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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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### 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 'megamidens' 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 Shuurman, 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 (Metcalf 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)), pelves 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 m<sup>2</sup> 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

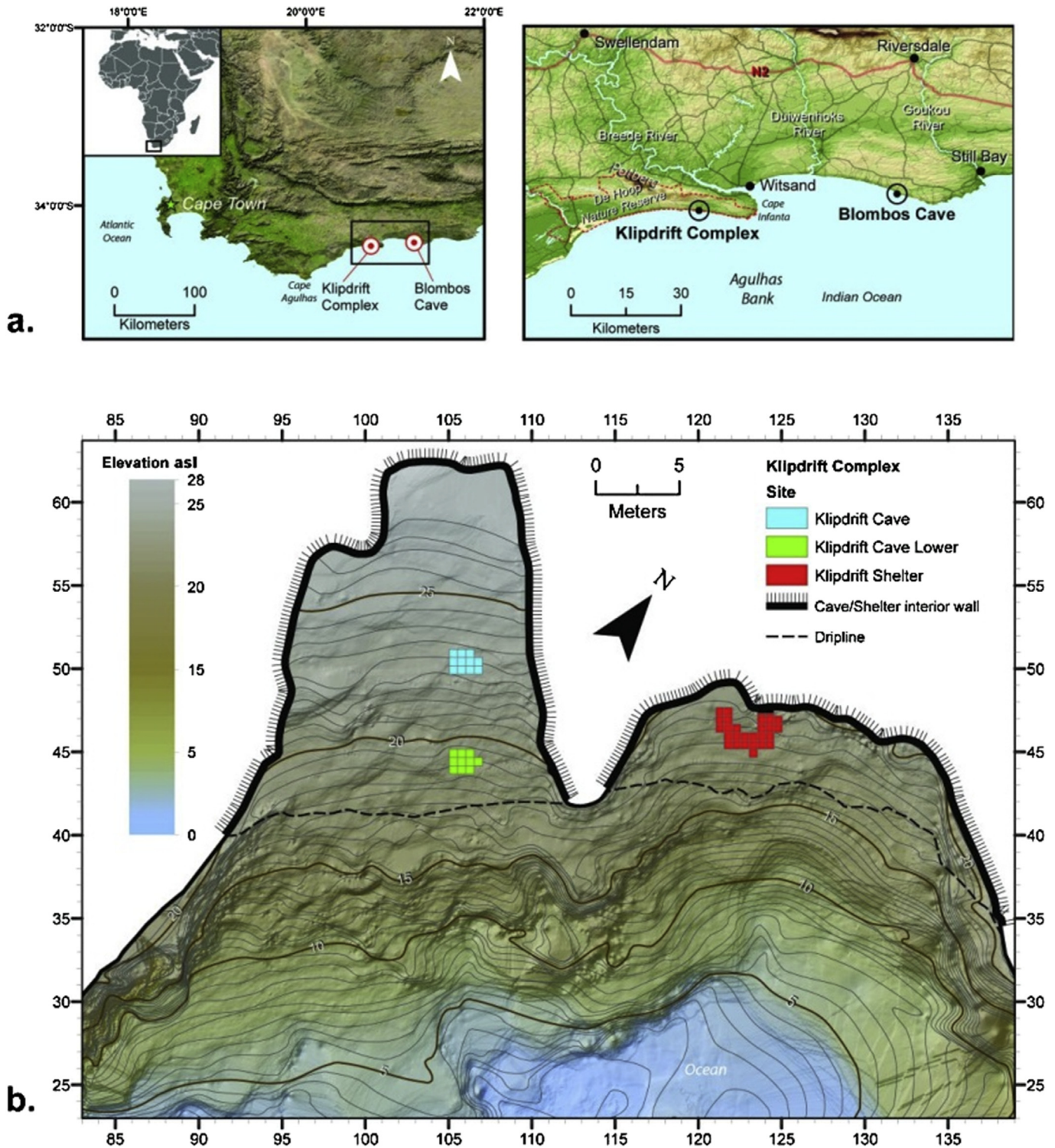


Fig. 1. a) Location of Klipdrift Complex and Blombos Cave in the southern Cape; b) topography of Klipdrift Cave and Klipdrift Shelter.

