DSPACE

https://dspace.org/

The unidentified long bone fragments from the middle stone age Still Bay layers at Blombos Cave, Southern Cape, South Africa

Reynard, Jerome Peter

2012-03-07
http://hdl.handle.net/10539/11398

Downloaded from a DSpace repository. https://dspace.org/

THE UNIDENTIFIED LONG BONE FRAGMENTS FROM THE MIDDLE STONE AGE STILL BAY LAYERS AT BLOMBOS CAVE, SOUTHERN CAPE, SOUTH AFRICA

Jerome Peter Reynard

A dissertation submitted to the Faculty of Science, University of the Witwatersrand, Johannesburg, in fulfillment of the requirements for the degree of Master of Science

Johannesburg, 2011

DECLARATION

I declare that this dissertation is my own, unaided work. It is being submitted for the Degree of Master of Science in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other University.



_____

Jerome P. Reynard

_____ Day of _____ 2011

ABSTRACT

The aim of this investigation was to explore the relationship between the unidentified and identified fauna from the Still Bay period at Blombos Cave between ca. 77 and 72 ka. The size, breakage patterns and surface modifications of unidentified long bone fragments from the M1 and upper M2 phases were analysed. The results of the analyses were then compared to a sample of faunal remains identified by Klein (Henshilwood *et al.* 2001b) and Thompson (2008) from the Still Bay layers at Blombos Cave. The length of each fragment was measured to ascertain the degree of fragmentation of the assemblage. Long bone fragments generally become slightly shorter with increasing depth. This may be because smaller fauna are relatively more prevalent in the deeper layers.

Cortical thickness of the bone fragments was measured and grouped into small, medium and large categories. These categories were correlated to Brain's (1974a) bovid size classes to investigate whether the unidentified faunal remains mimic the identified bone sample in terms of animal size. While small-sized fauna dominate the identified archaeofaunal assemblages at Blombos Cave, the cortical thickness of unidentified long bone fragments suggest that medium-sized fauna was more common.

The breakage pattern of each fragment was assessed, indicating that the majority of specimens exhibited spiral fractures. Burning is more common in the unidentified faunal sample than in the identified sample and may have resulted in the relatively low frequencies of cut-marked and percussion-marked fragments. Polished bone fragments may also be a consequence of burning, abrasion or compaction, though its prevalence in the upper M2 with formal bone tools suggests that it was the result of human activities. Higher bone fragment densities in the upper layers at Blombos Cave suggests that changes in human occupation and faunal density patterns during the Still Bay at Blombos Cave may relate to environmental conditions.

To my mother, Barbara, and my brother, James

ACKNOWLEDGEMENTS

Funding for this dissertation was provided by a National Research Foundation (NRF) SAChI Chair for 'The Origins of Modern Human Behaviour' bursary to Prof. Christopher Henshilwood, at the Institute for Human Evolution, and a grant from the Palaeontological Scientific Trust (PAST).

This study would not have been possible without the assistance of the following people:

My supervisor, Prof. Chris Henshilwood, for the opportunity to work with the Blombos Cave material. He not only encouraged me as a mature student and allowed me the latitude to explore all options in archaeology, but also generously provided me with financial assistance in the form of an NRF grant-holder bursary.

Dr. Shaw Badenhorst, my co-supervisor and faunal guru, who spent countless hours guiding me in academic writing and the intricacies of zooarchaeological analysis. His enthusiasm and humility has revealed to me the true nature of science.

Dr. Sarah Wurz, for her patience and counsel during the last few months of this project. Her comments and advice were both inspiring and gracious.

Dr. Gerrit Dusseldorp, for the many hours we spent discussing fauna, sometimes in his office, sometimes at the Pig. He made me realise you can have fun and be deep at the same time.

Dr. Marlize Lombard, for guiding me through my proposal and first year of study. I will always remember that 'project management beats crisis management.'

In addition, I thank:

Dr. Geeske Langehans, for all her input and advice. The participants of the Forum; Silje, Matt, Riaan, Helen and Jane for all their advice during my proposal. The staff at Iziko Museum of Cape Town: Petro Keene, Valerie Meintjies and Wilhelmina Seconna for all their help and support. Stephany Potze from the Ditsong National Museum of Natural History (former Transvaal Museum) in Pretoria for allowing me to examine the Gobabeb goat bone collection. Brian Kuhn, Steph and Luke for their invaluable assistance in teaching me faunal identification and forcing me to take the test. Our very own Indy Jones, Justin Pargeter, for showing me that you can be an archaeologist *and* cool. My family, Barbara and James

Reynard for looking after me during my Cape Town excursions; especially my brother, James, for patiently explaining the intricacies of MS Word and Excel to me. Stini Pillay, Kevin Leicher and Prof. Jaxon Rice for accommodating an academic refugee from Cape Town with limited financial resources.

