBC has significantly less anthropogenic markings (chi-squared for comparing specimens with cut and percussion marks with those without at BBC and KDS: $\chi^2 = 189.82$; df = 1; p < 0.0001). Tooth marks, while relatively common at BBC (6.1%; n = 82), are significantly less at KDS (0.4%; n = 13) ($\chi^2 = 141.955$; df = 1; p < 0.0001). Burnt bone is also significantly more prevalent at BBC (50%; n = 667) than at KDS (40%; n = 1226) ($\chi^2 = 33.809$; df = 1; p < 0.0001).

Table 3: Fracture patterns at Blombos Cave and Klipdrift Shelter. Percentages with numbers of fractured ends in brackets

Samples	Spiral	Transverse	Irregular
Blombos Cave	60.6 (287)	30.6 (145)	8.9 (42)
BBC (TH)*	73.8 (2002)	22.0 (597)	-----
Klipdrift Shelter	52.9 (222)	44.3 (186)	2.9 (12)

* Data from Thompson & Henshilwood (2011). Fracture outlines used to define breakage pattern. Curved outline = spiral fracture

Fragmentation The extent of the fragmentation of bone assemblages may relate to intensive anthropogenic processing. For this reason, we assess fragmentation patterns and bone density-

mediated attrition for both BBC and KDS. Burning desiccates bone making it more brittle. Burnt bone is therefore more likely to exhibit transvers or dry fractures. Fracture patterns are calculated for unburnt, identified ungulate long-bone and both BBC and KDS are dominated by spiral fractures (Table 3). Experimental research by Marean (2000) suggests that if the proportion of transverse fracture in an assemblage is above ~ 4.5%, it is usually the result of post-depositional breakage. Transverse fractures are substantially higher than 4.5% at both BBC and KDS which implies that post-depositional attrition was influential at both sites.

Generally, both medium-sized and large ungulates from BBC are affected by bone density-mediated attrition (Table 4). Following Marean and Cleghorn (2003), if only high-survival elements – i.e., the skull and long-bones – are included in the analysis, taphonomic attrition is less likely to affect skeletal-part profiles. We note that in the large mammal sample from KDS, even high-survival elements are affected by bone attrition. There is no significant relationship between element destruction and skeletal-part representation in medium mammals at KDS. Fragment lengths for unidentified long-bone fragments are smaller at KDS (mean code = 2.7) than at BBC (mean code = 3.2).

Table 4: Spearman's' rank-order correlation between skeletal-element abundance (normed NISP) of medium and large ungulates and 'high survival' element bone densities (caribou and wildebeest data in Lam et al., 1999). Size 2 mammals compared to caribou data. Large mammals compared to wildebeest data. Significant values emboldened

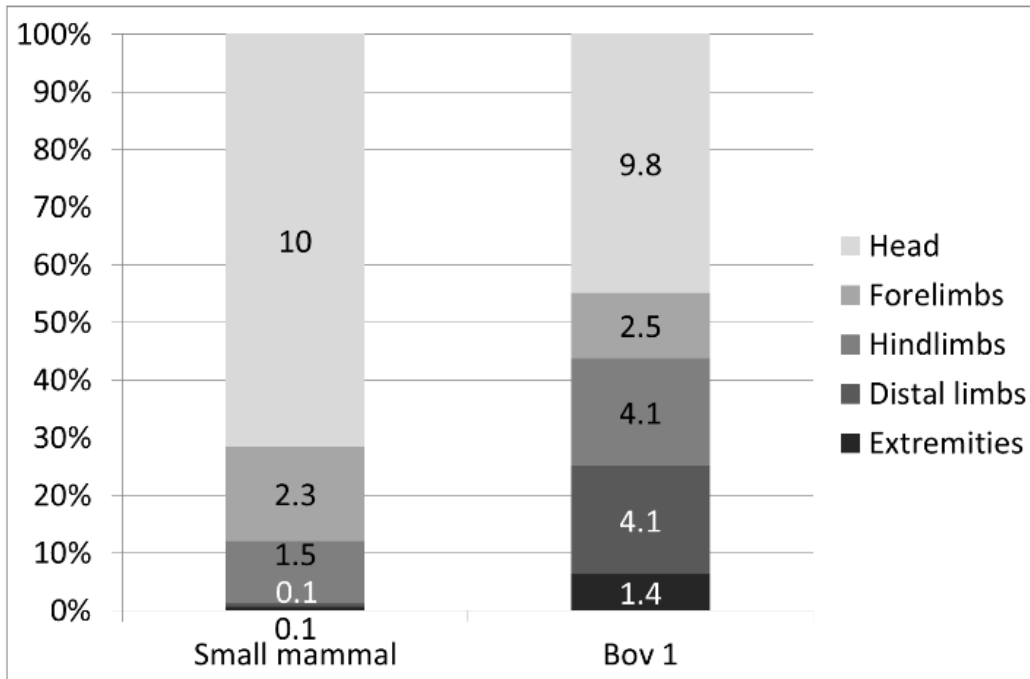
Sample	Blombos Cave		Klipdrift Shelter	
	r_s	ρ	r_s	ρ
Size 2 mammal ^a (all elements)	0.376	0.045	0.127	0.436
Size 2 mammal ^a (high survival)	0.437	0.103	0.323	0.166
Larger mammal ^b (all elements)	0.353	0.038	0.354	0.021
Larger mammal ^b (high survival)	0.282	0.256	0.575	0.004

a) Size 2 mammal comprises size 2 bovids and indeterminate 'medium mammal' remains. b) Larger mammal equals size 3, 4 & 5 bovids, perrisodactyls and indeterminate 'large mammal' remains. See table 3 for the definition of high-survival elements. BMD values were assigned to proximal, medial & distal portions of long-bone & rib, and to the densest portions of vertebrae, scapulae, pelves & mandibles.

Skeletal-part profiles

Bartram and Marean (1999) note that skeletal-part representation is often affected when mid-shaft long-bone fragments are ignored or underestimated in the identification procedure. At both BBC and KDS, mid-shafts are well represented, particularly at BBC. The majority of long-bones at BBC are represented by mid-shafts (mid-shafts = 90; 55.9%; epiphyses = 71; 44.1%) while at KDS epiphyses are more prevalent (mid-shafts = 72; 40.2%; epiphyses = 107; 59.8%). Since both size 2 mammals and larger mammals are affected by density-mediated attrition, we limit our analysis to high-survival elements. Because all high-survival elements – including crania and mandibles – are paired (see methods), both raw NISP skeletal-parts and normalized skeletal groups have the same distribution pattern (cf. Clark, 2011). At both BBC and KDS there are proportionally more skull remains of size 2 than size 1 bovids. This may be the result of identification bias: skull fragments were easier to categorise as size 2 than size 1 bovids due to the difficulty in discerning hyrax and other small mammals from small bovids. Size 1 skull specimens may therefore be under-estimated. Because of small sample sizes at BBC, we could not calculate skeletal profiles for hyrax but instead did so for combined identified small mammals. At BBC there are significant differences in the distribution of skeletal-parts between small mammals and size 1 bovids (for NISP: $\chi^2 = 18.94$; $df = 4$; $p = 0.0008$) (Fig. 4a); similar to what was found at KDS between hyrax and size 1 bovids (Fig. 4b) (Reynard et al., in press).

a



b

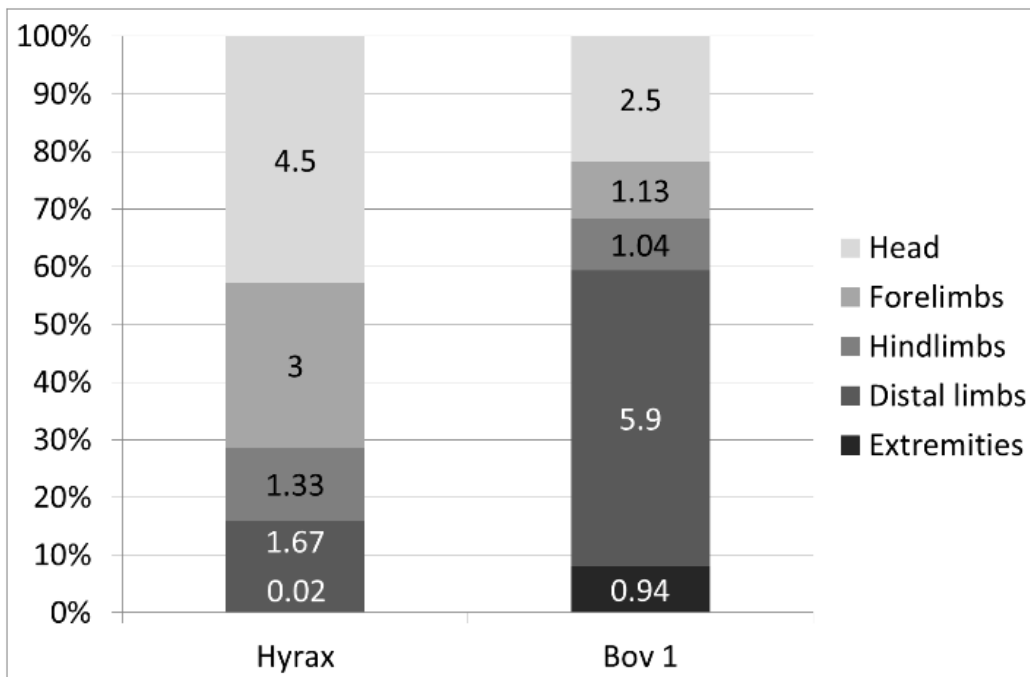


Figure 4: (a) Small mammal versus size 1 bovid skeletal-part distribution at Blombos Cave. (b) Hyrax versus size 1 bovids at Klipdrift Shelter. Data from Reynard et al., in press. Small mammals comprise identified lagomorphs, Cape dune mole rat and hyrax remains. Because bone

density-mediated attrition is inconsequential, all elements are used. Values in columns equal $\Sigma nNISP$ for each element within a skeletal group divided by the number of elements within that group. Expected values for a complete skeleton are one (1) for each skeletal group. See table 3 for the definition of heads, forelimbs, hindlimbs, distal limbs and extremities for all elements

Comparing skeletal-parts data between BBC and KDS is challenging. Representational patterns for large ungulates at KDS are likely a result of the extensive fragmentation of the faunal assemblage and a comparison between those taxa may be ineffective. Size 1 bovids and size 2 mammals at KDS, however, were not significantly affected by bone density-mediated attrition. Generally, BBC has a more equitable distribution of size 1 bovid skeletal-parts than KDS (Fig. 5). Distal limbs are more common at KDS than BBC but this may be because of extensive fragmentation (metapodia shafts are relatively easier to identify than other long-bones). Size 2 mammal remains are not significantly different between these sites ($\chi^2 = 0.503$; $df = 3$; $p = 0.9180$). The skeletal-parts of large mammals are also significantly different between BBC and KDS ($\chi^2 = 12.677$; $df = 3$; $p = 0.0054$). This is possibly because large mammal skulls are significantly more common than post-cranial remains at KDS than at BBC ($\chi^2 = 7.387$; $df = 1$; $p = 0.0066$).

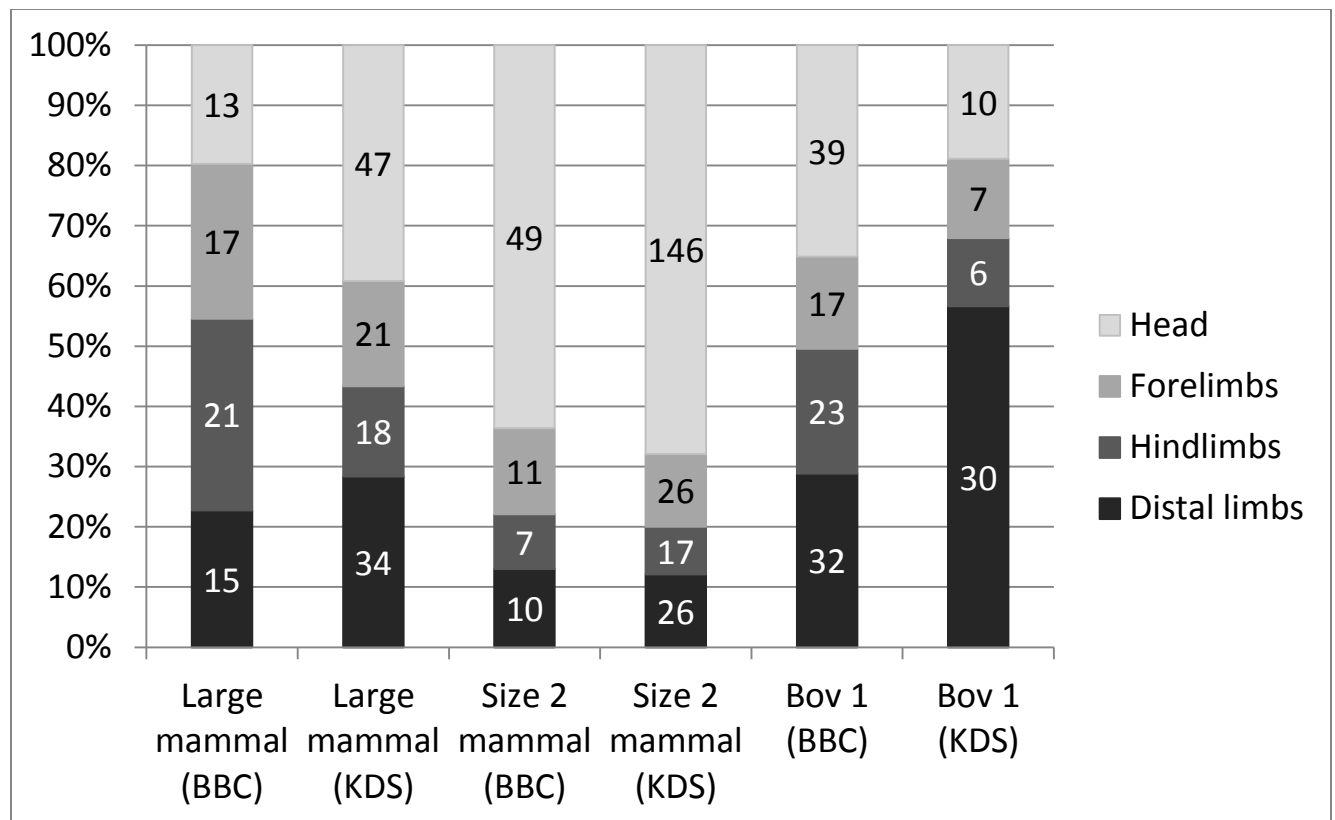


Figure 5: Comparisons of size 1 bovids, size 2 and large mammals from Blombos Cave (BBC) and Klipdrift Shelter (KDS). Size 2 mammals comprise size 2 bovids and indeterminate 'medium mammal' remains. Larger mammals comprise size 3, 4 & 5 bovids, perrisodactyls and indeterminate 'large mammal' remains. Only high-survival elements and raw NISP values are used. See table 3 for the definition of heads, forelimbs, hindlimbs and distal limbs for high-survival elements

Diet breadth

Despite the small sample size, a range of species was recovered from the BBC assemblage. While tortoise is by far the most prevalent taxon (Thompson and Henshilwood, 2014), small mammals are relatively common at BBC (NISP = 79; 46.8% of taxa identified to genus) (Table 5). Hyrax and Cape dune mole rats, for example, occur relatively frequently in our samples and carnivores are quite rare. We did not analyse reptiles, birds or micromammals but we did count microfauna. Of the 660 microfaunal specimens noted in the BBC assemblage, 17 are possibly bird remains. No fish remains were observed. It must be noted that microfauna in this study would be greatly underestimated since our focus is on the macrofaunal specimens recovered

through 3 mm sieves. With regards to ungulates, size 1 bovids such as steenbok/Cape grysbok (*Raphicerus* sp.) and klipspringer (*Oreotragus oreotragus*) are the most common. Large ungulates such as eland (*Tragelaphus oryx*) and the long-horned buffalo (*Syncerus antiquus*) were also identified (Table 5; for a more extensive list of mammals from BBC, see Henshilwood et al. 2001a). Based on Klein and Cruz-Uribe's data (Henshilwood et al., 2001a), browsers and mixed-feeders such as *Raphicerus* and eland are the most common ungulates in the M1 phase which suggests a more mixed/bushy habitat in the SB (Fig. 6).

Table 5: Number of identified specimens (NISP) at Blombos Cave (BBC) and Klipdrift Shelter (KDS). KDS data from Reynard et al. 2015. 'KC M1' and 'KC M2' from Klein and Cruz-Uribe's analysis of the M1 and M2 phases in Henshilwood et al. 2001a. 'Total ULBF' = Total unidentified long-bone fragments. 'Total Identified' include tortoise NISP for BBC and KDS data and only mammalian taxa for KC data. To compare bovid size classes from Henshilwood et al. 2001a: small bovids = Bov I; small-medium = Bov II; large-medium = Bov III; large bovids = Bov IV. NISP = number of specimens

Order	Taxa	Common Name	BBC	KC M1	KC M2	KDS
Chelonii	<i>Testudinidae</i>	Tortoise	5256			595
	<i>Chersina angulata</i>	Angulate tortoise	479			67
	cf. <i>Pelomedusidae</i>	Turtle				1
Lagomorpha	<i>Lepus</i> sp.	Hare	3	25	15	15
	<i>Lepus capensis</i>	Cape hare	1	11	4	-
Rodentia	<i>Bathyergus suillus</i>	Cape dune mole rat	20	419	303	9
	<i>Hystrix</i> sp.	Porcupine	1	1	-	-
Insectivora	<i>Atelerix frontalis</i>	Hedgehog	-	6	10	-
Primates	<i>Papio ursinus</i>	Chacma baboon	-	1	-	-
Carnivora	<i>Herpestes</i> sp.	Mongoose	2	3	4	1
	<i>Arctocephalus</i> cf. <i>pusillus</i>	Cape fur seal	21	126	32	2
	<i>Felis lybica</i>	African wildcat	1	16	1	-
	<i>Felis caracal/serval</i>	Caracal/Serval	3	-	-	2
	<i>Genetta</i> sp.	Genet	-	2	4	-
	<i>Ictonyx striatus</i>	Striped polecat	-	3	2	-

Order	Taxa	Common name	BBC	KC M1	KC M2	KDS
	<i>Mellivora capensis</i>	Honey badger	-	1	1	-
	<i>Parahyeana brunnea</i>	Brown hyena				1
	<i>Vulpes chama</i>	Cape fox	5	-	-	-
	<i>Canis mesomelas</i>	Black-backed jackal	-	1	-	-
Cetacea	<i>Delphinidae</i> indet.	Dolphin	-	2	1	-
Hyracoidea	<i>Procavia capensis</i>	Rock hyrax	48	169	190	111
Perissodactyla	<i>Rhinicerotidae</i> ind.	Rhinoceros	2	13	6	2
	<i>Equus</i> sp.	Zebra	1	-	-	40
Artiodactyla	<i>Tragelaphus oryx</i>	Eland	4	48	8	5
	<i>Antidorcas</i> sp.	Springbok	-	-	1	-
	<i>Redunca fulvorufula</i>	Mountain reedbuck	-	-	-	1
	<i>Redunca arundinum</i>	Southern reedbuck	-	-	-	1
	<i>Redunca</i> sp.	Reedbuck	-	-	-	4
	<i>Syncerus caffer</i>	African buffalo	1	2	-	-
	<i>Syncerus antiquus</i>	Giant buffalo	2	-	-	2
	<i>Pelea capreolus</i>	Grey (Vaal) rhebok	2	6	2	6
	<i>Raphicerus</i> sp.	Steenbok/Grysbok	36	111	51	23
	<i>Ourebia ourebi</i>	Oribi	-	-	-	1
	<i>Oreotragus oreotragus</i>	Klipspringer	21	-	-	4
	<i>Sylvicapra grimmia</i>	Grey duiker	2	-	2	4
	<i>Damaliscus</i> indet.	Bonte/blesbok/?D. niro	-	-	-	8
	<i>Alcelaphini</i> indet.	Hartebeest or Wilderbeest	1	5	-	18
	<i>Hippotragus leucophaeus</i>	Bluebuck	-	6	6	-
	<i>Hippopotamus amphibius</i>	Hippopotamus	-	3	1	-
	Bovidae indet.	Bov I	121	382	360	119
		Bov I/II	6	-		3
		Bov II	64	74	51	180
		Bov II/III	5	-		23
		Bov III	36	91	50	157
		Bov III/IV	32	-		23
		Bov IV	28	193	58	33
		Bov IV/V	4			-
		Bov V	4	-	-	-
		Large ungulate	8			-
	Carnivora indet.	Small carnivore	4			5
		Medium carnivore	6			3

Mammal indet.	Very small mammal	57			
Taxa	Common name	BBC	KC M1	KC M2	KDS
	Small mammal	162			297
	Medium mammal	169			369
	Large mammal	53			127
	Very large mammal	2			1
Total Identified		6194	1729	1167	2158
Total ULBF		390			692
Total Unidentified		25,997			29,816
Grand Total		32,581			32,666
Microfauna NSP					1724

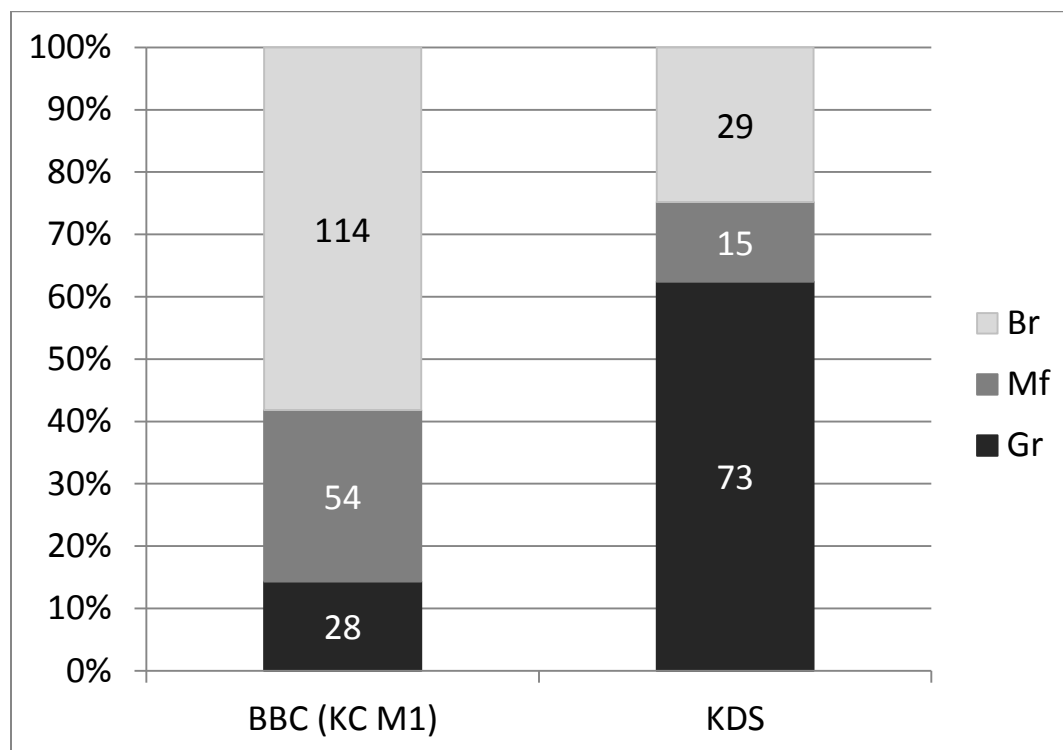


Figure 6: Comparison of ungulate dietary preferences at Blombos Cave (BBC) and Klipdrift Shelter (KDS). BBC (M1) = BBC data from Klein and Cruz-Urbe's analysis of the M1 phase in Henshilwood et al. 2001a. Br = browsers; Mf = mixed-feeders; Gr = grazers

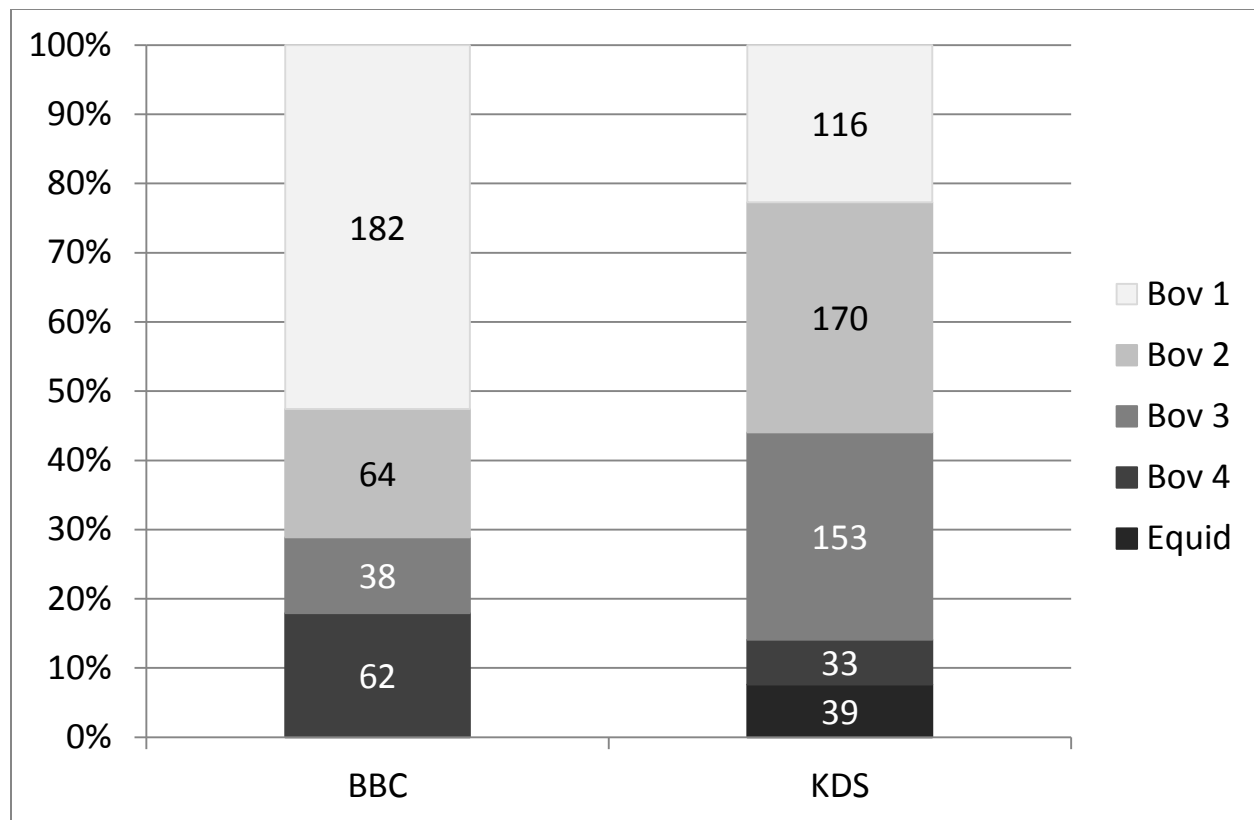


Figure 7: Comparison of ungulate size classes at Blombos Cave (BBC) and Klipdrift Shelter (KDS)

KDS shows a similar range of taxa, which is consistent with what is found in the CFR (Klein 1980) (Table 5). Small fauna and tortoises are also common at KDS. Of the 1724 microfaunal specimens, 47 are possibly bird while 29 may be fish remains. As mentioned previously, this is probably underestimated. Size 2 and 3 bovids are more common at KDS than at BBC while size 1 bovids are prevalent at the latter site (Fig. 7). difference between BBC and KDS is the increase in grazers such as zebra (*Equus* sp.), hartebeest (*Alcelaphus buselaphus*), wildebeest (*Connochaetes gnou*) and blesbok/bontebok (*Damaliscus pygargus*) in the middle layers at KDS (Reynard et al., 2016). Unlike at BBC, no African buffalo (*Syncerus caffer*) were identified and most of the large mammal remains recovered is probably eland. Despite KDS's smaller sample size – compared to Klein and Cruz-Uribe's BBC analysis (Henshilwood et al. 2001a) – identified bovid taxa are more abundant at KDS.

We compare the range of taxa at BBC and KDS with other MSA samples to explore diet breadth during the SB and HP. Richness indices (NTAXA/log NISP) for three SB assemblages and four HP assemblages are reported in Table 6. NTAXA and Σ NISP (log transformed) are significantly correlated for all faunal samples ($r_s = 0.964$; $p = 0.0005$) (Fig. 8). A residual analysis was conducted to minimize the effects of sample sizes. Larger residual values (those above the regression line) are indicative of taxonomically richer samples while negative residual values suggest less rich assemblages. Residuals are significantly correlated to the richness index ($r_s = 0.857$; $p = 0.014$) pointing to a strong link between these indices. The significant correlation between residuals and Fishers α also suggests a close association between richness and diversity for the samples. While the BBC assemblage has a relatively wide range of species, KDS is taxonomically richer (Table 6; Fig. 8).

Table 7: Taxonomic richness for Still Bay and Howiesons Poort sites.

	Samples	NISP	log NISP	NTAXA	NTAXA/log NISP	Residuals	Fishers α
Howiesons Poort	KDS	241	2.382	21	8.816	2.969	5.530
	Sibudu	1806	3.257	28	8.598	1.515	4.702
	DRS (HP)	1044	3.019	24	7.950	-0.186	4.381
	BPA	576	2.760	19	6.883	-2.683	3.774
Still Bay	BBC	169	2.228	17	7.631	0.457	4.713
	KC M1	987	2.994	23	7.681	-0.944	4.211
	DRS (SB)	95	1.978	13	6.573	-1.127	4.073

BBC = Blombos Cave; KC M1 = BBC M1 layers analysed by Klein/Cruz-Urbe (Henshilwood et al. 2001a); KDS = Klipdrift Shelter (Reynard et al. in press); Sibudu (Clark 2011); DRS = Diepkloof Rockshelter (Steele and Klein, 2013); HP = Howiesons Poort; SB = Still Bay; DRS (HP) comprises the 'Early HP', 'Inter HP' and 'Late HP' layers; BPA = Boomplaas Cave (OCH layer) (Faith, 2013a)

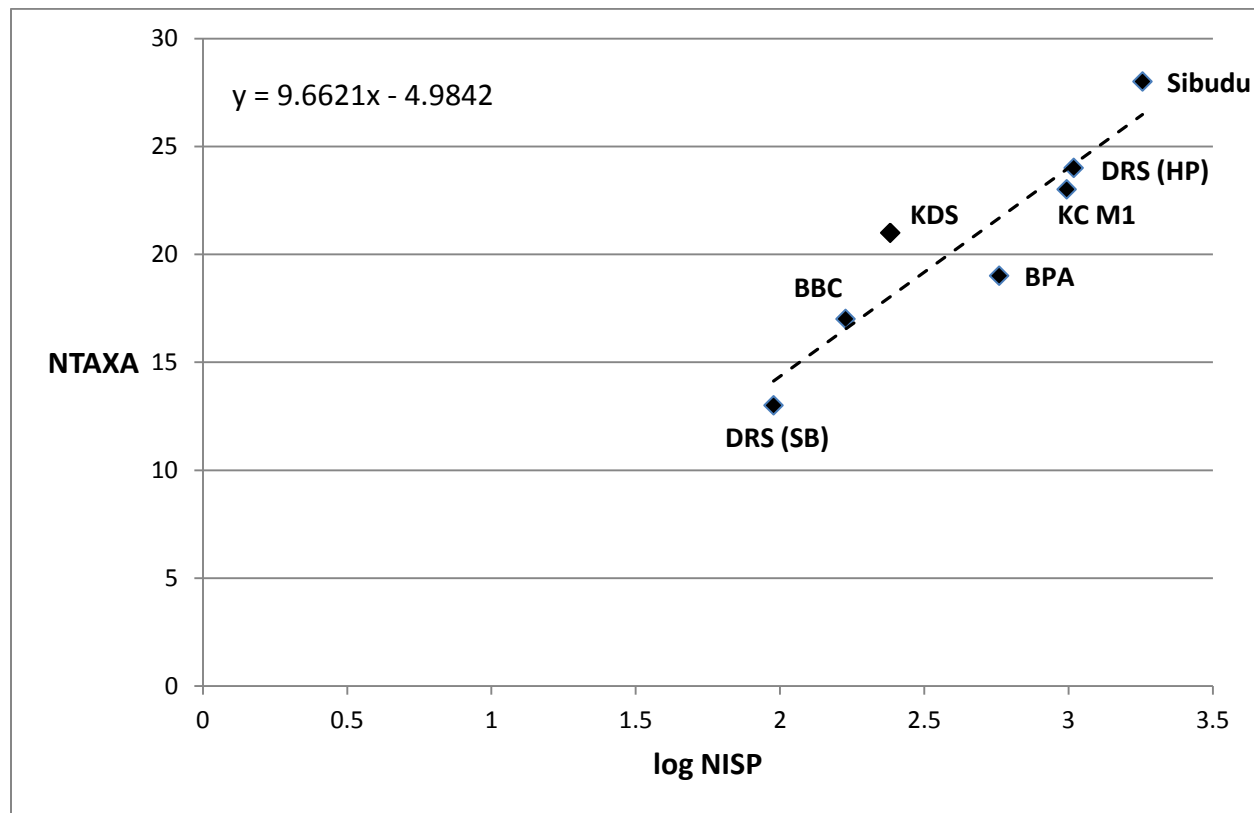


Figure 8: NTAXA versus log NISP for Blombos Cave (BBC) and other Still Bay (SB) and Howiesons Poort (HP) sites. KC M1 = BBC M1 layers analysed by Klein/Cruz-Urbe (Henshilwood et al. 2001a); KDS = Klipdrift Shelter (Reynard et al. 2016); Sibudu (Clark 2011); DRS = Diepkloof Rockshelter (Steele and Klein 2013); DRS (HP) comprises the 'Early HP', 'Inter HP' and 'Late HP' layers; BPA = Boomplaas Cave (OCH layer) (Faith 2013a). $r_s = 0.964$; $p = 0.0005$

Processing activities

On the whole, ungulates were extensively processed at both BBC and KDS (Table 7). Cut marks are significantly more common on larger mammals at BBC than size 2 bovinds ($\chi^2 = 5.065$; $df = 1$; $p = 0.0244$). Percussion marks are significantly more common on ungulate bone at KDS than at BBC ($\chi^2 = 47.493$; $df = 1$; $p < 0.0001$) and although cut marks are more prevalent at BBC, they are not significantly so ($\chi^2 = 0.004$; $df = 1$; $p = 0.9510$). There are also significantly more tooth marks on ungulate remains at BBC than at KDS ($\chi^2 = 47.617$; $df = 1$; $p < 0.0001$). Few

butchery marks and no percussion marks occur on BBC small mammals remains (identified hyrax, Cape dune mole rat and lagomorph) (Table 7). Cut and percussion marks are relatively common on carnivore remains at KDS but are absent on those from BBC. Descamps and Henshilwood (2015) found that cut marks were relatively high for large bovids (n = 28; 13%) compared to smaller ungulates (n = 14; 7.2%). In our sample, larger ungulates (n = 24; 13.3%) also displayed more cut marks than smaller bovids (n = 17; 4.3%) and there is no significant difference between his sample and ours ($\chi^2 = 0.586$; df = 1; p < 0.4440).

Table 7: Human and animal modification of mammals. Only identified hyrax, Cape dune mole rat and lagomorph remains classed as 'small mammal'

	Blombos Cave		Klipdrift Shelter	
Ungulate	N = 332	%	N = 524	%
B	161	48.5	445	84.9
PM	56	16.9	205	39.1
CM	34	10.2	42	8.0
TM	35	10.5	3	0.6
AE	5	1.5	22	4.2
Small mammal	N = 137	%	N = 119	%
B	52	38.0	90	75.6
PM	0	0	12	10.1
CM	3	2.2	6	5.0
TM	7	5.1	1	0.8
AE	5	3.7	9	7.6
Carnivore	N = 22	%	N = 14	%
B	4	18.2	11	78.6
PM	0	0	3	21.4
CM	0	0	2	14.3
TM	2	9.1	1	7.1
AE	2	9.1	1	7.1

B = burning; PM = percussion marks; CM = cut marks; TM = tooth marks; AE = gastric acid-etching. Carnivores exclude seal

Skinning At BBC a few phalanges display cut marks (n = 3; 5.8% of all phalanges) which may be indicative of skinning. Two of the phalangeal specimens with cut marks were assigned to bovids and one was from a Cape fur seal (*Arctocephalus pusillus*). Other elements where cut

marks may relate to skinning are metapodia and possibly sesamoids. Only three metapodial fragments display cut marks (4.7% of metapodia of all taxa). Overall, evidence of skinning is not common at BBC. At KDS there is more substantial evidence of skinning of ungulates and carnivores (Reynard et al., in press). A large proportion of cut marks occur on distal limb extremities such as phalanges, sesamoids the distal regions of metapodia (n = 17; 40.5%), although the distal regions of metapodia may signify disarticulation rather than skinning activities (Abe et al., 2002; Thompson, 2008). Cut marks on hyena and felid extremities also suggest the skinning of carnivores for fur.

Disarticulation At BBC marks at the base of the crania (occipital condyles) and on cervical vertebrae indicate decapitation of size 1 and 2 bovids. Two mandibular specimens also display cut marks near the mandibular foramen which suggest tongue removal or possibly mandible disarticulation. Cut marks seldom occur on the epiphyses of long-bone: only two marks on radii and one mark each on the proximal end of a metatarsal, tibia and femur suggest disarticulation action. This concurs with data from Thompson (2008: 276) indicating that disarticulation was not a major subsistence strategy at BBC and suggests that either whole-animals (for smaller bovid) or whole-limbs were transported back to the site. Evidence of disarticulation is more common at KDS and cut marks often occur near articular processes on mandibles, innominates and long-bones. The vast majority of cut marks on long-bones occurs near the epiphyses (n = 30; 71.4%) which suggests either disarticulation or, in the case of distal long-bones, skinning activities.

Filleting Filleting is often implied when cut marks are prevalent on the mid-shafts of long-bones (Domínguez-Rodrigo, 1999; Abe et al., 2002; Galán and Domínguez-Rodrigo, 2013). The BBC data indicate that the mid-shafts of ungulate long-bone are the most common region to exhibit cut marks (7.7% [4/52] of proximal ends, 13.8% [13/94] of shafts and 2.5% [1/40] of distal ends display cut marks). Thompson's (2008) research also suggests that filleting was common at BBC, particularly in the M1. At KDS cut marks are more common on epiphyses than shafts which suggest less evidence of filleting. Cut marks there are generally more prevalent on the epiphyses of smaller bovids and medium mammals (Proximal ends: n = 10; 17.2%. Shaft: n = 6; 13.3%. Distal ends: n = 6; 13.3%).

Bone marrow extraction At BBC percussion marks are more likely to occur on ungulate femora (NISP = 10; 40%) and tibiae (NISP = 9; 36%) with no crania, humeri or ulnae displaying

evidence of impact marks. Percussion marks are significantly less common on faunal remains from BBC than from KDS ($\chi^2 = 233.609$; $df = 1$; $p < 0.0001$). Only bovid remains from BBC display these marks. As mentioned previously, no identified small mammal remains have percussion-marked surfaces. Previous research has suggested that the long-bones of small mammals such as hares, hyraxes and Cape dune molerats are all < 2 mm thick (Reynard et al., in press). Unidentified long-bones with cortical thicknesses < 2 mm would therefore most likely be from small mammals such as these. Six out of 103 unidentified long-bone fragment at BBC with a cortical thickness < 2 mm (5.8%) exhibited percussion marks. However, four of those six are associated with highly-polished bone tools and only two marks (1.9%) may relate to marrow extraction. At KDS, on the other hand, 24.3% ($n = 36$) of identified small mammal specimens and long-bone fragments with a cortical thickness < 2 mm display impact marks. Similarly, there are significantly fewer percussion-marked phalanges, innominates, calcanei, mandibles and scapulae at BBC than at KDS ($\chi^2 = 233.609$; $df = 1$; $p < 0.0001$) which suggests less intensive processing of low-ranked elements at BBC than KDS (Table 8).

Table 8: Percussion marks on ungulate phalanges, innominates, calcanei, mandibles and scapulae

Layer	N	n	%
BBC Total	103	17	16.5
KDS Total	151	78	51.7

Burning Although 50% of the BBC identified sample is burnt, 18.3% ($n = 245$) is moderately (i.e., blackened) or severely burnt (grey or white), the rest in localised burning. To investigate whether burnt bone is indicative of roasting activities at BBC, we compare the proportion of burnt epiphyses and shafts in long-bone (Costamagno et al. 2005). Epiphyses ($n = 42$; 45.7%) are slightly more burnt than shafts ($n = 50$; 54.4%) but not significantly so. There is also no significant difference in the intensity of epiphyseal/shaft burning. Both regions are less likely to be moderately or severely burnt.

Experimental studies by Costamagno and colleagues (2005; Théry-Parisot et al. 2005) suggest that bone used as fuel frequently results in a predominance of burnt spongy bone in archaeo-

faunal assemblages. We compare the proportion of spongy versus compact bone fragments at BBC using unidentified faunal specimens > 2 cm (see methods) and note how intensely they were burnt. Of the 1052 unidentified specimens, most are cortical fragments (68.3%; n = 719) and just under half of all the unidentified specimens (48.9%; n = 514) are burnt (Fig. 9). There is no noticeable difference in the percentage of cortical or spongy bone displaying evidence of burning. The proportion of burning categories (mild, moderate or severe) is similar for both cortical and spongy bone. This suggests that burning at BBC was not the result of refuse disposal or fuel use. Similarly, at KDS, the lack of severely burnt specimens and the prevalence of partial burning suggest that bone was not burnt as fuel or refuse (Reynard et al., in press).