were dated to between c.  $71.6 \pm 5.1$  ka (PE) and  $51.7 \pm 3.3$  ka (PAN/PAO) and the HP layers (PCA – PAY) were dated to between c.  $65.5 \pm 4.8$  ka and  $59.4 \pm 4.6$  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

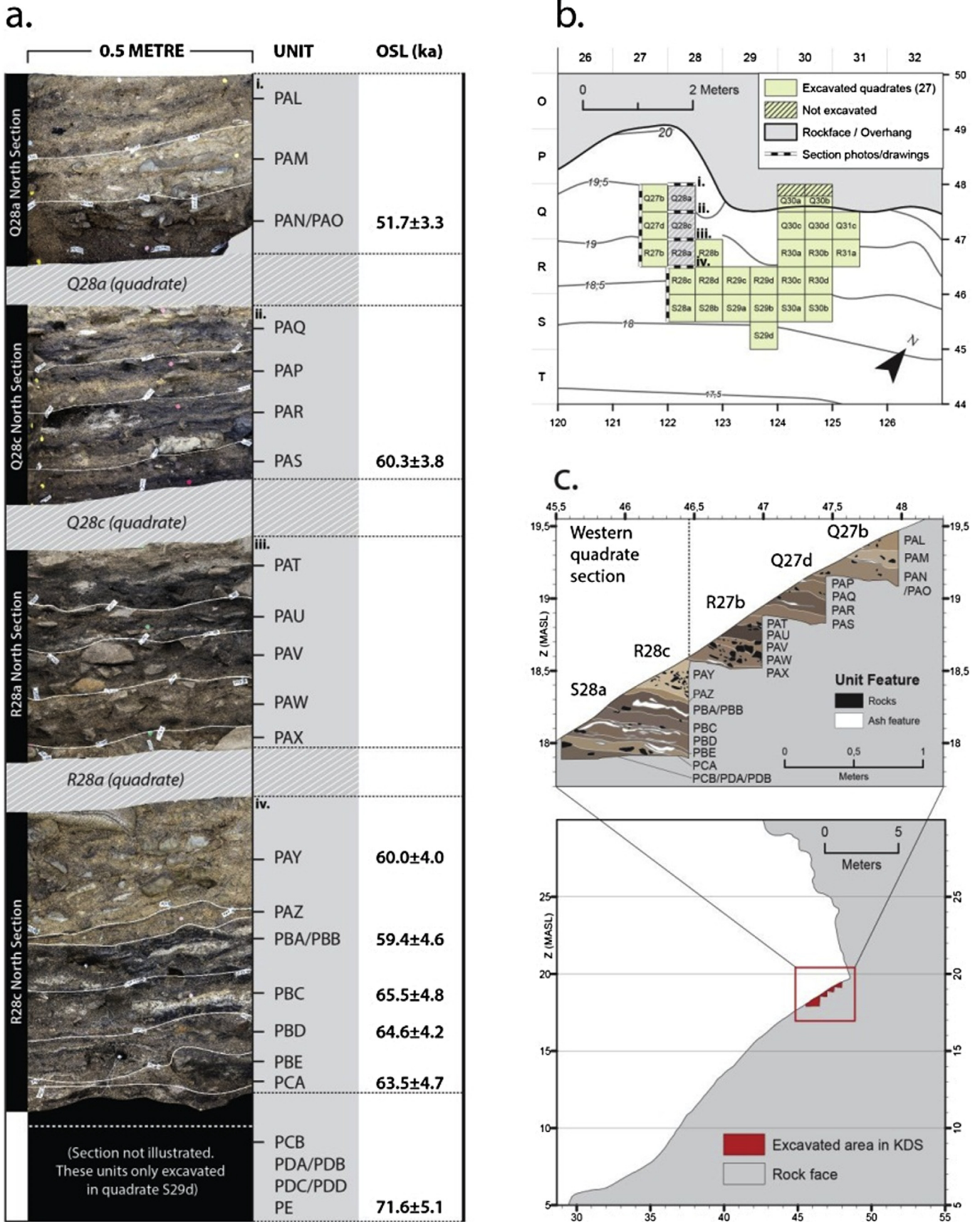


Fig. 2. a) Stratigraphy of Klipdrift Shelter with optimal stimulated luminescence dates; b) excavated quadrates; c) excavated layers in section showing the slope of deposits.

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 mole rat (*Bathyergus 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)	Bovid size class <sup>a</sup>	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 <sup>b</sup>	Medium/Large mammal
296–900	4		Large mammal
>900	5		Very large mammal

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

<sup>b</sup> 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
<b>Total specimens per layer</b>	<b>37</b>		<b>271</b>		<b>121</b>		<b>658</b>		<b>579</b>	

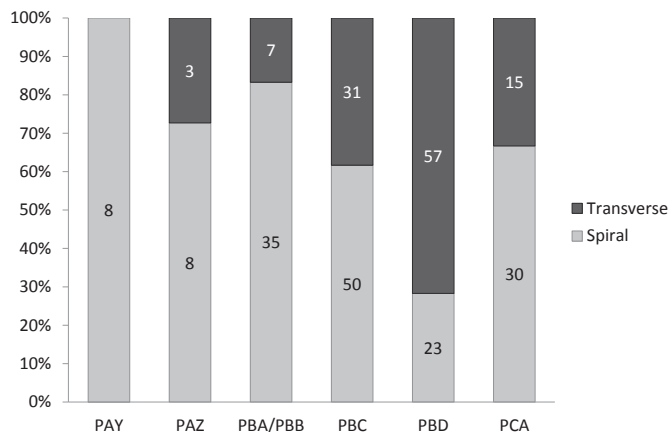
Modification	PBD		PBE		PCA		PCB		PDA-PDC		Total	
	n	%*	n	%*	n	%*	n	%*	n	%*	n	**
Burn (L)	129	18.2	23	11.6	86	26.5	14	22.2	6	8.8	588	19.4
Burn (Br)	361	50.9	143	71.9	172	52.9	33	52.4	46	67.7	1397	46.1
Burn (Bl)	92	13	6	3	36	11.1	7	11.1	5	7.4	392	12.9
Burn (Gr)	61	8.6	3	1.5	22	6.8	0	0	2	2.9	124	4.1
Burn (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
<b>Total specimens per layer</b>	<b>709</b>		<b>199</b>		<b>325</b>		<b>63</b>		<b>68</b>		<b>3030</b>	

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-

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).



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

**Table 3**Number 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
Lagomorpha	cf. Pelomedusidae	Turtle	0	0	0	0	0	1	0	0	0	0	0	1
	<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>Bathyergus 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
Hyracoidea	<i>Parahyeana brunnea</i>	Brown hyena	0	0	0	1	0	0	0	0	0	0	0	1
	<i>Procapra 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	0	1	4	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	0	1	0	2	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	5
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		<b>19</b>	<b>192</b>	<b>81</b>	<b>400</b>	<b>429</b>	<b>646</b>	<b>180</b>	<b>230</b>	<b>10</b>	<b>36</b>	<b>43</b>	<b>2266</b>
Total ULBF <sup>a</sup>		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	

<sup>a</sup> Unidentified long-bone fragments.