Finally, I'd like to thank Tammy Hodgskiss for both academic advice and her support...and having to deal with a man obsessed with bone fragments for two years.

TABLE OF CONTENTS

DECLARATION i

ABSTRACT ii

DEDICATION iii

ACKNOWLEDGEMENTS iv

LIST OF FIGURES ix

LIST OF TABLES xii

ABSTRACT ii

CHAPTER 1: INTRODUCTION 1

1.1 General Introduction 1

1.2 Aims 1

1.2 Thesis Layout 2

CHAPTER 2: BACKGROUND TO THE STUDY AND LITERATURE REVIEW 3

2.1 The Middle Stone Age and Zooarchaeology 3

2.2 Unidentified Faunal Remains 4

2.3 Zooarchaeological Investigations of Long Bone Fragments: A Literature Review 5

2.3.1 Lengths of bone fragments 6

2.3.2 Cortical thickness and animal size 8

2.3.3 Fracture patterns 10

2.3.4 Taphonomic agents associated with bone fragments 15

Anthropogenic modification to bone 17

CHAPTER 3: BACKGROUND TO BLOMBOS CAVE 19

3.1 Site Description 19

3.2 Dating and Chronology 23

3.3 Palaeoenvironment 23

3.4 Archaeological Context: The Still Bay 25

3.5 The Blombos Cave Fauna 28

3.5.1 Klein's analysis (1992 – 2000 excavations) 28

3.5.2 Thompson's taphonomic analysis (2000 – 2004 excavations) 29

CHAPTER 4: METHODOLOGY 31

4.1 Methodological Framework 31

4.2 The Blombos Cave Faunal Material 33

4.3 Bone Fragment Analysis 34

4.3.1 Fragment length 34

4.3.2 Cortical thickness and animal size class 35

4.3.3 Fracture patterns 37
4.3.4 Surface modifications 38
Cut marks 38
Percussion marks. 39
Chop marks. 40
Polish 41
Burning. 41
Non-human modification. 41
4.4 Analyses of Quantitative Data 44
CHAPTER 5: RESULTS 46
5.1 Sample Size and Spatial Distribution 46
5.2 Fragment Lengths 48
5.3 Cortical Thickness 54
5.3.1 Cortical thickness and animal size 61
5.4 Fracture Patterns 65
5.5 Surface Modifications 67
5.5.1 Burning 67
5.5.2 Anthropogenic modifications 70
5.5.3 Polish 75
5.5.4 Tooth and gnaw marks 77
5.6 Summary 80
CHAPTER 6: DISCUSSION AND CONCLUSION 82
6.1 Sample Density and Distribution 82
6.2 Fragment Length 83
6.3 Cortical Thickness 87
6.4 Fracture Patterns 95
6.5 Surface Modification 98
Burning. 98
Percussion marks. 101
Cut marks. 104
Polish 106
Bone tools at Blombos Cave. 107
Non-anthropogenic modification. 109
6.6 Implications for Human Behaviour during the Still Bay at Blombos Cave 113
6.7 Conclusion 116
6.8 Future Avenues of Research 119
1) Spatial Distribution. 119
2) Cortical Measurements. 120
3) Assessing Polish 120

4) Resource Intensification in the Still Bay. 120
REFERENCES 122
APPENDIX A 158
APPENDIX B 159
APPENDIX C 161
APPENDIX D 162