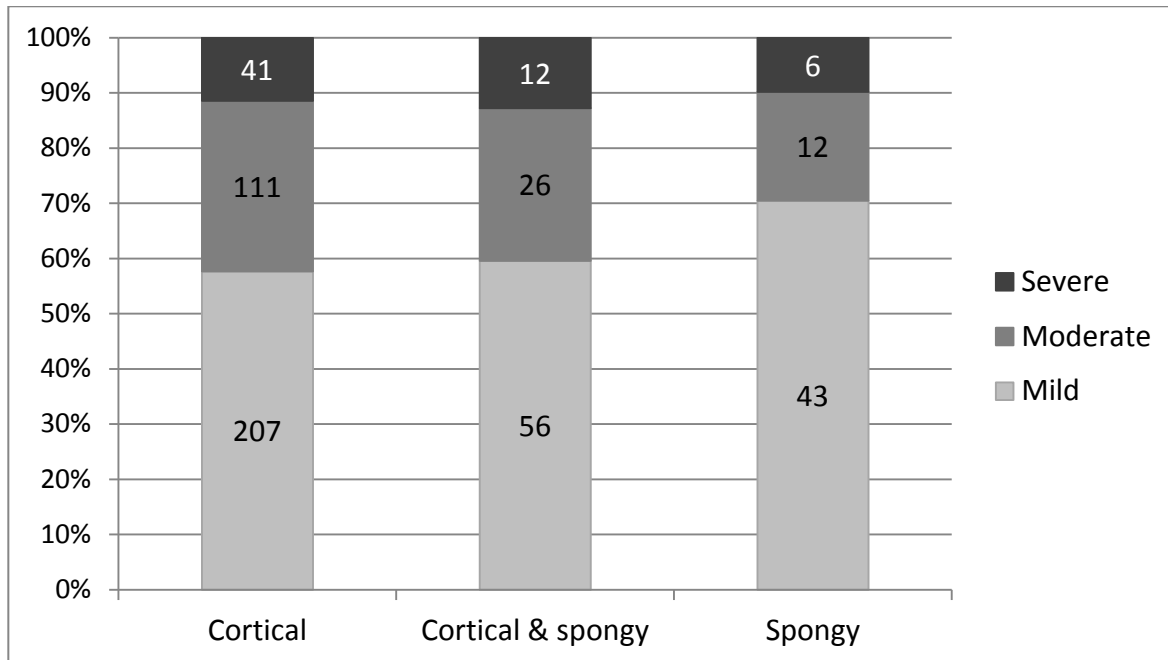


Figure 9: Proportions of unidentified burnt specimens from the Still Bay layers. Mild = burning code 1(partial); moderate = code 2(black); severe = code 3 (grey) & 4(white)

Table 9 Spearman's rank-order correlation between skeletal-abundance (nNISP) and Standardised Food Utility Indices (SFUI), Meat Utility Indices (MUI), Unsaturated Marrow Indices (UMI) and Meat Drying Indices (MDI) for all elements and high-survival elements at Blombos Cave and Klipdrift Shelter. Indices data from Metcalfe & Jones (1988) and Morin &

Ready (2013). Size 1 bovids and size 2 mammals compared to sheep, large mammal compared to bison data. Emboldened values are significant ($p < 0.05$). Values with asterisks are weakly significant ($p < 0.1$)

Blombos Cave

Samples	UMI		MDI	
	r	p-value	r	p-value
Size 1 bovid (all elements)	0.688	0.0134	-0.452	0.0518*
Size 2 mammal (all elements)	0.643	0.1194	-0.732	0.0068
Size 2 mammal (high survival)	0.427	0.3390	-0.340	0.3702
Large mammal (all elements)	0.857	0.0015	-0.625	0.0043
Large mammal (high survival)	0.493	0.3333	0.029	0.9833

Samples	MUI		SFUI	
	r	p-value	r	p-value
Size 1 bovid (all elements)	-0.155	0.5274	-0.226	0.1997
Size 2 mammal (all elements)	-0.556	0.0604*	-0.357	0.1914
Size 2 mammal (high survival)	0.021	0.9572	-0.366	0.3333
Large mammal (all elements)	0.171	0.4836	-0.093	0.7124
Large mammal (high survival)	0.2319	0.6722	0.422	0.3456

Klipdrift Shelter (from Reynard et al., in press)

Samples	UMI		MDI	
	r	p-value	r	p-value
Size 2 + medium mammal (all elements)	0.725	0.0120	-0.266	0.2870
Size 2 + medium mammal (high survival)	-0.314	0.5440	-0.262	0.5310
Large mammal (all elements)	0.527	0.1170	-0.678	0.0030
Large mammal (high survival)	-0.714	0.1110	0.314	0.5440

Samples	MUI		SFUI	
	r	p-value	r	p-value
Size 2 + medium mammal (all elements)	0.041	0.8753	-0.044	0.8460
Size 2 + medium mammal (high survival)	-0.050	0.8979	-0.418	0.2620
Large mammal (all elements)	0.114	0.6622	-0.147	0.5260
Large mammal (high survival)	-0.775	0.0041	-0.385	0.3060

Size 2 mammals comprise size 2 bovids and indeterminate 'medium mammal' remains. Larger mammal comprise bovids \geq size 3, perrisodactyls and indeterminate 'large mammal' remains

Utility indices Utility data is influenced by numerous factors: small sample sizes, equifinality in element abundance and/or the use of caribou to extrapolate information on African bovids or

other factors such as bone tool manufacturing. Although bone tool production is outside of the scope of this study, a significant number of long-bones in our sample were clearly worked tools (see also Henshilwood et al., 2001b and d'Errico and Henshilwood, 2007).

We compare utility indices, skeletal-abundance for all elements and, following Marean and Cleghorn (2003), for high-survival elements. Table 9 shows a range of relationships between element abundance and nutritional utility for small, medium and large ungulates at BBC and KDS. Because size 1 bovids have not been significantly affected by taphonomic destruction, we did not restrict the analysis to high-survival elements. At BBC, size 1 bovids are positively correlated with marrow utility and inversely correlated with meat-drying indices. Interestingly, the only significant relationships between medium-size and large mammal abundance and utility indices are when all elements are included in the analysis, and not just high-survival bones. For both medium-size and large mammals, there are inversely proportional correlations between skeletal abundance and meat-drying utility. At KDS, size 1 bovids were not assessed. There is a significant correlation with meat-drying and element abundance for large mammals at that site but only when all elements are included. There is also a significant relationship between marrow utility and skeletal-part abundance for size 2 mammals and for the combined ungulate element abundance (Reynard et al., in press).

Evenness index for size 2 mammals points to an 'unbiased' element transport strategy for BBC according to Faith and Gordons' (2007) model for a MNE of 50 elements. An MNE of 150 places the KDS sample between 'gourmet' and 'unbiased'. However, the correlation between high-survival element abundance and SFUI for both the BBC and KDS size 2 samples is not significant, militating against an 'unbiased' strategy. Large mammal element evenness for BBC suggests a 'bulk' transport strategy for an MNE of 50 (Table 10).

Table 10 Skeletal element evenness for size 2 and large mammals at Blombos Cave (BBC) and Klipdrift Shelter (KDS)

Elements	Size 2 mammal (KDS)	Size 2 mammal (BBC)	Large mammal (BBC)
Crania	125	39	1
Mandibles	23	10	11
Humerus	6	2	5
Radius	16	7	7
Ulna	4	2	5
Metacarpal	11.5	4.5	7
Femur	5	3	11
Tibia	12	4	10
Metatarsal	14.5	5.5	8
Total	217	77	65
Element evenness	0.685	0.751	0.949
Spearman's rho	-0.268	-0.366	0.422
Transport strategy	Gourmet/unbiased?	Unbiased?	Bulk?

KDS = Klipdrift Shelter; BBC = Blombos Cave. Size 2 mammals comprise size 2 bovids and indeterminate 'medium mammal' remains. Larger mammal comprise bovids \geq size 3, perrisodactyls and indeterminate 'large mammal' remains

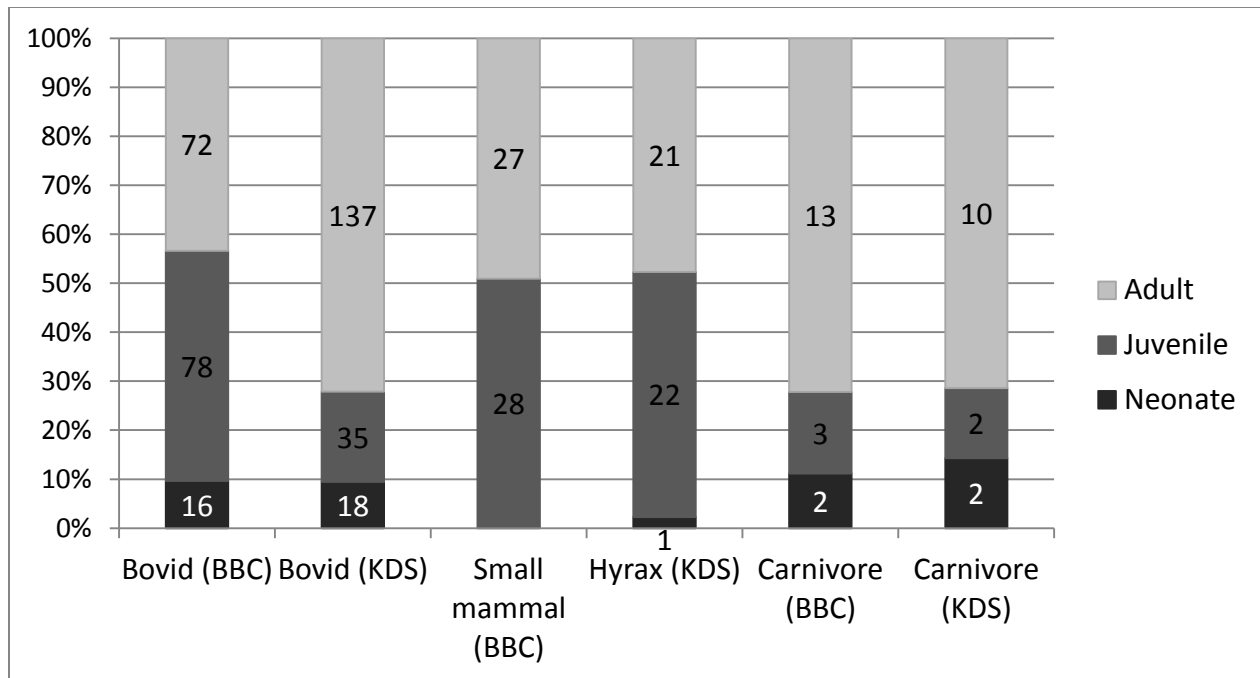
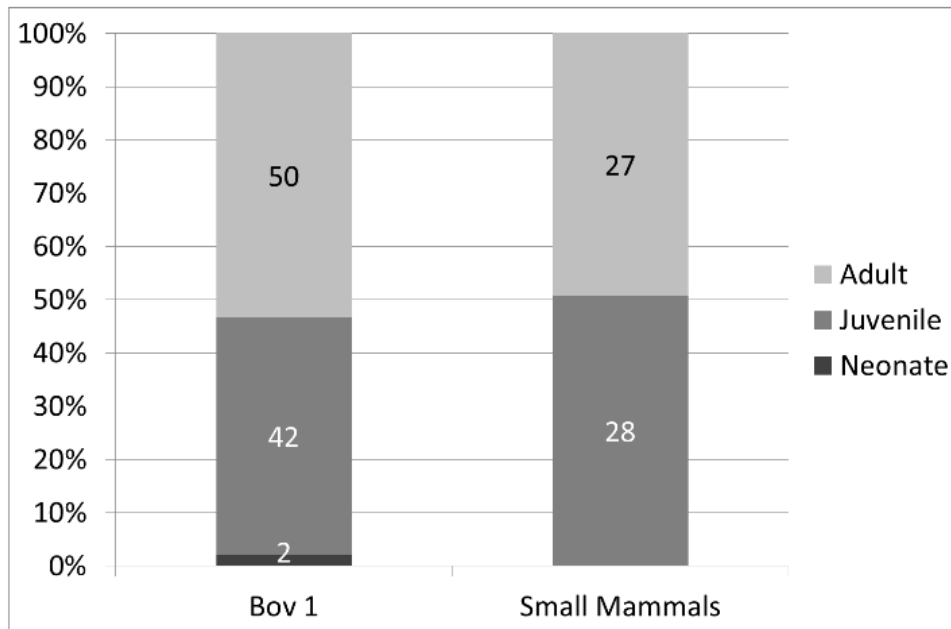


Figure 10: Comparison of mammal mortality patterns based on epiphyseal fusion at Blombos Cave (BBC) and Klipdrift Shelter (KDS). Small mammals comprise identified lagomorphs, Cape dune mole rat and hyrax remains. Number of epiphyseal ends in columns

Age profiles

At BBC, slightly more bone specimens displayed unfused/recently-fused ends ($n = 125$; 30.5%) and were noted as juveniles compared to fragments with fused ends ($n = 122$; 29.8%) or adults. Carnivores are significantly more juvenile-dominated at BBC and KDS compared to other families (for combined juvenile/neonates versus adults at BBC and KDS: $\chi^2 = 5.438$; $df = 1$; $p = 0.0197$) (Fig. 10). Small mammals and size 1 bovids have similar age profiles at BBC (Fig. 11a) ($\chi^2 = 0.234$; $df = 1$; $p = 0.629$) which contrast with significant differences apparent at KDS between hyrax and size 1 bovids (Fig. 11b) ($\chi^2 = 11.453$; $p = 0.0033$).

a



b

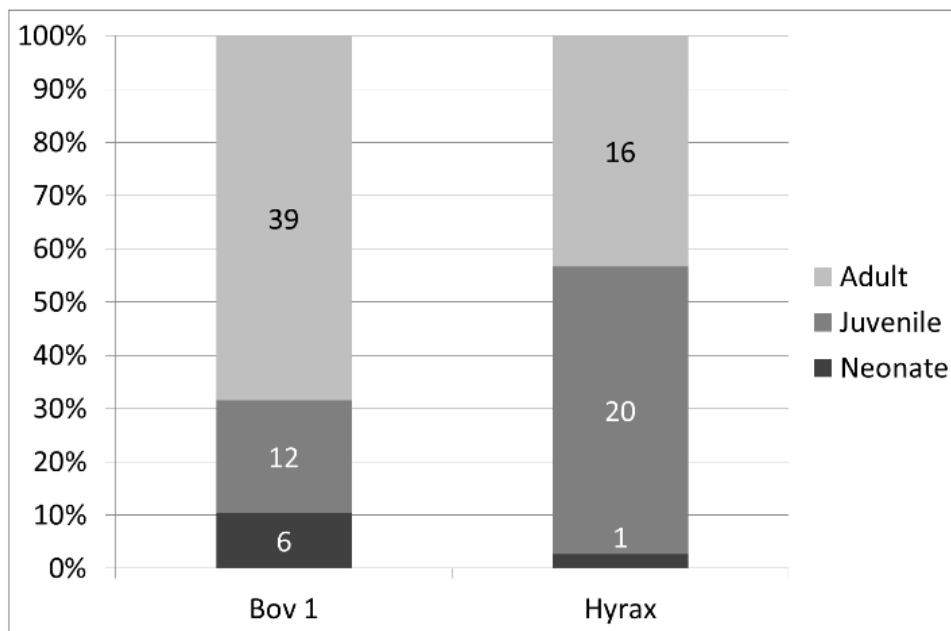


Figure 11 (a) Mortality profiles of size 1 bovids and small mammals based on epiphyseal fusion at Blombos Cave. (b) Mortality profiles of size 1 bovids and small mammals based on epiphyseal fusion at Klipdrift Shelter. Small mammals comprise identified lagomorphs, Cape dune mole rat and hyrax remains. Number of epiphyseal ends in columns

On the whole, there are slightly more juveniles at BBC than KDS (Fig. 12). Mortality profiles of the main taxonomic groups are similar between BBC and KDS, with the exception of bovids from BBC who are significantly younger than those from KDS ($\chi^2 = 35.238$; $df = 2$; $p < 0.0001$).

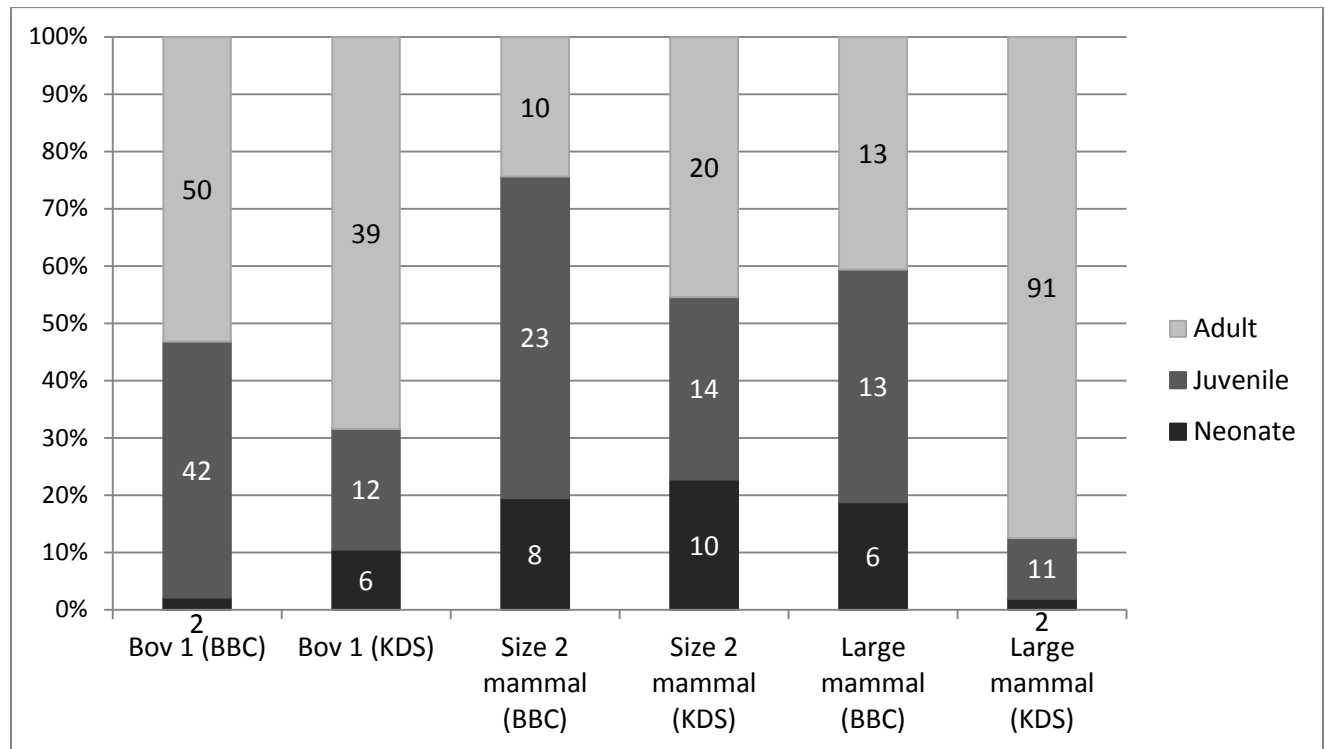


Figure 12 Mortality patterns for ungulate size classes at Blombos Cave (BBC) and Klipdrift Shelter (KDS) based on epiphyseal fusion. Number of bone epiphyses in columns

Discussion

Taphonomic history

Despite the relatively small sample size, the results suggest that BBC and KDS have different taphonomic histories. Data from our BBC sample and that analysed by Thompson (2008; Thompson and Henshilwood 2011) indicate that although humans were the dominant accumulators, animals had influenced the assemblage. Tooth marks at BBC average 6.1% ($n = 82$) during the SB, notably more than that at KDS (0.4%; $n = 13$). At KDS, carnivores and other

scavengers had very little effect on the fauna. Transverse fractures are also significantly more common at KDS than at BBC. This, the high percussion marks and bone density-mediated attrition suggests that extensive fragmentation of the KDS fauna was probably the result of human processing and trampling (Reynard et al., 2016). The different taphonomic histories imply that occupational intensity may have been less intense/frequent at BBC and longer/more frequent at KDS.

Burning is prevalent throughout the SB at BBC (Reynard 2016). At KDS, burning is high throughout the sequence but specifically prevalent in the middle layers (Reynard et al., in press). However, variation in the proportions of burnt faunal specimens in small samples such as this may be the result of the inclusion of hearths into datasets (cf. Discamps and Henshilwood, 2015). Burnt cortical bone fragments often display layers of various colours/categories of burning (Fig. 9) (Cain 2005). This type of 'layered' burning is likely due to burning of already-fragmented bone suggesting that these specimens were burnt after being discarded into fires as refuse. Only eight out of 928 burnt specimens at BBC and six out of 1226 burnt specimens at KDS display layered burning. Furthermore, significant proportions of burnt bone at BBC (63.3%; n = 422) and KDS (48%; n = 588) are not charred or calcined which suggest that bone was probably not burnt as fuel (Costamagno et al., 2005; Théry-Parisot et al., 2005) or refuse (Clark and Ligouis, 2010). The extensive localised burning at both sites may be related to roasting and, possibly, to cleaning activities such as the elimination of pests (cf. Wadley et al., 2011).

Transport decisions

Small sample size makes it difficult to infer concrete, meaningful information from this data, especially for BBC, but some patterns are evident. For example, skull remains are significantly less common at BBC than at KDS. Less than a fifth (19.7%; n = 13) of high-survival elements in the large mammal assemblage are skull fragments versus 39.2% (n = 47) at KDS (Fig. 5). Cranial specimens at BBC are also much rarer than mandibular remains: only two large mammal cranial specimens were recovered in the SB layers. In contrast, 22 out of 146 (15.1%) skull specimens are mandibular remains at KDS. If the proportion of skulls or crania is a function of foraging range then the lack of skull bones at BBC – and crania in particular – is indicative of increased transport distances for larger bovids during the SB. At KDS, size 2 mammal profiles are similar to those from BBC. Although large mammal skull fragments are more common at

KDS, this may be a result of extensive fragmentation and may not reflect transport decisions. Skeletal-element evenness indices suggest that a ‘bulk’ transport strategy for large mammals was employed at BBC but the evidence for size 2 mammals is more contentious. Element evenness does not correlate to SFUI for size 2 mammals for either the BBC or KDS collections so the transport strategies suggested in Table 11 may not be applicable. In any case, based on ethnographic studies, it may be problematic to infer transport decisions from size 2 mammal remains since all of these elements were most likely transported back to the home-base (Schoville and Otárola-Castillo, 2014).

Processing strategies

Utility and taphonomic data from these sites raise interesting possibilities on processing decisions in the southern Cape. Applying utility data to MSA fauna assemblages is often contentious. Utility indices have been criticised for not taking handling and transport costs into account (Lupo, 2006; Schoville and Otárola-Castillo, 2014). Furthermore, taphonomic influences on a 70 000 year old palimpsest would undoubtedly affect skeletal-part representations and any measure of the economic value thereof. A case in point is the significant correlations between marrow (UMI) and meat-drying indices (MDI) for large mammals at BBC. Because marrow and meat-drying indices inversely correlate for bison ($r_s = -0.794$; $p = 0.0061$), marrow utility is also often negatively correlated with MDI (Morin and Ready, 2013: 259). Inverse correlations like these may also occur when skeletal-parts are left behind after high-utility elements are transported to other locations (Friesen 2001: 329). So the question is whether these correlations at BBC signify marrow extraction or meat drying. Ethnographic evidence suggests another reason behind UMI/MDI correlations: because marrow and brains tends to spoil rapidly, they are usually removed before meat-drying processing (Friesen 2001). This may explain, not only the association of meat-drying and marrow utility, but also the lack of skull remains at BBC. Other evidence for meat-drying at BBC is size 2 mammal skeletal-parts which also correlate inversely with MDI. Another line of evidence is surface modification. At BBC percussion marks are relatively rare but filleting marks – or cut marks on shafts – are common. It is possible that the abundant evidence for filleting may be because shafts are significantly more prevalent at BBC than at KDS ($\chi^2 = 8.351$; $df = 1$; $p = 0.0039$). However, encrustation is significantly more common on shafts at BBC ($n = 32$; 78%) than shafts at KDS ($n = 10$; 45.5%) ($\chi^2 = 6.845$; $df = 1$;

$p = 0.0089$). So, despite the poorly preserved shafts at BBC, filleting-marks are still common. Thus, if we accept that filleting was an important strategy there, then these utility values may suggest a meat-based subsistence strategy. A tentative possibility therefore is that meat may have been taken from BBC to be consumed elsewhere. However, marrow-extraction may still have been an important strategy for larger mammals at BBC.

At KDS, there is a significant inverse relationship between larger mammal skeletal-part representation and MDI but there is little taphonomic evidence of filleting on long-bone (including the unidentified long-bone fragments [Reynard et al., in press]). At that site marrow utility indices are significantly correlated with element abundance for size 2 mammals and for the combined ungulate data (Reynard et al., in press) which suggests a marrow-based strategy for medium-size mammals there. At both sites – but particularly at KDS – density-mediated attrition makes it problematic to extrapolate models from large mammal utility data but the prevalence of percussion-marks at KDS suggest that marrow was systematically extracted from large mammal long-bones.

Diet breadth

The high numbers of small mammals at BBC (Table 5) may be an indication that they formed a significant component of the diet. Yet, evidence of tooth/gnaw marks and cut marks suggest that both carnivores and humans contributed to the accumulation of small mammals at BBC (see Cruz-Uribe and Klein, 1998; Klein and Cruz-Uribe, 2000). A prevalence of fragmented small mammal long-bone has been used to infer human-accumulated assemblages at BBC in the pre-SB M3 layers (Badenhorst et al., 2014) and similar high proportions of fragmented small mammal long-bones occur in the SB layers. Burning patterns on two hyrax and one Cape dune mole rat mandibular fragments in our BBC sample are similar to what Henshilwood (1997) found on mole rats in his actualistic study, suggesting that they were roasted. However, the fact that 38% ($n = 52$) of small mammal remains are burnt at BBC may partly be the result of incidental burning.

At KDS the evidence for human exploitation is more conclusive and small fauna such as small mammals, shellfish and tortoise were an important subsistence commodity (Reynard et al., in press). A high proportion of small mammal and some carnivore remains display evidence of

burning and butchering. Some hyrax mandibles at KDS display, not only burning patterns similar to what is described above, but associated cut marks as well. Very few small mammal long-bones are not fragmented and the lack of animal involvement in the small mammal assemblage at KDS is also strong evidence for almost exclusive human consumption of these taxa.

This raises the question as to whether these small mammals could have been accumulated through remote capture techniques. At both BBC and KDS juveniles form a significant proportion of the small mammal collection. Eagle roosts usually contain few young hyraxes and high proportions of juvenile small mammals have been used to infer snaring or net hunting (Cruz-Uribe and Klein, 1998). However, high numbers of juveniles could also imply natural death assemblages (Badenhorst et al., 2014). A prevalence of nocturnal animals in an assemblage may also suggest remote capture (Wadley, 2010). Based on the relatively high number of nocturnal animals such as Cape grysbok (*Raphicercus melanotis*) during MIS 5, Dusseldorp and Langejans (2015) argue that trapping and snaring could have occurred at BBC. Nocturnal animals such as these are also common during the SB. The prevalence of certain types of fish (e.g., *Chrysoblephus gibbiceps* and *Chrysoblephus cristiceps*) at BBC makes it likely that baited hooks (which are a string/cord-based technology) were involved in the procurement of marine fauna during the MSA (van Niekerk, 2011). This technology could also have been used for snaring or netting land-based fauna. Circumstantial evidence, such as the technological capabilities of people in the HP (Lombard and Phillipson, 2010; Lombard and Haidle, 2012) and the expansive diet breadth, means it is very possible that snares or traps were used at KDS. However, aside from this, there is no direct evidence of remote capture procurement at either BBC or KDS.

Mortality profiles

Age profiles may also inform on large mammal subsistence strategies. Catastrophic mortality patterns – so named because the pattern resembles a ‘mass kill’ – suggest that natural catastrophes or human hunters have a significant impact on ungulate communities (Klein, 1982). Attritional mortality patterns, on the other hand, generally mirror natural death assemblages and are dominated by both very young and old individuals. In archaeological assemblages, catastrophic patterns often contain numerous prime-aged adults and younger individuals and human foraging is usually the cause. Both BBC and KDS could therefore be characterised as

catastrophic. One question that arises is if carnivores could have influenced bovid mortality patterns. Large predators (e.g., lion or hyena) are not present in either our BBC sample or that analysed by Klein and Cruz-Urbe (Henshilwood et al., 2001a) so it is unlikely larger mammal mortality patterns were affected by these carnivores – although we cannot rule out raptor involvement with size 1 bovinds (Klein, 1981). At KDS, the general mortality profile is similar to that of BBC except for bovinds. Bovid juveniles are significantly more common at BBC than at KDS which may relate to ecology and /or intensification. Variability in ungulate age profiles in BBC and KDS fauna are therefore probably a result of human actions.

Intensification

Evidence of intensive subsistence occurs at both sites but is more prevalent in the KDS assemblage. Processing is more intense at KDS as demonstrated by the large numbers of percussion marks in general and on low-ranked elements (Table 2; Table 8). Diet breadth is also more extensive at KDS. Although the focus of this study is on the macromammal collection, microfauna are more common at KDS than at BBC. More bird and fish remains were also noted in the KDS than the BBC assemblages. The consumption of carnivores may have also occurred at KDS which is significant because it is generally rare in the Late Pleistocene (Charles, 1997; Stiner et al., 2000). Dangerous carnivores such as medium-sized cats (*Felis*. cf. *caracal*) and hyena (*Parahyaena brunnea*) at KDS display burning, cut and percussion marks while there is no evidence of carnivore processing at BBC. Thus, in terms of processing and taxonomic richness, foraging was more intensive at KDS.

There is also some evidence of intensification at BBC. Juvenile ungulates are more common there than at KDS (cf. Clark 2011). Seasonality could also have played a role in the accumulation of juvenile remains. Faith and Thompson (2013) suggest that the high proportions of bluebuck (*Hippotragus leucophaeus*) juveniles at BBC may have been the result of seasonal occupations at the site. Dusseldorp and Langejans (2015) also suggest that the large number of seal remains in the pre-SB layers at BBC could have been the result of seasonality. Regarding transport distances, the lack of large mammal crania means that foraging ranges were probably extensive at BBC. A ‘bulk’ strategy for large mammals also suggests the exploitation of entire carcasses, not just selected parts. The increase in exploitation of *Perna perna* during the SB – compared to the pre-SB layers at BBC – implies longer excursions to a more distant coastline (Henshilwood

1997; Langejans et al. 2012). In terms of assessing transport decisions at KDS, fragmentation had a significant effect on the bone assemblage so transport distances are difficult to infer from element proportions. It is possible however that the larger number of cranial fragments in PBD may point to smaller foraging ranges during that period (Reynard 2016). High shellfish densities in this layer suggest that the sea was relatively close at that time. There may thus be a link between a close shoreline and reduced foraging ranges but more research is needed to explore this.

Other factors affecting foraging behaviour

Other factors, besides intensification, would have affected foraging behaviour. Certainly, intensification itself is the result of numerous influences. The palaeoenvironment was possibly a key aspect in mediating transport distances in the southern Cape. Changing shorelines and vegetative habitats would have affected ungulate population and human access to large, grazing herds (Faith and Behrensmeyer, 2013). Indeed, the prevalence of size 1 bovids at BBC runs contrary to intensification models since can be linked to intensive procurement patterns. However, within the diet breadth model, high-ranked prey should be pursued whenever encountered. Thus if higher-ranked prey are not common on the landscape this could explain the relative rarity of size 2 and 3 bovids in the BBC bone assemblage. This may be a reflection of environmental conditions during the SB where *fynbos* shrubland – and the associated *Raphicerus* and klipspringer (*Oreotragus oreotragus*) size 1 bovids – was the dominant vegetation. Fluctuating shorelines would also have influenced subsistence patterns through access to shellfish. Micromammal data suggest a shift from a browse-dominated habitat in the earlier SB (Layer CF) to a grassier environment in the later SB (CC – CA) (Hillestad-Nel, 2013) which possibly corresponds to a retreating shoreline from the early to later SB (Fisher et al., 2010). The increase in larger ungulates from early to later SB and the corresponding decrease in size 1 bovids and smaller mammals also suggest a shift in vegetation (Discamps and Henshilwood, 2015).

At KDS, it is likely that shifting shorelines and changing vegetative patterns may have also affected foraging ranges there (Reynard et al., 2016). For example, in contrast to BBC, size 2 and 3 bovids are more abundant relative to size 1 bovids at KDS which suggests an increased representation of higher-ranked prey at that site (Fig. 7). As with the prevalence of size 1 bovids

at BBC discussed above, this does not necessarily contradict the diet breadth model since it could be linked to the differences in environments between KDS and BBC. The most common size 2 and 3 bovids at KDS are Alcelaphinae (wilderbeest, hartebeest and *Damaliscus*) which are consummate grazers. Although browsers and mixed-feeders dominate the early HP layers at KDS, their numbers are relatively low. Grazers (mostly size 2 and 3 ungulates) are numerically abundant and are particularly more common in the middle phase (PBD – PBA/PBB) (Reynard et al., 2016). This middle phase at KDS is also associated with high densities of shellfish. However, because the investment that goes into its acquisition of shellfish is minimal, this is unlikely to constitute an intensive strategy. What the increasing shellfish may suggest is a closer shoreline during the mid-HP at KDS. A drop in shellfish density, the appearance of dune mole rats and the prevalence of *Donax serra* – sand-loving mussels – in the later HP period (PAY and PAZ) at KDS infer increasing dune activity and possibly a more distant shoreline. It is also possible, however, that increased rates of aeolian sedimentation in the later HP at KDS could have affected shellfish/bone volumetric density which may give the impression of lower/less frequent activities and sea level regressions during that time.

Technology may also be linked to subsistence strategies. Thompson and Henshilwood (2014a) note that the faunal patterns at BBC suggests a shift in subsistence strategies from the M3 – with its emphasis on more collectable resources such as shellfish and small ungulates – to the SB with its focus on larger, higher-ranked bovids. They argue that this shift corresponds to increasing evidence of hunting technology in the later SB. SB bifacial points, probably functionally adaptable tools (Ambrose, 2002; Lombard, 2006), may have been a response to increasing foraging mobility proposed for the SB (McCall, 2007; McCall and Thomas, 2012). Changes in ungulate prey selection patterns through the SB could be associated with changing raw material patterns with silcrete more numerous in the upper layers (Table 12). Increases in the proportions of silcrete from the early to later SB may be linked to more extensive mobility patterns as grasslands expand. The shift from a dominance of bone tools in the early SB (upper M2) to lithic bifacial points in the later SB (upper M1) may similarly be related (Henshilwood et al., 2001a; Discamps and Henshilwood, 2015). At KDS, raw material procurement strategies and prey selection during the HP are linked to environmental conditions. Changes in lithic technology and material in the middle HP layers are also associated with increases in the proportion of grazing ungulates (see Reynard et al., 2016). Generally, grazer proportions and the procurement of quartz

increases in the middle HP. The development of a more open habitat at KDS during the middle HP period may have affected ungulate choices, access to raw materials and mobility strategies (Henshilwood et al., 2014).

Subsistence strategies in the Still Bay and Howiesons Poort

The SB has been characterised by frequent and /or long-distant mobility patterns and more temporary home-bases (McCall and Thomas, 2012). Our data appear to support this hypothesis. Evidence of both widespread human and animal activity during the SB suggests discontinuous occupations during this period. Extensive foraging ranges can be inferred from the lack of large mammal crania. Cut marks on long-bone shafts were common in our sample and in that of Thompson (2008; Thompson and Henshilwood, 2011) suggesting that filleting was widespread in the SB at BBC. Filleting is often linked to meat-drying with its implication for meat storage (Binford, 1978; O'Connell, 1988). Meat storage would have been an important component in highly-mobile settlements and foraging strategies and, although speculative, utility data for size 2 and large mammals may also document a meat storage/distribution system at BBC. Marrow from large mammals may have also been a significant commodity and there was possibly a complementary relationship between meat and marrow usage through the SB at BBC. Thompson (2008) notes that filleting strategies were also common in the M2 and M3 phases at BBC, so filleting may be specific to this site and is not necessarily only linked to the SB. In fact, it may be associated with more mobility during periods of less frequent/intense occupations since occupations during the lower phases (M2 and M3) at BBC were even less intense/frequent than those in the SB (Thompson and Henshilwood, 2011).

There is evidence of more settled residential patterns during the HP at KDS (cf. Ambrose and Lorenz, 1990; McCall and Thomas, 2012). The HP at KDS appears to be a high-intensity occupation period with less emphasis on meat and more on marrow exploitation (Table 12; Reynard et al., in press). High numbers of percussion marks and the extensive exploitation of low-ranked taxa and elements characterise the KDS assemblage. The extremely fragmented assemblage and evidence of extensive bone abrasion in the middle layers is very likely due to human activities and trampling (Reynard, 2014). There is thus reason to infer relatively continuous, intense occupations during the middle HP period at KDS (Reynard et al., 2016). Longer-term settlements would also result in more intensive processing and a greater diet

breadth (Dusseldorp, 2012) which is evident there. The one anomaly is tortoise. Tortoise remains are higher at BBC (8.2% of identified specimens) compared to KDS (3%). Studies by Thompson and Henshilwood (2014a, b) suggest that tortoise were a significant component of human diet at BBC. Yet if KDS had a longer-term residential function, one would expect tortoise to be more prevalent there. The relative lack of tortoise at KDS may be due to: 1) taphonomic issues – fauna from KDS is generally less well-preserved than those at BBC and tortoise remains may be ‘analytically absent’ (Lyman and O’Brien, 1987); 2) changing environmental conditions in the southern Cape during the HP which could have resulted in a relative decrease in tortoise abundance, or 3) it may be a consequence of intensification. Nutritional and caloric benefits would have made tortoise meat a highly-ranked resource but their slow-growth rate and ease-of-capture likely made them susceptible to over-exploitation (Thompson and Henshilwood 2014a). At KDS, layers where human occupations were more intense/frequent have the lowest proportion of tortoise remains (e.g., 2.6% in PBC and 2% in PBA/PBB) while low-occupational layers have the highest (4.9% in PAZ; 5.2% in PAY) (cf. Reynard et al., 2016). Excessive harvesting of tortoise at this site may therefore be linked to longer-term residential occupations. However, Thompson and Henshilwood (2014a) suggest that tortoise collection declined when sea levels were closer because the focus of subsistence switched to shellfish. It is thus possible that because sea levels were closer during the middle phase at KDS, there was less emphasis on tortoise. Generally, however, anthropogenically-modified small fauna – such as small mammals and shellfish and possibly birds and reptiles – are more common at KDS than BBC. Although site function may explain some of the variations in faunal patterns between BBC and KDS, both were likely residential base-camps (Henshilwood et al. 2001a, 2014). Larger samples of fauna from BBC and KDS could help clarify the specifics of site function and resource structures at both these sites.

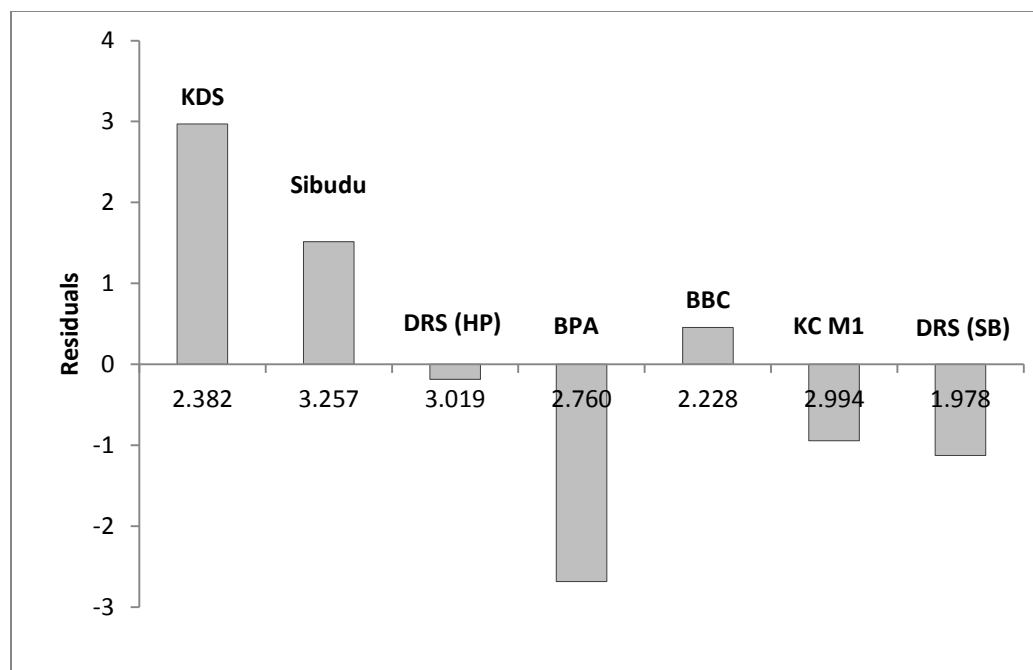


Figure 13: Residual values of richness for Blombos Cave (BBC) and other Howiesons Poort (HP) and Still Bay (SB) sites. KC M1 = BBC M1 layers analysed by Klein/Cruz-Uribe (Henshilwood et al. 2001a); KDS = Klipdrift Shelter (Reynard et al. 2016); DRS = Diepkloof Rockshelter (Steele and Klein 2013); DRS (HP) comprises the 'Early HP', 'Inter HP' and 'Late HP' layers; BPA = Boomplaas Cave (OCH layer) (Faith 2013a)

Data from other sites may also reflect more intensive patterns in the HP than in the SB. The HP at KDS is richer than all other SB and HP sites (Table 6; Figure 13) which suggest an extensive diet breadth there. One issue with using species richness to measure diet breadth may be that all animals, not just those processed by humans, are included in the analysis. However, disentangling human/carnivore accumulators is often difficult for small mammals (Badenhorst et al., 2014). Despite this, KDS is taxonomically richer than BBC even though carnivore involvement is more evident during the SB. In fact, most HP assemblages have higher richness values than SB collections (Fig. 13). The one exception, Boomplaas, had significant contributions by non-humans and probably low occupation rates during the HP (Faith, 2013a). The SB and HP of Diepkloof (Steele and Klein, 2013) appear less taxonomically rich than BBC or KDS (Table 6; Fig. 13) and this may reflect differences in habitat productivity between the

western and southern region of the CFR (cf. Rector and Verrilli, 2010; but see also Cowling and Lombard 2002). Taphonomic analyses have not been conducted on the faunal assemblage at Diepkloof so it is not possible to assess processing and subsistence strategies there. Sibudu is not in the CFR, so it is problematic to compare taxonomic diversity there to sites in the *Fynbos* Biome. Lower richness indices there may be a result of one or two factors. Firstly, the faunal assemblage at Sibudu is dominated by blue duiker (*Philantomba monticola*) – 1208 out of 3380 NISP are blue duiker (Clark, 2011) – so richness values may be affected by this. Secondly, ungulate richness normally correlates with precipitation levels until ~750 ml/year whereafter it declines (Faith, 2013b). Sibudu currently has an average precipitation level of > 1000 ml/year (Mucina and Rutherford, 2006) and, while botanical and faunal evidence suggest a changing environment between 60 and 50 ka, the environment during the HP was probably similar to what it is today (Sievers, 2006; Clark and Plug, 2008; Wadley et al., 2008). Although this does not necessarily relate to micromammal or overall taxonomic richness, it could be a factor in the lower richness values for Sibudu.

Generally, HP subsistence patterns appear to reflect greater occupational densities than that of the SB. It is tempting to suggest that the differences between the SB and HP documented in this study may be the result of population pressure but more research on other SB assemblages besides BBC is needed. Future research should also focus on the lower, pre-HP layers at KDS to assess how they compare with our BBC data. It is possible that the occupational history of both sites points to a close relationship between the two. The lower-most anthropogenically sterile layer at KDS (PE) has been OSL dated to approximately the same time as the cessation of MSA occupations at BBC: ~ 73 ka (Henshilwood et al., 2014). Based on their regional proximity, it is feasible that human populations shifted – possibly on a temporary or seasonable basis – from BBC to KDS during this period.

Table 12: Summary of subsistence patterns at Blombos Cave and Klipdrift Shelter

	Blombos Cave	Klipdrift Shelter
Taphonomy	Moderately affected by density-mediated attrition (high-survival elements less affected), Animal marks common (more non-human influence) Sporadic occupational intensity?	Severely affected by density-mediated attrition (all elements affected), Tooth and gnaw marks rare (more human influence) High, relatively continuous occupational intensity in middle HP
Processing activities	Cut marks common. Filleting prevalent, Low-ranked element processing not common Burning common but not as fuel/refuse	Percussion marks very common. Marrow extraction prevalent, Low-ranked element processing common Burning common but not as fuel/refuse
Taxa	Range of taxa that probably includes scavengers, No evidence of carnivore exploitation, Little evidence of small mammal consumption <i>Raphicerus</i> dominate	Extensive diet breadth, Evidence of carnivore exploitation, Strong evidence of small mammal consumption Equids dominate
Mortality profiles	Bovids: juveniles prevalent, particularly size 2 mammals, Carnivores: adults prevalent, Small mammal pattern similar to Bov 1	Bovids: adults prevalent, particularly large bovids, Carnivores: adults prevalent, Small mammal pattern different to Bov 1
Foraging range	Evidence for extended range: <ul style="list-style-type: none"> - Lack of large mammal crania - Prevalence of <i>Perna perna</i> However, skeletal element evenness index is <i>more</i> for size 2 mammals at BBC than KDS	<ul style="list-style-type: none"> - Prevalence of size 2 and large mammal crania suggest closer foraging range but could be a result of fragmentation - Dominance of Bov 1, tortoises and hyrax in PBD suggest close range but large, grazing ungulate in middle HP may imply more extensive range during that time - Skeletal element evenness <i>less</i> for size 2 mammals which suggest greater transport distances
Palaeoenvironment	<i>Fynbos</i> Biome Evidence of a shift from browse-dominated habitat in early SB to grassier terrain in later SB, Possible receding shoreline from early SB to later SB	<i>Fynbos</i> Biome Shift from more mixed terrain in early HP to grassland-dominated terrain in middle HP, Close shoreline during the middle HP to distant coast in later HP
Lithic technology	Bifacial (Still Bay) points common in later SB, Soft-hammer flakes common throughout the SB, Convex scrapers common, Silcrete increases from early to later SB, Quartz decreases from early to later SB	Shift from silcrete notched tools in early HP (PBE and PCA) to quartz backed tools in middle HP (PBA/PBB and PBC), Increase in quartz, decrease in silcrete in the middle HP (PBA/PBB and PBC)

Conclusions

Our analysis concurs with previous research that, although humans were the dominant accumulators of the BBC faunal assemblage, animals also affected the assemblage. High number of tooth marks throughout the sequence suggests that BBC was probably intermittently occupied during the SB. In comparing BBC with KDS our analysis shows that these sites have different taphonomic histories. KDS has little carnivore activity throughout the sequence and trampling and other than human activities probably resulted in the extensive fragmentation of the assemblage. Most of the taphonomic indicators suggest that the middle period of the HP at KDS was the most intensively/frequently occupied.