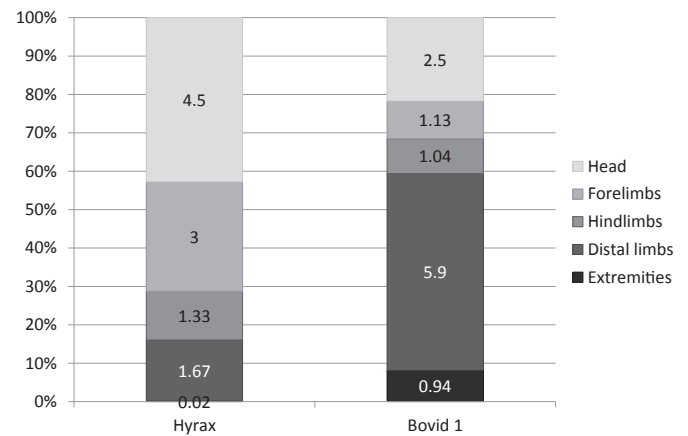
**Table 4**  
Mammal modification patterns per layer.

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	0	

B = burning; PM = percussion mark; CM = cut mark; AE = acid etching. T & GM = tooth and gnaw marks. Small mammal is Cape dune moleerat, 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-Uribe and Klein, 1998; Klein and Cruz-Uribe, 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  $\Sigma nNISP$  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.

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

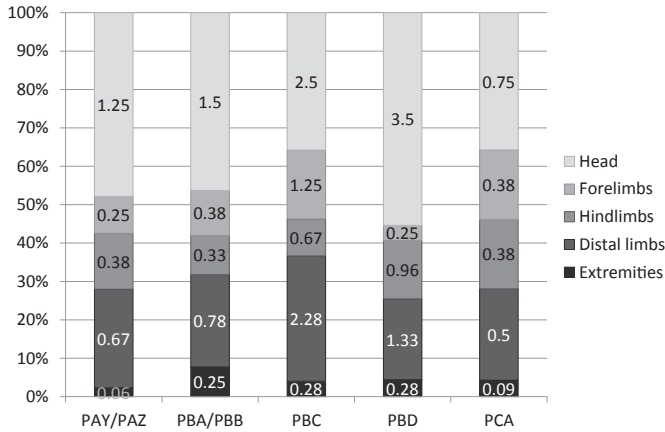
Skeletal-part	Modification	PAY N = 59	PAZ N = 23	PBA/PBB N = 72	PBC N = 51	PBD N = 252	PBE N = 105	PCA N = 28
Shell	B	48	18	56	50	251	105	28
	PM	17	9	23	9	7	1	1
	CM	2	0	1	0	1	0	0
	AE	4	6	3	0	0	0	0
		N = 10	N = 4	N = 8	N = 11	N = 21	N = 8	N = 3
Bone	B	6	4	8	9	21	7	3
	PM	0	1	0	1	0	1	0
	CM	0	1	0	0	2	1	0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

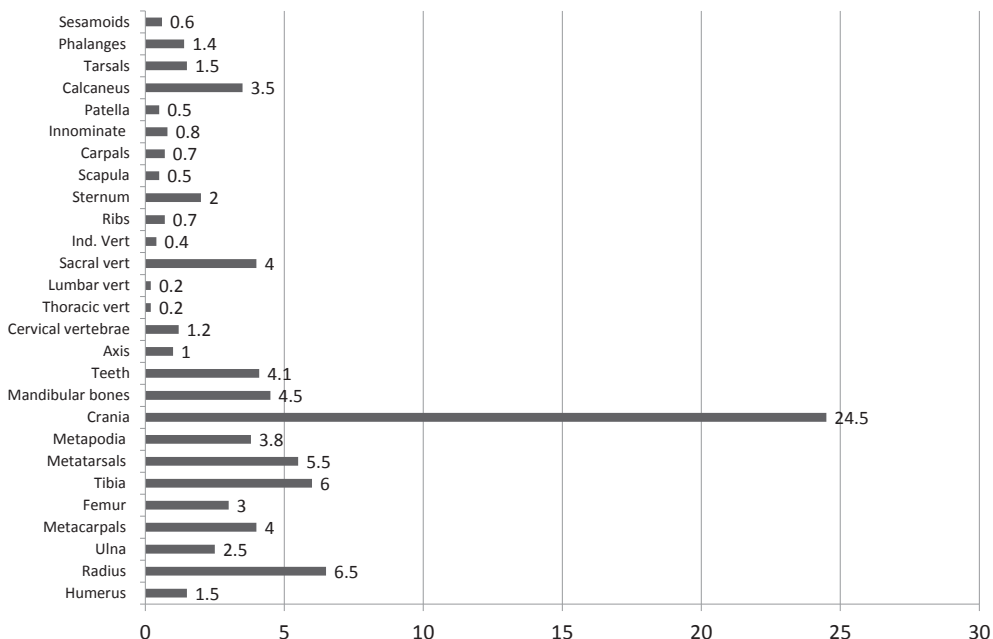
mentary Fig. S1a). Skeletal-part distribution is also significantly different between hyrax and size 1 bovids ( $\chi^2 = 61.115$ ;  $p < 0.0001$ ) (Fig. 4).