LIST OF FIGURES

Figures	Page
2.1: Fracture angles	13
2.2: Fracture outline	14
3.1: Map showing Blombos Cave, Die Kelders, Pinnacle Point and Klasies River (Image from Jacobs *et al.* 2006)	19
3.2: Stone tools from the M1 at BBC	22
3.3: Stratigraphy and OSL ages at BBC (Image from Jacobs *et al.* 2006)	23
3.4: Engraved ochre and pierced shell beads from the Still Bay layers at BBC (Images from Henshilwood *et al.* 2009 [a] and Henshilwood *et al.* 2004 [b])	27
4.1: Structure of long bone	32
4.2: Cross-section of long bone shaft	33
4.3: Examples of fracture patterns	38
4.4: Cut marks in bone	39
4.5: Percussion mark on bone (Image from Blumenschine *et al*. 1996)	40
4.6: Chop marks on bone (Image from Noe-Nygaard 1989)	40
4.7: Carnivore tooth marks	42 – 43
4.8: Cut and tooth marks	43
4.9: Rodent gnaw marks	44
5.1: The spatial distribution and stratigraphy of BBC (from Thompson & Henshilwood 2011)	47
5.2: Unidentified long bone fragment lengths at BBC by phase	49
5.3: Size distribution of unidentified long bone fragments from the M1 and upper M2 at BBC	50
5.4: Comparison between the lengths of burnt and unburnt fragments from the M1 and upper M2 at BBC	51
5.5: Surface modifications and the lengths of bone fragments from the M1 and upper M2 at BBC.	54
5.6: Cortical thickness of bone fragments at BBC from the M1 and upper M2 phases	55
5.7: Cortical thickness of unidentified long bone fragments from the M1 and upper M2 at BBC	57
5.8: Cortical thickness of burnt bone fragments from the M1 and upper M2 at BBC	58

5.9: Surface modifications and the cortical thickness of bone fragments from the M1 and upper M2 at BBC. 60

5.10: Comparison between the length and cortical thickness of unidentified long bone fragments. 64

5.11: Mean bone fragment lengths plotted against mean cortical thickness. 65

5.12: Fragment with spiral fractures 66

5.13: Calcined and carbonised fragments 68

5.14: Stratigraphic distribution of burnt fragments at BBC 69

5.15: Percussion mark on a calcined section of bone 69

5.16: Comparison of the frequencies of burnt and percussion-marked bone fragments at BBC. 70

5.17: Stratigraphic distribution of bone fragments with anthropogenic marks at BBC. 71

5.18: Stratigraphic distribution of undamaged bone fragments at BBC 72

5.19: A cut-marked fragment 73

5.20: Stratigraphic distribution of bone fragments with cut and chop marks at BBC 73

5.21: Percussion mark 74

5.22: Stratigraphic distribution of bone fragments with percussion marks at BBC 75

5.23: Polished specimen 76

5.24: Stratigraphic distribution of bone fragments with polish at BBC 76

5.25: Tooth marks and a carnivore bite mark 77

5.26: Stratigraphic distribution of tooth and gnaw-marked bone fragments at BBC 78

5.27: Relative frequency of surface modifications per layer at BBC 79

5.28: Bone fragments per volume at BBC 80

6.1: Distribution of animal size classes for identified fauna at BBC 92

6.2: Distribution of bovid size classes for large-mammal identified fauna at BBC 93

6.3: Distribution of animal size classes for unidentified fauna at BBC 94

6.4: Localised burning 100

6.5: Relationship between percussion marks and burning at southern African MSA sites 103

6.6: Cut marks on polished bone 107

6.7: Spatial distribution of bone tools and bone fragments in the M1 and M2 at BBC. 109

6.8: Root etchings resembling tooth marks 110

6.9: Possible tooth mark over a cut mark 111

6.10: Root etchings 112

LIST OF TABLES

Tables	Page
2.1: Bovid size class	8
4.1: Classification of fragment length	35
4.2: Classification of cortical thickness	36
5.1: The spatial distribution of bone fragments at BBC by square	47
5.2: The stratigraphic distribution of bone fragments at BBC by layer and phase	48
5.3: Length of bone fragments at BBC by phase (mm)	49
5.4: Length of bone fragments at BBC by layer (mm)	49
5.5: Length codes of bone fragments at BBC	49 – 50
5.6: Length of burnt fragments at BBC by phase (mm)	51
5.7: Length of carbonised fragments at BBC by phase (mm)	52
5.8: Length of calcined fragments at BBC by phase (mm)	52
5.9: Length of unburnt fragments at BBC by phase (mm)	52
5.10: Length of cut and chop-marked fragments at BBC by phase (mm)	52
5.11: Length of percussion-marked fragments at BBC by phase (mm)	52
5.12: Length of tooth and gnaw-marked fragments at BBC by phase (mm)	53
5.13: Length of polished fragments at BBC by phase (mm)	53
5.14: Length of undamaged fragments at BBC by phase (mm)	53
5.15: Cortical thickness of bone fragments at BBC by phase (mm)	55
5.16: The stratigraphic distribution of cortical thickness at BBC by layer (mm)	56
5.17: The spatial distribution of cortical thickness at BBC by square (mm)	56
5.18: Cortical thickness codes of bone fragments at BBC	56
5.19: Cortical thickness of burnt fragments from BBC by phase (mm)	58
5.20: Cortical thickness of carbonised fragments from BBC by phase (mm)	58
5.21: Cortical thickness of calcined fragments from BBC by phase (mm)	58
5.22: Cortical thickness of unburnt fragments from BBC by phase (mm)	59
5.23: Cortical thickness of percussion-marked fragments from BBC by layer (mm)	59
5.24: Cortical thickness of cut and chop-marked fragments from BBC by layer (mm)	59