Processing patterns are also different between these sites. Cut marks are slightly more prevalent at BBC and the high number of cut marks on shafts suggests the filleting was a common strategy there. Percussion marks dominate the KDS fauna indicating that marrow extraction was an important subsistence activity. There is evidence of skinning, disarticulation, filleting and marrow-extraction at both sites but – with the exception of filleting – these activities are more common at KDS. Burning is prevalent at both BBC and KDS but it is unlikely that bone was systematically used as fuel or burnt as refuse at either site. The high numbers of small mammals – and juvenile small mammals – recovered at BBC and KDS raise questions on the possible use of remote capture techniques but there is no direct evidence for this.

To assess intensification patterns at both sites, we investigated three key criteria: 1) The exploitation of low-ranked game (including diet breadth and juvenile profiles); 2) the processing low-utility elements, and; 2) transport and foraging distances using skeletal-part analyses. There is evidence of more intensive subsistence strategies at KDS than at BBC. This is particularly significant finding since low-ranked element processing is a useful measure on intensification. Diet breadth is greater at KDS and all taxa analysed – including carnivore remains – were extensively processed. In fact, taxonomic richness is greater at KDS than other HP and SB sites examined. At KDS, low-ranked elements are more intensively processed than at BBC. Evidence of widespread human-induced bone fragmentation also suggests intensive occupations and subsistence strategies at KDS.

There is, however, some evidence for intensification at BBC. Based on cranial remains, foraging distances were probably greater for larger mammals at BBC than at KDS. Juvenile bovids are also significantly more prevalent at BBC. It is possible that marine regressions and

seasonality may have played a role in these trends. Indeed, subsistence patterns at BBC and KDS would have been significantly affected by palaeoenvironmental conditions. Taphonomic and skeletal-part data suggests differences in residential/mobility strategies between the SB at BBC and the HP at KDS but larger samples are needed to confirm this. A key finding of this study is that occupations were more intense or frequent during the HP at KDS compared to the SB at BBC. This may be connected to demographic influences, especially as it relates to the availability of foraging and settlement terrain in the face of fluctuating sea levels. In general, larger sample sizes are needed to support many of the trends observed in this study. We must stress that this study involves only mammalian fauna so future studies need to include birds, reptiles and fish to effectively re-evaluate diet breadth to assess intensive subsistence behaviour. More research is also needed to explore subsistence patterns at other SB sites and the links between occupational intensity and environmental change during the SB at BBC.

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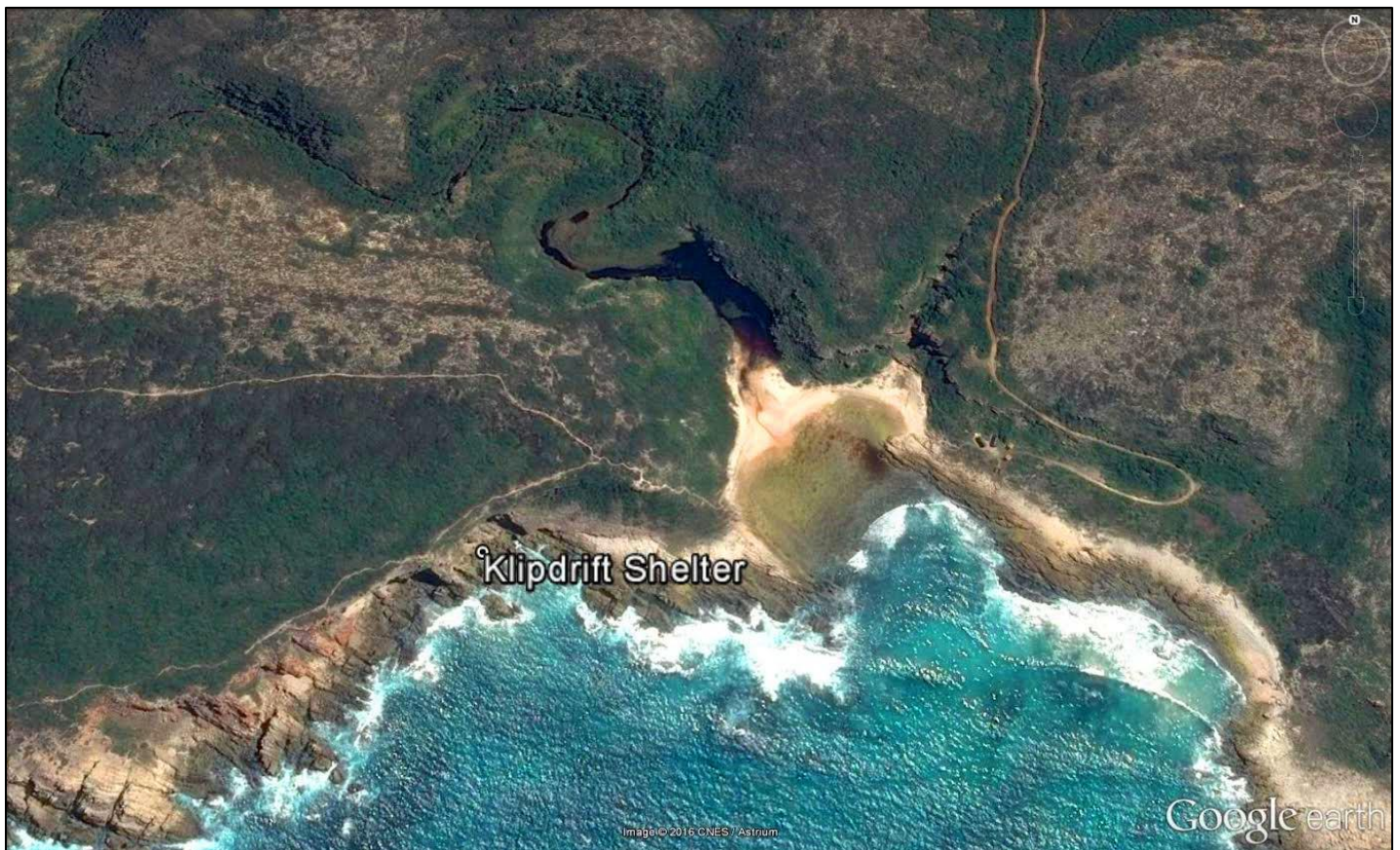
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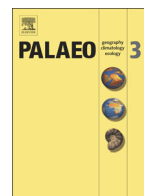
CHAPTER 5: PALAEOECOLOGY AT KLIPDRIFT SHELTER

Reynard *et al.*

“Occupational intensity and environmental change at Klipdrift Shelter, southern Cape, South Africa.”

Palaeogeography, Palaeoclimatology, Palaeoecology 449, 349-364.





Occupational intensity and environmental changes during the Howiesons Poort at Klipdrift Shelter, southern Cape, South Africa



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ABSTRACT

The Howiesons Poort, characterised by sophisticated lithic technologies and evidence of innovative behaviours, was a significant cultural phase in southern Africa during Marine Isotope Stage 4. It also coincided with substantial palaeoenvironmental and possible demographic changes in the southern Cape of South Africa, especially with regard to the shifting palaeo-coastline off the Agulhas Bank. The newly-excavated Klipdrift Shelter in the southern Cape presents a rare opportunity to compare faunal, lithic and palaeoenvironmental evidence from a single Howiesons Poort site along the present-day southern coast of South Africa. Here, we use faunal data from Klipdrift Shelter to explore the relationship between occupational intensity, subsistence behaviour and environment in the southern Cape during the Howiesons Poort period. Our results suggest a shift from a mixed terrain/browse-dominated environment during the earlier Howiesons Poort to open grasslands in the mid-later Howiesons Poort. This environmental shift corresponds to potential changes in occupational intensity or frequency throughout the sequence with evidence of increased occupations associated with grassier environments. Aspects of the cultural sequence, for example raw material procurement strategies, may be associated with shifting environmental conditions. The faunal evidence suggests links between occupation, environment and prey selection at Klipdrift. This raises interesting questions about the interplay between population density and the environment of the southern Cape, and its influence on subsistence behaviour during Marine Isotope Stage 4.

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1. Introduction

The recently excavated Klipdrift Shelter (KDS) sequence offers a window on environmental conditions and human occupations during late Marine Isotope Stage (MIS) 4 in the southern Cape of South Africa. With a diverse array of endemic plants (Cowling, 1992; Cowling and Lombard, 2002; Goldblatt and Manning, 2002; Manning, 2008), evidence of systematic shellfish exploitation (Marean et al., 2007; Jerardino, 2010; Jerardino and Marean, 2010; Langejans et al., 2012; Kyriacou et al., 2014) and a wide-range of ungulates during glacial periods (Klein, 1980; Faith, 2011), the unique Cape Floristic Region (CFR) in the south-western Cape likely played a key role in Late Pleistocene hominin development (Parkington, 2010; Faith, 2011; Marean,

2010; Marean et al., 2014). Palaeo-coastline fluctuations during the Pleistocene had significant effects on the southern Cape environment (van Andel, 1989; Fisher et al., 2010). During marine regressions, the Agulhas Bank continental shelf off the southern Cape may have been a possible refugium for hominin and ungulate populations (Faure et al., 2002; Fisher et al., 2010; Compton, 2011; Faith and Behrensmeier, 2013; Marean et al., 2014). Perhaps as a result of that, many important African Middle Stone Age (MSA) sites occur in the CFR (Deacon, 1995; Marean et al., 2000; Henshilwood et al., 2001; Marean, 2010).

From approximately 300 thousand years ago (ka) to 30 ka, the MSA encompassed both the anatomical and behavioural development of *Homo sapiens* (Klein, 2009; Wadley, 2015). One technological phase in the MSA, the Howiesons Poort (HP) – during MIS 4 – is particularly significant because it is associated with evidence of innovative behaviour and complex cognition (Lombard and Phillipson, 2010; Lombard and Haidle, 2012; Wurz, 2013; Soriano et al., 2015). A trigger for this innovative behaviour has been linked to demographic factors, as innovations are more likely to be assimilated, maintained and disseminated in

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larger populations (Shennan, 2001; Zilhão, 2007; Powell et al., 2009; Richerson et al., 2009; Clark, 2013). Powell et al. (2009) posit that population densities may have reached a critical threshold at ~100 ka when behaviourally modern traits could accumulate effectively. Yet some researchers have suggested that population density may have decreased between ~70 ka and ~30 ka (Klein, 2009; Ambrose, 2002; Ziegler et al., 2013; see also discussion by Mitchell, 2008).

These past demographic fluctuations are often associated with environmental changes (Stiner and Kuhn, 2006; Cochrane, 2008; Clark, 2011; d'Errico and Stringer, 2011; McCall and Thomas 2012). Environmental conditions may have played a critical role in the development of innovative behaviours in the MSA of southern Africa (Deacon, 1989; Ambrose and Lorentz, 1990; Ash and Gallup, 2007; Ziegler et al., 2013) as well as the expansion of people out of Africa after ~70 ka (Mellars, 2006; Scholz et al., 2007; Henn et al., 2012). Population expansions have been linked to favourable environmental conditions (Henshilwood and Marean, 2003), while resource stress resulting from deteriorating environmental conditions may have been a catalyst for new technologies and innovative economic strategies (McBrearty and Brooks, 2000; McCall, 2007). However, data on palaeoenvironmental changes, foraging strategies and occupational intensity are still notably rare at local scales thus hindering the investigation of specific relationships between innovation, demography and environmental conditions. Newly discovered MSA sites in the CFR may inform on the interaction between innovative behaviour and ecology during MIS 4. KDS is one of a handful of southern Cape sites where fauna is associated with a comprehensively-analysed HP lithic assemblage: only Klasies River (Klein, 1976; van Pletzen, 2000) and Boomplaas (Klein, 1978; Faith, 2013a) have well-provenanced HP fauna. KDS could therefore play a part in unravelling hominin/prey interactions and investigating demographic factors during this time. In this study of the terrestrial fauna, we explore the relationship between prey selection, technology and the palaeoenvironment throughout the HP at KDS. We examine the faunal assemblage at KDS to explore occupational intensity and the palaeoecological context of this region during terminal MIS 4.

1.1. Site background and environment

KDS forms part of the Klipdrift Complex (34°27.0963'S, 20°43.4582'E) and is situated in the De Hoop Nature Reserve along the coast of the southern Cape of South Africa, about 150 km east of Cape Town (see Henshilwood et al., 2014 for detailed information on the site). The Klipdriftfonteinsspruit stream (namesake of the cave complex) and Noetsie waterfall are perennial sources of fresh water and lie about 200 m east of the Klipdrift Complex. The Breede River estuary and Blombos Cave lie 10 km and 45 km east and south-east, respectively (Fig. 1). KDS lies within a wave-cut cliff ~17 m above sea level. Like most rockshelters along the southern Cape coast, the basal geology is Table Mountain Sandstone overlain with Bredasdorp Group Limestone (Malan, 1989; Henshilwood et al., 2014).

Excavations at KDS were conducted between 2011 and 2013 and ages suggest occupation during MIS 4 (~71–58 ka, Liseicki and Raymo, 2005). MSA layers at KDS were dated using single-grain optically stimulated luminescence (OSL) to between c. 71.6 ± 5.1 ka (Layer PE) and 51.7 ± 3.3 ka (Layer PAN/PAO) (Fig. 2a). All lithics between layers PCA and PAY were attributed to the HP techno-complex and PAY may be transitional to the post-HP (Henshilwood et al., 2014). The HP layers (PCA to PAY) have been dated to between 65.5 ± 4.8 ka and 59.4 ± 4.6 ka. PAY and PAZ are lighter and grittier layers while PBA/PBB and the deposits beneath them are generally black and grey layers with a relatively high number of hearths or ash features. Lithics from PDC to PCB have not been analysed and these may be from a pre-HP techno-complex. Shellfish remains occur in most layers with little or no shell below PCA. Engraved ostrich egg shell was recovered from layers PCA to PAY with most of these pieces occurring in PBD. Over 7 m² of severely

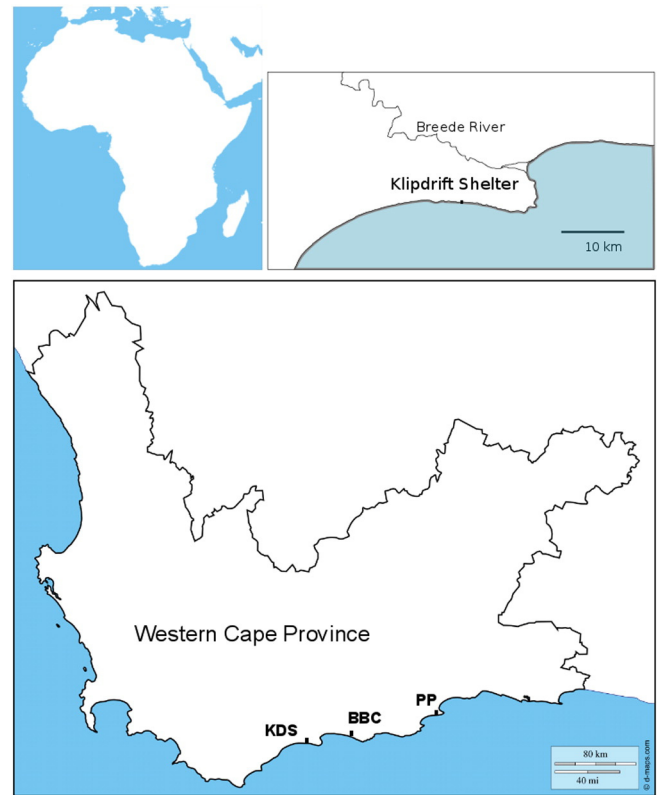


Fig. 1. Map of the south-western Cape showing Klipdrift Shelter (KDS), Blombos Cave (BBC) and Pinnacle Point (PP).

truncated deposits form a talus with a slope of ~38° (Fig. 2b). The site floor was divided into 50 × 50 cm² quadrants (Fig. 2c) and all excavated material was sieved through 3 mm and 1.5 mm mesh screens.

The winter rainfall zone (WRZ) of the south-western Cape of South Africa is characterised by cool, wet winters and warm, dry summers. KDS lies just to the east of the WRZ in the year-round rainfall zone (YRZ) and is influenced by a wide range of oceanic and atmospheric circulatory systems (Barrable et al., 2002; Chase and Meadows, 2007). The warm Agulhas Current from the south-east is especially important to the region, resulting in a relatively temperate climate throughout the year. The present-day CFR vegetation is dominated by fynbos (an evergreen, sclerophyllous shrub) but renosterveld and strandveld (shrubs and grasses) also occur nearby (Bergh et al., 2014). Mean annual precipitation (MAP) for the Fynbos Biome is ~480 mm although it is generally lower along the coastal belt west of Mossel Bay. In the vicinity of the De Hoop Nature Reserve, MAP is ~380 mm (Mucina and Rutherford, 2006). Considering the broad and shallow nature of the Agulhas Bank continental shelf off the present-day coast of the southern Cape, sea level fluctuations between glacial and interglacial periods would have resulted in severe landscape changes. Indeed, the truncation of the KDS deposits was likely caused by raised sea levels which may have washed out sediment during the mid-Holocene from the front of a more expansive Klipdrift Complex.

2. Materials and methods

In this study we use terrestrial and molluscan faunal data from the 2011 and 2012 excavation seasons at KDS. With regard to terrestrial fauna, all piece plotted specimens from 14 squares, as well as coarse fraction remains recovered from 3 mm sieve screens, were analysed from Layers PDC to PAU. The focus of this paper however is on Layers PCA to PAZ. The assemblage was analysed following Driver (2005) and Klein and Cruz-Urbe (1984) and only mammals of a similar size or larger than the Cape dune molerat (*Batherygus suillus*) are included

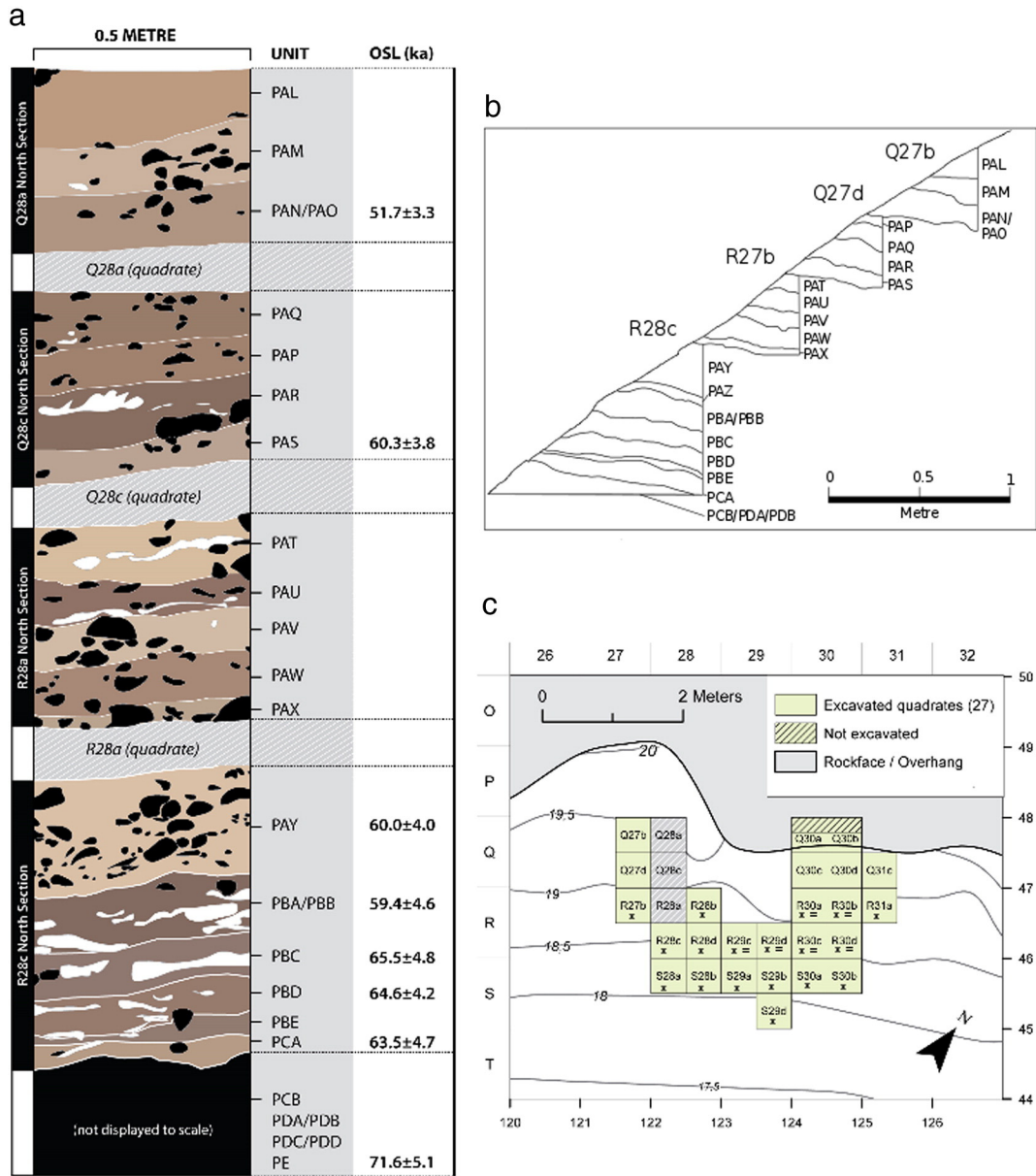


Fig. 2. (a) Stratigraphy and optically stimulated luminescence (OSL) dates for layers; (b) excavated layers in section; (c) site map of excavated area. Macro/microfauna from squares marked 'x', shellfish from squares marked '='.

in the analysis. The remains of micromammals (mammals with an adult weight <700 g) and other vertebrate taxa smaller than ~700 g (e.g., chameleons, small snakes, small birds and amphibians) are categorised as 'microfauna'. These specimens were counted but not included in our analysis. Faunal specimens were identified to taxon using the comparative faunal collections of the Ditsong Museum of Natural History (formerly the Transvaal Museum) in Pretoria. Taxa denoted as 'cf.' are included in the analysis. Although the number of identified specimens (NISP) is the preferred analytical quantitative unit (cf. Lyman, 2008), we also calculate the minimum numbers of individuals (MNI) and base these on left/right sides, distal/proximal portions and age. It must be noted that MNIs are very likely underrepresented due to extensive fragmentation of the assemblage (cf. Marshall and Pilgram, 1993). The post-cranial remains of Bovidae ('bovid') that could not be identified beyond Linnaean family were assigned to size classes based on Brain (1974). We combine larger ungulates (perrisodactyla and bovids ≥ size 3) due to the relatively small sample size (cf. Bunn and Kroll, 1986; Thompson and Henshilwood, 2011). Many faunal remains, such as cranial, rib and vertebral fragments,

could not be identified beyond class and were categorised in small, medium or large mammal size classes (Table 1). 'Small mammals' are defined as species ranging in size from the Cape dune molerat up to and including size 1 bovids, 'medium mammals' are equivalent to size 2 bovids, 'large mammals' to equids and size 3 and 4 bovids and 'very large mammals' equal rhinoceros and size 5 bovids.

In total, 35,864 specimens, weighing 12.7 kg, were examined. Of that, 2266 fragments (6.3%) were identified to at least the class level. With intra-stratigraphic analyses, we generally compare the layers with the highest NISP namely PCA, PBD, PBC and PBA/PBB because of small sample sizes in other layers. Although PAZ and PAY are small, these layers are included in the analysis. PAY is considered the last phase (*ultima periodus*) of the HP at KDS and transitional to the post-HP (Henshilwood et al., 2014). PAY and PAZ show distinct similarities in sediment texture, colour, engraved ostrich eggshell motifs and taxonomic composition relative to the layers below. Based on these similarities, we sometimes combine the data from PAY and PAZ where individual sample sizes are too small for meaningful interpretations.

Table 1
Terrestrial fauna from KDS. NISP = number of identified specimens; MNI = minimum number of individuals; ULBF = unidentified long-bone fragments; NSP = number of specimens.

Order	Taxa	Common name	PAU–PAW		PAY		PAZ		PBA/PBB		PBC					
			MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP				
Chelonii	<i>Testudinidae</i>	Tortoise		4		59		23		71		51				
	<i>Chersina angulata</i> cf. <i>Pelomedusidae</i>	Angulate tortoise Turtle	1	2	2	10	2	4	2	8	2	11				
Lagomorpha	<i>Lagomorpha</i>	Hare/rabbit	–	–	1	1	–	–	–	–	2	4				
	<i>Lepus</i> sp. <i>Lepus saxatilis</i>	Hare Scrub hare	1	1	–	–	–	–	–	–	1	1				
Rodentia	<i>Bathyergus suillus</i>	Cape dune moleerat	–	–	2	8	1	1	–	–	–	–				
Carnivora	<i>Herpestes</i> sp.	Mongoose	–	–	–	–	–	–	–	–	–	–				
	<i>Arctocephalus</i> cf. <i>pusillus</i> <i>Felis caracal/serval</i> <i>Parahyena brunnea</i>	Cape fur seal Caracal/serval Brown hyena	–	–	–	–	1	1	–	1	–	1				
Hyracoidea	<i>Procavia capensis</i>	Rock hyrax	1	5	3	22	2	11	1	1	3	31				
Perrisodactyla	<i>Diceros bicornis</i>	Black rhinoceros	–	–	–	–	–	–	–	–	1	2				
	<i>Equus</i> sp.	Zebra	–	–	–	–	–	–	2	10	3	25				
Artiodactyla	<i>Redunca fulvorufula</i> <i>Redunca arundinum</i> <i>Redunca</i> sp.	Mountain reedbuck Southern reedbuck Reedbuck	–	–	–	–	–	–	1	1	–	–				
	<i>Tragelaphus oryx</i> <i>Syncerus antiquus</i> <i>Pelea capreolus</i> <i>Raphicerus</i> sp. <i>Ourebia ourebi</i> <i>Oreotragus oreotragus</i> <i>Antidorcas</i> cf. <i>marsupialis</i> <i>Sylvicapra grimmia</i> <i>Damaliscus pygargus</i> <i>Damaliscus</i> indet.	Eland Giant buffalo Grey (Vaal) rhebok Steenbok/grysbok Oribi Klipspringer Springbok Grey duiker Bontebok/blesbok Bles/bontebok/?D. niro	–	–	–	–	–	–	1	1	–	–				
Artiodactyla	<i>Alcelaphus buselaphus</i> <i>Connochaetes gnou</i> <i>Alcelaphini</i> indet. Bovidae indet.	Red hartebeest Black wildebeest Hartebeest or wildebeest Bov I	–	–	–	–	–	–	1	1	1	1				
		Bov I/II Bov II Bov II/III Bov III Bov III/IV Bov IV	–	–	2	9	1	1	2	18	2	15				
Carnivora indet.		Small carnivore Medium carnivore	–	–	–	–	–	1	2	–	1	2				
	Mammal indet.	Small mammal Medium mammal Large mammal Very large mammal	1	1	3	41	2	8	3	33	3	78				
			1	1	2	16	2	8	3	134	3	80				
			–	–	2	5	1	3	2	25	3	45				
			–	–	–	–	–	–	1	1	–	–				
	Total identified		8	19	23	192	20	81	39	400	38	429				
	Total ULBF		18		79		40		258		150					
	Total unidentified		2		1660		969		4863		9367					
	Grand total		39		1931		1090		5521		9946					
	% ULBF		46.2		4.1		3.7		4.7		1.5					
	% identified		4.9		9.9		7.4		7.2		4.3					
	Microfauna NSP			6		1228		60		15		66				
Order	Taxa	Common name	PBD		PBE		PCA		PCA/PCB		PCB		PDA–PDC		Total	
			MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP
Chelonii	<i>Testudinidae</i>	Tortoise		251		105		24		4		1		2		595
	<i>Chersina angulata</i> cf. <i>Pelomedusidae</i>	Angulate tortoise Turtle	2	21	2	8	1	3	–	–	–	–	–	–	14	67
Lagomorpha	<i>Lagomorpha</i>	Hare/rabbit	1	1	–	–	–	–	–	–	–	–	–	–	1	1
	<i>Lepus</i> sp. <i>Lepus saxatilis</i>	Hare Scrub hare	1	3	–	–	1	3	1	1	–	–	–	–	6	12
Rodentia	<i>Bathyergus suillus</i>	Cape dune moleerat	1	1	–	–	–	–	–	–	–	–	–	3	3	
Carnivora	<i>Herpestes</i> sp.	Mongoose	–	–	–	–	–	–	–	–	–	–	–	–	1	1
	<i>Arctocephalus</i> cf. <i>pusillus</i> <i>Felis caracal/serval</i> <i>Parahyena brunnea</i>	Cape fur seal Caracal/serval Brown hyena	1	2	–	–	–	–	–	–	–	–	–	–	1	2
Hyracoidea	<i>Procavia capensis</i>	Rock hyrax	2	30	1	1	1	6	–	1	1	1	3	16	111	
Perrisodactyla	<i>Diceros bicornis</i>	Black rhinoceros	–	–	–	–	–	–	–	–	–	–	–	–	1	2
	<i>Equus</i> sp.	Zebra	1	2	–	–	1	2	–	–	–	–	1	1	8	40
Artiodactyla	<i>Redunca fulvorufula</i> <i>Redunca arundinum</i> <i>Redunca</i> sp.	Mountain reedbuck Southern reedbuck Reedbuck	–	–	–	–	–	–	–	–	–	–	–	–	1	1
	<i>Tragelaphus oryx</i> <i>Syncerus antiquus</i>	Eland Giant buffalo	–	–	1	1	1	4	–	–	–	–	–	–	2	5
			–	–	–	–	–	–	–	–	–	–	–	1	1	

Table 1 (continued)

Order	Taxa	Common name	PBD		PBE		PCA		PCA/PCB		PCB		PDA–PDC		Total	
			MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP
Artiodactyla	<i>Pelea capreolus</i>	Grey (Vaal) rhebok	–	–	–	–	1	2	–	–	–	–	–	–	3	6
	<i>Raphicerus</i> sp.	Steenbok/grysbok	1	7	1	5	–	–	–	–	–	–	–	–	7	23
	<i>Ourebia ourebi</i>	Oribi	–	–	–	–	–	–	–	–	–	–	–	–	1	1
	<i>Oreotragus oreotragus</i>	Klipspringer	1	4	–	–	–	–	–	–	–	–	–	–	1	4
	<i>Antidorcas</i> cf. <i>marsupialis</i>	Springbok	–	–	–	–	–	–	–	–	–	–	–	–	1	3
	<i>Sylvicapra grimmia</i>	Grey duiker	1	2	–	–	–	–	–	–	–	–	–	–	2	4
	<i>Damaliscus pygargus</i>	Bontebok/blesbok	–	–	–	–	1	1	–	–	–	–	–	–	4	5
	<i>Damaliscus</i> indet.	Bles/bontebok/?D. niro	–	–	–	–	–	–	–	–	–	–	–	–	1	3
	<i>Alcelaphus buselaphus</i>	Red hartebeest	1	2	–	–	1	1	–	–	–	–	–	–	4	5
	<i>Connochaetes gnou</i>	Black wildebeest	1	1	1	1	–	–	–	–	–	–	–	–	3	3
	<i>Alcelaphini</i> indet.	Hartebeest or Wildebeest	1	1	–	–	1	1	–	–	–	–	–	–	4	10
	<i>Bovidae</i> indet.	Bov I	3	62	2	7	1	4	–	–	–	–	2	3	15	119
		Bov I/II	–	–	–	–	1	1	–	–	1	2	–	–	2	3
		Bov II	3	30	1	14	2	40	–	–	1	3	1	2	18	180
		Bov II/III	1	3	–	–	1	4	–	–	–	–	1	7	5	23
		Bov III	2	45	1	2	1	40	–	–	1	1	1	3	15	157
		Bov III/IV	1	7	1	1	1	6	–	–	1	2	–	–	6	23
		Bov IV	1	4	1	3	1	19	–	–	1	1	–	–	7	33
	<i>Carnivora</i> indet.	Small carnivore	–	–	1	1	–	–	–	–	1	1	–	–	4	5
		Medium carnivore	–	–	–	–	–	–	–	–	–	–	–	–	2	3
<i>Mammal</i> indet.	Small mammal	3	78	2	8	2	31	–	–	1	7	2	12	22	297	
	Medium mammal	2	64	2	17	3	30	1	5	1	5	1	9	21	369	
	Large mammal	2	23	2	6	1	7	–	–	1	12	1	1	15	127	
	Very large mammal	–	–	–	–	–	–	–	–	–	–	–	–	1	1	
	Total identified		35	646	19	180	24	230	2	10	10	36	11	43	229	2266
	Total ULBF		63		19		83		2		27		25		764	
	Total unidentified		6791		4011		2155		207		1068		1741		32,834	
	Grand total		7500		4210		2468		219		1131		1809		35,864	
	% ULBF		0.8		0.5		3.4		0.9		2.4		1.4		2.1	
	% identified		8.6		4.3		9.3		4.6		3.2		2.4		6.3	
	Microfauna NSP			62		35		50		21		110		71		1724

Changes in faunal communities are investigated by analysing presence/absence data and taxonomic diversity throughout the sequence. The presence or absence of identified taxa can provide an indication of palaeoenvironmental conditions, despite small samples of identified taxa (cf. Rector and Verrelli, 2010). Assessments of animal habitat are based on modern data from Skinner and Chimimba (2005). To measure general taxonomic diversity in the KDS fauna, we calculated: 1) taxonomic richness or the number of taxa (NTAXA) at the genus level; 2) evenness or how equally NISP are distributed across taxa and; 3) heterogeneity, a simultaneous measurement of both evenness and richness (Lyman, 2008). The Shannon–Wiener heterogeneity index is used to determine heterogeneity and is calculated as $H = -\sum P_i (\ln P_i)$, where P_i is the proportion of taxon i in the assemblage. Larger values signify greater heterogeneity. For evenness, we use the Shannon index of evenness calculated as $e = H/\ln S$, where H is the Shannon–Wiener heterogeneity index and S is taxonomic richness or NTAXA. Values for this index fall between 0 and 1, with 1 representing a perfectly even assemblage. However, measuring NTAXA in small, fragmented assemblages is problematic on a number of levels. Different environments, subsistence strategies, the effects of archaeo-faunal palimpsests and identification methods all affect measures of taxonomic richness (Grayson, 1984; Lyman, 2008; Clark, 2011). Since larger samples are likely to produce higher NTAXA values, and the relationship between sample size and NTAXA is logarithmic (Wolff, 1975), we use a richness index (NTAXA/log NISP) calculated by dividing NTAXA by the log of the number of specimens in the taxa under consideration (Lyman, 2008).

Research suggests that ungulate richness and biomass is linked to precipitation and primary environmental productivity (Coe et al., 1976; Thackeray, 1980; Radloff, 2008; Faith, 2011, 2013b). Ungulate richness generally increases with precipitation up to ~750 ml/year, declining thereafter. However, ungulate richness may also be affected by marine regressions in the southern Cape as large herbivores, migrating

to exposed areas of the Agulhas Bank, affect faunal communities there (Marean, 2010; Faith, 2013b). To assess ungulate richness, we measure the number of ungulate taxa (uNTAXA) and calculate an ungulate richness index (uNTAXA/log NISP) (Lyman, 2008; Faith 2013b). We also calculate residual analyses (where residuals above or below regression lines are evaluated) as an additional compensation for sample size differences. Richness indices and residuals are then compared to Fisher's α – a simple measure of diversity reasonably insensitive to sample size discrepancies (Magurran, 2004; cf. Faith, 2013b).

Shellfish data are from six squares within KDS (Fig. 2c). Over 29 kg of shellfish from an excavated volume of 0.51 m³ from PCA to PAY has been analysed (Henshilwood et al., 2014). Shells were weighed and the MNI per layer was calculated. MNIs are based on the number of apices of gastropods; the left and right umbos of bivalves (with the most common side taken as the MNI); and the highest number of either front, back or middle valves of chitons (middle valve counts were divided by six). Apices and opercula of the giant periwinkle, *Turbo sarmaticus*, were counted separately with the highest count taken as the MNI.

To explore the frequency or intensity of human activities in the layers under analysis, the concentration of faunal remains in the deposits – including shellfish – was examined (cf. Marean et al., 2000; Hillestad-Nel, 2013). We measured the number of specimens (NSP) and weight of bone specimens per unit of sediment volume and compared it with densities for shellfish. Faunal density for bone and shellfish was calculated by dividing the volume of excavated material from each unit by the NSP, MNI and weight of specimens in those units. Only excavated volumes of material from the relevant units and layers were used in the calculation. We also recorded abraded specimens as a proxy for trampling modification based on previous research (Reynard, 2014). A sample of unidentified bone fragments >2 cm ($n = 1468$) was included in this dataset. Only unburnt and anthropogenically unmodified specimens – i.e., specimens with no use-wear – were used to assess abrasion.

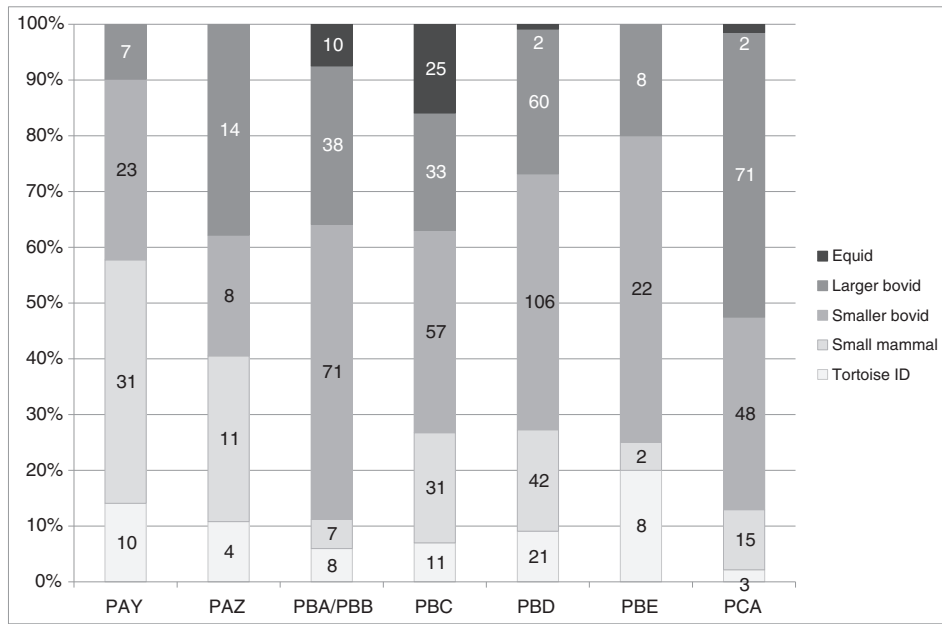


Fig. 3. Distribution of major taxonomic classes at KDS. ‘Tortoise ID’ is tortoise bone identified to genus/species. Small mammal = identified hyrax, lagomorphs & Cape dune molerat; Smaller bovid = Bov 1, 1/2 & 2; Larger bovid = Bov 3 & above. NISP in columns.

3. Results

3.1. Taxonomic composition

Despite the relatively small sample size, a diverse range of taxa was recovered from KDS (Table 1). Important diachronic changes are evident in the taxonomic composition throughout the KDS sequence. *Raphicerus* (Cape grybok or steenbok), hyrax and angulate tortoise remains are prevalent at KDS and are all associated with CFR fynbos. Eland, *Raphicerus* and klipspringer are mixed-feeders or browsers and are relatively common in PCA, PBE and PBD, respectively. Size 4 bovids are also prevalent in PCA and these are most likely eland since no Cape buffalo (*Syncerus caffer*) were identified in the assemblage. Most of the identified ungulate taxa in PBC and PBA/PBB such as

the alcelaphines and equids are preferential grazers. Based on osteomorphology of metapodia (Plug, 2014) it is likely that at least two equid specimens are plains zebra (*Equus quagga burchellii*) or quagga (*E. q. quagga*) and not the Cape mountain zebra (*E. zebra zebra*).

Fig. 3 shows a significant variation through time in the proportion of the major categories of terrestrial fauna at KDS ($\chi^2 = 143.17$; $p < 0.0001$). Equids are significantly more prevalent in PBC ($\chi^2 = 16.35$; $p < 0.05$ between equid and other identified taxa in PBC and PBA/PBB) (Fig. 3). Larger bovids dominate PCA but become less widespread in the upper layers. There is no major variation in ungulate size classes between PBC, PBA/PBB and PAY/PAZ (Fig. 4). However, there are significant differences in the proportion of size classes between PBD and PBC ($\chi^2 = 46.64$; $p < 0.0001$), PBE and PBD ($\chi^2 = 15.77$; $p = 0.001$) and between PCA and PBE ($\chi^2 = 19.05$; $p = 0.0003$).

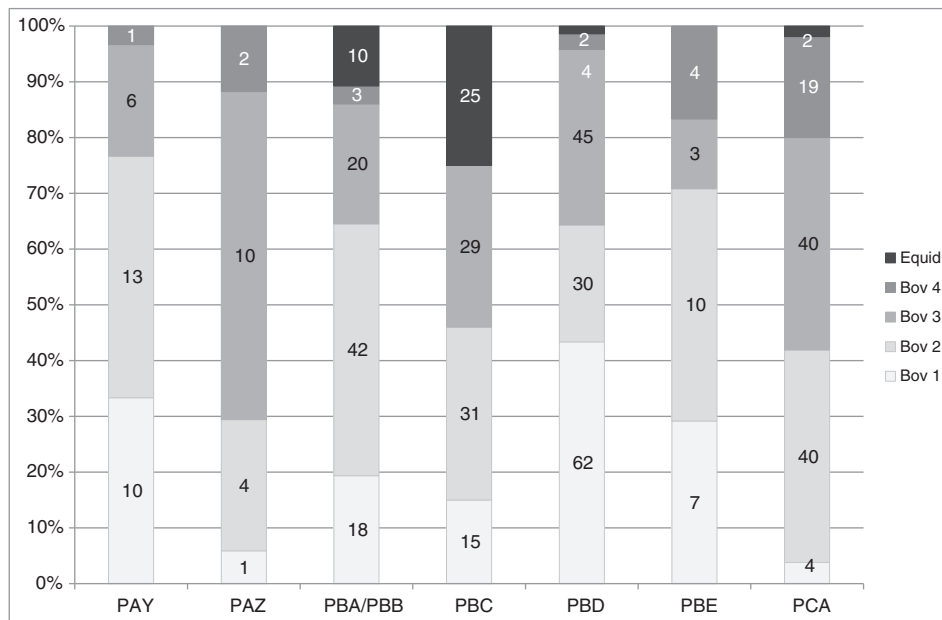


Fig. 4. Ungulate size classes per layer. NISP in columns.

Table 2

Chi-squared and Fishers exact test for identified small mammals vs larger mammal at KDS. Asterisks are Fishers exact test. Identified small mammals are Cape dune mole rat, hyrax and lagomorphs.