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

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

<sup>a</sup> Data from high survival elements of all ungulates per layer.

<sup>b</sup> Size 2 bovids and indeterminate 'medium mammal' remains.

<sup>c</sup> 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 <sup>a</sup> 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 <sup>b</sup> 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.

<sup>a</sup> Percentage of identified specimens <1 cm in length.

<sup>b</sup> 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

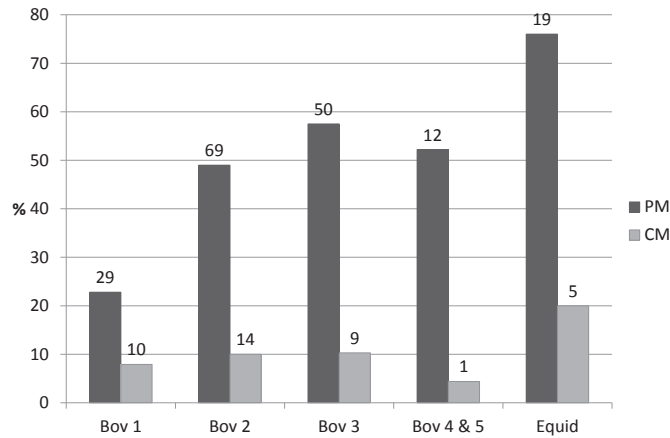


Fig. 7. Butchery mark frequencies per ungulate size class. PM = percussion marks; CM = cut marks, NISP above columns.