5.25: Cortical thickness of tooth and gnaw-marked fragments from BBC by phase (mm) 59

5.26: Cortical thickness of polished fragments from BBC by phase (mm) 60

5.27: Cortical thickness of undamaged fragments from BBC by phase (mm) 60

5.28: Cortical thickness of goat long bones from Gobabeb 61

5.29: Cortical thickness measurements of identified bones from BBC. 62 – 63

5.30: Fracture patterns of bone fragments from the M1 and upper M2 at BBC 66

5.31: Comparison between the lengths of spirally and transversely-fractured fragments at BBC (mm) 66 – 67

5.32: Fracture patterns of burnt fragments from the M1 and upper M2 at BBC 67

5.33: Fracture pattern of unburnt fragments from the M1 and upper M2 at BBC 67

5.34a: Observed frequencies of percussion-marked burnt bone from BBC 70

5.34b: Expected frequencies of percussion-marked burnt bone from BBC 70

5.35: Surface modifications per layer at BBC 79

5.36: Density of bone fragments at BBC per layer 80

6.1: Mean unidentified bone fragment lengths from early Pleistocene and Late Quaternary faunal assemblages 86 – 87

6.2: Animal size classes based on cortical thickness codes 89

6.3: Size class of identified fauna at BBC (data from Henshilwood *et al.* 2001b) 90 – 91

6.4: Size class of unidentified fauna at BBC 93

6.5: Comparisons between the fracture patterns at BBC and other MSA sites 97

6.6: Spatial distribution of unidentified burnt bone and hearths 99

6.7: Cut mark frequencies in southern African MSA assemblages 105 – 106

6.8: Frequency (%) of surface modification at southern African MSA sites 113

6.9: Bone fragment and lithic density in the M1 and M2 at BBC 116

APPENDIX A: Summary of statistics for fragment lengths from the M1 and M2 phases at BBC 158

APPENDIX B: Summary of statistics for fragment lengths from the Still Bay (M1 & upper M2 phases) and taphonomic modifications at BBC 157

APPENDIX C: Summary of statistics for cortical thickness of fragments from the M1 and M2 161

APPENDIX D: Summary of statistics for cortical thickness of fragments from the Still Bay (M1 & upper M2 phases) and taphonomic modifications 162

CHAPTER 1: INTRODUCTION

1.1 General Introduction

In this study, I examine the unidentified long bone fragments from the Still Bay layers at Blombos Cave (BBC) and compare the results to data obtained from the analyses of previously identified BBC fauna. Differences between the two studies suggest that the analyses of unidentified long bone fragments may reveal patterns of subsistence behaviour not apparent from bone studies that only examine identified body parts. The analyses of the unidentified fauna from the BBC Still Bay levels may help show subsistence patterns associated with these people that until now were not clear.

1.2 Aims

The aim of this study was to examine the unidentified long bone fragments recovered from the Still Bay levels at BBC. The results were then compared to those from previous analyses of identified faunal remains from the same levels at the site (e.g. Henshilwood *et al.* 2001b; Thompson 2008, Thompson & Henshilwood 2011) to explore any differences between the identified and unidentified datasets. The method used was to analyse the size, breakage patterns and surface modification of the unidentified long bone fragments from the Still Bay layers (the M1 and upper M2 phases) at BBC and then compare these with data from known fauna in comparative collections and from BBC.

In particular, this research focuses on:

1. The length of unidentified long bone fragments: fragments were measured in order to ascertain the degree of fragmentation of the assemblage.
2. The cortical thickness of unidentified long bone fragments: cortical bone thicknesses were measured to group unidentified long bone fragments into mammal size classes. This was undertaken to investigate whether or not the unidentified faunal remains mimic the identified bone sample in terms of animal sizes.

3. The breakage patterns of unidentified long bones: breakage patterns were recorded to differentiate fresh from dry bone and to assess the level of post-depositional fragmentation.
4. The surface modification of the unidentified long bone fragments: modifications affecting the bone fragments were investigated to determine the agent(s) of fragmentation and accumulation.