Layers compared		χ^2/T_E	Probability	Significance
PAY	PAZ	0.037*	<0.05	Yes
PAZ	PBA/PBB	13.209	0.0003	Yes
PBA/PBB	PBC	20.752	<0.0001	Yes
PBC	PBD	3.327	0.068	No
PBD	PBE	0.018*	<0.05	Yes
PBE	PCA	0.110*	>0.05	No

Like other Late Pleistocene sites in South Africa, small mammals and tortoise are common. Bird and fish remains also occur, although these have not yet been analysed. PAZ and PAY have higher percentages of identified small mammals (PAZ: NISP = 12; 13.6% and PAY: NISP = 30; 13%, respectively) compared to lower layers (e.g., PBC: NISP = 32; 7.2% and PBA/PBB: NISP = 1; 1.8%). Small mammal abundance increases significantly from PBE to PBD, dropping in PBA/PBB and rising again from PAZ to PAY (Table 2).

The proportions of grazers, browsers and mixed-feeders vary through the HP sequence with less grazers identified in PBE and PAY/PAZ and a greater abundance of grazers in PBC and PBA/PBB (Fig. 5). There is a significant increase in the proportion of grazers from PBD to PBC, dropping in PAY/PAZ (Table 3). Generally, increases in the numbers of grazers for each layer correspond to increased ungulate abundance ($r_s = 0.986$; $p = 0.0003$).

3.2. Taxonomic diversity

Table 4 provides taxonomic diversity indicators for all layers at KDS as well as for various other HP sites in South Africa. There is no relationship between the taxonomic richness index (NTAXA/log NISP) and Σ NISP ($r_s = 0.252$; $p = 0.585$). There is, however, a close association between the richness index and NTAXA ($r_s = 0.919$; $p = 0.003$). Correlation tests for Σ NISP versus heterogeneity (H) ($r_s = 0.126$; $p = 0.788$) and evenness (e) ($r_s = 0.218$; $p = 0.638$) indicate no clear relationship between sample size and those indices. The richness index is significantly correlated with H ($r_s = 0.964$; $p = 0.0004$) which suggest an

Table 3

Chi-squared and Fishers exact test for grazers vs mixed-feeders/browsers at KDS. Asterisks are Fishers exact test.

Layers compared		χ^2/T_E	Probability	Significance
PAY/PAZ	PBA/PBB	0.038*	<0.05	Yes
PBA/PBB	PBC	0.349	0.555	No
PBC	PBD	9.851	0.002	Yes
PBD	PBE	0.389*	>0.05	No
PBE	PCA	0.316*	>0.05	No

association between richness and diversity at KDS. Most KDS layers have H values higher than Sibudu and comparable with Diepkloof and Boomplaas HP layers; except PBE, with a low H value (potentially due to its small sample size), and PBA/PBB and PCA, with relatively higher values. PBA/PBB is the most heterogeneous layer with a relatively even distribution of individuals per taxa. Of all layers analysed, taxa in PCA are the most evenly distributed and are also relatively heterogeneous. The proportion of grazers through the layers (Fig. 5) is significantly correlated to NTAXA ($r_s = 0.883$; $p = 0.009$), the general taxonomic richness index (NTAXA/log NISP) ($r_s = 0.893$; $p = 0.0008$) and heterogeneity ($r_s = 0.857$; $p = 0.014$) (Table 3).

Table 5 shows data related to ungulate richness. We measure richness by means of an index (uNTAXA/log NISP). A residual analysis was also employed to alleviate the effects of sample size. High values represent a rich ungulate assemblage while low values indicate less rich layers. Residuals are significantly correlated to the richness index ($r_s = 0.933$; $p = 0.0003$). There is also a close association between uNTAXA and Σ NISP ($r_s = 0.943$; $p < 0.00001$) and log NISP ($r_s = 0.923$; $p < 0.0002$) (Fig. 6). The significant correlation between Fishers α and the richness index ($r_s = 0.917$; $p = 0.0005$) and residuals ($r_s = 0.883$; $p = 0.002$) also points to a close relationship between diversity and richness.

Ungulate richness varies through the KDS sequence (Fig. 7). PBA/PBB has the highest richness and diversity value and PBE has the lowest. There are substantial difference in richness and diversity between PBD, PBC and PBA/PBB. Ungulate richness also varies significantly between different HP sites. Richness and diversity is similar at Diepkloof and Boomplaas and greater at KDS than at any of the HP sites analysed. Sibudu is the least rich site in our dataset. There is no significant

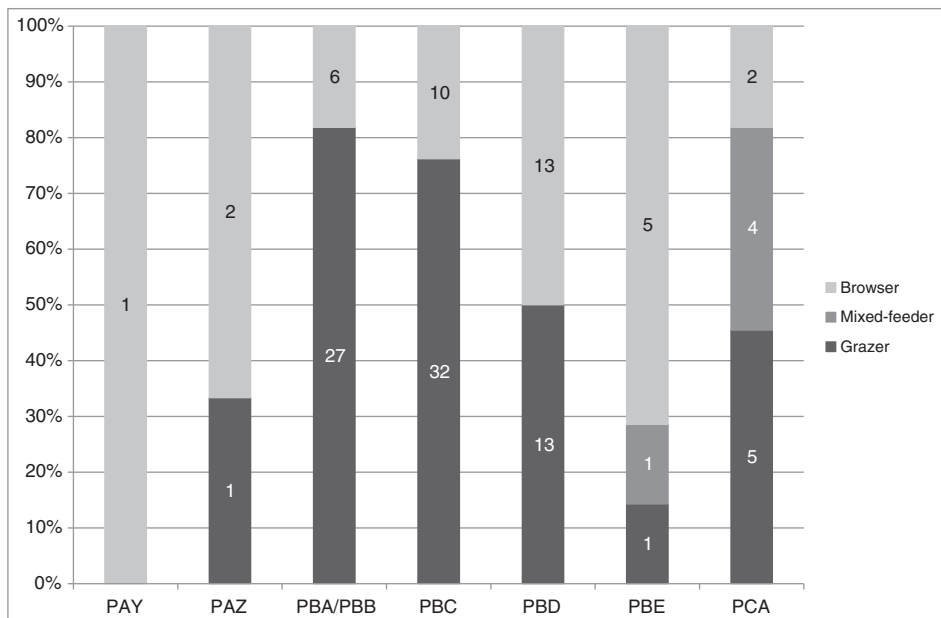


Fig. 5. Ungulate dietary preferences at KDS. NISP in columns.

Table 4

General taxonomic richness (NTAXA), richness index (NTAXA/log NISP), heterogeneity (*H*) and evenness (*e*) at KDS and other HP sites.

Site	Layer	NTAXA	ΣNISP	NTAXA/ log NISP	H	e	Source
KDS	PAY	5	41	3.100	1.123	0.698	This study
	PAZ	7	20	5.380	1.342	0.645	This study
	PBA/PBB	12	37	7.652	2.112	0.850	This study
	PBC	11	84	5.716	1.660	0.692	This study
	PBD	13	75	6.933	1.775	0.692	This study
	PBE	5	16	4.152	1.233	0.145	This study
	PCA	8	20	6.149	1.878	0.903	This study
–	KDS total	20	293	8.107	2.091	0.667	This study
Sibudu	HP	28	1806	8.598	1.279	0.389	Clark (2011)
Diepkloof	HP	24	1044	7.950	1.867	0.589	Steele & Klein (2013)
Boomplaas	HP (layer OCH)	19	576	6.833	2.072	0.704	Faith (2013a)

Table 5

Ungulate richness for KDS and other HP sites. DRS = Diepkloof Rockshelter comprising the 'Early HP', 'Inter HP' & 'Late HP' layers (Steele & Klein, 2013); BPA = Boomplaas Cave (OCH layer) (Faith, 2013a). Sibudu data from Clark (2011).

Samples	NISP	log NISP	NTAXA	NTAXA/log NISP	Residuals	Fishers α
PAY	1	0	1	–	0.207	
PAZ	3	0.477	3	6.288	–0.063	4.000 ^a
PBA/PBB	27	1.431	9	6.288	1.397	4.724
PBC	40	1.602	7	4.369	–1.417	2.454
PBD	19	1.279	7	5.474	0.121	4.002
PBE	7	0.845	3	3.550	–1.814	1.988
PCA	10	1.000	5	5.000	–0.552	3.978
Total KDS	111	2.045	14	6.845	3.475	4.238
Sibudu	1592	3.202	14	4.372	–2.031	2.112
DRS	135	2.130	11	5.164	0.071	2.831
BPC	274	2.438	13	5.333	0.605	2.840

^a For PAY and PAZ combined.

relationship between the proportion of grazers in the sequence and Fishers α ($r_s = 0.6$; $p = 0.208$), the ungulate richness index ($r_s = 0.377$; $p = 0.465$) or residual values ($r_s = 0.214$; $p = 0.645$).

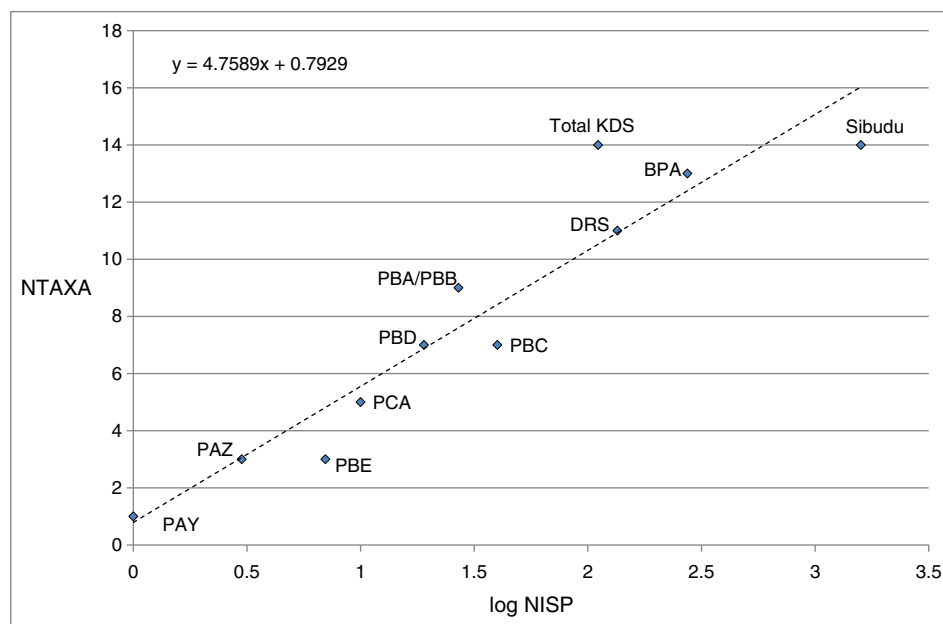


Fig. 6. NTAXA versus log NISP for KDS and other HP sites. DRS = Diepkloof Rockshelter comprising the 'Early HP', 'Inter HP' & 'Late HP' layers (Steele & Klein, 2013); BPA = Boomplaas Cave (OCH layer) (Faith, 2013a). Sibudu data from Clark (2011). $r_s = 0.943$; $p < 0.00001$.

3.3. Faunal density per volume

Both in terms of weight and NSP; PBD, PBC and PBA/PBB have the highest macrofaunal bone densities per sediment volume (Fig. 8a, b). Shellfish density is highest in PBC, followed by PBA/PBB and PBD (Table 6). The weight per volume (kg/m^3) and MNI/m^3 are significantly correlated for shellfish ($r_s = 0.893$; $p = 0.0068$). There is also a significant correlation between the NSP/m^3 of bone and the MNI/m^3 of shellfish per layer (Table 6) ($r_s = 0.857$; $p = 0.0137$). There is a weak relationship between general taxonomic richness indices (NTAXA/log NISP) and bone weight per volume (kg/m^3) ($r_s = 0.714$; $p = 0.071$). The percentage of grazers through the sequence is significantly correlated to bone density (kg/m^3) and to shell MNI/m^3 ($r_s = 0.857$; $p = 0.0137$). Microfauna are common in PAZ/PAY (NISP = 1288) and are rare in deeper layers (NISP for all layers below PAZ = 430) (Table 1). The predominance of microfauna in those top layers suggest that raptors or other rodent/small reptile predators were prevalent then, and may relate to lower frequencies of human occupation at that time (Cruz-Urbe and Klein, 1998).

3.4. Trampling modification

Trampling data from KDS suggests bioturbationary events peaked in the middle layers (Fig. 9). There are significantly more abraded specimens in PBA/PBB (PBA/PBB vs PAZ: $\chi^2 = 14.35$; $p < 0.0002$; PBC vs PBA/PBB: $\chi^2 = 19.64$; $p < 0.0001$) and although PBE has proportionally less abrasion, it is not significantly different from other layers (e.g., PCA vs PBE: $\chi^2 = 2.28$; $p = 0.131$). There is also a significant relationship between abrasion and bone density (kg/m^3) ($r_s = 0.786$; $p = 0.0362$) and the proportion of grazing ungulates ($r_s = 0.964$; $p < 0.0005$) through the HP sequence.

4. Discussion

4.1. Palaeoenvironment

Generally, variation in faunal composition and grazer/browser proportions from PCA to PAY suggests gradual environmental change from the earlier to later HP period (Table 7). Significant associations between the proportion of grazers, ungulate abundance and general

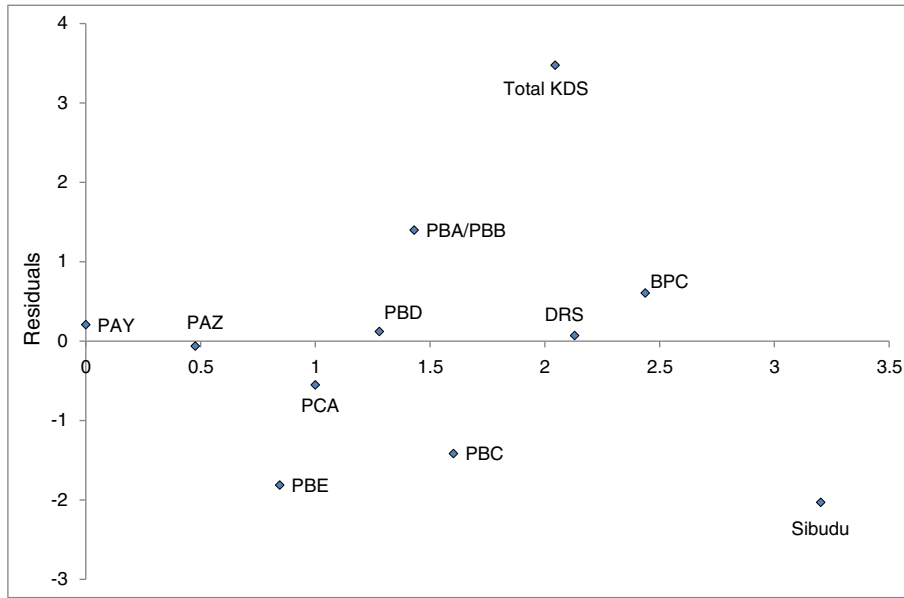


Fig. 7. Ungulate residual values at KDS and other HP sites. DRS = Diepkloof Rockshelter comprising the 'Early HP', 'Inter HP' & 'Late HP' layers (Steele & Klein, 2013); BPA = Boomplaas Cave (OCH layer) (Faith, 2013a). Sibudu data from Clark (2011).

taxonomic diversity suggest links between prey selection and richer faunal assemblages. However, even if the faunal changes documented are related to changes in prey selection, the fact that these changes are

in good agreement with other independent palaeoenvironmental proxies (cf. Henshilwood et al., 2014 and discussion below) supports the idea that the faunal signal at KDS speaks, at least in part, of palaeoenvironmental changes.

Eland and alcelaphines in PCA imply an open/mixed terrain becoming more closed and bushy with the predominance of size 1 bovinds, hyrax and tortoise in PBD. The prevalence of equid and alcelaphines in PBC and PBA/PBB (and oribi in PBA/PBB) suggests a grass-dominated terrain in those layers. The identification of plains zebra or quagga (*E. quagga*) in these layers – a species associated with savannah is also consistent with more open, grasslands. Reedbuck in PBC and PBA/PBB imply grasslands near a fresh-water source such as a wetland or riverbed. Cape dune molerat in PAZ and PAY suggests an expansion of dune or sea-sand during this time while the occurrence of springbok in the top layers (PAU–PAW) (Table 1) makes it feasible that this may have been drier in the post-HP period.

The HP layers analysed in this assemblage have been OSL dated to between ~66 and 59 ka (Henshilwood et al., 2014); a period corresponding to the latter part of MIS 4. Some researchers contend that the shifting of westerly storm-cycles during glacial periods may have resulted in wetter conditions during MIS 4 relative to the more arid MIS 3 (Stuut et al., 2004; Chase, 2010). Micromammal and molluscan evidence from Klasies River also suggest that this period was wetter in the south-eastern Cape (Avery, 1987; Thackeray, 1988). Bar-Matthews et al. (2010) argue that glacial periods along the southern Cape near Pinnacle Point were characterised by more summer rain and an expansion

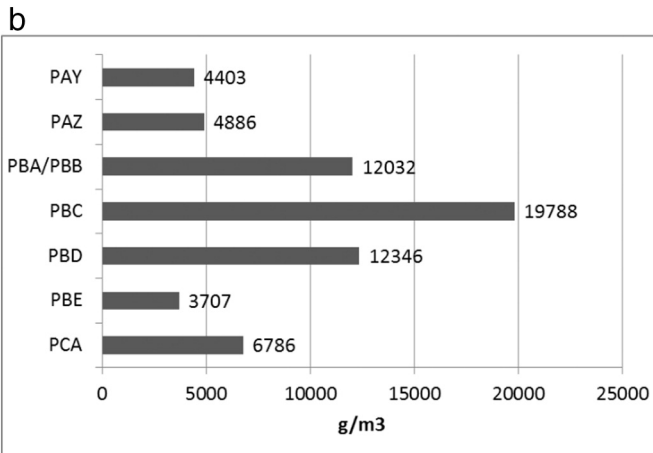
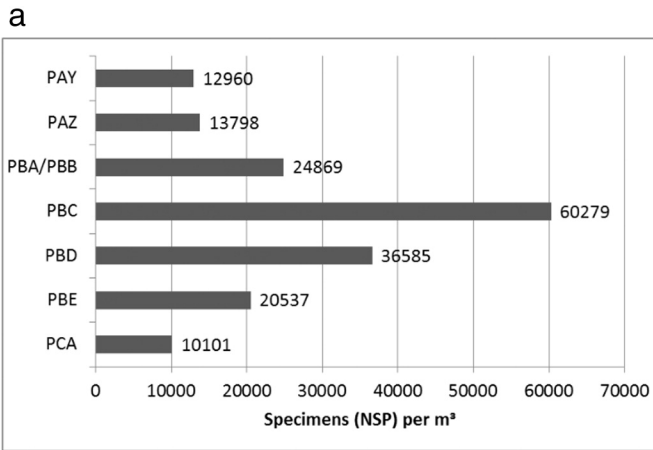


Fig. 8. (a) Macrofaunal density by specimens per layer. NSP = number of specimens; (b) Macrofaunal density by bone weight (in grammes) per layer.

Table 6

Faunal density per layer. MNI = minimum number of individuals. NSP = number of specimens. NISP = number of identified specimens. Shellfish data from Henshilwood et al. (2014).

Layer	Shell		Macrofauna		Microfauna
	kg/m ³	MNI/m ³	kg/m ³	NSP/m ³	NSP/m ³
PAY	3	15	4.4	12,960	8242
PAZ	16	46	4.9	13,797	760
PBA/PBB	32	168	12.0	24,869	68
PBC	183	423	19.8	60,279	400
PBD	181	141	12.3	36,585	302
PBE	40	126	3.7	20,537	171
PCA	25	80	6.8	10,101	188

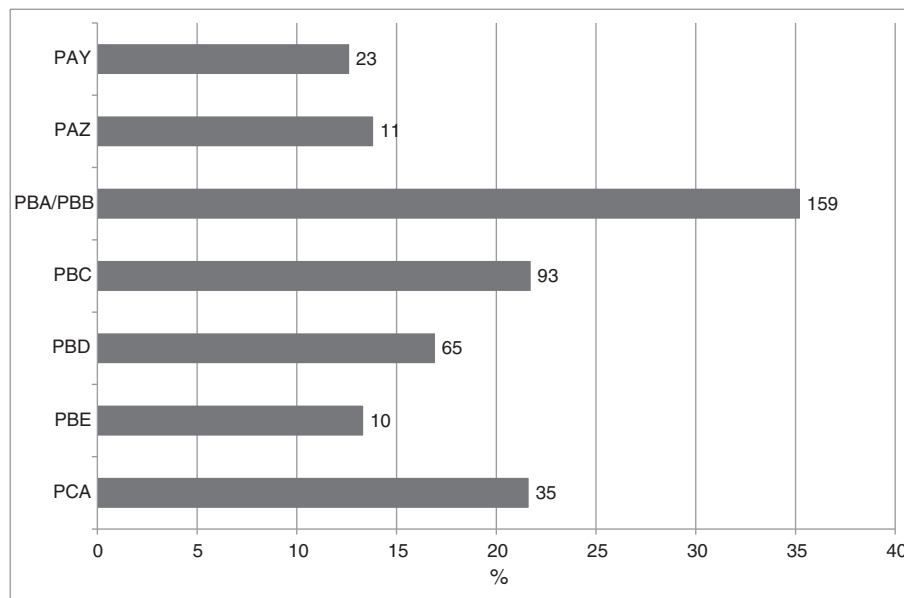


Fig. 9. Proportions of abraded specimens in the HP sequence at KDS. Numbers of specimens (NSP) next to columns.

of C4 grasses. The presence of *Cymbula granatina* throughout the HP sequence at KDS indicates cooler sea surface temperatures than at present (Henshilwood et al., 2014). Part of the HP sequence at Klasies River Cave also relates to a cooling period, but a warming period has been recorded there as well (Thackeray and Avery, 1990).

Ungulate indices also point to significant variation in palaeo-environmental conditions during the HP at KDS. Ungulate richness values suggest that the environment of KDS may have been more humid than at other HP sites. The exception is Sibudu where the low richness index for that site (Fig. 7) is likely a result of very high levels of precipitation in the Subtropical Forest biome surrounding Sibudu which exceed 750 ml/year (Mucina and Rutherford, 2006). Ungulate richness varies throughout the KDS sequence with PBC significantly

less rich than PBA/PBB. There are also substantial variations in small mammal abundance between these layers (Table 2) which may point to important environmental or subsistence changes then. This may reflect humidity levels but it could also be a result of marine regressions. Fluctuating small mammal abundances (Table 2) and isotopic studies on ostrich egg shell (OES) at KDS also suggest substantial periods of variability in vegetation and precipitation during the HP (Roberts, 2013).

The faunal composition of PBC and PBA/PBB points to the development of a grassland-dominated ecosystem that corresponds to an increased frequency of C4 plants at around 66 ka (Bar-Matthews et al., 2010). Grazers dominate PBC and PBA/PBB and there is also relatively more OES in PBA/PBB (Table 6 in Henshilwood et al., 2014). Ostriches

Table 7
Summary of faunal and lithic characteristics per layer.

	PAY	PAZ	PBA/PBB	PBC	PBD	PBE	PCA
Faunal density/occupational intensity	Low proportion bone and shellfish. Low abrasion. Low occupation?		High bone and shellfish. Highest abrasion. High occupation?	Highest bone and shellfish. High abrasion. High occupation?	High bone and shellfish. High abrasion. High occupation?	Low bone and shellfish. Low abrasion. Low occupation?	Low bone and shellfish. Relatively high abrasion. Low/intermediate occupation?
Microfauna	Highest occurrence	Common	Very rare	Rare	Rare	Very rare	Very rare
Proportional taxonomic abundance	Tortoise and small mammal prevalent		Equids common. Size 2 bovinds relatively common. 'Medium' mammal very common	Equid dominates	Tortoise & Size 1 bovinds prevalent	Tortoise, <i>Raphicerus</i> & Size 2 bovinds common	Size 3 & 4 bovinds common
Palaeoenvironment	Sandy (<i>Donax serra</i> and Cape dune molerat present)		Open grasslands (grazers dominate) with nearby fresh water (reed buck relatively common)	Open grasslands (grazers dominate)	Bushy, closed terrain (browsers dominate)	Bushy, closed (<i>Raphicerus</i> dominate)	Possibly mixed/open terrain (eland common)
Lithic technology	Unifacial points. Backed artefacts. Larger blades. Levallois flakes	Backed artefacts	Backed artefacts	Backed artefacts. Mostly segments	Backed artefacts. Borers. Silcrete blades with retouch on lateral edge	Backed artefacts. Strangulated blades	Silcrete blades. Notched tools
Raw material proportional change	Quartzite very clearly dominates (72%). Quartz (13%). Silcrete (10%)	Quartzite more prevalent (45%). Quartz less prevalent (37%). Silcrete (14%)	Quartz more prevalent (54%). Quartzite less prevalent (37%) (Note the switch in representation). Silcrete (5%)	Quartzite clearly dominates (60%) with a lower proportion of quartz (29%). Silcrete (10%)	Quartzite (46%) and silcrete (37%) dominate (highest proportion of silcrete in the sequence). Quartz (17%)	Quartzite dominates (52%), with low proportions of quartz (22%) and silcrete 24%	Quartzite dominates (49%), with low proportions of quartz (22%) and silcrete (13%)

are indicative of open, grassy terrain (Sauer and Sauer, 1966). Given the evidence of variable ungulate richness indices and changing $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ OES values (Roberts, 2013) in PBC and PBA/PBB, this suggests that open, grassy terrain during this period may be associated with changing levels of precipitation and/or changing shorelines (but see Chase and Meadows, 2007 and Faith, 2011: 224 for a discussion on aridity and precipitation). Compton (2011) contends that the vegetation on the exposed Agulhas Bank surrounding KDS during low sea stands was likely predominantly renosterveld which typically contains a mix of C3 and C4 grasses (Cowling, 1983; Goldblatt and Manning, 2002; Bergh et al., 2014). Historical accounts of grazers in the renosterveld-dominated WRZ of the south-western Cape also suggest that a prevalence of C4 grasses is not necessary for large-bodied grazers (Skead, 1987). Although the nature of prevailing photosynthetic pathways of grasses in the WRZ is contentious (e.g., Klein and Cruz-Urbe, 1991; Franz-Odenaal et al., 2002; Stynder, 2009; Faith, 2011), $\delta^{13}\text{C}$ values of KDS OES falls within the range of C4 plants and suggests a dominance of C4 grasses near KDS (Roberts 2013). Isotopic studies of the nearby Crevice Cave speleothems at Pinnacle Point (Bar-Matthews et al., 2010) support this scenario.

4.2. Intensity of human occupation

The extent and intensity of human occupations in the Late Pleistocene of southern Africa is often debated (Mitchell, 2008; Marean, 2010; Dusseldorp, 2014; MacKay et al., 2014; Karkanas et al., 2015). McCall and Thomas (2012) argue that increased demographic pressure during the HP resulted in longer-term residential occupation. Other researchers have suggested occupational shifts from the interior to the coast (Faure et al., 2002; Compton, 2011; Faith, 2013a; Wadley, 2013) and a general decline in populations during cooler, glacial periods (Deacon and Thackeray, 1984; Klein, 2009). Much of our investigation of occupation rates at KDS is based on molluscan and bone volumetric density data. Processing behaviour, changing depositional rates, mechanisms of sedimentation and environmental conditions all affect faunal density volumes and these should be taken into account when assessing these data (Jerardino, 1995, 2015). Detailed information on site formation processes is lacking at KDS and pending adequate geoarchaeological and related taphonomic data, we can only assume that shifts in assemblage densities are – at least in part – related to changes in occupational intensity. Based on this assumption, the significant correlation between shellfish and bone volumetric densities through the layers suggests varying intensities of human occupation at KDS through time and implies that the middle layers (PBD, PBC and PBA/PBB) were the most intensely occupied periods (Tables 4 and 5). Compelling evidence can also be found in the trampling data. The significant relationship between the volumetric density of bone per layer and abrasion also indicates that the middle layers were more intensely occupied. However, given the similar OSL ages in PAY and the layers above PAY at ~60 ka (Fig. 2) – which may suggest a period of rapid sedimentation – and the colour/texture differences between PAY/PAZ and the lower layers, it is possible that bone and shell volumetric densities may have been affected by increased aeolian contributions in PAY/PAZ (Jerardino, 2015). Still, other data suggests that these layers do indeed reflect a less frequent/intense occupational phase than the middle layers.

Some taphonomic data support the notion of shifting occupational intensities through the sequence. Generally, the taphonomic history of the KDS faunal assemblage does not vary significantly through layers, with two exceptions: PBD and PAY/PAZ (Reynard et al., 2015). PBD is a faunally dense layer dominated by small bone fragments with a prevalence of tortoise, hyrax and small bovids. On the whole, terrestrial fauna from KDS is severely fragmented; probably due to intensive marrow extraction strategies and post-depositional processes (Reynard et al., 2015). In PBD, unlike other layers, transverse fractures are common on ungulate long-bone (Fig. 10). This suggests a greater influence

of post-depositional processes (probably trampling) and more intense human occupations in the middle layers which include PBD. In fact, in terms of shellfish and macrofauna, PBD, PBC and PBA/PBB are the three densest layers (Fig. 8; Table 5). The significant correlations between grazer proportions, trampling modification and bone density per volume suggest that occupational intensity in these middle layers may have been an important factor in subsistence strategies. It is feasible, for example, that population pressure may have linked extended foraging rangers to increase grazer selections. The upper layer PAY – and, to a lesser extent, PAZ – show less evidence of anthropogenic modification for all taxa (Reynard et al., 2015). These low-density layers are also characterised by high inclusions of microfauna, suggesting a greater influence of non-human bone accumulators during that period.

4.3. Occupational intensity and the palaeo-coastline

The KDS data raise interesting questions about occupation rates at near-coastal locations during the MIS 4 glacial period. If we assume that faunal density fluctuations imply varying intensities of human occupation at KDS, then occupational rates/intensity might have been affected by distances to the shoreline. Indeed, research indicates that human occupation at coastal sites was in some instances heavily influenced by access to shellfish (Jacobs et al., 2006; Fisher et al., 2010; Marean, 2010; Marean et al., 2014; Karkanas et al., 2015, but see Jerardino, 2015) and points to a link between shellfish density and changing sea levels. PAY and PAZ appear to be low-density occupational layers. The occurrence of *Donax serra* in PAY, a sandy beach mollusc, and Cape dune molerat remains in PAZ and PAY suggests a local environment dominated by dune-sands. Likewise, the increase in *Dinoplax gigas* towards the top of the sequence can also be considered an indicator of increasing sandy conditions. Given the decrease in shellfish, and evidence of increased dune activity, it is possible that the shoreline was further away during PAY/PAZ. Previous research suggests that marine regressions on the southern Cape coast were generally accompanied by increasing sea sand/dune activity (Roberts et al., 2008; Fisher et al., 2010; Bateman et al., 2011). However, a further shoreline does not correspond to what is expected during terminal HP or the transition to the post-HP – a phase normally associated with the warmer MIS 3. Perhaps the period from PBA/PBB to PAY represents a site-specific marine regression period possibly due to the complicated topography off KDS. High shellfish densities in the middle layers (PBD, PBC and PBA/PBB), on the other hand, may point to a relatively close shore (Fisher et al., 2010; Marean, 2010; Langejans et al., 2012; Dusseldorp and Langejans, 2013) and taphonomic data support a high-occupational phase then (Fig. 9; Reynard et al., 2015). However, the high meat-yielding species *D. gigas*, *Haliotis midae* and *T. sarmaticus* are the most prevalent species by weight relative to other molluscs at KDS. The abundance of these taxa suggests that species with high meat-yield rates were targeted throughout the sequence and may imply that the shore had not shifted more than 5 km away during the period under analysis (Langejans et al., 2012; Henshilwood et al., 2014). It is therefore possible that occupational intensities at KDS were not linked to fluctuating shorelines. Increased sedimentation rates may explain the lower faunal densities in PAY/PAZ. Even if density does reflect less frequent/intense occupations in those layers, low densities may not relate to shoreline regression but to changes in coastal ecology. Ricciardi and Bourget (1999) note that rocky shorelines are 10 to 100 times more productive than sandy beaches so the presence of *D. serra* in PAY may signify a drop in coastal productivity at KDS. A decrease in coastal productivity at KDS may have made this site less attractive to foraging groups during PAY/PAZ resulting in less intense occupational periods at that time.

Yet, the rich ungulate community evidenced in the middle layers points to an open, environmentally productive habitat. Current understanding of palaeo-coastlines in the southern Cape indicates that

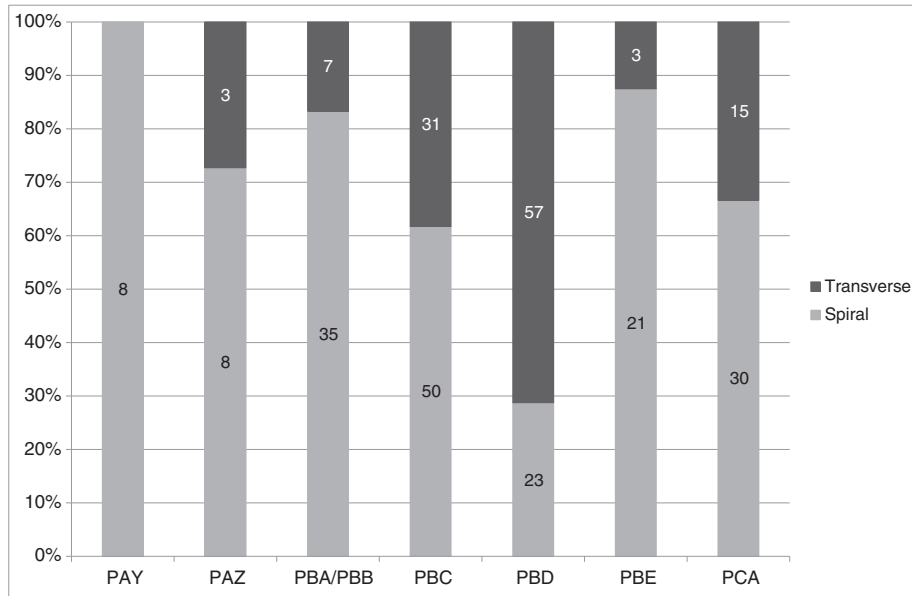


Fig. 10. Ungulate long-bone fracture patterns per layer. Data from Reynard et al. (2015).

sea-levels would have dropped significantly during MIS 4 – up to 80 m near Blombos Cave (Fisher et al., 2010, Supplementary material Appendix 3.2) – exposing a vast swathe of the Agulhas Bank (van Andel, 1989; Fisher et al., 2010; Compton, 2011). Palaeoecological studies of the southern Cape also suggest that this exposed coastal plain was likely to attract large grazers from the southern African interior through a coastal portal between Plettenberg Bay and Port Elizabeth in the south-east Cape (Compton, 2011; Faith and Behrensmeier, 2013). Under this model, the exposed Agulhas Bank would be the ideal habitat for large, gregarious ungulates which corresponds to what was recovered in PBC and PBA/PBB. Seal remains, common at coastal sites (Marean, 1986; Klein and Cruz-Urbe, 1996; Dusseldorp and Langejans, 2013), are rare at KDS. However, Marean (1986: 144) argues that seal bones not associated with meat are unlikely to have been transported back to home-base while Dusseldorp and Langejans (2013: 113) suggests that the consumption of seal ‘sculp’ (skin and subcutaneous fat) would result in an under-representation of seal bones in assemblages. The very high concentrations of shellfish in the middle layers suggest that sea levels may have been close, at least during that period.

An explanation for the prevalence of both shellfish and ungulates may lie in the disparate topography of the exposed Agulhas Bank off the coast of KDS (de Wet, 2012). By ~65 ka, the glacial optimum would have relented and sea-levels on the southern Cape coast would have begun rising (Compton, 2011). Jacobs and Roberts (2008) contend that the HP coincided with a warming interval during terminal MIS 4 which may account for the relatively close sea levels implied in the middle layers at KDS. The palaeoscape model of Fisher et al. (2010, Supplementary material Appendix 3.2) shows a relatively close shoreline near Blombos Cave (averaging 7.7 km with minimum distances of ~2.3 km) at around 60 ka. A bathymetric study of the southern Cape coast by de Wet (2012: Appendix pg. 290) suggests that the shore off KDS – about 45 km west of Blombos Cave – may have been even closer during that time which is concordant with high shellfish densities in the middle layers at KDS (Fig. 11).

Other sites in the southern Cape also indicate variable palaeo-coastlines during MIS 4. At Klasies River the significant densities of artefact and bone in the HP layers suggest that occupational intensity was generally high during the HP (Deacon and Geleijnse, 1988: 12). Yet changes in proportions of seal remains, bone and shellfish volumetric

densities and micromammal frequencies also suggest variable occupational rates and possible fluctuating distances-to-shore during the HP at Klasies River (Klein, 1976; Avery, 1987; Deacon and Geleijnse, 1988; Thackeray, 1988). A recent micromorphological study of Pinnacle Point Sites 5–6, ~127 km east of KDS, suggests that MIS 5 was a relatively low-occupation phase compared to more intense occupations during MIS 4 (Karkanas et al., 2015) despite a generally further shoreline during the latter Stage (van Andel, 1989; Fisher et al., 2010).

This presents an interesting scenario on subsistence behaviour and the palaeo-coastline. De Wet (2012: 170) shows a relatively wide rocky inner shelf near Cape Agulhas that narrows to ~5 km just off the coast of KDS (Fig. 10). South of this rocky plateau off Cape Infanta, the topography is generally featureless, gently sloping down to the Breede River Palaeo-Drainage Valley, about 40 km south of KDS (de Wet, 2012: 181 and Appendix Fig. 5.30). It is reasonable to suppose that, as sea levels regressed, the relatively rocky terrain to the south-west of KDS could have given rise to a series of inter-tidal pools that may have sustained high numbers of molluscan fauna (J. Compton, pers. comm.). Indeed, *D. gigas*, which are common in PBA/PBB and PBC, prefer rocky pools and are normally associated with more tranquil shorelines (Kilburn and Rippey, 1982). Sediment flow from the Breede River to the Palaeo-Drainage Valley could have resulted in an ecologically-productive landscape south of KDS, attracting a wide range of ungulates. Taxonomic and ungulate diversity indices in Tables 4 and 5 suggest that, relative to its small sample size, KDS was taxonomically richer – and more taxonomically even and heterogeneous – than most other HP sites. Ungulate diversity indices also indicate that KDS had a relatively rich and diverse large herbivore community. These data suggest that KDS was part of an environmentally productive palaeoscape. Faure et al.’s (2002: 54) ‘coastal oasis’ model is consistent with this scenario (cf. Henshilwood, 2008). They propose that shifting hydrostatic pressure as sea levels regress would result in freshwater springs and wetlands (‘oases’) along the coast, encouraging new vegetation/large mammal habitats. The inhabitants of KDS would therefore have had access to both colonies of shellfish to the south-west and herds of migrating ungulates from the south/south-east. It is feasible to suggest that rising sea-levels of terminal MIS 4 drove gregarious herds from the diminishing Agulhas Bank coastal plain through the Klipdriftfonteinsspruit and Breede River valleys to open terrain north of KDS.

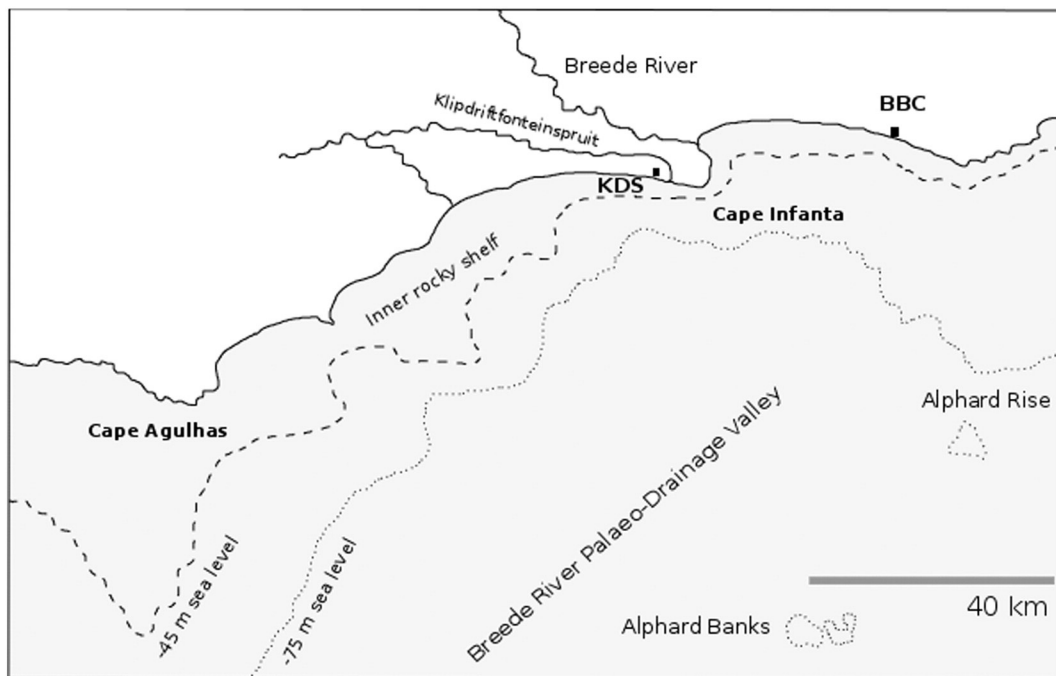


Fig. 11. Simplified bathymetry of the coast off KDS (map adapted from de Wet, 2012). The Breede River Palaeo-Drainage Valley is the extended river route during sea-level recessions. Alphard Banks and Rise are rocky plateaus. 'Inner rocky shelf' generally follows the -45 m sea-level indicator. KDS = Klipdrift Shelter; BBC = Blombos Cave.

4.4. Subsistence vs. technological patterns

Subsistence behaviour at KDS appears to vary through time and may be connected to environmental conditions and access to shellfish. Due to small sample sizes, inferring zooarchaeological trends in the lower layers is challenging. We may, however, be able to construct a model of subsistence variability from layers PCA to PAY. Prey focus changes through the sequence. PCA has the largest proportion of bovids, in particular, size 4 bovids while equids are more abundant in PBC and especially PBA/PBB. The proportion of size 1 bovids is significantly more abundant in PBD. Shellfish was an important component of diet in the middle layers (PBD, PBC, and PBA/PBB). Tortoise and small mammals are abundant in PAY/PAZ. The concordance of taxonomic changes and independent environmental proxies suggest that at KDS humans adapted their subsistence strategies to changing environments during the HP.

Links between the preliminary lithic results and faunal patterns are evident at KDS. PCA, PBE and PBD share some technological similarities and are characterised by relative increased usage of silcrete with notched strangulated blades restricted to PCA and PBE. These strangulated artefacts and increased silcrete usage coincide with large numbers of size 4 bovids (probably eland) (Table 7). The lithic data demonstrate an increase in quartz use and a concomitant decrease in silcrete during PBC and PBA/PBB and a corresponding increase in backed tools (segments) peaking in PBC (Henshilwood et al., 2014). There appears therefore to be an association between an increase in large-bodied, grazing ungulates – possibly because of environmental conditions – and changes in raw material procurement strategies. The development of an open landscape at KDS might have influenced general mobility strategies, affecting both hunted species and access to raw materials. Because faunal and lithic material was recovered from different squares, it is challenging to compare the data statistically but some trends are evident. There is a possible relationship between an increase in quartz procurement and open habitats at KDS, although the correlation between the proportion of quartz and grazer abundance is not statistically significant ($r_s = 0.6$; $p = 0.208$). In contrast, at MSA sites such as Blombos Cave, silcrete is often associated with open grasslands (Villa

et al., 2009; Reynard and Henshilwood, in review). In fact, there is a weakly significant inverse correlation between silcrete abundance and proportions of grazers at KDS ($r_s = -0.771$; $p = 0.072$) suggesting that silcrete procurement may be linked to a more closed environment at KDS. Mackay (2011) notes a similar association between lithic variability and environmental conditions at Klein Kliphuis but urges caution between correlation and causation there. The predominance of OES in PBA/PBB may also indicate an increase in the use of containers to transport water and, by implication, an expanded foraging range (McCall and Thomas, 2012). PAY has been argued to be transitional to the post-HP (Henshilwood et al., 2014). The post-HP is sometimes associated with lower population densities which may explain the less intense or fewer periods of occupation during PAY. However, other factors such as the distance to the shoreline or water availability may also be at play (Dusseldorp, 2014).