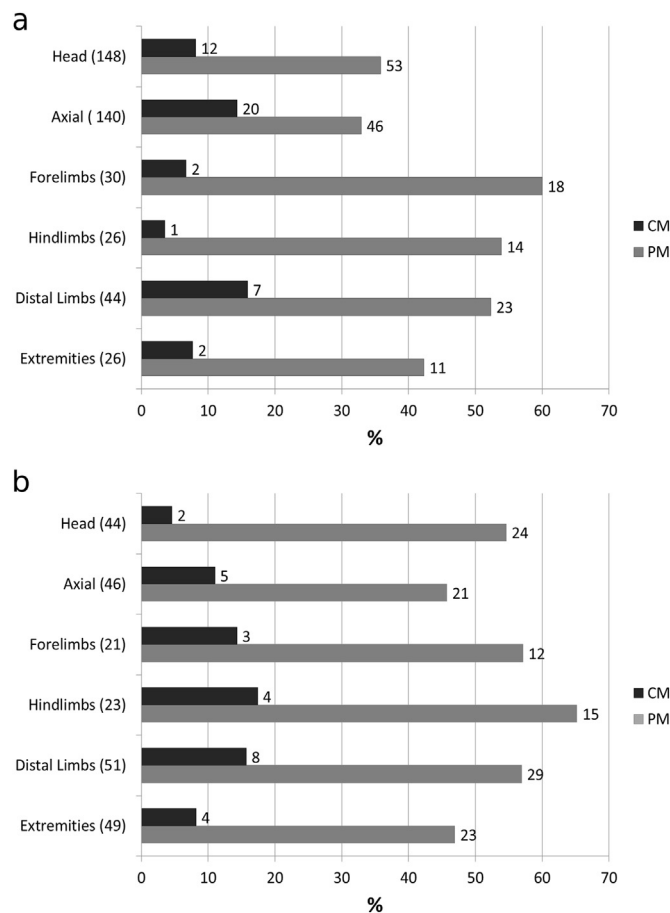


Fig. 8. a) Butchery mark frequency on skeletal-groups of medium mammal (Bovid 2 and indeterminate 'medium mammal' remains). NISP in brackets. Axial consist of ribs and vertebrae. PM = percussion marks; CM = cut marks. Head = crania, mandibles; Forelimbs = scapula, humeri, radii, ulna; Hindlimbs = pelvis, 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.

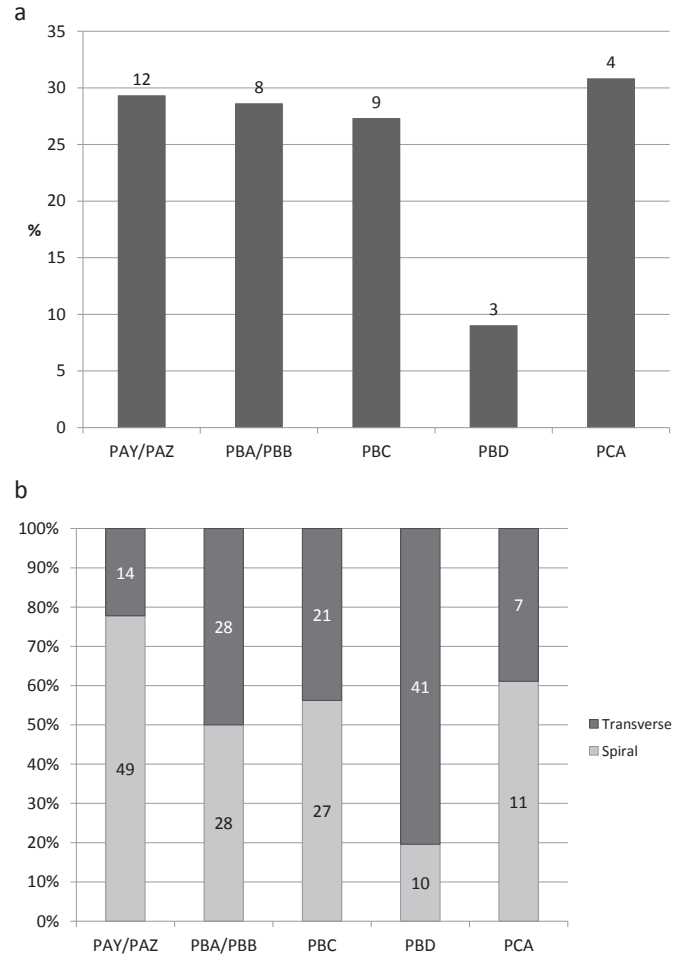


Fig. 9. a) Proportion of percussion marked small mammal long-bone per layer including unidentified long-bone with a cortical thickness  $\leq 2$  mm. NISP above columns. b) Fracture patterns of small mammal long-bone per layer including unidentified long-bone with a cortical thickness  $\leq 2$  mm. 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, pelvis 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. (11.8.4%; 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 pelvis, 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 molerat 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 molerat 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.