1.2 Thesis Layout

Each chapter begins with a brief introduction, describing the layout and structure. The layout of each chapter will be structured, where appropriate, according to the four aims of this dissertation; namely bone fragment length, cortical thickness, breakage patterns and surface modification. In chapter 2, I present my rationale and the background to the study of bone fragments with a literature review. Chapter 3 describes the archaeology, fauna and palaeoenvironment that existed at the time that BBC was occupied during the Middle Stone Age (MSA). I also introduce the Still Bay and address the significance of this techno-complex to MSA research. In chapter 4, I discuss the methodology used to assess and analyse the data. I also describe the dataset and explain why this sample has been used in the investigation. In chapter 5, I present the results of my analyses. Chapter 6 focuses on the discussion and conclusion. In this chapter, I compare the results of the analyses to one another and with other archaeofaunal assemblages. I then discuss the implications of my results with regards to the occupational history and subsistence behaviour during the Still Bay at BBC. Finally, after a brief conclusion, I discuss the limitations of this study and explore future avenues of research.

CHAPTER 2: BACKGROUND TO THE STUDY AND LITERATURE REVIEW

2.1 The Middle Stone Age and Zooarchaeology

The significance of the MSA, dating from about 250 to 40 000 years ago (ka), is that it encompassed the evolution of both biological and behavioural modernity in *Homo sapiens* (Rightmire 1984; Deacon 1992; Lahr & Foley 1998; Stringer 2001, 2002; Mellars 2006; d'Errico & Stringer 2011). The recovery of some of the earliest anatomically modern human remains at Klasies River and evidence of an early marine-based subsistence economy during the MSA at Pinnacle Point has underscored the importance of the southern Cape coast in the study of modern human origins (Klein 1995; Grine *et al.* 1998; Marean *et al.* 2007; McBrearty & Stringer 2007). The discovery of symbolic artefacts such as personal ornamentation from the Still Bay layers at BBC has highlighted the significance of both the southern Cape and the Still Bay techno-complex in the origins of cognitive modernity (d'Errico *et al.* 2001, 2005; d'Errico 2003; Henshilwood *et al.* 2001a, 2001b, 2002, 2009; Henshilwood 2004, 2007, 2008a; Minichillo 2005; Henshilwood & Marean 2006; Mellars 2006; Barham & Mitchell 2008; Mourre *et al.* 2010; d'Errico & Stringer 2011; Henshilwood & Dubreuil 2011).

The Still Bay techno-complex is defined by the occurrence of foliate, bifacial lithic points (Goodwin & Van Riet Lowe 1929; Goodwin 1933; Minichillo 2005; McCall 2007; Wadley 2007; Villa *et al.* 2009). The appearance of these lanceolate points at BBC at around 78 ka (Tribolo *et al.* 2006; Henshilwood 2008a; Mourre *et al.* 2010) coincided with an increase in the complexity of social, economic and cognitive behaviour amongst southern African groups. In addition, the Still Bay techno-complex very likely occurred just before a period of demographic expansion by modern humans out of Africa between 80 and 60 ka (Lahr & Foley 1998; Mellars 2006; Behar *et al.* 2008; Chase 2010).

Whereas lithics are indicative of technological capabilities, bone potentially reflects both the technology and the subsistence base of past societies. For example, although bone fragments in archaeofaunal assemblages are generally the remains of foraging activities, they may also have been used in tool production as both hammers and tool blanks (d'Errico & Henshilwood 2007). Archaeofaunal studies, or zooarchaeology, may offer insights into the subsistence

acuity, nutritional and social preferences of past peoples (Chaplin 1971; Isaac 1983; Davis 1987; O'Connor 1996, 2000; Reitz & Wing 1999; Gifford-Gonzalez 2007; Hedges 2009; Wadley 2010). Zooarchaeology has contributed significantly to the understanding of MSA lifeways in the southern Cape by revealing the foraging behaviours of past people (for example, Klein 1976, 1989; Binford 1984; Klein & Cruz-Uribe 1996, 2000; Milo 1998; Marean *et al.* 2000; Outram 2000; Henshilwood *et al.* 2001a, 2001b, 2009; Henshilwood 2004, 2007; Faith 2008; Lombard & Clark 2008; Thompson 2010; Thompson & Henshilwood 2011).