5. Conclusion

In this study of the KDS fauna, we focus on the interplay between palaeoenvironmental conditions, occupational intensity, subsistence behaviour and HP technology during MIS 4. Faunal and shellfish data suggests that KDS was more frequently or intensely occupied during the middle layers – PBD, PBC and PBA/PBA – with less occupation during the lower (PDC to PCA) and upper layers (PAZ and PAY) although higher rates of sedimentation may have also played a role in lower faunal densities in the upper layers. The extensive fragmentation of the KDS fauna and the relatively small sample sizes per layer make it difficult to accurately extrapolate significant behavioural information from the assemblage through time. It is possible, however, to correlate some aspects of the KDS assemblage with temporal changes. Evidence suggests that the earlier HP period at KDS was characterised by a mixed/closed-terrain and an environment dominated by large bovids. Higher occupational intensities in PBD coincide with a change in subsistence strategies. A technological transition to a 'Middle Phase' is apparent from PBC. This Middle Phase (PBC and PBA/PBB) was likely more open and grassier than previous periods with probable high rates of human occupation and an increase in shellfish exploitation. The correlation

between macrofaunal and shellfish densities makes it likely that these high occupation periods were driven by access to shellfish and suggests a fluctuating shoreline. The implied high occupation period in the Middle Phase is similar to what may have occurred at other southern Cape sites during parts of MIS 4 such as Klasies River and Pinnacle Point (Deacon, 1995; Karkanas et al., 2015). This is significant because it may suggest the influence of demographic factors during the later HP at KDS. Changes in raw material and toolkit components during the Middle Phase at KDS may also reflect changes in foraging strategies, especially since these changes coincide with a significant rise in equid and large-bodied grazer remains. Independent isotopic evidence suggests that this open habitat may have been a result of an expansion of C4 grasses (Bar-Matthews et al., 2010; Roberts, 2013). PAY could be considered a transitional phase to the post-HP and coincides with possibly lower population densities and a faunal assemblage dominated by tortoise and small mammals. Considering its small sample size, diversity indices suggest relatively rich, environmentally-productive habitats during the HP at KDS and appear to show shifts in precipitation levels or the palaeo-landscapes through the sequence. The faunal evidence from KDS suggest that occupational intensity/frequency may be associated with changing environmental conditions, which may also be linked to shifts in raw material procurement strategies during the HP. Due to small sample sizes, however, these conclusions should be considered tentative. Future research on the links between environment, occupation rates and subsistence behaviour would require larger datasets from KDS and further studies from other contemporaneous sites in the southern Cape.

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CHAPTER 6: THE EFFECTS OF TRAMPLING IN CAVE SITES

Reynard, J.P. 2014

“Trampling in coastal sites: an experimental study on the effects of shell on bone in coastal sediment.”

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Trampling in coastal sites: An experimental study on the effects of shell on bone in coastal sediment



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ABSTRACT

Faunal remains are often recovered from shelly deposits in coastal sites but little is known about the trampling effects of shell on bone. Here, trampling experiments were conducted to investigate these effects and to describe the types of surface modification that could occur on bone in coastal sediment. The results suggest that bone is significantly more likely to exhibit surface modification if trampled in shelly rather than sandy sediment. Burnt bone is less likely to display trampling modification. This is probably because, prior to trampling, burning exfoliates the cortex making the observation of markings on bone problematic. Pitting, trampling lines and sheen were found to be the most prevalent form of surface modification. Pitting is a particularly over-looked criterion and its presence on archaeological bone suggests that the effects of trampling should be considered in zooarchaeological analyses. The pervasiveness of sheen and trampling lines on the experimental bone makes it possible that some incidence of trampling could be mistaken for use-wear or intentional polish. However, the vast majority of trampled bone exhibits sheen which does not resemble anthropogenic specimens and trampling is unlikely to smooth bone fragment edges. This experiment demonstrates that modification caused by trampling can generally be differentiated from butchery markings. The high percentage of modified trampled bone in the shelly deposits suggests that some shell-marks may be mistaken for cut marks, if recovered in an archaeological context.

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1. Introduction

Exploring the taphonomic processes affecting faunal remains from African Middle Stone Age (MSA) sites between 300 and 30 thousand years ago plays a key role in the evaluation of subsistence patterns of early modern humans (e.g., Binford, 1984; Klein, 1989; Marean, 1998; Milo, 1998; Klein and Cruz-Urbe, 1996; Bartram and Marean, 1999; Faith, 2008, 2011). The recovery of worked bone and bone tools from a number of sites has demonstrated both the extent of bone technology in southern Africa during the Late Pleistocene (Henshilwood et al. 2001a; d'Errico and Henshilwood, 2007; Backwell et al. 2008; d'Errico et al., 2012a, 2012b) and the value of understanding the processes that affect the modification of bone surfaces from archaeofaunal remains.

1.1. Background

Previous research has shown the significance of trampling as a taphonomic agent (Gifford and Behrensmeier, 1977; Myers et al.

1980; Brain, 1981; Haynes and Stanford, 1984; Andrews and Cook, 1985; Behrensmeier et al. 1986; Olsen and Shipman, 1988; Fiorillo, 1989; Blasco et al. 2008; Dominguez-Rodrigo et al. 2012). Researchers have maintained that trampling is a significant source of anthropogenic-like markings on bone and sometimes results in the production of tool-like bone fragments (e.g., Brain, 1967a, 1981; Myers et al. 1980; Haynes and Stanford, 1984; Behrensmeier et al. 1986, 1989; Haynes, 1988; Oliver, 1989; Blasco et al. 2008; Dominguez-Rodrigo et al. 2010, 2012). Observations of bone damage caused by animals (e.g., Brain, 1967b, 1981; Andrews and Cook, 1985; Haynes, 1986; Haynes, 1988; Fiorillo, 1989) and people (e.g., Brain, 1967b; Gifford and Behrensmeier, 1977; Gifford-Gonzalez, 1989) have demonstrated that the effects of trampling can mimic cut marks (Behrensmeier et al. 1986) and use-wear polish (Brain, 1967a). A number of experimental replication studies have been undertaken to determine the extent of the effects of trampling on bone (e.g., Behrensmeier et al. 1986; Olsen and Shipman, 1988; Nielsen, 1991; Nicholson, 1992; Blasco et al. 2008; Dominguez-Rodrigo et al., 2009, 2012).

Shell has the potential to mark bone in archaeological deposits (Toth and Woods, 1989; Choi and Driwantoro, 2007) and bone remains are often recovered from shelly sediment or within shell middens (Klein, 1972). While many studies have investigated

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molluscan shell-bed trampling (e.g., Muckle, 1985; Povey and Keough, 1991; Zuschin et al. 2003; Smith and Murray, 2005; Cintra-Beunrosto, 2007), these generally focus on the extent of fragmentation of shell within middens and not the effect of trampling on bone. Previous studies have demonstrated the importance of recognising cut marks in understanding past behaviour (e.g., Bunn, 1981; Potts and Shipman, 1981; Marean, 1998; Milo, 1998; Peresani et al. 2011). Polished bone tools have been recovered from MSA coastal sites (e.g., Henshilwood et al. 2001a; d'Errico and Henshilwood, 2007; d'Errico et al., 2012c) but bone polish could also be the result of sedimentary abrasion and trampling in coarse sea sand (Olsen and Shipman, 1988). Many of the faunal remains and some bone tools recovered from Stone Age sites are burnt (Henshilwood et al. 2001a; Clark and Ligouis, 2010) but few studies have been conducted on the effects of trampling on burnt bone (but see Nicholson, 1992). Bone fragments recovered from shell-dominated deposits along coastlines raises the question of equifinality in traces of polish and butchery marks and whether shell-marks could mimic lithic cut marks in trampled assemblages. The interest in this paper is to investigate and document the effects of trampling on bone in coastal sediment and to contribute to the body of research differentiating trampling from anthropogenic marks.

1.2. Experimental framework

Experimentation and actualistic studies are key methods used by researchers to understand the taphonomic processes affecting bone (Yellen, 1977; Shipman, 1981; Shipman and Rose, 1988; Bonnichsen, 1989; Andrews, 1995; Dominguez-Rodrigo, 2008; Outram, 2008). In this study a specific set of conditions were investigated. At coastal and near-coastal sites along the southern African coast, those conditions generally involve a taphonomic environment of sandy sediment containing the remains of molluscan shell (cf. Butzer, 1973, 1978; Henshilwood et al. 2001b; Marean, 2010) and burnt bone (Clark and Ligouis, 2010; Stiner et al. 2011). Rock shelters were frequently re-occupied (cf. Miller et al. 2013) and trampling by successive inhabitants would have formed a palimpsest of these elements after successive occupations. The specific conditions are:

1. *Sand*. Sedimentary abrasion affects the bone modification pattern produced by trampling and is affected by grain-size (Schiffer, 1987; Lyman, 1994; Fisher, 1995). Sea sand is relatively coarse (Doeglas, 1968; Livingstone, 1989). Samples of beach sand recovered from the De Hoop Nature reserve along the southern Cape coast, for example, are generally large-grained (between 0.5 and 1 mm). This type of sand is likely to produce polish and fine trampling marks on bone (Olsen and Shipman, 1988). Beach sand, however, varies in grain size and aeolian sediment from within southern Cape coastal sites also consists of fine to medium-sized grains (Ahlbrandt, 1979; Deacon and Geleijnse, 1988). Many experimental studies, however, have not used sea sand in their experiments and their results are therefore less relevant to coastal conditions (e.g., Nielsen, 1991; Nicholson, 1992; Andrews, 1995).
2. *Moisture*. Continuous ocean mists and sea-sprays contribute to a high level of water content in coastal sediments. Although rock shelter sites are typically protected from rain, moisture content in the sediment may be high due to cave drip-water (Butzer, 1973; Malan, 1989). Water can also contribute to smoothing and polishing on bone fragments through erosional wear (Bromage, 1984; Andrews and Ersoy, 1990; Boschian and Saccá, 2010). Water abrasion may thus be a factor in polished bone fragments recovered from coastal sites.
3. *Shell*. Extensive shellfish middens occur on coasts throughout the world (Erlandson, 1988; Parkington et al. 1988; Gutiérrez-Zugasti et al. 2011). The role of shellfish in the diets of Late Pleistocene and Holocene people is well supported (e.g., Parkington, 2003; Steele and Klein, 2008; Langejans et al. 2012) and bone is often recovered from within shell middens (Klein, 1972; Brink and Deacon, 1982).
4. *Burnt bone*. Taphonomic analyses of sites such as Sibudu (Cain, 2005; Clark and Ligouis, 2010) and micromorphological studies of the ashy sediment at Wonderwerk Cave (Berna et al. 2012) suggest that bones were likely discarded into hearths. Some bone tools recovered from the MSA levels at Sibudu (d'Errico et al., 2012a) and Blombos Cave (d'Errico and Henshilwood, 2007) are burnt. At the latter site, 18 out of 37 bone tools (48.7%) show evidence of burning (d'Errico and Henshilwood, 2007).

In this study, experiments involving four samples were selected to replicate a palimpsest of the above conditions at archaeological sites in coastal environments. The samples were: 1) shell, sea sand and unburnt bone; 2) shell, sea sand and burnt bone; 3) sea sand and unburnt bone and; 4) sea sand and burnt bone. Stone is capable of leaving marks on bones that may resemble shell marks (Choi and Driwantoro, 2007) and was therefore excluded from the experiments. Following Blumenschine et al. (1996) and Dominguez-Rodrigo et al. (2009), all microscopic analyses were conducted with an optical light microscope under relatively low magnification ($\leq \times 40$).

2. Materials and methods

2.1. Materials and procedures before trampling

2.1.1. Bone

The fore-limbs (radio-ulnae and humeri) of three male cattle (*Bos taurus*), obtained from a local butcher, were used in the experiment. The cattle were between 1 and 2 years old and had been hung for three weeks before being defleshed. After defleshing, three of the fore-limbs were disarticulated with a metal knife and boiled in a pot with soapy water for about six hours to remove excess grease, muscle and connective tissue. The other three fore-limbs were burned on an open wood-based fire using five kilograms of Sickie bush wood (*Dichrostachys cinerea* subsp. *africana*) as fuel. Intact fore-limbs were placed on a grill over the coals when the temperature reached about 320 °C, approximately two hours after ignition. Temperature was measured with a Major Tech MT 632 digital thermometer with probes. The fore-limbs were roasted over the coals for approximately an hour or until most of the bones' muscle and connective tissue was burned off. The bones were then fragmented with a steel mallet. Diaphyses were covered with cotton fabrics before being struck to prevent excessive modification of cortical surfaces. Boiled and burnt bone was fragmented into 154 and 178 fragments, respectively. Hereafter, the sample of bone that had been boiled and not grilled is called 'unburnt bone'. Of the burnt bone, 129 fragments, weighing a total of 851 g and 142 unburnt bone specimens weighing 2220 g were used in this experiment. Before burial, each fragment was numbered and photographed. The fragment edge and cortical surface conditions were recorded by describing the modification marks in terms of the criteria used in this study (see Section 2.3.3). Two micrographs of the cortices of each fragment at different magnifications were taken.

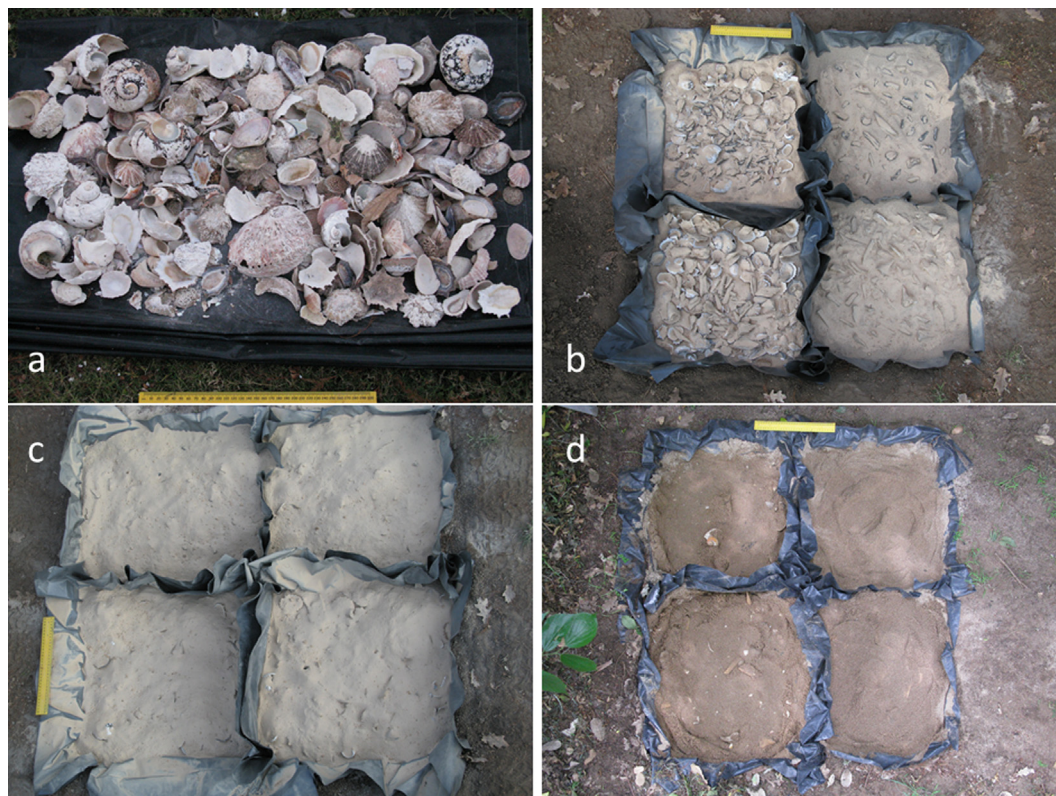


Fig. 1. (a) Shell collection used in the experiments; (b) Pits before trampling showing the distribution of shell and bone; (c) Pits before trampling with layer of fine sand; (d) Pits after one month of trampling. Clockwise from bottom left: pit 1 (unburnt bone and shell); pit 2 (burnt bone and shell); pit 3 (burnt bone and sand); pit 4 (unburnt bone and sand). Scale = 30 cm.

2.1.2. Shell

Shells from species common along the southern Cape coast were collected along the coast of the De Hoop Nature Reserve (34°27'S, 20°43'E) (Fig. 1a). These include *Haliotis midae* (507 g), *Turbo sarmaticus* (1823 g), various *Patella* species (2040 g), *Dinoplax* (209 g), *Choromytilus* (203 g), fragments of operculum (328 g) and other miscellaneous shell species (493 g). About 80% of the shells used were whole while the rest were fragments.

2.2. The trampling experiment

Four shallow pits, each 50 × 50 cm across and 20 cm deep were dug in an outside area exposed to the elements. First, 14 cm of sea sand with an individual grain diameter between 0.4 and 1.5 mm, defined here as 'coarse sand' (Doeglas, 1968; Olsen and Shipman, 1988), was deposited in the pits to replicate sediment along a beach. Bone and shell were then distributed within the pits as shown in Table 1 and Fig. 1b. About 2–3 cm of fine sub-angular play-pen sand with a grain diameter of between 0.1 and 0.5 mm was then deposited over the bone and shell in all pits to replicate the effects of fine sediment common at many South African coastal sites (Deacon and Geleijnse, 1988; Henshilwood et al. 2001b) (Fig. 1c). Trampling was undertaken using rubber-soled shoes due to the hazards posed by sharp bone and shell fragments. Because of the size of the pits, only one person at a time was able to trample each sample. The experiment was conducted over a 2 month period. Infrequent rain meant that the pits were occasionally watered (7 times). Although infrequent, by the end of the first month, sediment in the pits was constantly moist

(Fig. 1d). A total of 180 h were spent trampling. On average, each pit was trampled for 5 min every second day.

Table 1
Trampling pit structures (see Fig. 1).

Pit 1	Pit 2
Fine, play-pen sand: 0.1–0.5 mm grain-size; ~3 cm in depth	Fine, play-pen sand: 0.1–0.5 mm grain-size; ~3 cm in depth
Shell	Shell
Unburnt bone	Burnt bone
Coarse sea sand: 0.4–1.5 mm grain size; ~14 cm in depth	Coarse sea sand: 0.4–1.5 mm grain size; ~14 cm in depth
Pit 3	Pit 4
Fine, play-pen sand: 0.1–0.5 mm grain-size; ~3 cm in depth	Fine, play-pen sand: 0.1–0.5 mm grain-size; ~3 cm in depth
Unburnt bone	Burnt bone
Coarse sea sand: 0.4–1.5 mm grain size; ~14 cm in depth	Coarse sea sand: 0.4–1.5 mm grain size; ~14 cm in depth

2.3. Post-trampling procedure

2.3.1. Fragment assessment

After excavation, trampled bone fragments were cleaned with water and examined. Each fragment was identified by number. Because numbers were engraved on the inner cortex of each fragment, trampled fragments could be identified and reconciled with their pre-burial numbers. However, bone – especially burnt bone –

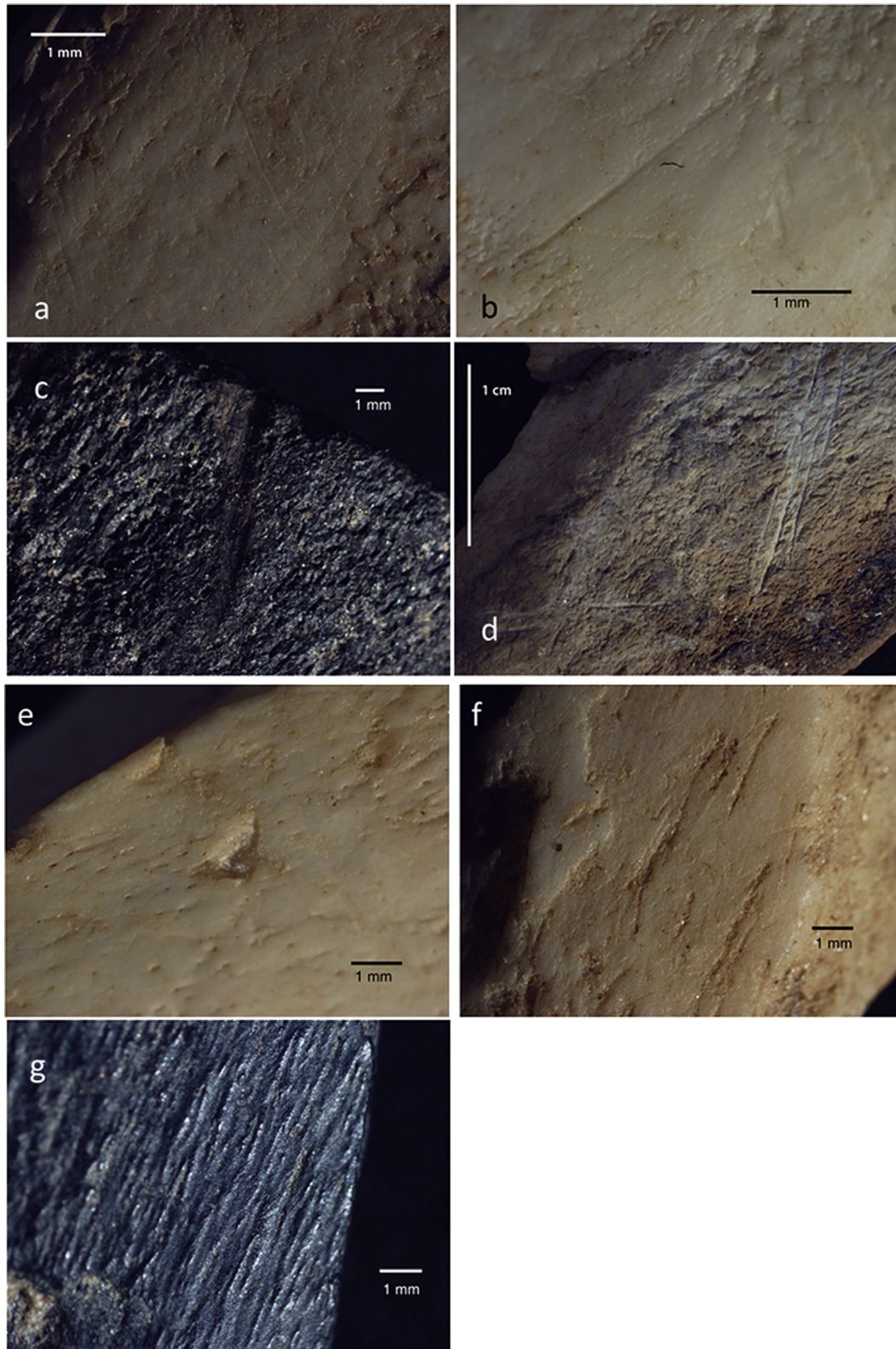


Fig. 2. (a) Scratches; (b) Trampling lines; (c) Groove; (d) Groove with W-shaped profile. Note shell damage; (e) Pit. Note sand grain in the depression; (f) Elongated pits; (g) Sheen on burnt bone.

often fragmented during trampling resulting in additional, non-reconciled bone fragments. Unless otherwise noted, both identified and additional (non-reconciled) bone fragments were included in the analysis.

2.3.2. Categories and definitions

The surface modification and fracture edge characteristics of each fragment were noted. Bone specimens were examined with the aid of an Olympus SZ61 optical binocular microscope (between

$\times 10$ and $\times 70$ magnification) under oblique, unidirectional, incandescent lighting and photographed with an Olympus DP 12 digital camera linked to the microscope. Fragment edges correspond, to an extent, to the fracture angles noted by [Villa and Mahieu \(1991\)](#) and here were determined as: 1) sharp, where the angle of the edge was either less or more than 90° ; 2) blunt, where the angle was approximately 90° ; 3) smooth, if any of the edges were worn; or 4) rounded, if the wear was so extensive that entire edge was semi-circular. After evaluation, six types of post-depositional surface modification were observed: scratches, lines, grooves, pits, elongated pits and sheen. The criteria of modification used are adapted from previous research and here the terminology is defined and clarified for this study.

2.3.3. Terminology

- 1) *Scratches* are inconspicuous, shallow, fine lines that are only visible at $\sim \times 40$ magnification (cf. [Cook, 1986](#)) (Fig. 2a). These marks resemble the micro-striae associated with percussion marks ([Blumenschine et al. 1996](#)) but unlike micro-striae they are generally randomly orientated and 'erratically placed' ([Hodgskiss, 2010](#): 3347). Other studies also note the occurrence of these markings ([Cook, 1986](#); [Fiorillo, 1989](#)) which are sometimes called 'microabrasions' ([Dominguez-Rodrigo et al. 2009](#)) or 'chatter marks' ([Shipman and Rose, 1983](#); [Olsen and Shipman, 1988](#)).
- 2) *Lines* are inconspicuous or barely-conspicuous furrows that are usually defined as trampling marks by others ([Behrensmeyer et al. 1986](#); [Cook, 1986](#); [Olsen and Shipman, 1988](#); [Dominguez-Rodrigo et al. 2009](#)) (Fig. 2b). They resemble fine cut marks in that they frequently have V-shaped profiles ([Walker and Long, 1977](#); [Bunn, 1981](#); [Potts and Shipman, 1981](#)). Unlike cut marks, however, they are liable to be shallow ([Olsen and Shipman, 1988](#)) with irregular, S-shaped trajectories ([Dominguez-Rodrigo et al. 2009](#)) and rounded profiles ([Behrensmeyer et al. 1986](#)).
- 3) *Grooves* are conspicuous furrows larger than the trampling lines defined above and are more likely to resemble butchery marks. They are distinguishable from trampling lines in that the depth of the furrow generally exceeds its width (Fig. 2c). The profile is usually V-shaped but can sometimes be $_/-$ -shaped. These

furrows sometimes clustered together as multiple striations with a W-shaped profile ([Cook, 1986](#)) (Fig. 2d).

- 4) *Pits* are inconspicuous, or barely conspicuous, punctures or roughly-symmetrical depressions on the bone cortex resembling impact craters and are on average ~ 1 mm in diameter (Fig. 2e). Their profiles vary from V and U-shape to $_/-$ -shape and a raised platform or 'lip' often occurs on at least one side of the depression. Unlike the depressions produced by dynamic impact (percussion marks), pits are deeper, not as wide and not associated with micro-striae (cf. [Blumenschine et al. 1996](#)).
- 5) *Elongated pits* are elliptical-shaped pits where the length exceeds the breadth (Fig. 2f). These marks resemble the spindle and comet-shaped scratches observed by [d'Errico et al. \(1984\)](#) but tend to be wider and deeper.
- 6) *Sheen* is a measure of the reflection of the surface of the cortex and is generally indicative of polishing or abrasion (Fig. 2g). Polish is the result of abrasion at the microscopic level that produces an extremely smoothed surface that exhibits sheen ([LeMoine, 1994](#)). Burnt bone, however, also displays a glossiness that can be characterised as sheen but is not necessarily caused by abrasion ([Shipman et al. 1984](#); [Nicholson, 1993](#)). Thus, sheen is used here instead of polish since polish implies abrasion, while sheen describes the reflective properties of the bone surface.

Modifications observed before burial that resembled the above criteria are named as such. If a deep cut mark was noted on a pre-burial fragment, for example, it was classed as a groove, while a percussion-mark related micro-striae was termed a scratch. Lines and grooves were noted as having U, V, W or $_/-$ -shaped profiles. W-shaped profiles occur when furrows display internal striations or when striae are in such close proximity that they appear as a single groove with a shared plateau ([Hodgskiss, 2010](#)). The trajectories of lines and grooves were classified as straight or sinuous. The borders of grooves were noted as straight or 'jagged' if the border appeared irregular or 'zigzagged'.

Lines were also noted as being parallel, if most of the lines are parallel or semi-parallel, or 'randomly orientated' if the direction of lines is highly variable and in random directions. For each fragment; profiles, trajectories, borders and furrow orientation were determined by what the majority of lines or grooves were classed

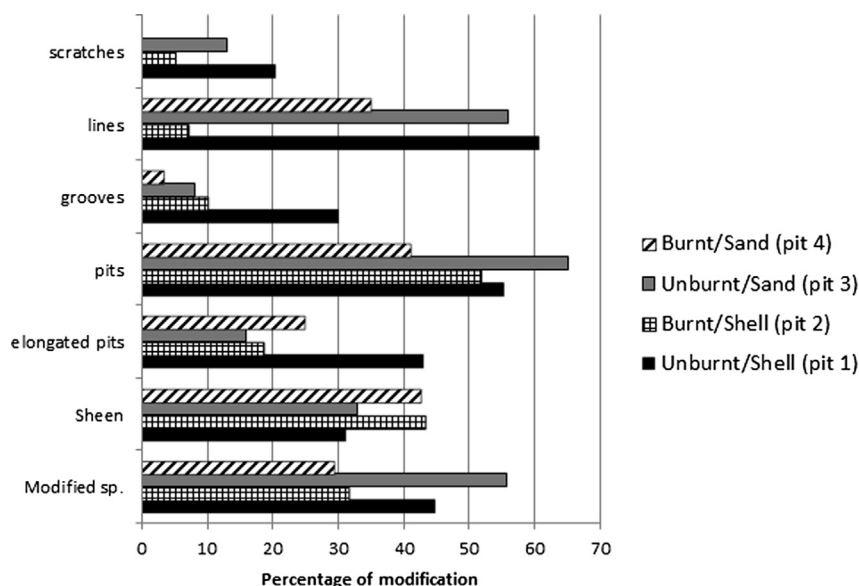


Fig. 3. Percentage of modified specimens. Percentage used here is the difference between pre-burial percentages and after trampling percentages (from [Table 1](#)).

as. For example, if 20 separate lines are observed on a bone fragment, with 8 having V-shaped, 5 having U-shaped, 4 having _/_-shaped and 3 having W-shaped profiles, then lines from that specimen are determined to have V-shaped profiles. For each fragment; scratch marks, lines, grooves, pits and elongated pits were scored as 0, 1, 2 or 3 with 0 indicating no marking, 1 being 'few marks', 2 being a fair amount of modification and 3 being many incidence of modification. Sheen was classed as 0 (no sheen), 1 (the beginning of a sheen), 2 (moderate sheen) and 3 (heavy sheen).

Marks were defined in relation to each other so that 'light', 'moderate' and 'heavy' categories can be considered as relative terms. To ensure that the classification of marks assessed early in the analysis did not differ substantially from assessments done later, all specimens were analysed again after the initial assessment. Marks that could only be discerned microscopically or with hand lenses are termed 'inconspicuous' while those that could be observed with the naked eye are called 'conspicuous' (Cruz-Uribe and Klein, 1994; Blumenschine et al. 1996; Dominguez-Rodrigo et al. 2009). The term 'striation' or 'striae' is used when furrows are parallel or semi-parallel. Trampling lines or grooves are used where other researchers use the term trampling mark. Here, 'trampling mark' is a general term for all modification caused by trampling.

3. Results and discussion

3.1. Overview of modification criteria

Over a third ($n = 105$; 38.7%, Table 2) of all specimens displayed the modification traces recorded in Section 2.3.3 before trampling and 77.4% ($n = 322$) of fragments (exactly double the proportion) were modified after trampling. Therefore, on average, 38.7% ($n = 217$) of all specimens displayed some form of modification inflicted by trampling. Numerical (n_d) values used hereafter for modification frequencies were obtained by the equation:

$$n_d = n_a - n_b$$

where n_d is the number of fragments modified after burial, n_b is the number of modified specimens noted before burial and n_d is the difference between the two. Percentage values used henceforth are also obtained by subtracting the proportion of specimens modified before burial from those modified by trampling. This was done to exclude the effects of specimens modified by processes acting prior to and other than trampling. For data on pre-burial and post-trampling results, see Table 2. The majority of specimens exhibited pitting ($n_d = 213$; 50.5%), while scratches were the least common ($n_d = 62$; 9.9%) (Fig. 3). The unburnt bone in sand sample (pit 3) contained the highest number of modified specimens ($n_d = 43$; 55.7%). The burnt bone in sand sample (pit 4) contained the least amount of modified specimens ($n_d = 75$; 29.5%).

3.1.1. Fragment edges

There is a noticeable change in sharp and blunted edges in the unburnt/shell sample (pit 1) (Table 3a). This may be because bone caught between shell fragments are more likely to break when trampled underfoot. Fragment ends are more likely to be rounded or smoothed in the burnt bone/sand sample (pit 2) (by 7.4%) and burnt bone/shell (pit 4) (by 5.4%). Before trampling, edges of unburnt bone were predominantly sharp ($n_b = 136$; 47.9%) (Table 3b). Blunted edges were also slightly more common in the burnt bone ($n_b = 154$; 59.7%), shell ($n_b = 158$; 58.1%) and sand-

Table 2 Number of specimens with modification before and after trampling. BT = Before Trampling, AT = After Trampling, Δ = difference between BT and AT values. Numerical values (n_d) equals $n_a - n_b$. Percentages equal the proportion of modified specimens before trampling subtracted from the proportion of modified specimens observed after trampling. These values represent the resultant proportion of modified bones and are the values used in the text and Fig. 3. Emboldened numbers represent highest value for modification trait, numbers in italics represent lowest value.

	Unburnt/Shell (pit 1)		Δn_d (%)		Burnt/Shell (pit 2)		Δn_d (%)		Unburnt/Sand (pit 3)		Δn_d (%)		Burnt/Sand (pit 4)		Δn_d (%)		Combined sample	
	BT	AT	BT	AT	BT	AT	BT	AT	BT	AT	BT	AT	BT	AT	BT	AT	BT	AT
Number of specimens	71	79	65	118	71	75	64	144	64	144	64	144	64	144	271	416	271	416
	n_b (%)	n_a (%)	n_b (%)	n_d (%)	n_b (%)	n_d (%)	n_b (%)	n_d (%)	n_b (%)	n_d (%)	n_b (%)	n_d (%)	n_b (%)	n_d (%)	n_b (%)	n_d (%)	n_b (%)	n_d (%)
Modified specimens	29 (40.1)	67 (84.8)	29 (44.7)	90 (76.3)	21 (29.6)	64 (85.3)	21 (29.6)	64 (85.3)	21 (29.6)	64 (85.3)	21 (29.6)	64 (85.3)	21 (29.6)	64 (85.3)	105 (38.7)	322 (77.4)	105 (38.7)	322 (77.4)
Scratches	7 (9.9)	24 (30.4)	17 (26.2)	37 (31.4)	3 (4.2)	13 (17.3)	3 (4.2)	13 (17.3)	3 (4.2)	13 (17.3)	3 (4.2)	13 (17.3)	3 (4.2)	13 (17.3)	10 (13.1)	43 (55.7)	10 (13.1)	43 (55.7)
Lines	1 (1.4)	49 (62.0)	9 (13.9)	25 (21.2)	2 (2.8)	16 (7.3)	2 (2.8)	16 (7.3)	2 (2.8)	16 (7.3)	2 (2.8)	16 (7.3)	2 (2.8)	16 (7.3)	10 (13.1)	48 (60.6)	10 (13.1)	48 (60.6)
Grooves	2 (2.8)	26 (32.9)	0 (0.0)	12 (10.2)	0 (0.0)	12 (10.2)	0 (0.0)	12 (10.2)	0 (0.0)	12 (10.2)	0 (0.0)	12 (10.2)	0 (0.0)	12 (10.2)	6 (8.0)	24 (30.1)	6 (8.0)	24 (30.1)
Pits	4 (5.6)	48 (60.8)	0 (0.0)	61 (51.7)	2 (2.8)	51 (68.0)	2 (2.8)	51 (68.0)	2 (2.8)	51 (68.0)	2 (2.8)	51 (68.0)	2 (2.8)	51 (68.0)	49 (65.2)	104 (25.0)	49 (65.2)	104 (25.0)
Elongated pits	0 (0.0)	34 (43.0)	0 (0.0)	22 (18.6)	0 (0.0)	22 (18.6)	0 (0.0)	22 (18.6)	0 (0.0)	22 (18.6)	0 (0.0)	22 (18.6)	0 (0.0)	22 (18.6)	12 (16.0)	34 (43.0)	12 (16.0)	34 (43.0)
Sheen	4 (5.6)	29 (36.7)	16 (24.6)	80 (67.8)	6 (8.5)	64 (43.2)	6 (8.5)	64 (43.2)	6 (8.5)	64 (43.2)	6 (8.5)	64 (43.2)	6 (8.5)	64 (43.2)	25 (32.8)	90 (22.0)	25 (32.8)	90 (22.0)

only samples ($n_b = 64$; 47.4%). After trampling, sharp edges decreased conspicuously in the sand-only (by 15.8%) and burnt samples (14.6%).

sediment (pit 2) has the least number of specimens with lines ($n_d = 16$; 7.3%). Lines are generally randomly orientated ($n_a = 150$; 86.7%) (Table 4). The majority of trampling lines are straight

Table 3a

Fragment edges. BT = Before Trampling; AT = After Trampling. $\Delta\%$ = difference in percentage between BT and AT values. Because of the small quantity of rounded fragment edges, rounded and smoothed edges were combined.

	Unburnt/Shell (pit 1)				$\Delta\%$	Burnt/Shell (pit 2)				$\Delta\%$	Unburnt/Sand (pit 3)				$\Delta\%$	Burnt/Sand (pit 4)				$\Delta\%$
	BT		AT			BT		AT			BT		AT			BT		AT		
	n_b	%	n_a	%		n_b	%	n_a	%		n_b	%	n_a	%		n_b	%	n_a	%	
Fragment ends (N)	142		154			130		236			142		150			128		288		
Rounded/smooth	8	5.6	6	3.8	-1.8	8	6.2	32	13.6	7.4	8	5.6	14	9.3	3.7	10	7.8	38	13.2	5.4
Blunt	78	54.9	46	29.1	-25.8	80	61.5	168	71.2	9.7	54	38	66	44.0	6.0	74	57.8	188	65.3	7.5
Sharp	56	39.4	106	67.1	27.7	42	32.3	36	15.3	-17.0	80	56.3	70	46.7	-9.6	44	34.4	62	21.5	-12.9

Table 3b

Fragment edge of combined samples.

	Unburnt sample				$\Delta\%$	Burnt sample				$\Delta\%$	Shell sample				$\Delta\%$	Sand only sample				$\Delta\%$
	BT		AT			BT		AT			BT		AT			BT		AT		
	n_b	%	n_a	%		n_b	%	n_a	%		n_b	%	n_a	%		n_b	%	n_a	%	
Fragment ends (N)	284		304			258		524			272		390			270		438		
Rounded/smooth	16	5.6	20	6.6	1.0	18	7.0	70	13.4	6.4	16	5.9	38	9.7	3.8	18	6.7	52	11.9	5.2
Blunt	132	46.5	112	36.8	-9.7	154	59.7	356	67.9	8.2	158	58.1	214	54.9	-3.2	128	47.4	254	58.0	10.6
Sharp	136	47.9	176	58.0	10.1	86	33.3	98	18.7	-14.6	98	36.0	142	36.4	0.4	124	45.9	132	30.1	-15.8

3.1.2. Scratches

Scratches were the least common modification ($n_d = 62$; 9.9%). Unburnt bone with shell (pit 1) contained more fragments with scratches than any other pit ($n_d = 17$; 20.5%). Burnt bone in sand (pit 4) contained the least number of fragments with scratches ($n_d = 15$; 0%).

In many instances, the outer cortex of burnt bone was sloughed off after trampling. The inner layer beneath often displayed vascular canals that resemble root etchings and the fine, trampling scratches defined in this study (Fig. 4a). d'Errico and Villa (1997) note that these canals are also often confused with anthropogenic striations and evidence from this study supports this (Fig. 4b). In this study, scratches were not as prevalent as suggested by others (Olsen and Shipman, 1988; Dominguez-Rodrigo et al. 2009: 2651). Although individually resembling micro-striations (Blumenschine et al. 1996), scratches are not associated with percussion marks and tend to be randomly orientated rather than occurring as parallel marks in patches. Even though many scratch-like marks were noted on the bone samples before trampling, it was still possible to distinguish scratches from micro-striae.

3.1.3. Trampling lines

Unburnt bone with shell (pit 1) was more likely to display lines ($n_d = 48$; 60.6%) than bone in other samples. Burnt bone in shelly

($n_a = 104$; 60.1%) with V-shaped profiles ($n_a = 121$; 69.9%) in this experiment.

Unlike the trampling lines observed here, cut marks are generally parallel or sub-parallel to one another (Potts and Shipman, 1981; Behrensmeyer et al. 1986; Dominguez-Rodrigo et al. 2012) and also tend to occur as clusters in anatomically significant areas (Bunn, 1981; but see; Dominguez-Rodrigo et al. 2009). The experimental findings are in keeping with Behrensmeyer et al. (1986) and Olsen and Shipman (1988: 550) suggestions that there is 'considerable variation in directionality' of the trampling marks in their experimental studies of trampled bone. They propose that this variation is a significant criterion for distinguishing trampling marks. A substantial number of specimens have U-shaped profiles ($n_a = 46$; 26.6%). This may be due to repeated or extended trampling that transforms profiles that are initially V-shaped, due to the sub-angular shape of some sand particles, to a more rounded U-shape (Behrensmeyer et al. 1986). The majority of trampling lines have straight trajectories ($n_a = 33$; 67.4%) and V-shaped profiles ($n_a = 121$; 69.9%). This suggests that these marks may resemble shallow cut marks or individual scrape/polish striae. More than likely it is the context of these lines that determine whether they are classed as natural or anthropogenic marks.

Table 4

Line and groove properties after trampling. Emboldened numbers represent highest value for variable, numbers in italics represent lowest value.

		Unburnt/Shell (pit 1)			Burnt/Shell (pit 2)			Unburnt/Sand (pit 3)			Burnt/Sand (pit 4)			Combined total		
		N_a	n_a	%	N_a	n_a	%	N_a	n_a	%	N_a	n_a	%	N_a	n_a	%
Line	U	49	11	22.5	25	7	28.0	44	11	25.0	55	17	30.9	173	46	26.6
Profile	V		37	75.1		17	68.0		31	70.5		36	65.5		121	69.9
	W		0	<i>0.0</i>		1	4.0		0	<i>0.0</i>		1	1.8		2	1.2
	_/		0	<i>0.0</i>		0	<i>0.0</i>		0	<i>0.0</i>		0	<i>0.0</i>		0	<i>0.0</i>
	Straight	33	67.4		11	44.0		28	63.6		32	58.2		104	60.1	
Trajectory	Sinusuous	14	28.6		14	56.0		14	31.8		22	40.0		64	37.0	
	Parallel	5	10.2		2	<i>8.0</i>		5	11.4		11	20.0		23	13.2	
Random		44	89.8		23	92.0		39	88.6		44	<i>80.0</i>		150	86.7	

Table 4 (continued)

		Unburnt/Shell (pit 1)			Burnt/Shell (pit 2)			Unburnt/Sand (pit 3)			Burnt/Sand (pit 4)			Combined total		
		<i>N_a</i>	<i>n_a</i>	%	<i>N_a</i>	<i>n_a</i>	%	<i>N_a</i>	<i>n_a</i>	%	<i>N_a</i>	<i>n_a</i>	%	<i>N_a</i>	<i>n_a</i>	%
Groove	U	26	3	11.5	12	1	8.3	6	0	0.0	5	0	0.0	49	4	8.2
	V		13	50.0		8	66.6		4	66.6		4	80.0		29	59.2
Profile	W		9	34.6		3	25.0		1	16.6		1	20.0		14	28.6
	_/		1	3.9		0	0.0		1	16.6		0	0.0		2	4.1
Trajectory	Straight		8	30.8		3	25.0		4	66.6		4	80.0		19	38.8
	Sinuuous		18	69.2		9	75.0		2	33.3		1	20.0		30	61.2
Border	Straight		12	46.2		7	58.3		3	50.0		1	20.0		23	46.9
	Jagged		14	53.9		5	41.7		3	50.0		4	80.0		26	53.1

It was of interest in this paper to investigate the difference between polish striae (d'Errico et al., 1984) and trampling. The many incidences of trampling lines with U-shaped profiles (*n_a* = 46; 26.6%) and sinuous trajectories (*n_a* = 64; 37%) (Table 4) and the prevalence of sheen (*n_d* = 204; 42.7%) (Table 2) makes it likely that some fragments would exhibit modification that could mimic polish striae. More than 80% of the lines in this experiment, however, are randomly orientated while use-wear or intentional polishing results in parallel or semi-parallel striations emulating the 'preferred axis of motion' of the applied force (Shipman and Rose, 1988: 329; cf.; Backwell and d'Errico, 2001, 2005; Henshilwood et al. 2001a; d'Errico and Backwell, 2009). However, a number of specimens in the dataset with sheen exhibit trampling lines that could be mistaken for intentional polishing. Lines are more likely to be parallel on burnt bone in sandy sediment (pit 4) (*n_a* = 11; 20%) and more lines with U-shaped profiles are also most prevalent in that sample (*n_a* = 17; 30.9%) (Table 4). Some specimens from pit 4 are therefore likely to mimic polish striae. One specimen from the unburnt bone/sand-only sample (pit 3) resembles intentionally polished bone with scrape marks (Fig. 5). Most likely, the marks on this specimen were the result of two phases of abrasion: the first was probably that of sediment abrasion and the second, overlaying phase could have occurred when the specimen was trampled against another bone fragment, with sand granules caught between producing the parallel striations. Along with other research (e.g.,

Olsen and Shipman, 1988; Dominguez-Rodrigo et al. 2009) this study suggests that trampling lines are distinguishable from anthropogenic modification by criteria that include trajectory shape and orientation.