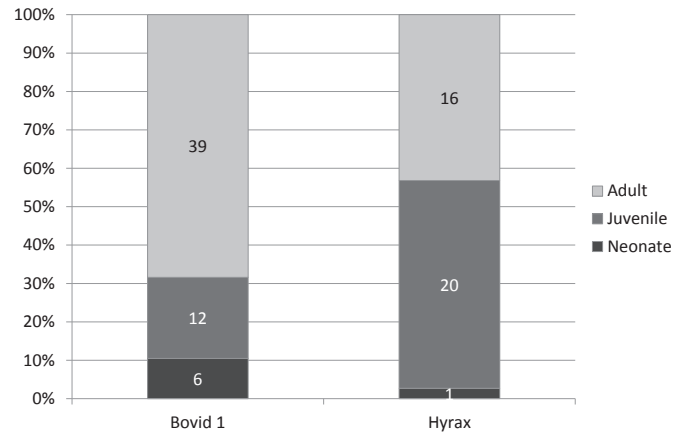
**Table 8**

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**

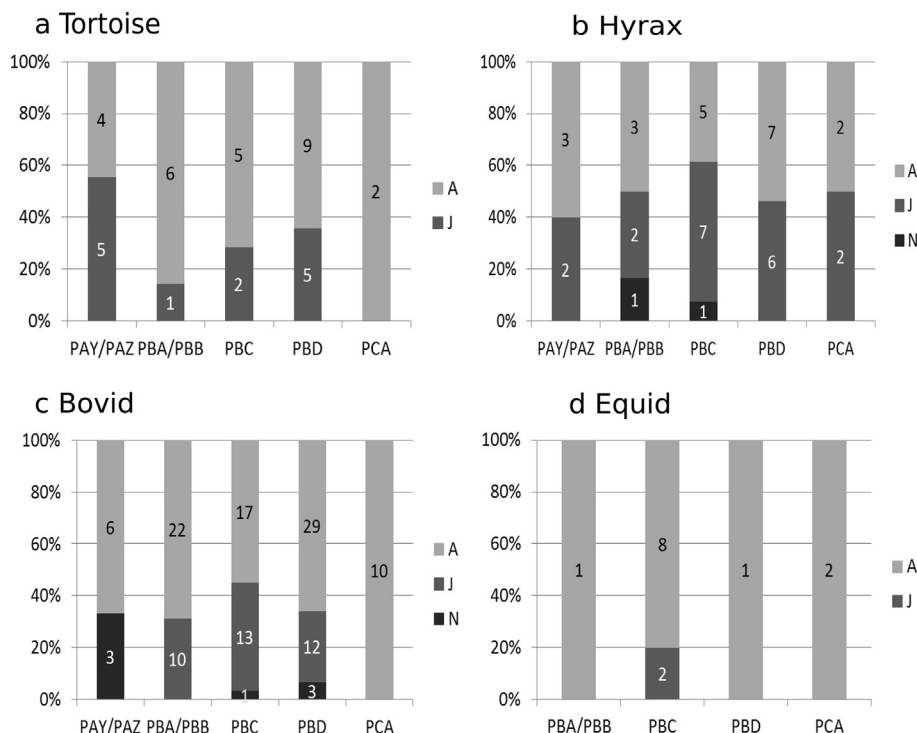
Sediment compaction is often cited as a significant factor in the taphonomic history of archaeological assemblages (e.g., Klein and Cruz-Uribe, 1984; Kidwell, 1986) and bone affected by diagenesis is particularly liable to fragment under sediment weight (Lyman, 1994). Research suggests that if soil compaction 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 Behrensmeier, 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 bovinds while small bovinds are represented by more distal limbs and phalanges (Fig. 4). Small bovinds 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 bovinds 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 bovinds may point to seasonality and this will be discussed in more detail in a future study. Yet these differences could also imply that bovinds 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., Blumenshine, 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 (Blumenshine 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 bovinds discussed earlier. There is a significant relationship at KDS between nNISP values and marrow utility indices for both smaller and medium-sized bovinds (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 <sup>a</sup>	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
<b>High-survival elements only</b>						
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

<sup>a</sup> 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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