MSA faunal assemblages are generally highly fragmented with the majority of the excavated material not identifiable to either element or taxon (Binford 1981; Klein *et al.* 1999a; Plug 2004; Cain 2005; Clark & Plug 2008; De Ruiter *et al.* 2008; Clark 2009). For example, of the 58 000 bone specimens from the Sibudu MSA site in Kwa-Zulu Natal, only 7% could be identified to species or animal size class (Plug 2004). At Later Stone Age (LSA) sites the percentage of identifiable bone can also be very low, for example at the SK400 gazelle 'mass kill' site in Namaqualand, only 5.8% of the faunal material could be taxonomically identified (Dewar *et al.* 2006). Research on the fragmentation and fracture patterns of bone has allowed unidentified long bone fragments to be incorporated into the analysis of archaeofaunal remains (Todd & Rapson 1988; Marean & Spencer 1991; Marean *et al.* 1992; Villa & Mahieu 1991; Lyman 1994; Outram 2001; Pickering *et al.* 2003, 2005; Yravedra & Dominguez-Rodrigo 2009). By analysing long bone fragments from the Still Bay layers at BBC, I will attempt to explore aspects of the subsistence behaviour of southern Cape people during the MSA.

2.2 Unidentified Faunal Remains

Zooarchaeological studies involve the assessment of animal remains although analyses are usually restricted to identified fauna (Davis 1987; Butler & Lyman 1996; Reitz & Wing 1999; O'Connor 2000). The majority of faunal remains are defined as 'unidentified' because they cannot be identified to species, genus, family, order or size class (Enloe 1993; O'Connor 2000). Unidentified faunal remains present the zooarchaeologist with an analytical dilemma. Identifiable bone can be assigned to elemental or taxonomic groups, with these groups essentially defining the statistical units used in analyses. Unidentified bone cannot be

accommodated within these zoological constructs and artificial typologies have to be developed in order to categorise these bone fragments (Driver 1992). Unidentified faunal remains represent a potentially important source of information for archaeologists (Brain 1974a; Enloe 1993) yet generally they are separated from the identified remains and not analysed (Klein & Cruz-Uribe 1984; Plug 1997; Outram 2001). In this regard, unidentified long bone fragments could be viewed as under-utilised faunal datasets with the potential to explore human subsistence behaviour.

The amount of identifiable bone fragments available for zooarchaeological analyses is directly related to the fragmentation of faunal assemblages. As taphonomic processes fragment bone, diagnostic landmarks used to identify elements and taxa, such as articular surfaces and muscular attachments are degraded or destroyed (Grayson 1984; Driver 1992; Lyman 1994, 2008; Reitz & Wing 1999). It is therefore possible that bones of a particular animal could be recovered in an assemblage but remain unidentified because key diagnostic features are no longer present. At Sibudu Cave in Kwa-Zulu Natal, for example, only 0.83% of the Howieson's Poort and Post-Howieson's Poort faunal remains were identified (Clark & Plug 2008). Plug's (1997: 719) analysis of the Late Pleistocene sites of the eastern highlands of southern Africa shows that less than 2% of the fauna was identified while "*faunal remains predating 21 000 BP were reduced to unidentifiable crumbs and were unsuitable for analysis*".

2.3 Zooarchaeological Investigations of Long Bone Fragments: A Literature Review

Few published studies have been undertaken on the analyses of unidentified bone fragments. In the 1950's Dart introduced the idea that an 'Osteodontokeratic Culture' (bone, teeth and horn) was present during the Plio-Pleistocene. He argued that the bones from early hominid kills or scavenged carcasses were utilised as tools and weapons by australopithecines (Dart 1957, 1958). Dart's theory proved highly controversial (e.g., Oakley 1954; Singer 1956; Clark 1957; Straus 1957; Washburn 1957; Dart 1958; Wolberg 1971; Brain 1981; Lyman 1994) and he systematically analysed long bone fragments to confirm the existence of this bone tool culture (Dart 1949a, 1949b, Dart & Kitching 1958). Some researchers (e.g., Brain 1981; Davis 1987; Lyman 1994: 315) regard Dart's theory as the catalyst for the intensive research into taphonomy that followed (cf. Washburn 1957; Wolberg 1971; Brain 1981).