3.1.4. Grooves

Grooves occur, on average, on 11.1% of specimens (*n_d* = 47) from all samples and are more common on unburnt bone in shelly sediment (pit 1) (*n_d* = 24; 30.1%). Burnt bone in sand (pit 4) has the least number of specimens with grooves (*n_d* = 5; 3.5%). The borders of grooves were divided almost equally between straight (*n_d* = 23; 46.9%) and jagged (*n_d* = 26; 53.1%) edges.

Grooves are, in effect, large trampling lines. This is likely the type of modification that most researchers would suggest resemble cut marks (e.g., Behrensmeier et al. 1986; Olsen and Shipman, 1988; Dominguez-Rodrigo et al. 2010). Claims that a bone specimen from the ~3.4 Ma Dikika site displays butchery marks (McPherron et al. 2010) have been contested by Dominguez-Rodrigo et al. (2010, 2012: 214) who argue that they are likely to be the result of 'incidental movement' in sediment. In this study, the Dikika marks – assuming they are trampling marks – would have been classified as grooves. What differentiates trampling grooves from anthropogenic markings is trajectory: cut marks are generally straight and geometrical while most of the grooves in this study have sinuous trajectories (*n_d* = 30; 61.2%) (Table 6). Still, a large proportion of grooves were classed as straight (*n_a* = 19; 38.8%) and most had either V (*n_a* = 29; 59.2%) or W-shaped profiles (*n_a* = 14; 28.6%). This implies that many of these trampling marks, if found on archaeological bone, could be confused with butchery modification.

3.1.5. Pits

Pitting is the most common form of modification (*n_d* = 213; 50.5%). The Unburnt bone in sand sample (pit 3) contains the highest number of specimens with pitting (*n_d* = 49; 65.2%). Burnt bone in sand (pit 4) is less likely to display pitting (*n_d* = 59; 41%).

Table 5
Observed and expected frequencies between line and groove profiles and sediment type after trampling. $\chi^2 = 6.409$; *df* = 2; *p* < 0.05.

	Profile ^a			
	U-shape	V-shape	W-shape	Total
Sand	28 (24.537)	75 (73.611)	3 (7.851)	106
Shell and sand	22 (25.463)	75 (76.389)	13 (8.148)	110
Total	50	150	16	216

^a Both sand and shell and sand contained 1 specimen each with _/ shaped profiles which were excluded from the contingency table.

Table 6
Number of reconciled fragments with modification. Reconciled fragments are specimens recovered after trampling that could be identified to their pre-burial numbers. Numerical (*n_d*) values were calculated by subtracting the amount of specimens with modification before trampling (*n_b*), from the amount observed after trampling (*n_a*) (see Table 1).

	Unburnt/Shell (pit 1)		Burnt/Shell (pit 2)		Unburnt/Sand (pit 3)		Burnt/Sand (pit 4)		Total sample	
	<i>n_d</i>	%	<i>n_d</i>	%	<i>n_d</i>	%	<i>n_d</i>	%	<i>n_d</i>	%
Number of specimens	71		65		71		64		271	
Modified specimens	34	47.9	22	33.9	39	54.9	34	53.1	129	47.6
Scratches	16	22.5	9	13.9	9	12.7	7	10.9	41	15.1
Lines	46	64.8	10	15.4	38	53.5	41	64.1	135	49.8
Grooves	23	32.4	11	16.9	6	8.5	3	4.7	43	15.9
Pits	42	59.2	32	49.2	46	64.8	39	60.9	159	58.7
Elongated pits	31	43.7	14	21.5	12	16.9	26	40.6	83	30.6
Sheen	21	29.6	29	44.6	23	32.4	31	48.4	104	38.4

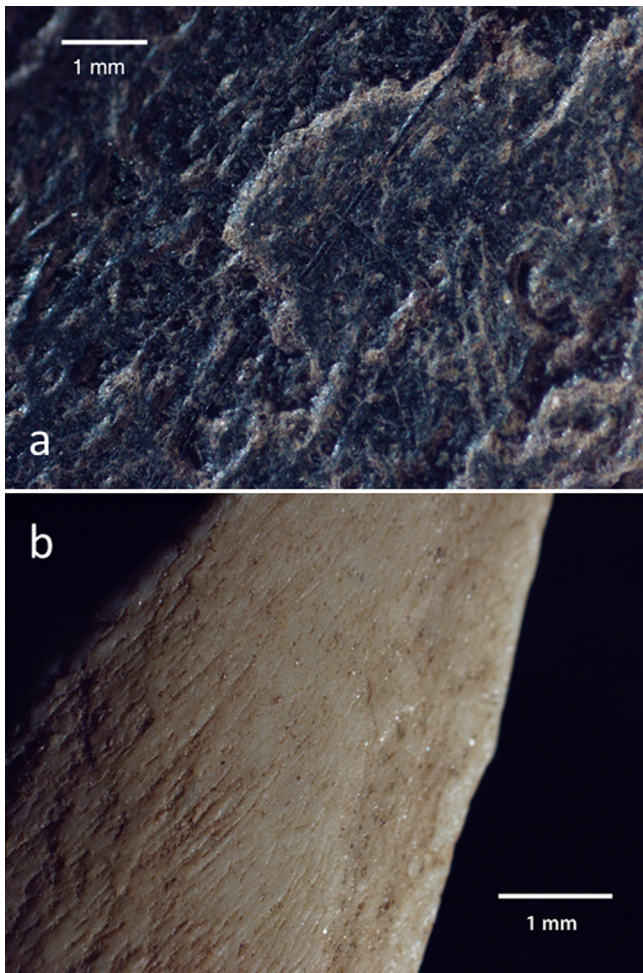


Fig. 4. (a) Natural, scratch-like marks beneath the outer cortex; (b) Vascular grooves resembling polish striations.

Only two cases of pit-like marks on pre-trampled bone were observed. Pits are therefore particularly indicative of trampling and are not likely to be confused with anthropogenic markings. Shipman (1989), in her analysis of modified bone from Olduvai



Fig. 5. Trampling abrasion resembling intentional polishing.

Gorge, does note that wind-borne sedimentary abrasion can cause pitting on the surface of bone. Backwell et al. (2012: 80) also observe 'surface pits' in their experimental study of the taphonomic effects of termites. Unlike both those markings, however, pitting on trampled bone resembles impact craters resulting from static impact loading. Termite pits also generally occur with star-shaped lines or bore-holes unlike the pitting here.

3.1.6. Elongated pits

On average, a quarter ($n_d = 104$; 25%) of all fragments display elongated pitting. Unburnt bone in shelly sediment (pit 1) is more likely to display elongated pitting ($n_d = 34$; 43%). Unburnt bone in sand (pit 3) contains the least amount of elongated pits ($n_d = 12$; 16%). Pits and elongated pits were uncommon on pre-trampled bone fragments with no incidences of elongated pits observed. The elongated pits from this experiment are more robust than the spindle and comet-shaped polish striae noted by d'Errico et al. (1984). Elongated pits may be indicative of a transitional phase between pitting and trampling lines and appear decidedly characteristic of trampling.

3.1.7. Sheen

Sheen occurs on 42.7% ($n_d = 204$) of all specimens. It is most common on burnt bone in shell (pit 2) ($n_d = 64$; 43.2%) and less likely to occur on unburnt bone in shelly sediment (pit 1) ($n_d = 25$; 31.1%). Sheen was relatively common in the pre-trampled burnt sample (e.g. $n_d = 23$, 35.9%) in burnt/sand [pit 4]. Sheen seldom occurred on pre-trampled unburnt bone – compare pits 1 and 3 with pits 2 and 4 – but after trampling, a substantial proportion of unburnt bone fragments exhibit sheen ($n_d = 25$; 32.8% in pit 3 [unburnt/sand]) (e.g., Fig. 6a and b). Sheen is generally present on the whole surface of specimens. However, it is likely to be more intense around the edges of bone fragments probably because sediment was more likely to abrade these regions. When sheen occurs only around the edges of bone fragments (especially the tips), it appears similar to use-wear polish. The small surface area of bone fragment tips makes it difficult to observe striations and to therefore differentiate natural smoothness from anthropogenic polish (Fig. 7a and b). However, wide-spread distribution of polish around the edge of the entire specimen is indicative of trampling (e.g., Fig. 7c). Studies suggest that water and sand granules contribute to the development of sheen on bone (Shipman and Rose, 1983; Bromage, 1984). Trampling in moist sediment, therefore, probably increases the extent of polish on specimens. Shipman et al. (1984) note that burning increases the crystal size of bone hydroxyapatite. This increase in crystal size as bone is burned at lower temperatures (~ 300 °C) results in a 'glassy' cortical surface that is denser but also more brittle than unburnt bone (Nicholson, 1993: 418). The abrasive force of sand or shell is therefore liable to scrape the surface of burnt bone causing polish or sheen. Sheen is difficult to distinguish from polish since both are a measure of the reflectiveness of the surface. In this regard, this experiment confirms that the presence of sheen alone is not sufficient to classify a surface as polished. It is the presence of diagnostic striae associated with sheen that indicates whether the sheen was the result of anthropogenic or natural actions.

3.1.8. Defining trampling modification

The experiments suggest that trampling marks are the result of a continuous pedoturbationary process and the categories defining surface modification in this study can be regarded as arbitrary classifications. It could be argued that the scratches, pits, elongated pits, lines, and grooves form a continuous spectrum of the effects of abrasion on the bone cortex. For example, scratches and pits may be the initial impressions of shell or sand particles on the cortex.

Longitudinal pressure from the trampled object across the bone surface would result in 'elongated' pits, while further movement would produce trampling lines and, in severe cases, grooves (e.g., Fig. 8). Likewise, line and groove profiles are a continuous spectrum where, for example, octagonal shaped profiles could be classed as U, V or W-shaped profiles, depending on how it appears to the observer. The experiments raise a series of questions with regard to the effects of trampling in coastal environments.

3.2. Implications for archaeological assemblages

One question that arises is whether trampling could smooth the edges of bone, mimicking anthropogenic use-wear. The data suggests that trampling does not substantially affect the rounding or smoothing of fragment edges. Incidents of rounding and smoothing that do occur, however, resemble use-wear polish. Smoothed bone tips in the sample would probably resemble bone points used for digging since both trampled bone and bone used as digging sticks are the result of sedimentary abrasion (Brain and Shipman, 1993; Backwell and d'Errico, 2005). Although the smoothing/rounding of bone edges is not common, it would be difficult to differentiate sedimentary abraded bone tips and edges from use-wear without the aid of scanning electron microscopy (SEM). However, on trampled bone, the smoothing/rounding of bone edges are also more likely to occur over the entire edge of the fragment. Bone tips or edges polished through use-wear are more likely to display wear on the working area of the tool such as the cutting edge or digging tip (Brain, 1981; Brain and Shipman, 1993; d'Errico and Backwell, 2009).

Correctly identifying taphonomic agents is necessary to distinguish intentional from natural sources of bone polish. Bone abrasion caused by trampling has been argued to resemble human use-wear (e.g., Brain, 1967b, 1981; Olsen and Shipman, 1988; Shipman and Rose, 1988). Intentional polishing on late Pleistocene bone tools generally occur on the shafts and tips of tools (Henshilwood et al. 2001b; d'Errico and Henshilwood, 2007; Backwell et al., 2008; d'Errico et al., 2012a, 2012c) and may also mimic sedimentary abrasion. In this study, sheen is widespread on bone in all samples. It is not restricted to certain areas, such as bone shafts or fragment edges, and is generally present across the entire specimen. Even though it often occurs more *intensely* along the edges of specimens, it is still present across the whole fragment. A combination of sheen and parallel lines on trampled bone fragments in archaeological material could also result in naturally abraded specimens being confused with intentionally polished bone fragments (cf. Cook, 1986). Although the majority of bone fragments displayed lines that are randomly orientated, 23 specimens (13.2%) have trampling lines that are parallel or semi-parallel (Table 6). Moreover, 25.4% ($n_a = 106$) of specimens display both trampling lines and sheen and 13 of those specimens (3.1%) exhibit trampling lines that appear as parallel or semi-parallel striations. Despite its low prevalence, some of these 13 fragments could be mistaken for pieces of anthropogenically polished bone (e.g., Fig. 9).

Differentiating between the effects of sandy and shelly sediment is another key issue, particularly as it pertains to equifinality in anthropogenic bone surface modification from coastal sites. Unburnt bone fragments in sand (pit 3) were the most modified specimens (Table 2). The high frequency of lines and pitting in this sample and previous studies (Olsen and Shipman, 1988; Shipman and Rose, 1988) suggests that pressure from coarse sand granules is an effective modification agent. In contrast, elongated pits and grooves are relatively more prevalent on unburnt bone in shell (pit 1); likely the result of the abrasive pressure of shell fragments. Generally, bone buried in shelly sediment tends to more intensely

modified: pits and lines are deeper and grooves are more severe. Archaeofaunal remains are thus likely to be highly susceptible to modification by trampling in shelly deposits such as middens. There is also a significant association between line and groove profiles and sediment type ($\chi^2 = 6.409$; $df = 2$; $p < 0.05$) (Table 5). The similar frequencies between U and V-shaped profiles between sandy and shelly sediment in Table 7 suggest that W-shaped profiles are significantly more likely to occur in shelly sediment. Over half the trajectories of grooves have jagged borders ($n_a = 26$; 53.1%) (Fig. 10). The presence of this type of modification on archaeological bone may therefore indicate shell marks. Burnt bone trampled in shelly sediment (pit 2), however, is not likely to display more traces of modification. This is possibly because burnt bone is more likely to fragment due to the pedoturbationary effects of shell.

To explore whether there is statistically significant associations between modification and burnt/unburnt bone or sediment type, a subset of the data from Table 2 was used for chi-squared tests. This sub-set consists of trampled bone fragments that could be reconciled with pre-burial specimens (Table 6). Only trampled bone specimens that could be identified to their numbers were used in this data-set thereby eliminating any additional fragments. The number of specimens in the 'before' and 'after' categories in each sample pit is thus the same. Using this sub-set is a statistically parsimonious method of testing for significance and all chi-squared

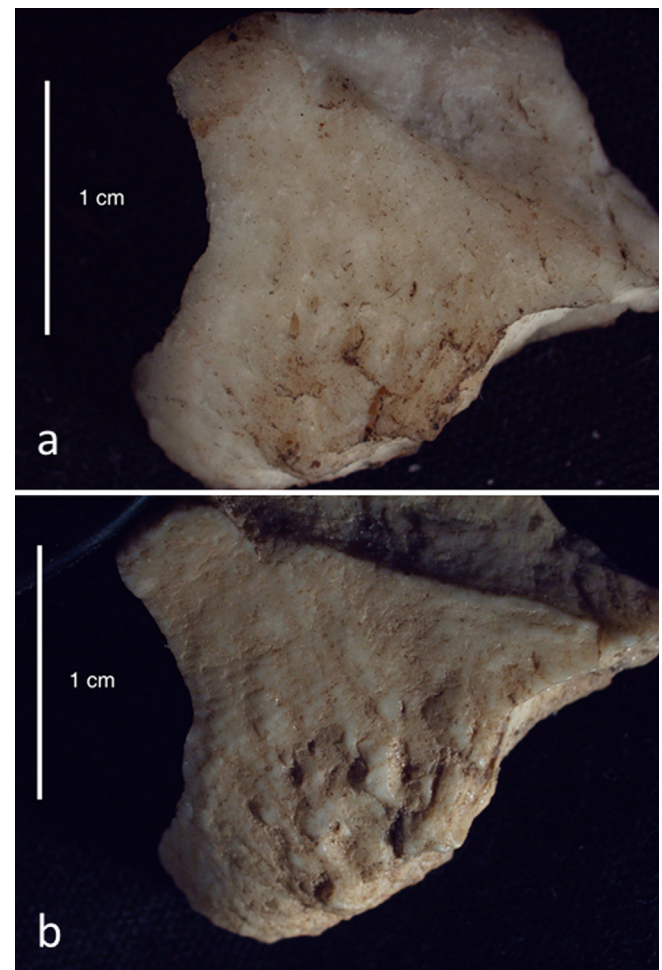


Fig. 6. Unburnt bone specimen in sand (a) before and (b) after trampling. Note sheen.

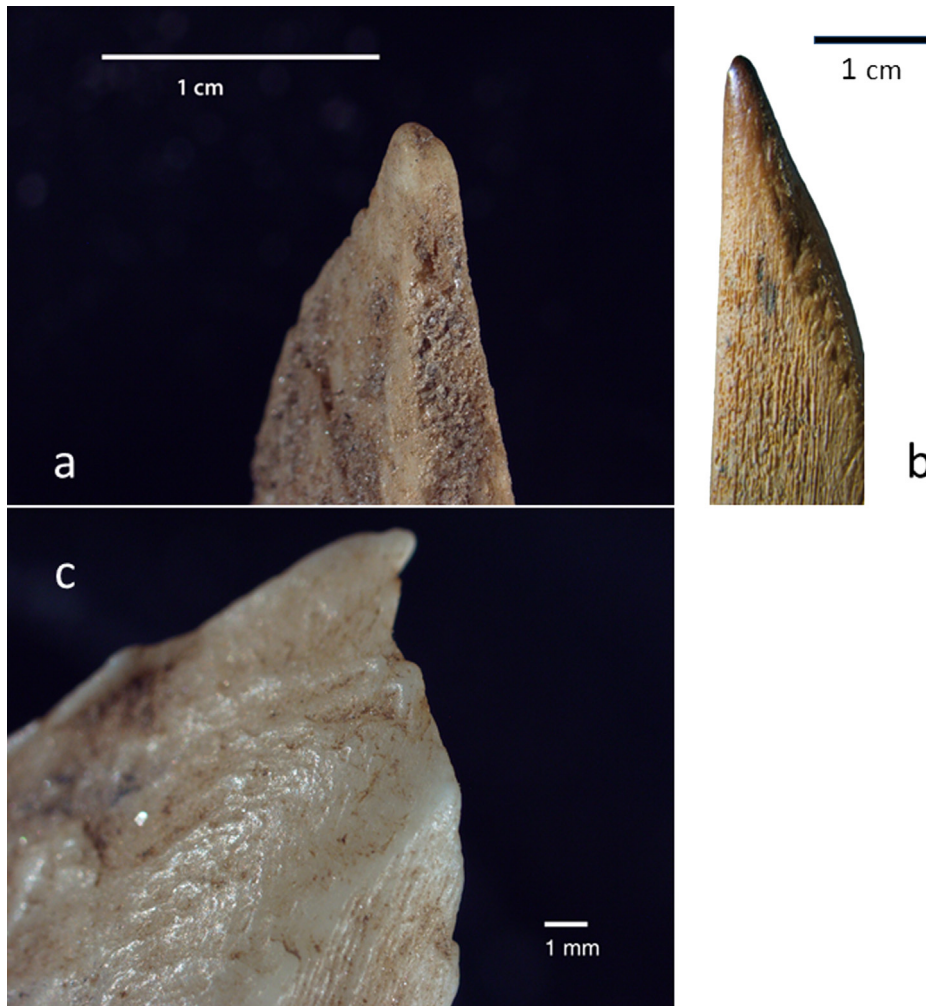


Fig. 7. (a) Sheen on a bone fragment tip; (b) Polished tip of a bone point from the MSA layers at Blombos Cave (image courtesy of Christopher Henshilwood); (c) Polish on the edge of a bone fragment.

values given hereafter are based on this data-set. The distribution of modified specimens in the reconciled sub-set generally corresponds to that of the combined samples except that lines are the most common form of modification in the reconciled dataset while pits were more prevalent in the combined samples.

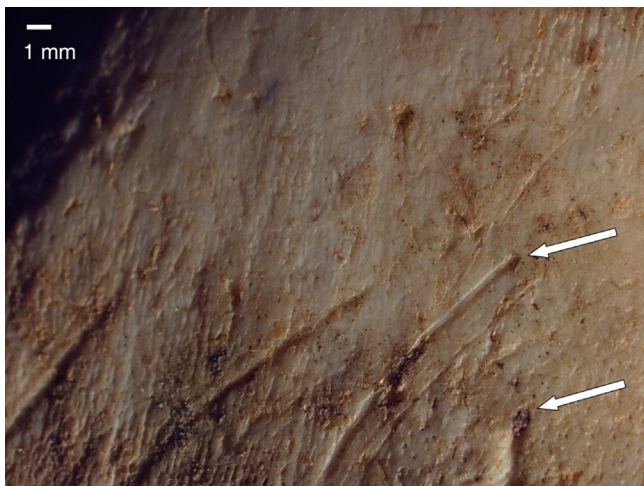


Fig. 8. The effects of coarse sand grains on bone surfaces. Note embedded sand grains in the cortex (arrows).

The effects of burning on the analyses of bone modification are particularly relevant to zooarchaeological remains from late Pleistocene sites such as Klasie River (Milo, 1998), Sibudu (Clark and Ligouis, 2010), Blombos Cave (Thompson and Henshilwood, 2011) and Diepkloof (Steele and Klein, 2013). The propensity for burnt bone to exhibit a ‘glossiness’ (Shipman et al. 1984; Nicholson, 1993: 418) combined with the smoothing effect of weight on bone (Bromage, 1984: 166) probably explains the high frequency and intensity of sheen on trampled burnt bone. Burnt bone generally displays less evidence of modification than unburnt bone. There is a significant relationship between modification and whether bone is burnt or not in the reconciled fragments sub-set ($\chi^2 = 30.766$; $df = 5$; $p < 0.005$) (Table 7a) suggesting that lines, grooves, elongated pits and pitting are less likely to occur on burnt bone. This is probably because much of the burnt bone in this experiment was carbonised and fragile. Most likely, burning affects the diagnoses of surface modifications on bone by exfoliating the outer cortex and making it more difficult to observe markings. This results in a form of ‘laboratory taphonomy’ where modification frequencies are likely to be under-represented (Bartram and Marean, 1999: 22; cf. Nicholson, 1993; Clark and Ligouis, 2010). At very high temperature, bone also has a tendency to become ceramic-like (Shipman et al. 1984; Nicholson, 1993: 417). Abrasive objects in the trampling pits are, therefore, liable to fragment bone instead of marking the surface.

Table 7

a. Observed and expected frequencies between modification and burning. $\chi^2 = 30.766$; $df = 5$; $p < 0.005$. **b.** Observed and expected frequencies between modification and sediment type. $\chi^2 = 21.92$; $df = 5$; $p < 0.005$.

	Modification						Total
	Scratches	Lines	Grooves	Pits	Elongated pits	Sheen	
a)							
Burnt bone	16 (18.287)	51 (60.212)	14 (19.179)	71 (70.917)	40 (37.020)	60 (46.386)	252
Unburnt bone	25 (22.713)	84 (74.788)	29 (23.821)	88 (88.083)	43 (45.981)	44 (57.614)	313
Total	41	135	43	159	83	104	565
b)							
Sand	16 (20.391)	79 (67.142)	9 (21.386)	85 (79.078)	38 (41.280)	54 (51.724)	281
Shell and sand	25 (20.609)	56 (67.858)	34 (21.614)	74 (79.922)	45 (41.720)	50 (52.276)	284
Total	41	135	43	159	83	104	565

The potential similarity between shell and cut marks raises the issue of whether they could be the result of human or natural processes. Trampling lines, grooves, pits and elongated pits are more prevalent on bones from shelly sediment. The reconciled data-set also demonstrates a significant association between sediment type and the number of specimens with modification ($\chi^2 = 21.920$; $df = 5$; $p < 0.005$) (Table 7b). This suggests that faunal remains recovered from shelly sediment are likely to exhibit more

modification than bone recovered from sandy deposits. The experimental data implies that modification on these remains would probably resemble cut marks. There is no definitive means to differentiate butchery marks from trampling marks so the chances of 'butchery marks' being observed increases if trampling marks are prevalent on faunal remains. A substantial proportion of grooves in the combined samples have straight borders ($n_a = 23$; 46.9%) and trajectories ($n = 8$; 30.8%) which likely resemble cut marks. Many grooves on unburnt bone in shell (pit 1) ($n_a = 9$; 34.6%) and burnt bone in shell (pit 2) ($n_a = 3$; 25%) have W-shaped profiles which suggests that shell may be more likely to produce clustered, parallel striations or furrows with internal striations (Fig. 2d). Choi and Driwantoro (2007: 53) demonstrate that shell marks can often exhibit _/_or W-shaped profiles. Dominguez-Rodrigo et al. (2009: 2653) also note that the majority of trampling marks (75%) in their experiment have 'internal microstriations', equivalent to W-shaped profiles in this study. Marks such as these could be mistaken for cut marks since butchery marks often consist of multiple furrows in close proximity. It is reasonable, therefore, to assume that shell-marks could resemble cut marks. The feasibility of this is demonstrated in the archaeological record, where shell tools have been used as effective cutting implements (Schmidt et al. 2001; Choi and Driwantoro, 2007; Douka, 2011) capable of cut mark-like modification (Toth and Woods, 1989). This is particularly true if trampling marks are short. Short nicks made by shell fragments on bone would very likely resemble chop marks (e.g., Fig. 11). Trampling in shell middens could therefore be, not only destructive to bone, but could also result in incidence of trampling marks that mimic cut marks.

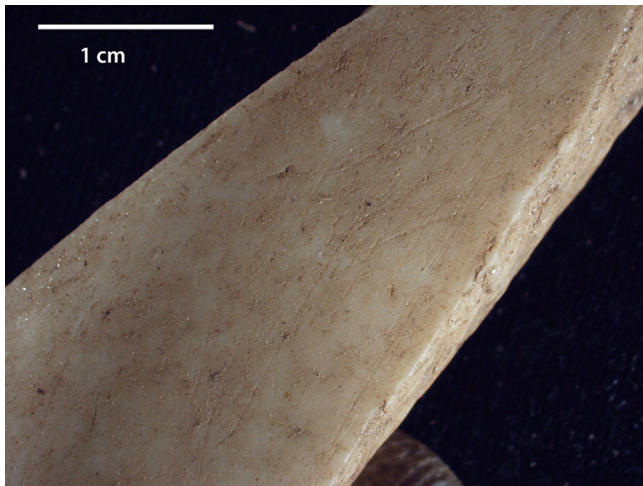


Fig. 9. Trampled specimen with parallel and semi-parallel trampling lines and sheen resembling polished bone.

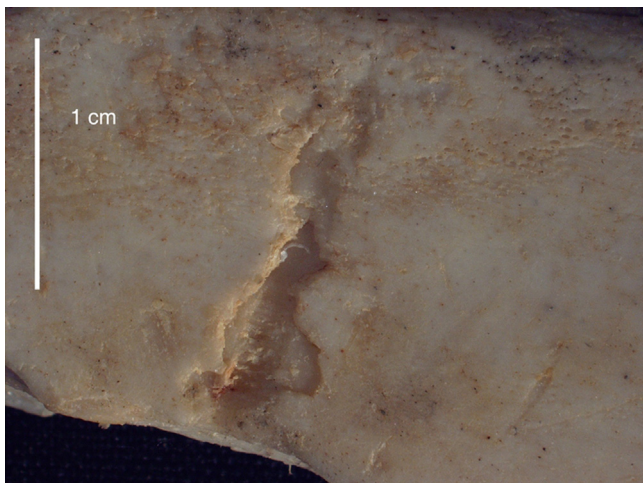


Fig. 10. Groove with jagged border.

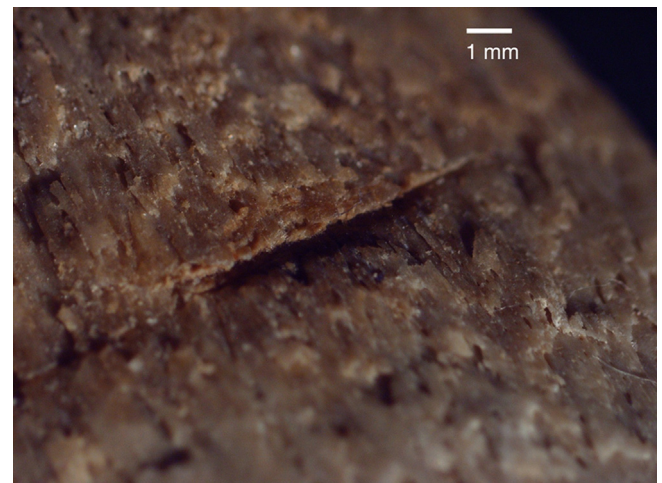


Fig. 11. Short groove with straight border resembling a cut mark.

4. Conclusion

In this study, the types of modification that can occur on bone fragments recovered from coastal sediments were documented. The experiments suggest that burning and the presence of shell in deposits are likely to affect the way archaeological bone is modified through trampling. Burnt bone is significantly less likely to exhibit surface modification than unburnt bone. Sheen or polish is prevalent on both burnt and unburnt trampled bone fragments and its presence is highly characteristic of trampling. Sheen is unlikely to mimic intentional polishing because deliberate polish is usually associated with parallel striae and specific 'worked areas' on the tool (Backwell et al., 2012; d'Errico and Henshilwood, 2007; d'Errico and Backwell, 2009). This study suggests that the presence of sheen on the entire specimen (including both sides of the fragment) is generally indicative of trampling. However, the pervasiveness of sheen makes it feasible that some naturally trampled bone could mimic intentionally polished bone fragments. In these experiments, trampling is not likely to cause smoothing or rounding of bone edges. When this does occur, the entire edge of the trampled specimen is smoothed, unlike deliberate tools where only the working area is affected. Grooves caused by shell fragments are liable to have sinuous trajectories with V-shaped profiles although a significant proportion may have W-shaped profiles. The borders of grooves are equally likely to be either straight or jagged. Sinuous trajectories and jagged borders may thus signify trampling modification in shelly deposits while short grooves with straight trajectories and borders may mimic cut marks.

In contrast to sheen, lines and grooves; pitting and elongated pits are not likely to mimic other surface markings. Pitting is highly characteristic of trampled bone and appears to be overlooked as a diagnostic feature of trampling (although see Gaudzinski-Windheuser et al., 2010). The presence of pits may therefore be an important criterion in characterising the effects of trampling in an archaeological assemblage. Although this criterion also occurs on bones that have been intentionally polished, elongated pits resulting from trampling are morphologically distinct from those resulting from polishing. Elongated pits from trampling tend to be more pronounced: depressions are deeper and furrows are wider. Moreover, elongated pits caused by intentional polishing are restricted to the surface being worked. Like sheen, pits and elongated pits resulting from trampling occur over the entire specimen. Generally, if modification is present over the entire fragment this would imply trampling. The experiment demonstrates that bone fragments can undergo considerable modification when trampled with shell remains. Bone recovered from middens and shelly sediment could be affected by trampling and this should be considered when analysing patterns of surface modification on faunal remains from coastal sites.

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CHAPTER 8: TAPHONOMIC MODIFICATION AND OCCUPATIONAL INTENSITY

In this chapter, I apply the results of my research in chapter 6, a paper published in *Quaternary International* (Reynard 2014) to explore occupational intensity through the SB sequence at BBC. This chapter is structured like a research paper with an introduction/background, materials and method, and discussion sections. The background section contains the aims and rationale for this aspect of my study.

8.1 Background

Demographic factors are believed to have had a significant influence on the development of behaviour during the Late Pleistocene (Henshilwood & Marean 2003; Mellars 2006; Steele & Klein 2009; Compton 2011; Clark 2011). Increased diet breadth and evidence of more intensive processing at KDS suggests that occupational intensity may have had an impact on subsistence patterns during the HP in the southern Cape (Reynard *et al.* 2015). Recognising traces of more intense occupation in the archaeological record is therefore useful in exploring links between subsistence behaviour and demography. Geoarchaeological studies are crucial to this but another way to explore periods of occupation at archaeological sites is to examine the taphonomic history of faunal assemblages. Archaeofaunal collections could represent a valuable means of investigating demographic trends and the analysis involves little more than the use of a hand-lens.

Trampling marks on bone are the most obvious evidence of bioturbary activity at sites (Behrensmeyer *et al.* 1986). Although many studies of natural bone abrasion focus on its role in pseudo-tool production, it can also be indicative of trampling (Brain 1967, 1981; Madgwick 2014). Most studies of trampling concentrate on the furrows ('trampling marks') that are sometimes confused for cut-marks (Behrensmeyer *et al.* 1986; Olsen & Shipman 1988; Gaudzinski-Windheuser *et al.* 2010; Dominguez-Rodrigo *et al.* 2009). My research shows that these marks are rare and that other types of modification such as natural abrasion and pitting may be a more common indicator of trampling (Reynard 2014). It can, however, be difficult to distinguish human from animal trampling activity (Brain 1967; Fiorillo 1989;

Oliver 1989). At costal rock-shelters like those at BBC and KDS, however, it is unlikely that any agents apart from humans would have caused trampling modification (Klein 1975).

The question remains whether – as indicators of trampling activity – trampling marks can be linked to occupational intensity. Equifinality in bone modification means that other processes may mimic the effects of human trampling. Water, rockfalls and burning, for example, all modify bone similar to human trampling (Wood & Johnson 1978; Nicholson 1992; Boschian & Saccá 2010; Karr & Outram 2012). Previous research, however, shows that it is possible to successfully differentiate between natural or anthropogenic modification and bioturbation (Dominguez-Rodrigo *et al.* 2009; Reynard 2014) and this is supported by my data from KDS (Reynard *et al.* 2015). The KDS assemblage was analysed before I had refined the criteria for identifying trampling marks, so only bone abrasion was noted. Still, the highest proportion of abraded specimens was found to be in middle layers (PBD - PBA/PBB), the most compact layers in terms of shellfish and macrofaunal volumetric density. While faunal density may be the result of a number of processes (Jerardino 1995), the research presented in chapter 5 (Reynard *et al.* in press) suggests that the concentration of faunal remains within the KDS deposits can infer occupational intensity. It therefore seems that examining the effects of trampling through the BBC sequence may be an effective means of assessing the influence of occupational intensity. An even more prudent method may be to compare trampling/abrasion marks with other taphonomic patterns in the faunal assemblage.

Besides trampling marks, other taphonomic signatures can also inform on the presence of people. Evidence of animal activity such tooth marks and gastric acid-etching in an assemblage, for example, implies infrequent or no human occupations (Blumenshine 1988). Highly fragmented bone assemblages – especially in enclosed-sites such as rock shelters – are also indicative of intense occupational periods (Klein 1975). Breakage patterns may point to high or intense occupation periods at a site. Moist, fresh bone tends to fracture differently from dry, old bone. Old bone is more brittle and generally fractures transversely with breaks at right-angles to the cortex in contrast to the spiral fractures prevalent on fresh, ‘green’ bone (Johnson 1985). Spiral fractures indicate marrow-extraction activities but it can be difficult to differentiate between human and animal agents (Brain 1981; Marean 1991). Transverse breaks on long-bone have also been associated with sediment compaction (Villa & Mahieu 1990) which may be linked to the presence – and accumulative weight – of people at a site. The concentration of faunal remains in deposits could also be used to explore the intensity or frequency of human activities at a site (*cf.* Marean *et al.* 2000; Thompson & Henshilwood

2011). Comparing these different types of proxies for occupation with trampling modification may elucidate trends in the occupation history of a site that a single proxy may not provide.

8.2 Materials and method

Identified fauna is defined as specimens that can be identified to at least the class level while unidentified specimens are those that could only be identified as bone. The faunal dataset utilised in chapter 4 and 5 (identified fauna and unidentified long-bone fragments) and unidentified faunal remains from BBC larger than 2 cm are included in this analysis. In total, 1,807 identified faunal remains (both piece plotted specimens and faunal specimens recovered from coarse fraction from 3 mm sieves) and 1,442 unidentified specimens weighing 12.9 kg from Layer CF to CA are used (see page 64, chapter 4, for details of the identification procedure for the identified BBC fauna). Unidentified specimens are classified as ‘trabecular’ (spongy bone fragment) or ‘cortical’ (retaining a cortical surface). Only specimens that retain a cortical surface were used in the analysis of surface modification while all fragments (including 30,061 specimens of bone debris) were used to determine faunal density. I use the term ‘all specimens’ or ‘all faunal remains’ when discussing the combined identified and unidentified samples.

All faunal remains were examined with a Nikon binocular light microscope (10 – 40x magnification) under oblique, unidirectional, incandescent lighting. The method of analysis for pre- and post-depositional surface modification (Behrensmeyer, 1978; Brain 1981; Blumenschine & Selvaggio 1988; Lyman 1994; Blumenschine *et al.* 1996; Pobiner 2003), burning (e.g., Brain, 1981; Shipman *et al.*, 1984; Nicholson, 1993; Stiner *et al.*, 1995; Driver, 2005), fracture patterns (Driver 2005; Villa & Mahieu 1990) and the classification of lengths for the unidentified specimens is the same used to assess the identified fauna (Reynard *et al.* 2015, in press). Trampling modification is based on criteria presented in chapter 6 (Reynard 2014) and through previous research (Behrensmeyer *et al.* 1986; Olsen & Shipman 1988; Dominguez-Rodrigo *et al.* 2009). Although the characteristics of bone modified by trampling have been discussed in chapter 7 (Reynard 2014), it is repeated here for the sake of clarity. Four main types of trampling modification were recorded: 1) *abrasive modification*; 2) *lines and grooves*; 3) *pitting* and 4) *scratches* (see chapter 7 for a detailed explanation of these and other trampling marks) (Fig. 8.1). Abrasive modification was noted when specimen surfaces were ‘smoothed’ (i.e., based on surface tactility and exhibiting no roughness), displayed polish/sheen, or when the edges of fragments were ‘rounded’. Intentionally polished

specimens or those with use-wear were not included in the dataset. Because thermally-altered specimens sometimes exhibit a glossy polish, only unburnt fragments were analysed for sheen. Water-worn specimens can also display rounded edges and sheen but these tend to be excessively polished. Based on previous research (Thompson 2008; Reynard 2012), it is unlikely any of the fragments in our sample are water worn. Lines and grooves are generally distinguishable from anthropogenic marks by the orientation and shape of the furrow. Pits are small impact craters less than 1 mm in diameter and are discernible from those caused by animals by their small size and shallowness. Scratches (also known as ‘microabrasions’ [Dominguez-Rodrigo *et al.* 2009] or ‘chatter marks’ [Shipman & Rose 1983]) are also characteristic of trampling. Lines and grooves are the ‘trampling marks’ referred to in most research (e.g., Behrensmeyer *et al.* 1986; Olsen & Shipman 1988; Dominguez-Rodrigo *et al.* 2012) and are called ‘furrows’ in this chapter. Here, trampling marks are defined as furrows, pits and scratches while unintentional bone polish and fragment rounding/smoothing are called abrasive marks. These modifications – called ‘trampling modification’ – are compared with other taphonomic evidence from the BBC assemblage. I use four comparative datasets to investigate occupational intensity at BBC: 1) trampling modification; 2) faunal density; 3) fragmentation patterns; and 4) non-anthropogenic surface modification patterns.

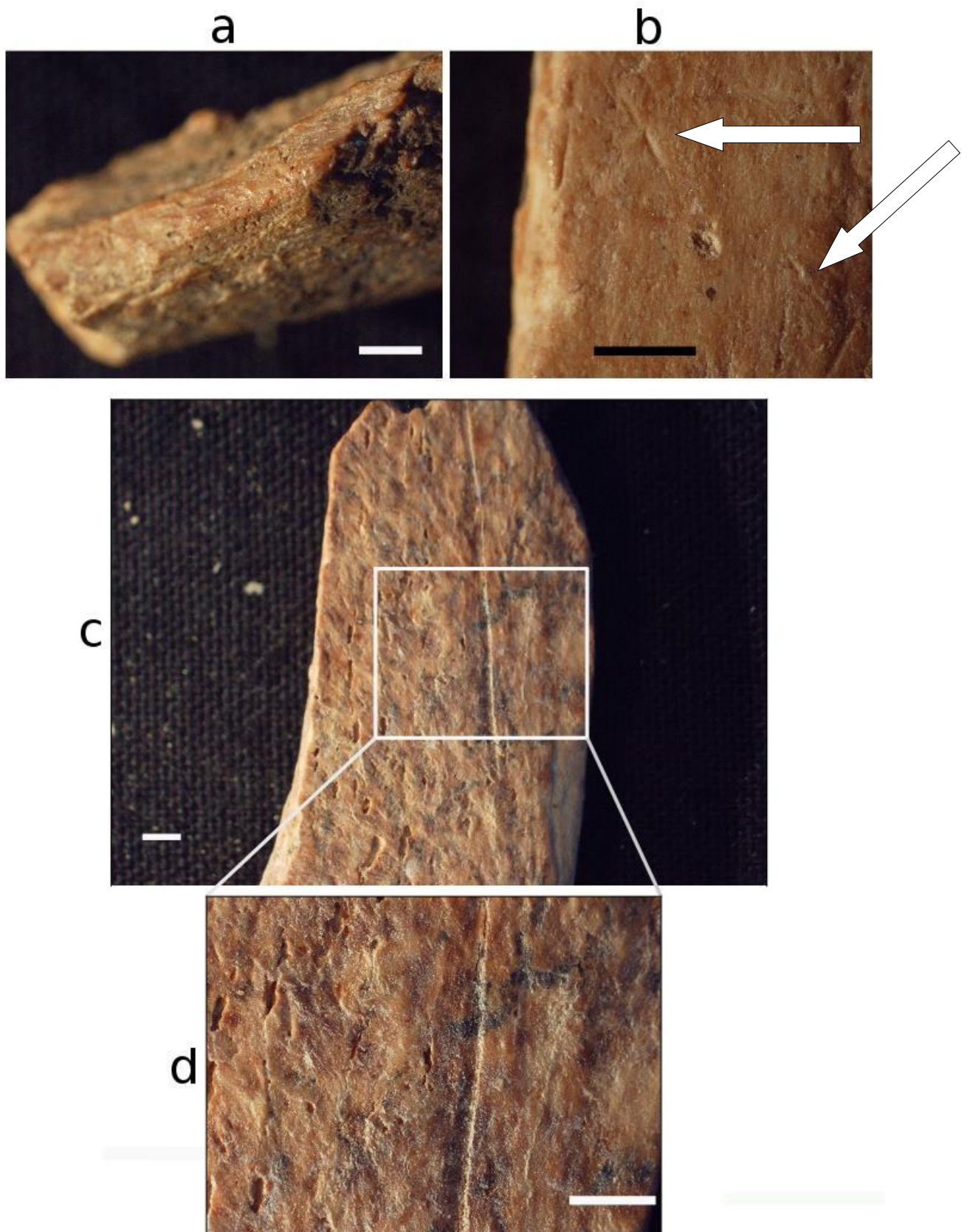


Figure 8.1: Examples of trampling modification at Blombos Cave (a) abrasion (b) pitting and scratches (arrows) (c) trampling furrow (d) Note the shallow depth of the groove
Bars equal 1 mm

1. *Trampling modification*

The proportion of specimens with trampling marks – per layer – is used to determine the extent of trampling throughout the sequence. Specimens were also graded according to the intensity of trampling modification with ‘1’ representing little evidence of trampling and ‘5’ representing the most. As noted in chapter 7, trampling intensity is a relative term. For the BBC specimens, intensity was based on the average number of marks observed on a specimen under ~ 7 x magnification. A specimen where an average of one mark is observed on a surface area represents an intensity of ‘1’, specimens with an average of five marks are noted within a viewing area represents an intensity of ‘5’. Thus intensity corresponds to the average number of marks noted. I use an ‘intensity index’ – defined as the average intensity value of all specimens in a particular layer – to categorise the intensity of trampling per layer. As opposed to the *extent* of trampling, *intensity* is not based on the number of specimens. Unless otherwise noted, results of this analysis are based on the extent of trampling.