With the development of taphonomy as a distinct discipline (Efremov 1940), Brain (1974a: 3) suggested that all unidentified long bone fragments from archaeofaunal assemblages should be assessed during zooarchaeological analyses. These long bone fragments conform to the following criteria: (a) they were originally from the shafts of long bones; (b) they lack articular ends and (c) they do not include more than half the circumference of the long bone shaft. In my study, these criteria were used to define the unidentified long bone fragments used in the analysis. In the following section, I discuss why my study has been undertaken. The relevant literature has also been reviewed in terms of the four goals of this dissertation: length, cortical thickness and animal size class, fracture patterns and taphonomic history.

2.3.1 Lengths of bone fragments

The length of long bone fragments is indicative of the degree of fragmentation of the faunal assemblage (Brain 1969, 1974a, 1981; Voigt 1983). Fragmentation is the result of the effects of pre- and post-depositional taphonomic processes (Lyman 1994, 2008) and occurs when dynamic stress or tension on bone results in the formation of cracks (Wright & Hayes 1977; Malik *et al.* 2003; Herrmann *et al.* 2006). The intersection of these cracks determines the size and shape of fragments (Wright & Hayes 1977; Shockey 1985). The more cracks that are formed, the more fragments occur and the smaller the fragment size (Shockey 1985; Zhang *et al.* 2004). Leaving aside the brittleness of the material, there is a direct proportional relationship between the applied kinetic energy and fragment size: the greater the force, the smaller the fragment size (Tavassoli & Shirvani 2000; Zhang *et al.* 2004; Herrmann *et al.* 2006). Larger bone fragments may possibly be the result of human subsistence activity such as systematic marrow fracturing (Noe-Nyaard 1977; Enloe 1993) or taphonomic processes that eliminate smaller fragments such as fluvial activity or recovery bias (Monaham 1995; Pickering *et al.* 2003). They may also signify the presence of large animal size classes within the assemblage (Clark 2009; Thompson & Henshilwood 2011). Smaller fragments may be indicative of human activity such as burning (Stiner *et al.* 1995; Costamagno *et al.* 2005) or post-depositional processes such as trampling (Voigt 1983; Blasco *et al*. 2008; Thompson 2008). They may also represent the remains of smaller animals such as dune molerats or small birds (Thompson & Henshilwood 2011).

Brain recorded the lengths of bone fragments in his analyses (for example, Brain 1969, 1974b, 1981) and noted any 'special features' (Brain 1974a: 4) such as cut marks, carnivore damage, surface abrasion and pathology. In Brain's (1969) preliminary analyses of the fauna from Bushman's Rock Shelter, he measured all unidentified long bone fragments and placed them in size classes according to their length. He noted that bone fragments were smaller in the upper Iron Age levels than in the deeper LSA and MSA levels. The fragmentation of bone in the upper levels was attributed to post-depositional trampling caused when the cave was recently used as a tobacco barn. He also noted that the lengths of bone fragments in the MSA and LSA collections tended to be 'remarkably consistent' (Brain 1981: 53), suggesting that the processes responsible for bone fragmentation were similar for both assemblages. Brain (1981) indicated that the lengths of human-produced fragments have less variability and a narrower range than those produced by hyenas. He suggested that larger fragments may signify hyena action although he was not confident in his ability to separate human from carnivore produced fragments (cf. Villa *et al*. 2004; Thackeray 2007). In a similar analysis of the length of bone fragments from the Pleistocene-aged Kromdraai fauna, Brain (1981) found the short fragment lengths and the narrow size range to be similar to those from LSA sites. He suggested that the extreme fragmentation of the assemblage was the result of hominid activity but that it also may have been the result of the decalcification process of the breccias (Brain 1981).

Voigt (1983) analysed unidentified long bone fragments in her study of the Iron Age fauna from Mapungubwe to ascertain the degree of fragmentation of the assemblage. She categorised the unidentified fragments into size classes of 1cm length intervals. Two different patterns of fragmentation were observed, with the majority of fragments falling into either the 2-4 or 4-5cm categories. She attributed this variation to three conditions: low levels of activity (less trampling), the texture of the deposit (e.g. soft ash) and the rate of accumulation. In comparing the unidentified fragments to the identified material she noted that the patterns were not identical. The size range of the identified sample was greater than that of the unidentified 'bone flakes' and the tail of the histogram for the identified material was longer. Identified fragments were, on average, larger than unidentified 'bone flakes'.

Enloe (1993), in his analysis of bone shaft splinters, suggested that shaft fragment lengths may reflect subsistence behaviour. Three samples of faunal material from two ethnohistorical Nunamiut Eskimo sites were studied. One sample was drawn from a site associated with mass marrow processing; the other from two kitchen middens that accumulated as the result

of marrow removal incidental to meat eating. He found that fragment lengths were greater for the marrow processing assemblage. However, all analysed bone was from caribou and the samples were drawn from restricted locations where non-human scavengers such as dogs had limited access to the assemblages.