2. *Faunal density*

The concentration of faunal remains in the deposits is used to explore the intensity of human activities in the SB layers at BBC (*cf.* Marean *et al.*, 2000; Reynard *et al.* in press). I measured the number of specimens (NSP) and weight of bone/shellfish specimens per unit of sediment volume. Since one bucket equals 11 litres, sediment volume was measured by multiplying the total number of buckets excavated from the specific layers/quadrates used in the analysis, with 0.011 to calculate the volume in cubic meters. Faunal density for bone and shellfish was calculated by dividing the volume of excavated material from each unit by the NSP, the minimum numbers of individual (MNI) – for shellfish – and weight of specimens in those units. Only excavated volumes of material from the relevant units and layers were used in the calculation.

3. *Fragmentation patterns*

Fracture patterns: Following previous research, the analyses on breakage patterns are based on long-bones (Shipman *et al.* 1981; Villa & Mahieu 1991; Marean *et al.* 2000; Pickering *et al.* 2005). Unidentified long-bones are included in the dataset because element taxonomy is not important in the analysis and the inclusion of unidentified specimens increases the sample size. Burning affects the structure and morphology of bone making it brittle and more likely

to fracture transversely (Shipman *et al.* 1984; Marean *et al.* 2000). Thus only unburnt long-bone > 2 cm long is used to assess breakage patterns. Bone is considered transversely fractured when the outline of the long-bone is straight and transverse to the long bone axis. Fracture angles for transverse breakage are perpendicular to the long bone axis (or ‘right-angled’).

Degree of fragmentation: Two proxies are used to assess fragmentation. The first is a measure of the estimated weight of a single specimen from the assemblage. To counter the effects of different bone densities between tortoise and mammals (the two most common faunal remains), only data of mammalian fauna are utilised. The NISP is divided by the weight of those specimens per layer. The lengths of specimens were not measured and because weight per specimens is calculated and the lengths and weight of unidentified specimens from BBC are significantly correlated ($r_s = 0.947$; $p < 0.0001$) (Reynard *et al.* 2014), I use specimen weight as a proxy for size.

The second proxy is a measure of the percentage of identified versus unidentified remains. Researchers have used various methods of measuring fragmentation based on quantitative units (Binford 1978; Grayson 1984; Klein & Cruz-Urbe 1984; Lyman 2008). Human activities generally fragment bone; thus the proportion of identified versus unidentified specimens can be used to infer occupation intensity at an archaeological site (but see Gifford-Gonzalez 1989). Here I use the NISP divided by the total NSP.

4. *Other surface modification patterns*

I use other types of taphonomic modification that are assumed to imply an absence of human occupation. Weathering results from the long-term exposure of bone to natural processes such as sunlight or severe temperature fluctuations (Behrensmeyer 1978). The relative abundance of weathered bone may therefore reflect long periods of undisturbed deposits. Similarly, tooth and gnaw marked bone are caused by carnivore and rodent actions and would most likely occur when human occupation was minimal or infrequent (Brain 1981; Blumenschine 1988). Long-bone shaft circumferences are also used to infer the presence of carnivores since carnivores tend not to splinter shafts leaving more complete circumferences (Klein 1975; Bunn 1983; Marean *et al.* 1992).

8.3 Results

8.3.1 *Trampling modification*

Abrasive marks or unintentional surface polish (abrasion) and fragment-edge smoothing ('rounding') are relatively common in the BBC assemblage and many specimens in the assemblage display extensive abrasive modification. Abrasive marks are relatively prevalent in CB, CC and CCC becoming rare in CDA and CDB, and increasing again in the CF/CFA (Fig. 8.2a). The combined layers figure shows that abrasion is most common in the middle layers (CB and CC) dropping in CD (Fig. 8.2b).

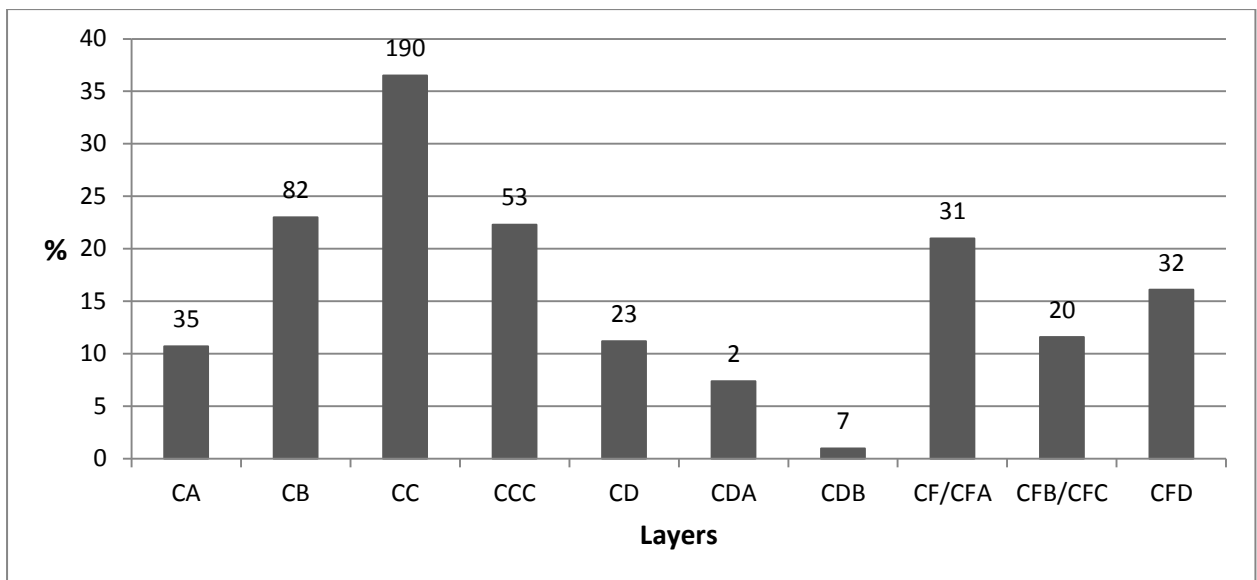


Figure 8.2a: Abrasive modification during the Still Bay at Blombos Cave. Values above columns are the numbers of specimens

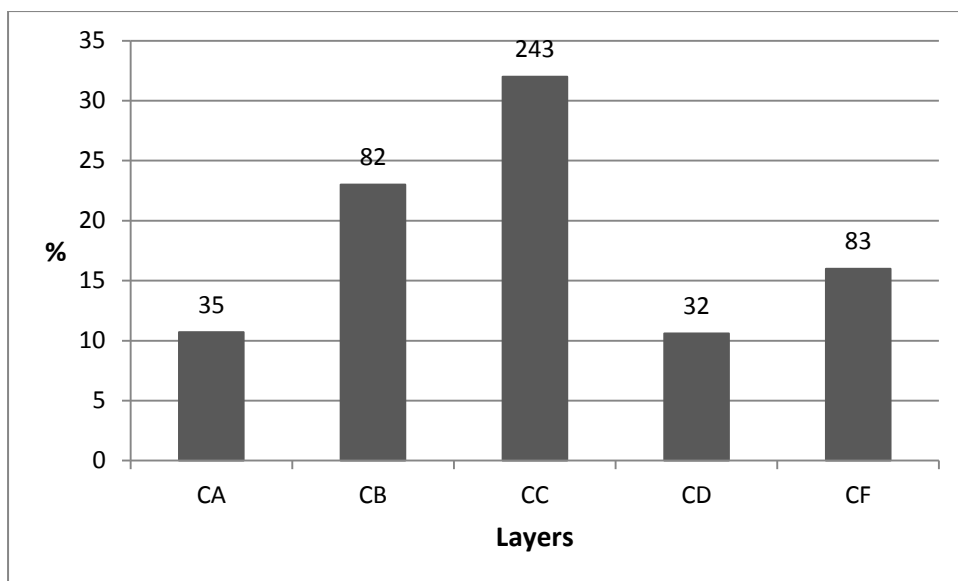


Figure 8.2b: Abrasive modification through the combined Still Bay layers at Blombos Cave. Values above columns are the numbers of specimens

Pits, furrows (lines/grooves) and scratches also occur quite frequently in the assemblage. These marks can be considered ‘classic’ indicators of trampling but are generally less common than abrasion. Of all the trampling marks, pitting is the most prevalent (NSP = 190). Pits are the most common in the upper layers, occurring less frequently down the sequence.

Furrows (NSP = 70) and scratches (NSP = 84) are less common but are still significant forms of modification. Furrows are generally more prevalent in CA and CC while scratches are common in CC and CF. Interestingly, pits, furrows and scratches show dissimilar trends through the SB layers (Fig 8.3a, b & c). This could be explained by the way trampling modification is quantified. I measure the frequency of *specimens* with marks. Some specimens have multiple forms of trampling marks but only fragments with the specific modification under consideration – for example, furrows – are measured when dealing with those marks. Adding up the various specimens with pits, furrows or scratches, therefore, will not produce the same number of specimens as the ‘combined’ marks category (i.e., any type of trampling marks: pits, furrows or scratches). Specimens that display the ‘combined’ marks are significantly correlated with abrasion through the layers ($r_s = 0.9$; $p = 0.037$). Trampling marks are considered as a single dataset because the types of marks that make up pits, furrows and scratches can be considered a continuum (Reynard 2014: 164). For example pits are sometimes ‘elongated’ and these, like intensive scratches, often resemble furrows.

Mean trampling intensity was 1.46 for all specimens. It was lowest in CD and highest in CC (Table 7.1). There is no significant correlation between trampling marks and intensity ($r_s = 0.7$; $p = 0.1881$) but there is a significant relationship between intensity and abrasive modification ($r_s = 0.9$; $p = 0.0337$) which suggests a link between the how intensely a specimen is modified and abrasion. The lack of a significant correlation between intensity and trampling marks may mean that the quantity of specimens trampled is not related to how much they are modified.

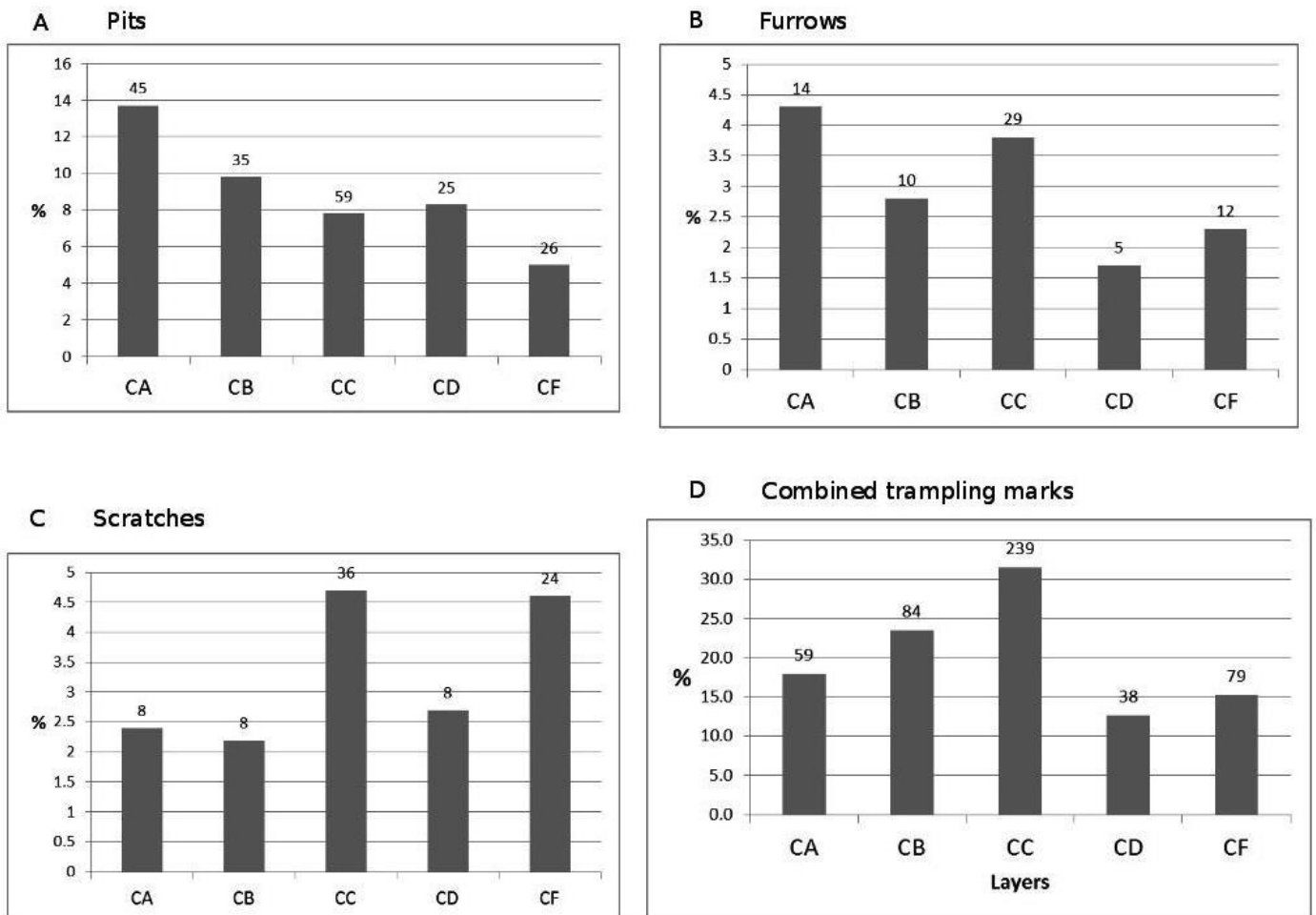


Figure 8.3: Number of specimens with trampling marks through the sequence. A) Pits; B) Furrows (lines and grooves); C) Scratches; D) Combined pits, furrows and scratches

Table 8.1: Trampling modification through the layers

Layers	N	Abrasion		Trampling marks		Intensity
		n	%	n	%	
CA	328	35	10.7	59	18.0	1.34
CB	358	82	23.0	84	23.5	1.35
CC	759	243	32.0	239	31.5	1.58
CD	302	32	10.6	38	12.6	1.25
CF	519	83	16.0	79	15.2	1.45

Table 8.2: Number of specimens (NSP) and weight (kg) of specimens through the sequence

Layers	All specimens		Without tortoise	
	NSP/m ³	kg/m ³	NSP/m ³	kg/m ³
CA	78812	34.00	58934	20.73
CB	63833	27.10	55751	20.45
CC	67543	23.22	62795	19.04
CCC	106036	32.99	97848	24.32
CD	66148	19.78	55115	13.62
CF/CFA	44045	23.60	35404	7.58
CFB/CFC	50147	26.53	35498	13.13
CFD	17469	15.82	15589	14.51

8.3.2 Faunal density

Table 8.2 presents the quantity and weight of faunal fragments per cubic meter through the SB layers. The highest NSP are concentrated in CA and CC and the lowest are in CF (Fig. 8.4). CA has the largest concentration by weight of bone specimens with the lowest concentration in CD. NSP and weight are not significantly correlated ($r_s = 0.619$; $p = 0.1020$) but if tortoise remains are excluded, they are ($r_s = 0.786$; $p = 0.0210$).

Table 8.3: Weight (kg) and minimum number of individuals (MNI) of shellfish through the sequence

Layers	MNI/m ³	kg/m ³
CA	3220	25.1
CB	4290	31.2
CC	2550	22.7
CD	1987	18.6
CF	6627	52.8

Shellfish MNI and weight densities are significantly correlated ($r_s = 1$; $p < 0.0001$). Density for both weight and MNI is highest in CF and lowest in CD. Unlike at KDS, shellfish and bone densities are not significantly correlated in the BBC assemblage (for MNI vs NSP: $r_s = -0.600$; $p = 0.2850$, for bone and shellfish weight: $r_s = 0.300$; $p = 0.6240$).

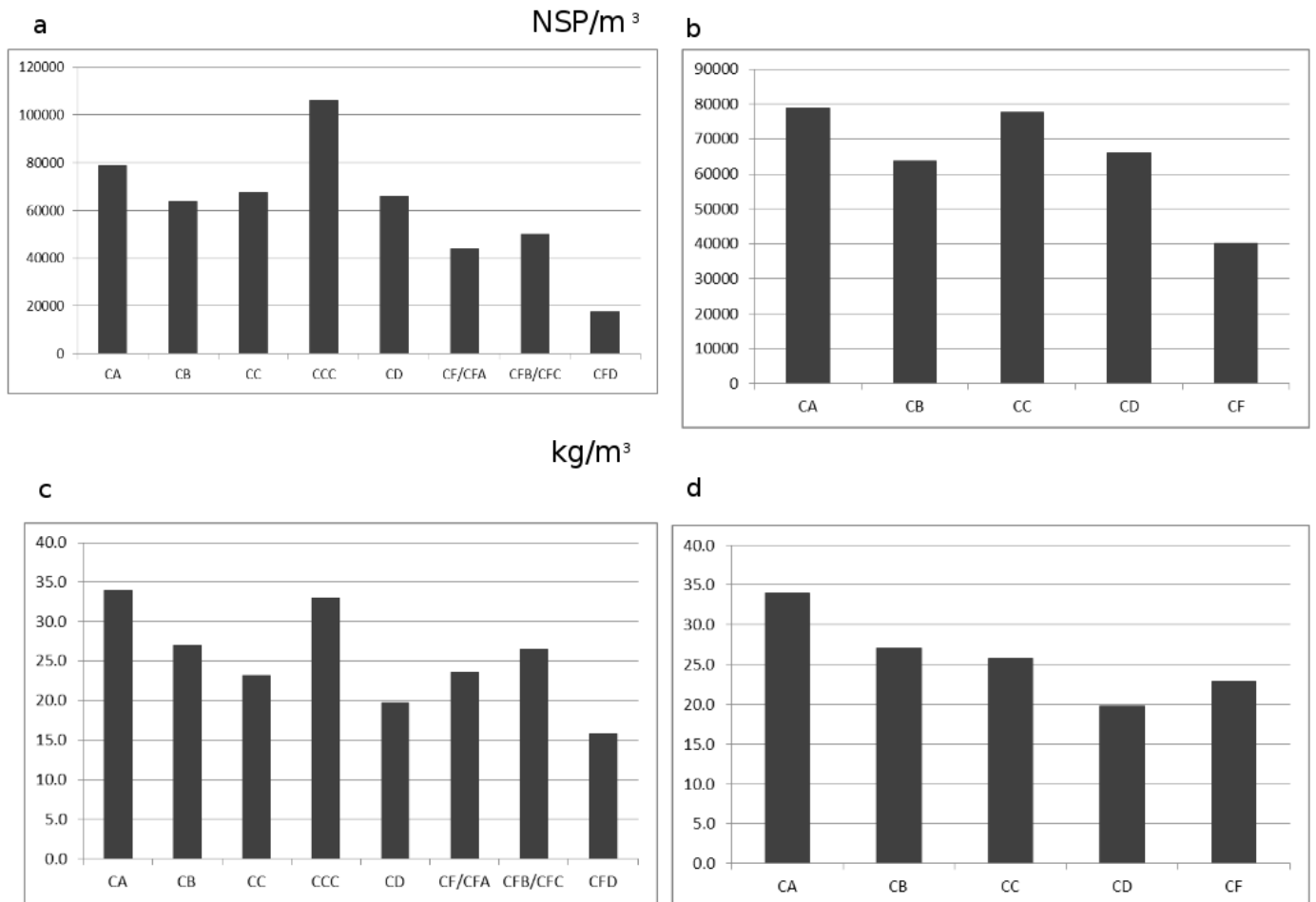


Figure 8.4: Bone density per layer at Blombos Cave. Number of specimens (NSP) per cubic meter per layer for all layers (a) and combined layers (b); Combined weight of specimens per cubic meter per layer for all layers (c) and combined layers (d)

8.3.3 Fragmentation patterns

Variability in the fragmentation of the assemblage is evident in both specimen sizes and the ratio of identified to unidentified remains. Specimen size decreases from the early SB (CFD) to the middle layers (CCC) (Fig. 8.5a). Fragments are largest in CF and smallest in CC (Fig. 8.5b). As a percentage of total NSP, identified specimens (including tortoise) are more

prevent in CA and CF and less common in CC (Fig. 7.6a). The proportion of identified mammalian remains is not significantly different through the M1 but increases in CF (Fig. 8.6b).

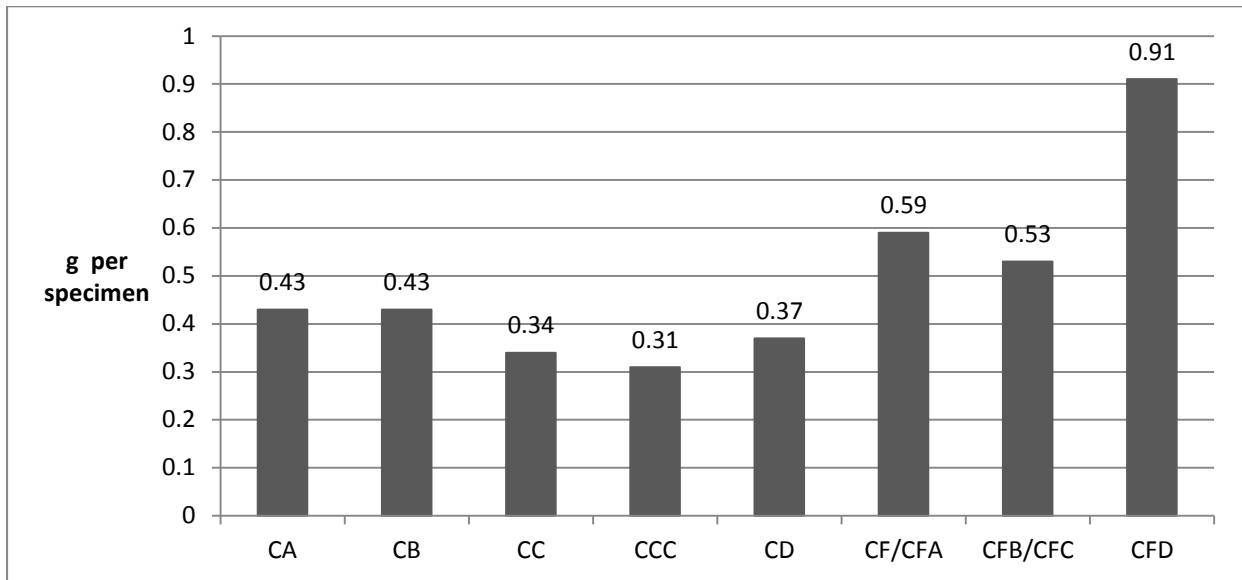


Figure 8.5a: Weight per specimen through the Still Bay sequence (weight divided by all specimens - excluding tortoise)

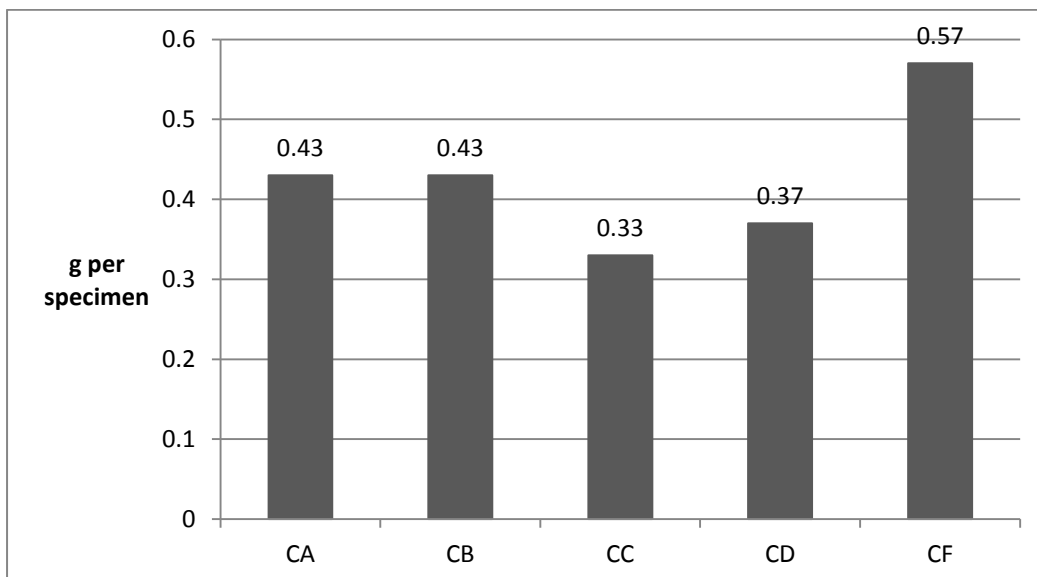


Figure 8.5b: Weight per specimen for combined layers (weight divided by all specimens - excluding tortoise)

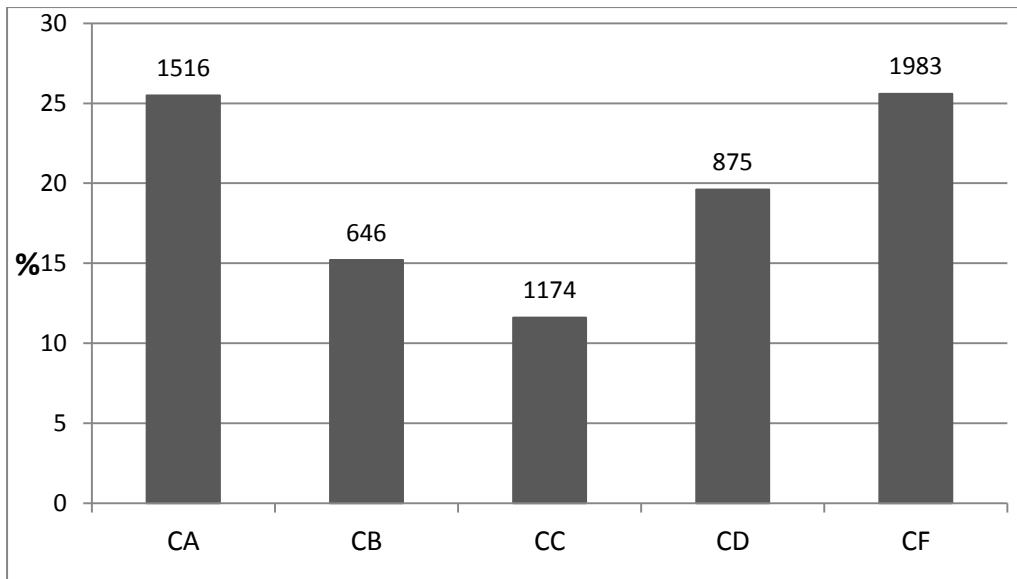


Figure 8.6a: Proportion of all identified remains –including tortoise– in the Still Bay (NISP divided by total specimens). NISP above columns

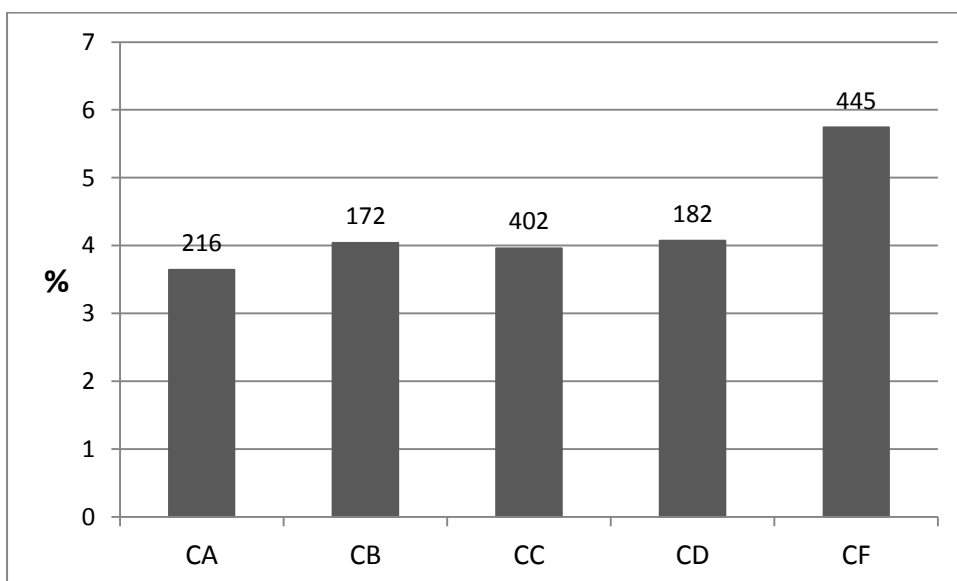


Figure 8.6b: Proportion of identified mammal remains in the Still Bay (mammal NISP divided by total specimens). NISP above columns

Table 8.4: Degree of fragmentation in the Still Bay

Layer	% ID remains		Weight per specimen (g/NSP)	
	All	Mammal only	Excluding tortoise	Including tortoise
CA	25.5	3.64	0.43	0.63
CB	15.2	4.04	0.43	0.36
CC	11.6	3.96	0.33	0.34
CD	19.6	4.07	0.37	0.67
CF	25.6	5.74	0.57	0.50

Fracture patterns from the SB layers are similar to other MSA sites such as Pinnacle Point (Thompson 2010), Die Kelders (Marean *et al.* 2000), Sibudu (Clark 2009) and KDS (Reynard *et al.* in press). As can be expected from a Stone Age site where marrow-extraction occurred, the majority of long-bones exhibit spiral fractures (number of ends = 287; 60.5%) (Table 8.5). Transverse fractures are highest in CCC and CFB/CFC and lowest in CA (Fig. 8.7a). The trend resembles a bimodal pattern with peaks in CC and CF (Fig. 8.7b). Neither transverse fractures nor spiral fractures are significantly different between layers, except for between CA and CB (Table 8.6).

Table 8.5: Fracture patterns in the Still Bay

Layer	Spiral		Irregular		Transverse		Total (n)
	n	%	n	%	n	%	
CA	82	70.1	10	8.6	25	21.4	117
CB	34	51.5	9	13.6	23	34.8	66
CC	47	63.5	0	0	27	36.5	74
CCC	29	56.9	3	5.9	19	37.3	51
CD	35	58.3	8	13.3	17	28.3	60
CF/CFA	24	55.8	3	7.0	16	37.2	43
CFB/CFC	19	59.4	1	31.3	12	37.5	32
CFD	27	55.1	8	16.3	14	28.6	49
Total	297	60.4	42	8.5	153	31.1	492

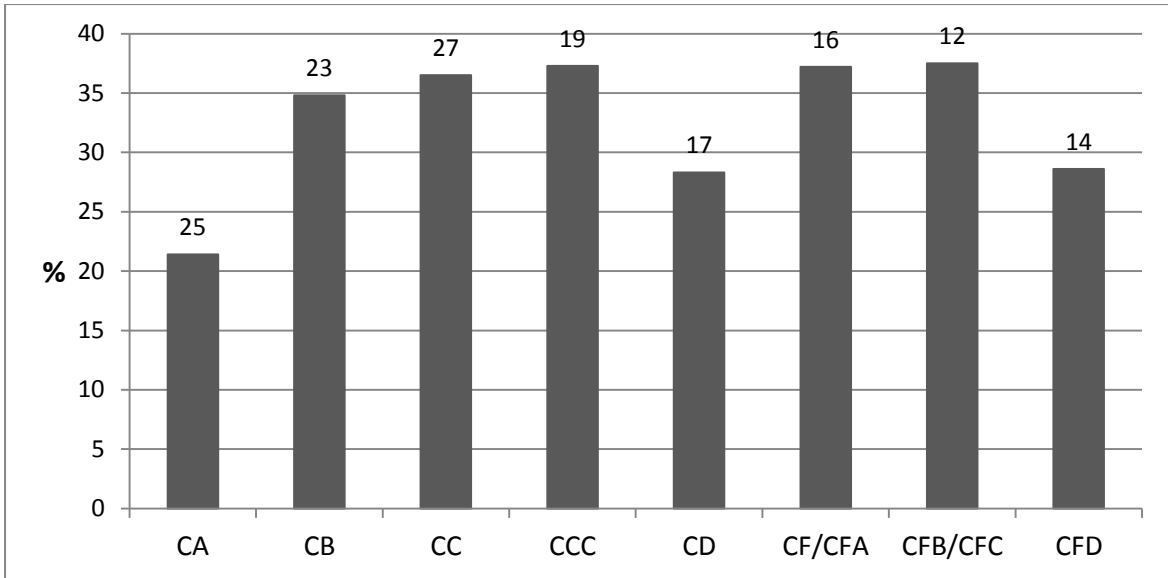


Figure 8.7a: Transverse fractures in the Still Bay. Values above columns equal the number of transverse fractures

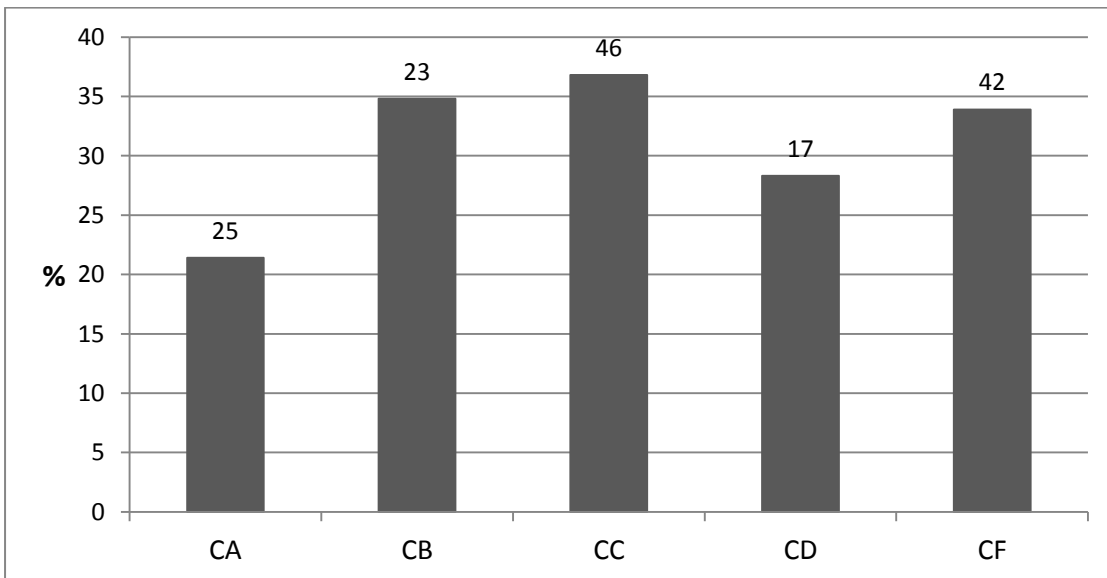


Figure 8.7b: Transverse fractures in the Still Bay for combined layers. Values above columns equal the number of transverse fractures

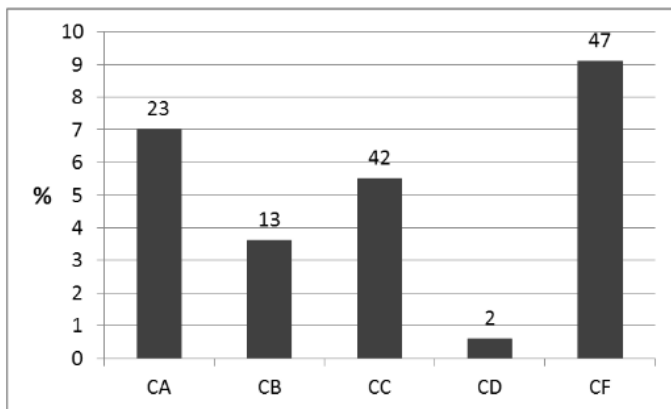
Table 8.6: Statistical differences between fracture patterns in the Still Bay. Significant values embolden

Layers	Transverse versus other fractures		Spiral versus other fractures	
	χ^2	<i>p</i>	χ^2	<i>p</i>
CA & CB	3.963	0.047	6.270	0.013
CB & CC	0.071	0.789	1.525	0.217
CC & CD	1.294	0.255	0.102	0.749
CD & CF	0.569	0.451	0.058	0.809

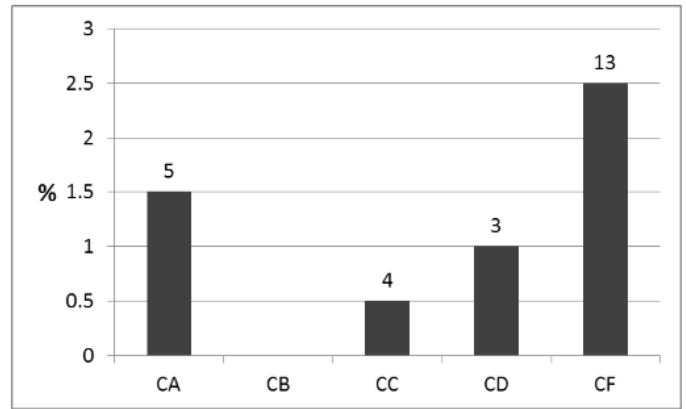
8.3.4 Other taphonomic evidence

Tooth and gnaw marks are highest in CF and lowest in CD (Fig.8.8). Gastric acid-etched bone is rare with just over one percent of the SB sample affected (n = 25; 1.1%). These marks are more common in CF and no specimen in CB displayed acid-etching. Weathering is the rarest modification. Generally, only one or two specimens per layer exhibits weathering. When specimens with tooth marks, acid-etching and weathering are combined, these modifications are most common in CF and rare in CD and CB.

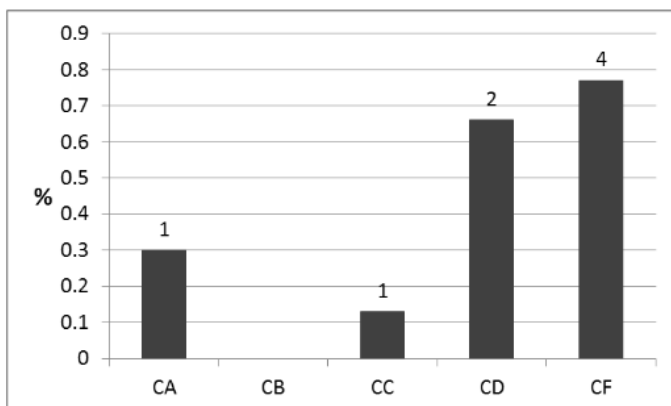
a Tooth & gnaw marks



b Gastric acid-etching



c Weathering



d Combined

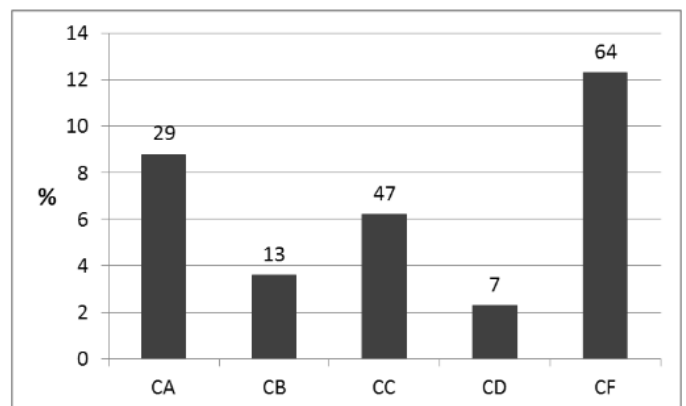


Figure 8.8: Other taphonomic indicators during the Still Bay. (a) Tooth and gnaw marks; (b) Acid-etching; (c) Weathering & (d) Combined modification

8.4 Discussion

It is important to differentiate between intentional polish and abrasion in an assemblage like BBC, particularly in light of the recovery of numerous bone tools in the SB (see Henshilwood *et al.* 2001 and d'Errico & Henshilwood 2007). As noted in the previous chapter (Reynard 2014), unintentional abrasion tends to occur over the entire specimen while intentional polish is more likely to be prevalent around a particular area such as the working tip. Anthropogenic polish is also often present as grip-wear on the 'handles' of tools. Indeed, polish on working edges and grip-areas are definitive evidence of use-wear polish. Even when specimens are extremely comminuted, anthropogenic marks could be relatively confidently distinguished from unintentional polish by the orientation of striations and edge wear (*cf.* Reynard 2011; Reynard 2014). As with abrasive markings, it is also critical to ensure that trampling marks are not the result of other agents. Pitting, for example, can often result from carnivore activity (Lyman 1994; Pobiner 2003). The pitting assigned as trampling marks in the BBC collection, however, are notably different from tooth marks. Pits generally occur in combination with other forms of trampling and are usually smaller than tooth marks. In my experimental sample (Reynard 2014), pits were ~ 1 mm in diameter; consistent with the larger sediment grain sizes. At BBC, they were slightly smaller (from 0.5 to 1 mm) and also corresponded to the smaller grain sizes at the site. Moreover, in contrast to tooth marks, trampling pits are only noticeable through low-magnification microscopy. The significant relationship between abrasion and trampling marks through the SB implies that both patterns are the result of similar bioturbatory processes. Both types of trampling suggest that the middle layers (particularly Layer CC) yield more – and more intensely – trampled specimens.

The concentration of faunal material per layer and fragmentation patterns reveals a more complex relationship. Some researchers propose that sediment weight can compact faunal accumulations, resulting in higher specimen densities in lower layers (Kidwell 1986; Brain 1975). Jerardino (1995, 2015), for example, is sceptical of the use of density values (particularly shellfish density) as a proxy for occupational intensity because of the underlying assumptions of constant deposition rates. Yet, NSP density is lowest in the deeper layers at

BBC when sediment compaction suggests these values should increase with stratigraphic depth. Density by weight and by NSP per volume through the SB sequence is not correlated; possibly due to the effects of fragmentation. This is not surprising since the degree of fragmentation in an assemblage is not related to the weight of the bone in that assemblage. Specimen size is also significantly, and inversely, correlated with NSP per volume ($r_s = -0.898$; $p = 0.0024$) implying that layers with the smallest specimens contain the highest concentration of faunal remains. There is also a weakly significant relationship between the proportion of identified faunal specimens per layer and fragments size ($r_s = 0.821$; $p = 0.089$). There are thus links between fragment size, identifiability and NSP per volume (Fig. 7.4a & b). NSP per volume may therefore inform on processing intensity. In fact, there is also a weak correlation between NSP per volume and the percentage of cut-marked bone through the sequence ($r_s = 0.714$; $p = 0.071$) (Reynard & Henshilwood, in review). In light of this, it could be speculated that while quantity per volume points to intensification, weight per volume may be more representative of occupation phases. Regardless of what these indices represent, both weight and NSP per volume peak in the middle of the SB sequence (CCC). Fragmentation data suggest differences between the early and later SB. Individual specimens are largest in the early SB (CF), and proportionally more identified remains occur there as well (Table 8.4). The middle SB (CC) yields the smallest specimens and the lowest proportion of identified remains. Interestingly, there is a weak correlation between bone fragment size and shellfish weight per layer ($r_s = 0.872$; $p = 0.0539$). This may also point to intensification processes. Perhaps as more shellfish was exploited, marrow-extraction was less common and terrestrial fauna was less likely to be fragmented. These data shows that the early (CF) and middle SB (CC) are substantially different to each other.

In general long-bone breakages are challenging to interpret. For example, increases in spiral fractures may imply more intensive bone processing but it could also point to the influence of carnivores. Transverse fractures peak in the middle (CC) and early SB (CF) which imply two key sediment compaction phases. In any case, except for the uppermost layers CA and CB, fracture patterns are not significantly different through the sequence so these peaks may not be representative of any major variation. Changes in fracture patterns between CA and CB – where both transverse and spiral fracture are significantly different to the lower layers (Table 8.6) – may be the result of less sediment pressure in the upper-most layer. Circumferentially complete shafts generally imply carnivore-ravaged long-bone (Bunn 1983; Villa & Mahieu 1991; Marean *et al.* 1992). There are significantly more complete long-bone shafts in the

early SB (CF) than in the other layers ($\chi^2 = 7.058$; $df = 1$; $p = 0.008$) (Fig. 8.9). Tooth and gnaw marks, weathering and gastric-etched bone are more prevalent in the early (CF), rare in the later (CB) and non-existent in the middle SB (CDA). On the whole, this shows that animals influenced the assemblage throughout the sequence but particularly in the early SB (CF).

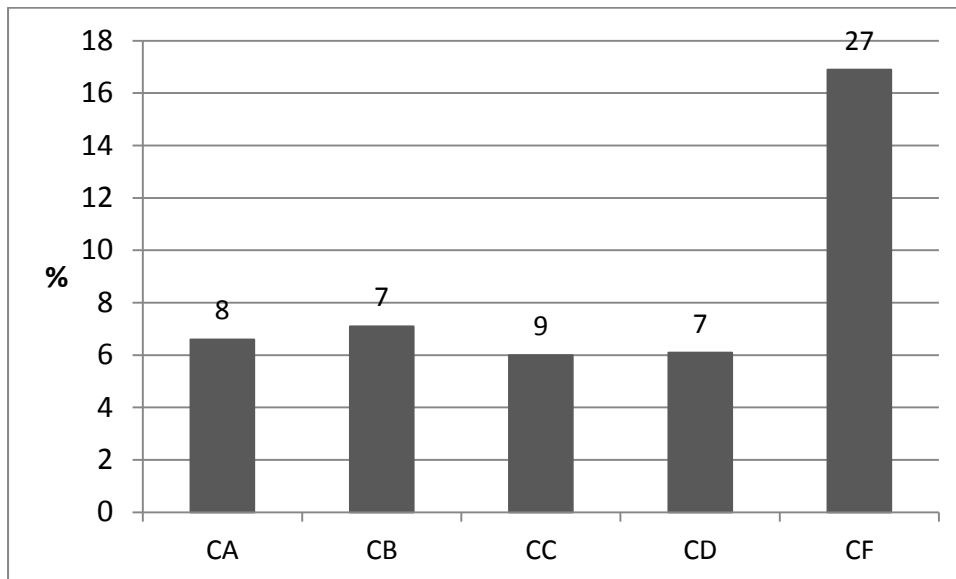


Figure 7.9: Proportions of circumferentially complete shafts in the Still Bay. Values above columns equal the number of complete shafts

8.4.1 Implications for occupation

Trampling modification indicates a shift from more (or more intensive) occupations in the early SB (CF), dropping to fewer occupations in CD then peaking in the middle layers (CB and CC) before becoming less in the later SB (CA). The other datasets, however, rarely reflect this trend. Except for abrasion and trampling marks, the datasets utilised in this study do not indicate significant trends in relation to occupation density. Site formation processes, for example, have probably affected specimen density through time. Research shows that the rate of sediment accumulation has a significant effect on artefact density (Brain 1975; Klein 1975; Kidwell 1985, 1986; Jerardino 1995, 2015). This suggests a complex depositional history during the SB that cannot easily be quantified. However, some trends may be significant. The early SB (CF), for example, appears substantially different from the middle

and later SB. It has more non-anthropogenic bone, larger specimens, a greater proportion of identified bone and generally high proportions of transverse fractures. Concomitantly, it also has lower densities of bone but the highest shellfish density (Henshilwood *et al.* 2001a). Burning is also very common in this layer (Reynard *et al.* in press). The results in chapter 5 (Reynard & Henshilwood, in press) imply that SB people may have been part of highly mobile foraging patterns (McCall & Thomas 2012) and the seemingly conflicting signatures in the early SB (CF) – and indeed throughout the sequence – may be a result of that. High frequencies of both tooth-marked and burnt bone may point to intense but intermittent occupational phases during this period. This would also correspond with low faunal densities. The variable trends in the middle and later SB (the M1 phase) also shows multiple occupational periods yet it can be argued that much of the data points to significant developments in the middle of the sequence in CC. Trampling modification and bone weight per volume is highest, fragments are smaller and transverse fractures are more common in that layer. The proportion of identified bone is also lowest in CC. All this point to the effects of intensive fragmentation in the middle period of the SB.

Equifinality is a persistent issue in the analysis of bone assemblages. Even when multiple proxies are used to examine a specific hypothesis, analysts must be cognisant of taphonomic, sedimentological and palaeoecological considerations. In the case of BBC, this study suggests that trampling modification can play a role in inferring occupational histories. Other taphonomic indicators may also inform on depositional periods. Still, other geoarchaeological analyses would benefit this research. Micro-sedimentological studies may show that bioturbation was indeed a factor in Layer CC and CF and could therefore confirm whether the middle (CC) and early SB (CF) are as significant as the faunal data indicate. Presently, the faunal data suggest that the taphonomic history of the SB at BBC varied between two key periods – the lowest layers of the SB (upper M2 phase) and the middle SB (the middle layers of the M1 phase) – which exhibit evidence of more intense/frequent occupations than other layers. In the next chapter I discuss how these data link palaeoecological evidence with variable occupational intensities at BBC and KDS.

CHAPTER 9: DISCUSSION AND CONCLUSION

This final chapter is divided into three sections: a discussion, a conclusion and future avenues of research. In the discussion section, I deliberate on the results of the previous chapters with a specific emphasis on issues not raised – or superficially discussed – in the papers. The conclusion then draws together the important outcomes of this research and compares it to the hypotheses presented in chapter 1. Finally, I suggest future avenues of research involving aspects of this thesis that warrant further study. After the references, the appendices contain data I was unable to present in my papers due to space limitations.

9.1 Discussion

9.1.1 *Mobility Patterns*

The results of the previous chapters show that mobility patterns, occupational intensity and prey selection may all be linked. This is especially true for KDS where occupations are concentrated in the middle layers of the site. This concentration makes it relatively easy to compare data and explore patterns of subsistence behaviour. Although the large numbers of cranial fragments in PBD is likely the result of extensive fragmentation (see Reynard *et al.* in press), it could also be argued that the prevalence of cranial specimens is at least partly a result of reduced transport distances (see Appendices 9.5.1). While this may seemingly contradict models of intensification and transport decisions by suggesting decreased foraging ranges and possibly less resource stress (Clark 2011), it leads to an interesting scenario regarding procurement patterns at KDS. PBD in the middle of the HP layers shows a significant increase in shellfish remains and high numbers of size 1 bovinds, tortoises and small mammals from PBE. It is feasible that, with increasing occupations at KDS (possibly as result of better access to shellfish), foraging initially focused on resources close to the site (e.g., shellfish, hyrax, tortoise and *Raphicerus*). Shellfish densities are also very high in PBD (181 kg/m³) and PBC (183 kg/m³) which suggest marine exploitation was an important subsistence strategy. In fact, these shellfish densities are more than the highest densities for Klasies River in MSA II (162 kg/m³) (Thackeray 1988) or for BBC (164 kg/m³) in the M3 phases (Henshilwood *et al.* 2001a). By the time of occupation of the PBC and PBA/PBB layers, population pressure may have resulted in an expansion of foraging ranges leading to the large numbers of grazers recovered from those layers. Decreasing tortoise size between

the M3 and M1 layers at BBC suggests that intensive exploitation was a factor in southern Cape ecology and points to increasing population pressure (Klein & Cruz-Urbe 2000; Henshilwood et al. 2001a.). There is a highly significant inverse relationship between the proportion of tortoise remains and bone abrasion in the SB at BBC ($r_s = -0.90$; $p = 0.037$) (Fig. 4.8). This could mean that as growing population pressure led to increasing foraging ranges, easy-to-catch tortoise may have been over-exploited. It may therefore demonstrate a connection between prey choice and expanded foraging ranges, although a similar pattern between trampling and tortoise abundance is not evident at KDS. Thompson and Henshilwood (2014b) argue that increasing tortoise exploitation at BBC was linked to marine regression during the SB. They argue that as sea levels rose and the focus shifted to shellfish exploitation, tortoise collection dropped and *vice versa*. Thus, the large tortoise component in our sample – particularly in CA – may imply a receding shoreline at that time.

Differences in raw material procurement strategies at BBC and KDS may also inform on mobility. Like other HP sites, KDS has a significant amount of quartz and silcrete, although quartzite – a coarse-grained material – is still the dominant material. Silcrete at KDS was sourced from outcrops in small rocky hills about 10 km from the site (Henshilwood *et al.* 2014: 289) while quartz most likely came from beach and river pebbles and rocky outcrops (S. Wurz, pers. comm.). At BBC, on the other hand, fine-grained lithics are prevalent. Silcrete, the most common material used to construct bifacial points, occurs about 30 km north of BBC (Henshilwood *et al.* 2001a; Henshilwood 2008; Villa *et al.* 2009: 443). As noted earlier, grazers at KDS are linked to a prevalence of quartz while at BBC, grazing ungulates are associated with silcrete. I have argued previously that grazers are linked to increasing foraging ranges and mobility (Reynard *et al.* in press). The sources of these fine-grained materials appear further away at BBC than at KDS perhaps supporting the idea of more extensive foraging ranges in the SB than HP or simply that raw materials were transported further at BBC. This, along with the divergent taphonomic data for BBC and KDS may affirm the argument for more settled residential patterns in the HP and long-distant mobility patterns for the SB in the southern Cape. Yet, defining mobility patterns in these terms should not undermine the importance of extensive social networks during both periods.

9.1.2 Ecology

The environment may have had a significant effect on mobility patterns and occupational intensity at both sites. One factor that must be taken into account is the different

geomorphology of BBC and KDS. BBC is significantly smaller and more difficult to access than KDS. This could translate to very different ways in which the caves were used by people, with the latter more conducive to larger-scale and more intensive occupations. However, we must also be aware that rock shelters, especially along the Southern Coastal Plain (SCP), change continuously through time. It is therefore possible that KDS may have been significantly harder to access than at present (Simon Armitage, pers. comm.). As mentioned in chapter 6 (Reynard *et al.* in press), changing proportions of ungulate taxa tracks an environmental shift from closed/mixed-habitats in the early HP to a more open grass-dominated environment in the middle/late period. An important outcome of this study is the documentation of changing environmental conditions during the HP at KDS using ungulate richness indices (Reynard *et al.* in press). Although grazers dominate both PBC and PBA/PBB, richness values shift substantially between these two layers (Table 5 & Fig. 7 in Reynard *et al.* in press). Three causes could explain this. Firstly, it could be the result of changing precipitation levels since there is a strong correlation between ungulate richness and precipitation (Faith 2013b). Differences in general taxonomic richness between the western Cape region (as represented by Diepkloof) and the southern Cape region (BBC and KDS) shows that precipitation may have some effect on the richness of faunal communities (Reynard *et al.* in press). Secondly, it could only reflect prey choices since the targeting of specific taxa may affectNTAXA and NISP values. The varying richness indices may therefore simply be a result of preferential foraging decisions and not imply any environmental change. This is unlikely because fluctuating diversity values in the middle layers (between PBC and PBA/PBB) seem to support other data that also suggest environmental change in these two layers at KDS (Roberts 2013). Thirdly, the changes in ungulate richness in PBC and PBA/PBB may be the result of changing landscapes brought about by an expanding/contracting SCP (Marean 2010). In all likelihood, fluctuating richness in those layers may be a combination of sea level shifts and a change in precipitation levels. Regardless of the reason, this signifies that occupational intensity at KDS is not necessarily associated with environmental stability. It may also mean that HP occupations were relatively continuous or intense despite changing environmental conditions and again points to more settled residential pattern at KDS.

Taxonomic frequencies at BBC generally show gradual changes from the early and the later SB. An over-riding impression as a result of the research in my thesis is that the most significant differences at BBC are between the bushier upper M2 (CF) in the early SB and the

more grass-dominated upper M1 phase (CC – CA) in the middle/late SB (Hillestad-Nel 2013) (Fig. 4.7 & Fig. 7 in Reynard & Henshilwood, in press). What this could signify is that fauna reacted to a contracting SCP. It has been noted earlier that sea levels probably retreated from the early to the late SB (Fisher *et al.* 2010). In the CFR, the habitat of the immediate coastal belt generally consists of typical bushy, *fynbos* vegetation with grassier *renosterveld* further inland (Bergh *et al.* 2014). As sea levels fluctuate, and dependent on the soil type of the SCP, this band of *fynbos* may track the coastline. The result could be that habitats surrounding near-coastal MSA sites may switch from bushy to grassy and *vice versa* (Faith & Behrensmeier 2013). This may be what is documented at BBC and possibly at KDS. In terms of ecology, the differences between the lower and upper layers may also relate to marine subsistence. Shellfish density is significantly higher in early SB (CF) than the middle or upper layers (M1 phase) (Henshilwood *et al.* 2001a). Taphonomic data also point to different foraging – and possibly mobility – strategies in the early SB. This could be related to the influence that shellfish had on subsistence strategies and may inform on seasonality (Jew *et al.* 2013). For example, *Haliotis midae* and *Scutellastra argenvillei* occur more frequently at BBC than predicted by OFT and their exploitation may be the result of seasonal visits to the site (Langejans *et al.* 2012).

9.1.3 *Trampling and occupational intensity*

Much contemporary research focuses on population pressure in the MSA (e.g., Stiner *et al.* 1999; Powell *et al.* 2009; Wadley 2015) and trampling may potentially be a significant proxy for demographic research. Ultimately the value of this proxy is based on how reliable trampling modification is as an indicator of bioturbation. The effects of bioturbation on bone are well documented (see Reynard 2014 and references therein) yet, the question remains as to how a site's occupational 'living-floor' is affected by specific human bioturbatory events. In other words, down to what depositional depth can we attribute trampled bone to the effects of human movement/pressure? Villa and Courtin (1986: 279) found that vertical displacement has a significant influence on artefacts and may cause mixing between layers. They noted that specimens generally moved 7 to 8 cm and more (10 to 16 cm) in sandy soil. I found this not to be the case. My own experience suggests that trampling modifies bone down to a depth of ~ 5 cm (*cf.* Reynard 2014). Beyond that depth, bone is compacted by the sediment and unaffected by bioturbation. The difference between my sample and Villa and Courtin (1986) is probably size: the trampled bones used in my experiments were larger than

the artefacts used by them and averaged ~ 5 cm in length (Reynard 2014). It also makes sense that trampling modification would only be effective in a relatively thin layer of deposit since human trampling usually involves accidental downward forces – and some sideways movement – over an occupational floor. Consciously or not, trampling experiments often involve exaggerated foot actions where bone is pushed into the substrate with more force than is likely to occur in reality. Thus, trampled bone almost certainly reflects bioturbatory events through thin layers of deposits. As such it is probably a reliable proxy for occupational phases and the data presented in chapter 8 is therefore useful.

Another issue is the relationship between trampling modification, taphonomic indicators and occupational intensity. At KDS there is generally a close relationship between macrofaunal volumetric density, abrasion and other taphonomic indicators. Transverse fracture are significantly more common at KDS than at BBC ($\chi^2 = 50.160$; $p < 0.0001$) which suggest the effects of sediment compaction resulting from occupational activity. Abrasion marks at KDS are also significantly associated with bone density per volume (Appendices 9.5.1) which implies the following: 1) it confirms other data that indicate a concentration of occupational phases in the middle HP layers at KDS (Table 6 in Reynard *et al.* in press), and: 2) it suggests that abrasion modification may be a proxy for trampling. Indeed, abrasion and trampling modification were the only two datasets that were significantly correlated in the BBC data presented in chapter 7. At BBC, trampling data suggest a bimodal occupational pattern with more frequent/intense occupational periods in the early (Layer CF) and middle SB (CC), and lower occupational intensity in the middle (CD) and possibly the uppermost layer (CA) (Fig. 8.1, 8.3E & 8.7). This is supported by some taphonomic indicators (Table 3, Fig. 3 & Fig. 4 in Reynard & Henshilwood, in press) and juvenile data (Fig. 4.9) which show limited occupations in the middle of the sequence in CD. However, as most of the data do not correlate or display any significant relationships, it may indicate a complex taphonomic history.

Animals had a significant influence on bone modification in the early SB in layer CF which initially seems to contradict evidence of more frequent/more intensive occupations in that period. However, these different taphonomic signatures may not necessarily contradict each other. The high proportion of trampled bone in this layer possibly signifies *frequent* rather than *intense* occupational periods. Frequent occupations could entail a group of people repeatedly visit a locale. Intense occupations would imply a group's continuous occupation of a locale. In terms of trampled bone, the results of these two occupational patterns may be

similar. Thus, while trampled bone at BBC may inform on residential mobility, discriminating specific occupational patterns may be challenging. At KDS, the focus of significant trends in the middle layers and the lack of animal-affected bone contrasts with the both animal and human-affected bone at BBC. The ephemeral presence of more mobile human groups at BBC would encourage carnivore scavenging at the site, while the more long-term settlement patterns at KDS would probably discourage animal scavengers. On the whole, these corresponding patterns for occupations at KDS and the diverse datasets from BBC also support an argument for more stable, settled residential site use at KDS and highly mobile, more irregular settlement patterns at BBC.

9.1.4 *Implications for subsistence behaviour*

BBC and KDS show different subsistence patterns. The SB at BBC was a ‘human first’ faunal assemblage where humans were the primary collectors of the remains, followed by animal scavenging (Blumenschine 1988). Despite this, the SB was more intensely occupied than the earlier pre-SB phases at BBC dated to 80 ka (Henshilwood *et al.* 2001a; Thompson & Henshilwood 2011). Trampling data suggest that Layer CF in the early SB was a relatively ‘high’ occupation period. The large proportion of animal modified bone in this layer, however, implies that occupations were probably not intense. It could mean that the early SB was less intensely but more frequently occupied than the middle/later period and points to an interesting relationship between occupations and marine regressions at BBC. The early SB (layer CF) probably coincided with a close shoreline and BBC may have been less intensely occupied when the sea was closer. This is not unheard of – Pinnacle Point was probably also less intensely occupied when the shoreline was closer during MIS 5 (Karkanas *et al.* 2015). Juvenile ungulates are also more common at BBC than at KDS and other research argues that the significant number of juvenile bovids and seal at BBC may be due to seasonality (e.g., Faith & Thompson 2013; Dusseldorp & Langejans 2015). Thus, high occupational pulses in the early SB in CF may indicate frequent shell fishing expeditions or seasonal occupations driven by bovid lambing that may have involved short-term camps rather than longer-term home-bases. In the middle SB, occupations oscillate between low and high frequencies in CD and CC, respectively. Other data (Fisher *et al.* 2010; Hillestad-Nel 2013) also suggests that marine regressions from the early (CF) to the later SB (CA) coincided with a changing environment. What this implies is that environmental conditions were not necessarily linked to the intensity of occupational phases during the SB at BBC, although Thompson and

Henshilwood (2014b) suggest that site abandonment at the end of the SB may be associated with marine regression and the resultant over-exploitation of key local resources such as tortoise. In fact, they argue that increasing evidence for symbolically-mediated ornamentation and SB hunting-tools may be connected to resource stress linked in part to environmental change.

At KDS, the data show that the HP was an intensely occupied period with very little carnivore involvement. Unlike at BBC, taxonomic, taphonomic, shellfish and trampling data all point to a specific phase – the middle layers – as high occupation periods. These, in turn, link with lithic and environmental data that indicate significant changes in subsistence behaviour during that time. Although deposits in MSA sites are seldom continuous, my data imply that occupations in the middle HP at KDS were both frequent and intense. Despite the link between grassier habitats and high occupations in the middle layers at KDS, ungulate richness and other data (Roberts 2013) suggest that within these open, grass-dominated vegetative habitats, environmental change is evident. More than likely, these fluctuating indices reflect a combination of shifting precipitation values and periods of marine regressions. Occupations were probably more intense when the shoreline was close. On the whole, diet breadth is greater at KDS than at BBC. Taxonomic richness is more extensive at HP than SB sites which support research that found dietary breadth in southern Africa may have peaked during MIS 4 (e.g., Clark 2011; Clark & Kandel 2013).

9.2 Conclusion

I summarise the conclusions of the various papers and chapters in this section based on the hypotheses I presented in chapter 1. I conclude by indicating why I believe this thesis contributes to current understanding of subsistence behaviour during the Late Pleistocene in the southern Cape.

9.2.1 Hypothesis 1: Subsistence intensification is more evident in the Howiesons Poort than in the Still Bay

Four factors were investigated at BBC and KDS to examine intensive subsistence strategies: 1) Increases in diet breadth through the exploitation of small game (hyrax, Cape dune moleerat and hare); 2) Increases in the exploitation of ‘low-ranked’ elements such as marrow extraction in calcanei, phalanges and mandibles; 3) Increases in foraging and transport

distances based on the proportions of skulls versus long-bones or crania versus mandibles, and; 4) A prevalence of juvenile remains since these are also considered ‘low-ranked’ game.

Generally, I found more evidence of intensive subsistence during the HP at KDS than the SB at BBC. Processing activities such as skinning, disarticulation and marrow extraction is more evident at KDS than BBC although filleting is prevalent at BBC. Percussion marks occur more frequently at KDS than at BBC. This can be linked to taphonomic and utility data suggesting that marrow was an important commodity and marrow-extraction was likely a significant subsistence strategy. At KDS, more low-ranked elements and small fauna display evidence of processing. On the whole, anthropogenic modification is more prevalent at KDS than BBC. Diet breadth is also more extensive at KDS. Taxonomic and ungulate richness is higher at KDS than other HP or SB sites assessed. In fact, all the HP sites investigated display higher richness values than BBC or Diepkloof – the only two SB sites with available data (Reynard *et al.* 2016). In addition to very high richness values, shellfish density is also higher at KDS than at BBC and there is evidence of carnivore exploitation during the HP. There is no direct evidence for the utilisation of remote capture techniques at KDS, although circumstantial evidence implies that it was a possibility. For example, carnivore remains from KDS are from relatively dangerous animals such as caracal/serval and hyena. Although it is possible they were scavenged (perhaps because they utilised the shelter when humans were absent), it is also likely they were caught with snares or traps.

Other data are not associated with subsistence intensification at KDS. Due to extensive fragmentation at KDS, foraging ranges could not be confidently assessed. However, the proportion of skulls versus post-cranials for size 2 mammals suggests that foraging ranges may have fluctuated through the HP and was relatively close during PBD. Juvenile bovids are also more common at BBC but this may relate to seasonality (*cf.* Langejans *et al.* 2012; Faith & Thompson 2013; Dussledorp & Langejans 2015). On the whole, the data from KDS and BBC – and from other sites – show that intensification was more common during the HP than the SB.

9.2.2 Hypothesis 2: Foraging strategies are linked to environmental change in MIS 5a/4

Data in this thesis indicate that the environment surrounding BBC and KDS changed during the SB and HP periods, respectively. At KDS, the evidence is more substantial. Changes in faunal communities in the HP layers suggest shifts from a more closed/mixed habitat in the lowest c. 65 ka HP level (PCA) to open, grass-dominated environments in the middle layers

(PBC and PBA/PBB) and finally to sandy, possibly drier terrain in the upper c. 59 ka HP in PAY. Besides vegetative change, marine regression would also have affected the palaeoenvironment of the southern Cape. Shellfish densities are extremely high in the middle layers (PBD – PBA/PBB) and low in the upper layers. This implies that shorelines may have been closer during the middle period and farther away in the later HP (Reynard *et al.* 2016). However, it is also possible that changing sedimentation rates may have affected shellfish densities, especially in the later HP layers. Changes in grazer/browser proportions at KDS that document shifts in environments are also linked to variations in size 2 skull/long-bone proportions, small game abundance and lithic data. This suggests that large-scale foraging strategies and mobility patterns are probably associated with environmental conditions.

At BBC, the faunal sample is too small to link environments to changes in subsistence behaviour but other studies (Henshilwood *et al.* 2001a; Hillestad-Nel 2013) point to a shift in vegetative ecosystems from bushy habitats in the early c. 76 ka SB (Layer CF) to grassy environments in the later c. 72 ka SB (CC – CA). My data from BBC support this change and document a shift from smaller animals such as size 1 bovids and small mammals in CF to larger bovids in CA. As with KDS, independent data (Fisher *et al.* 2010) indicate marine regressions from the early to later SB are concordant with increases in animal size classes. These shifts in human prey selection patterns, however, may be more consistent with how faunal communities respond to changes in the vegetative biome than independent human behaviour. However, utility data (although problematic due to small sample sizes), change in size 2 and large mammal skeletal-part representations, and raw material proportions suggest that subsistence behaviour at BBC is essentially linked to changing environments.

Subsistence strategies can be defined as more than just prey selection patterns and would also include snaring/trapping, shellfishing and transport decisions. It may therefore be difficult to discern whether foraging decisions were based on access to prey or more subtle technological capabilities or socio-cultural choices. In this thesis, the available evidence supports the hypothesis that foraging decisions are linked to environmental changes in MIS 5a/4. Insofar as environmental conditions determine faunal communities, this association is probably based on humans' access to prey. At KDS, the data also suggest that foraging mobility may have been influenced by changes in the environment. Due to smaller sample sizes, the evidence is less conclusive at BBC. At both sites, marine regression may have had a significant effect on subsistence strategies.

9.2.3 Hypothesis 3: *Trampling can be used to infer occupation phases*

An important contribution of this thesis is the use of trampling marks and other taphonomic indicators to infer occupational intensity. Various marks including abrasion, pitting, scratches and lines/grooves (called ‘trampling marks’ in the literature) were observed on a collection of experimental trampled bone. These marks were also noted on archaeological bone in the BBC collection. Because the KDS assemblage was analysed after the trampling experiments, only abrasion and lines/grooves were documented in that collection. The close correlation between abrasion and trampling marks at BBC shows that abrasion is a useful proxy for trampling. Abrasion is also significantly related to other indicators of occupational intensity at KDS which implies that both abrasion and trampling marks can be used to infer occupational pulses. However, data from the early SB at BBC also suggest that it could be difficult to discern frequent from intense occupational phases. My data thus support the hypothesis that trampling modification can be used as a proxy for exploring occupational phases.

9.2.4 Hypothesis 4: *Occupational intensity is more apparent in the HP than in the SB in the southern Cape*

There is overwhelming evidence that this is the case, at least for these sites. Taphonomic and taxonomic data suggest that occupational intensity is more evident at KDS than BBC. For example, the prevalence of percussion marked bone at KDS – compared to BBC – is indicative of intensive processing. Transverse fractures are significantly more prevalent at KDS than BBC and this is probably because sediment compaction and trampling had a greater influence at KDS than at BBC. Bone density-mediated attrition also affected the KDS assemblage more significantly than BBC bone. In fact, fragment size is smaller at KDS than BBC even though the proportion of moderately and severely burnt bone is approximately the same. Very likely, the combination of human processing and trampling resulted in the extensively fragmented KDS assemblage. Tooth and gnaw marks, and other indicators of animal activity are also rare at KDS which indicates a more sustained human presence at KDS. In contrast, the significant number of animal affected bone at BBC implies that occupations there were less intense and more discontinuous. There is also a greater diet breadth at KDS than at BBC. Taxonomic richness is more at HP than SB sites and is particularly high at KDS. Shellfish density is also higher at KDS than other southern Cape sites. This shows that human subsistence activities were intensive at KDS and other HP sites and suggest that subsistence intensification relates to high occupational phases.

Probably the most convincing evidence for occupational intensity during the HP is the contrasting relationships between the KDS and BBC data. At KDS, there is a significant correlation of datasets. Macrofauna volumetric densities, shellfish densities, abrasion modification and grazer abundance are all significantly concentrated in the middle layers – PBD, PBC and PBA/PBB – of the site. What this signifies is a more sedentary residential pattern at KDS during this period of the HP. The lower and upper periods of the HP display less evidence of human activities. While this may be the result of sedimentation and depositional taphonomy, it is more likely that this reflects less intensely occupied periods. At BBC, on the other hand, taphonomic, trampling and faunal/shellfish densities do not indicate significant trends in relation to occupation density which suggests a more disparate occupational history for that site.

9.2.5 *Significance of this thesis*

This thesis has contributed to the understanding of subsistence behaviour in the southern Cape in the following ways:

1. SB and HP faunal assemblages have not previously been compared to this extent using empirical primary data. I have applied statistical methods to assess and compare the BBC and KDS assemblages and found significant differences between the fauna.
2. The analyses of taphonomic and trampling data suggest that residential patterns may have been different between the SB of BBC and the HP of KDS.
3. Subsistence intensification is more apparent during the HP than the SB. This is the first study to show empirical evidence for relatively greater subsistence intensification in the HP than the SB in the faunal record.
4. I have also demonstrated significant links between environmental conditions, subsistence strategies, occupational intensity and lithic patterns during the HP.

9.3 Future Avenues of Research

9.3.1 *Blombos Cave*

BBC has been extensively studied, yet much of the previous research has focused on the SB as a whole. More research is needed to examine temporal relationships within the SB by exploring individual layers (*cf.* Discamps & Henshilwood 2015). The questions that have arisen in this thesis refer specifically to changing environmental conditions and occupational

pulses during the SB. Given the small sample size of identified taxa from the SB layers at BBC, it is imperative that larger samples of fauna are analysed to investigate the links between environment and foraging strategies during the SB in the southern Cape. The relationship between the SB and pre-SB layers also needs to be investigated more thoroughly. Ideally, this analysis would involve a layer-by-layer assessment and not the larger-scale phase-by-phase analyses that have defined previous studies. This too would require larger fauna samples.

Given that trampled bone is a good reflection of occupational pulses and that there are a large number of faunal specimens that exhibit trampling modification, it is reasonable to refine the investigation of occupational intensity in the SB at BBC by exploring each individual layer in the M1 and upper M2 phases (e.g., CCC or CDB) and not only the combined layers (e.g., CC or CF). This would be key to an understanding of diachronic changes in subsistence and mobility patterns during the SB. Micro-sedimentological analyses would also refine and confirm occupational patterns.

9.3.2 *Klipdrift Shelter*

Because KDS is a newly-excavated site, it holds much potential for further research. Larger samples from the HP layers are needed to fully explore the patterns that have emerged in this thesis. It is also necessary to analyse the pre- and post-HP layers at KDS to understand environmental conditions and human behaviour before and after this period. Trampling modification suggests that lowest layers (PCD – PCB) may have been ‘high’ occupational periods (see Figure S3 in Appendices 8.5.1). Very few lithic artefacts have been recovered from these layers. The question then is what the relationship is between these layers and the HP. Does this period belong to a pre-HP techno-complex or is it an early version of the HP? PBE has yielded no artefacts and is considered ‘sterile’ (Henshilwood *et al.* 2014). Does PBE signify the earliest occupational period at KDS or is it simply a hiatus? It is therefore important to investigate these early layers since they may inform on any possible relationship between the emergence or continuation of settlements at KDS and the termination of occupations at BBC. The layers above the uppermost HP layer PAY (PAU – PAX) show significant environmental changes from the HP to post-HP periods and this could be particularly important in understanding the effects of glacial/interglacial shifts in the southern Cape. To fully explore environmental changes, however, micromammal, charcoal and pollen proxies are needed. Micromorphological analyses are also necessary to effectively investigate

the high occupational intensities during the middle HP (PBD, PBC and PBA/PBB). In particular this may help in understanding residential patterns at KDS. Is there evidence of cleaning activities? Are there spatial patterns to trampling or is it consistent across all squares?

Another aspect raised by this thesis is bone tool technology at KDS. A preliminary analysis of the modified bone at KDS suggests that a large proportion of the assemblage may have been used as tools. However, exploring bone tool use at KDS may not be an unambiguous endeavour. The extensive fragmentation means that any bone tools that may have occurred would more than likely be fragmented and difficult to identify. Moreover, many of these bone fragments exhibit edge-wear that may or may not be retouching. This is where experimental research becomes crucial. I have already conducted experiments to investigate the role that trampling plays in producing polish-wear which would benefit the analysis of the KDS modified bone assemblage. Future studies would also involve experimental research on whether trampling may produce bone edge-wear similar to retouching.

9.3.3 *Middle Stone Age research at other sites*

Most of the hypotheses in this thesis focus on comparing the HP with the SB in the southern Cape. The fact is that, while I was able to use data from other HP sites in addition to KDS, virtually no other data from SB besides BBC were available to me. Data from Diepkloof are limited because detailed zooarchaeological and taphonomic analyses have, as yet, not been conducted. It was thus not possible to assess fragmentation patterns, processing behaviour, intensive or other subsistence strategies at Diepkloof and compare it with BBC or KDS. The only viable analysis involved diet breadth and taxonomic richness. It is necessary, therefore, that the few other SB sites with well-provenanced fauna (i.e., Diepkloof, Sibudu, Apollo 11) be taphonomically examined and the data published. Newly excavated sites such as those discovered in the Knersvlakte region of southern Namaqualand in the Western Cape (see Mackay *et al.* 2010 and Steele *et al.* 2012) may reveal a better understanding of how human adapted to other regions. New excavations and data from Klasies River may also reveal important information on subsistence strategies especially on the relationship between the HP and pre-HP periods. Another issue to be investigated is comparison between MSA II and SB faunal assemblages and here is where Klasies River would be an important reference site.

Statistical methods may also refine our understanding of subsistence patterns and ecology. In this thesis I suggest that residential patterns may be different between SB and HP sites. This

also needs to be explored and other SB and HP sites are critical to this. My research shows that utility indices may be a constructive means of extrapolating transport decisions and mobility strategies from faunal assemblages. This, however, requires relatively large and unfragmented faunal collections. Limited research has also been conducted on the influence of the exposed Agulhas Bank on precipitation levels in the southern Cape and ungulate richness indices could be used to compare precipitation levels during glacial and interglacial periods. Ideally, the important MSA sites along the southern Cape coast should be investigated (e.g., Die Kelders, KDS, BBC, Pinnacle Point and Klasies River) using similar methods and large faunal, charcoal, pollen and micro-sedimentological samples. It may not be practical but it could help us understand changing environmental conditions during the Late Pleistocene in the southern Cape.

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9.5 Appendices

9.5.1 Klipdrift supplementary results

Skeletal-parts profiles (Chapter 3)

Skeletal-element profiles can be used to explore transport decisions or distances from kill-sites which may, in turn, inform on the ecology of prey-procurement ranges (Faith 2007; Faith & Gordon 2007; Clark 2011). Reynard *et al.* (2015) demonstrates that the distribution of skeletal-parts at KDS is affected by both fragmentation and density-mediated attrition. This makes the analysis of utility indices based on the frequency of skeletal-parts per layer problematic at KDS (Marean & Frey 1998) and we have abstained from deliberating further on this aspect of the analysis in the published paper due to space constraints. Here, however, we address these issues.

The only possibly significant variation may be in the proportions of crania to long-bone. We note that there is a significant difference in the proportion of skulls and long-bone elements of large mammals between PBD and PBC ($\chi^2 = 4.42$; $p = 0.036$) (Table S1). This pattern is also evident when unidentified long-bone are included in the analysis. If we expand this analysis even further to include crania and identified long-bone of size 2 and medium mammals; PBD still has a significantly higher proportion of skull remains than either PBC ($\chi^2 = 8.20$; $p = 0.0042$) or PCA ($\chi^2 = 9.48$; $p = 0.0021$).

Table S1. Skull versus long-bone fragments for large mammal[#] per layer (PBE excluded because of small sample sizes)

	PAY/PAZ	PBA/PBB	PBC	PBD	PCA
Crania (NISP)	4	11	8	12	2
Identified long-bone elements (NISP)	7	17	28	13	7
% Skulls vs identified long-bone	57.1	64.7	28.6	92.3	28.6
Average length code for skull fragments	4.0	5.0	4.4	5.0	3.5
Total number of long-bone fragments*	31	113	59	28	34
Crania (nNISP)**	2	5.5	4	6	1
Identified and unidentified long bone (nNISP)**	2.6	9.4	4.9	2.3	2.8
Proportion of normed crania to long bone	0.8	0.6	0.8	2.6	2.8
% Skulls vs identified long-bone (medium mammals) [@]	23.6	31.2	35.3	75.0	16.4

Includes equid, 'large mammal' and Bovids \geq size 3, only 'high-survival' elements used in the analysis.

*Includes unidentified long-bone with cortical thickness \geq 5 mm. 80% of identified ungulate \geq size 3 have cortical thicknesses \geq 5 mm. **Adjusted frequency for the amount of times that element occurs in an individual. Cranial fragments divided by 2 since cranial parts are paired as left and right elements (cf. Clark 2013: 284) and long-bone fragments are divided by 12. Expected proportion of crania to long-bone fragments in a complete skeleton is therefore at least 1:6 or \leq 0.2. @ Includes bovids \geq size 2, 'medium mammal', equids and 'large mammal'

Taphonomy and subsistence patterns

Transverse fractures are common on long-bone in PBD (Fig. 6a & Table 5 in Reynard *et al.* 2015). It has been proposed Chapter 3 that this indicates a greater influence of post-depositional processes and more intense human occupations in PBD and the layers above it. The low proportion of long-bone specimens (both identified and unidentified) to cranial remains for ungulates in this layer, however, raises some questions. Two main factors could explain this pattern: a decrease in transport distances or an increase in fragmentation. As explained earlier, the proportion of skulls to post-crania in an assemblage is sometimes used to infer distances to kill-sites where proportionally fewer cranial remains signify greater distances between home-base and kill-sites (Speth & Clark 2006; Clark 2011). Yet fragmentation can also affect skull/long-bone proportions. Crania and long-bone fragments are both high survival elements with similar bone densities (Behrensmeier 1975; Binford & Bertram 1977). The general shape and robustness of these elements makes it likely that, with increased post-depositional damage, cranial bones will fracture into more fragments than long bones. More intense fragmentation might thus explain this skeletal pattern. Other evidence in PBD (increased transverse fractures, generally smaller fragments) further supports the hypothesis of an increase in post-depositional damage in that layer (Reynard *et al.*, in press).

However, fragmentation may not be the only source of taphonomic variability in that layer and other factors may be at play. Cranial fragments are not smaller in PBD (Table S1) and percussion marks are significantly lower in this layer for ungulate and small mammal long-bone (Fig. S1). Furthermore, identifiable teeth of large bovids are more common in PBD than in other layers which imply that crania may indeed have been more prevalent there. If the prevalence of crania to long-bone in PBD is a result of transport decisions, this may show the influence that access to shellfish may have had on subsistence behaviour during this time. A focus on shellfish resources during PBD may have diverted subsistence exploitation from more mobile game such as large-bodied, grazing ungulates to more sedentary resources

closer to home-base such as tortoises and small mammals (*cf.* Jerardino 2010). This could explain the low numbers of percussion marks in this layer. It must be emphasised, that because of small sample sizes, more data from KDS would be necessary to explore transport and subsistence decisions and, from the available evidence, taphonomic changes in PBD is more likely the result of fragmentation.

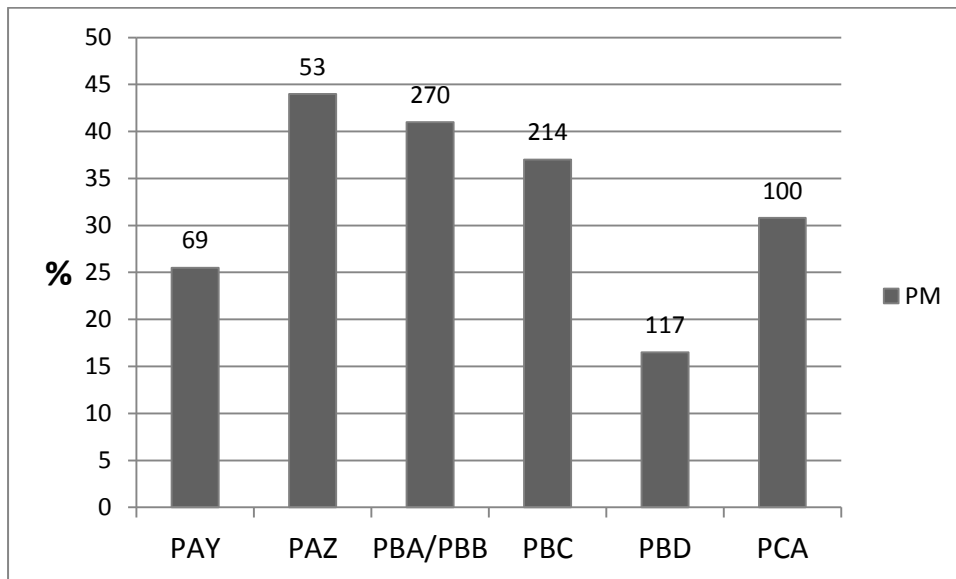


Figure S1: Proportions of percussion-marks on identified specimens and long-bone fragments per layer. PM = percussion marks. Number of percussion-marked specimens above columns

Abrasion at Klipdrift Shelter (Chapter 8)

Abrasion data from KDS imply changes in occupational phases during the HP. The data I use here for KDS differs slightly from that presented in chapter 3 because the data here includes a sample of unidentified specimens > 2cm in length. According to both datasets, the frequency of abraded specimens peak in PBA/PBB and in the lower layers (PCB and PDA-PDC) (*cf.* Reynard *et al.* 2015) (Fig. S2). Small sample sizes in the lower layers at KDS make interpretation of any of the taxonomic and taphonomic data challenging, hence we restricted our analysis to the HP layers in chapter 3 (Reynard *et al.* 2015). Abrasion is significantly correlated to bone volumetric density (g/m^3) ($r_s = 0.786$; $p = 0.036$) which suggests that this trampling indicator effectively tracks occupational intensity. Abrasion marks imply that

occupations at KDS intensified not only in the mid-HP but possibly in the pre-HP periods there.

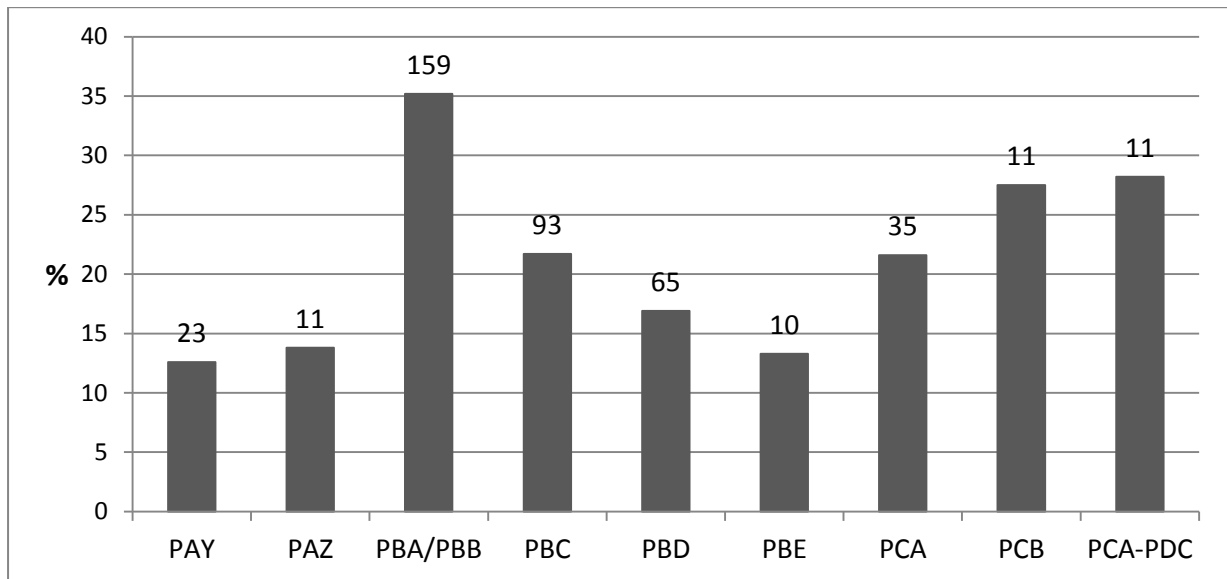


Figure S2: Abrasion at Klipdrift Shelter. Values above columns equal the number of abraded specimens