2.3.2 Cortical thickness and animal size

Size and body weight are the most obvious and significant characteristics of any animal (Calder 1984; Jablonski 1996). Bovids usually dominate faunal assemblages in southern Africa in both numbers and species but these archaeofaunas are often fragmented (e.g., Brain 1981; Klein & Cruz-Uribe 1984; Kappelman *et al.* 1997). Because it is not always possible to identify bovid remains according to taxonomy, size classes have been developed by faunal analysts to categorise fauna (Brain 1974a; Vrba 1976; Schmitt & Lupo 1995; Lyman 2008). Brain (1974a) proposed that antelope remains which could not be identified to species, genus or family be grouped according to size according to four size classes (Table 2.1). Klein (1976) added a fifth, 'very large', size class to Brain's categories in his study of the Klasies River fauna. Vrba (1976), in her study of bovid remains as palaeoenvironmental indicators, used four weight classes of 7, 27, 125 and 343 kg. These measurements have cube roots of 3, 5 and 7 which she suggested aided graphic representation.

Thompson (2008) used Brain's (1974a) system to categorise the identified fauna at BBC and included a size 5 class, equivalent to Klein's (1976) 'very large' category. This classificatory scheme has often been used in the analyses of southern African MSA faunal assemblages (e.g., Marean *et al*. 2000; Clark & Plug 2008; Lombard & Clark 2008; Thompson 2010). The size classes devised by Brain (1974a) and adapted by Thompson (2008) are used in my analysis.

Table 2.1: Bovid size class

Bovid size class (Brain 1974a)	Klein (1976) equivalent	Weight range (kg)	Genus & Species examples
I	small	4.5 - 23	*Oreotragus oreotragus* (klipspringer), *Raphicerus campestris* (steenbok), *Sylvicapra grimmia* (common duiker)

II	small-medium	23 - 84	*Antidorcas marsupialis* (springbok), *Redunca arundinum* (southern reedbuck)
III	large-medium	84 - 296	*Tragelaphus strepsiceros* (kudu), *Oryx gazella* (gemsbok), *Connochaetes gnou* (black wildebeest)
IV	large	296 - 900	*Syncerus caffer* (Cape buffalo), *Tragelaphus oryx* (eland)
	very large	> 900	*Pelorovis antiquus* (giant buffalo)

The cortical thickness of long bone elements is indicative of the size of the animal (McMahon 1975; Alexander 1977; Biewener 1983a, 1983b; Currey & Alexander 1985). Bone has broadly similar biomechanical properties in a diversity of mammalian species and taxa (Biewener 1991: 20). The shape and geometry of long bones are the result of biomechanical force and reflects their structural function (Selker & Carter 1989; Skedros *et al.* 1994). Larger animals bear a greater load. To compensate structurally, higher load-bearing bones have thicker cortices (Barba & Dominguez-Rodrigo 2005; Croker *et al.* 2009). In quadrupeds, for example, larger animals have thick long bone cortices as a result of the locomotory and load-bearing forces acting on the limbs (McMahon 1975; Alexander 1977, 1979; Woo *et al.* 1981; Biewener 1983a, 1983b; Malik *et al.* 2003; Garcia & Da Silva 2006). For artiodactyls, such as bovids, the diameters of long bone scale allometrically with animal mass: the heavier an animal, the greater the cross-sectional area of its long bone shaft (Selker & Carter 1989: 1179). The cortical thickness of long bone fragments could, therefore, be used to infer the size class of the animal (Uerpman 1973; Driver 1992).

Limited research has been done on correlating cortical thickness to animal size classes and few studies focus on the MSA faunal assemblages of the southern Cape. Uerpmann (1973) proposed that unidentified animal bones could be classified according to animal size. He suggested that most bones could be 'fairly easily' attributed to large (cattle, large antelope, horse, etc.), medium (smaller bovids, dogs, etc.) and small (small dogs, cats, hares, etc.) animals. These size groups could then be treated as statistical units (Uerpmann 1973: 309). The context of his discourse, however, was Europe and North America where fewer animal species occur compared to Africa (Hofmann 1989). Driver (1992: 37) urged zooarchaeologists to be "*explicit in developing non-zoological typologies to describe bone fragments*." "*It may be possible*", he argued, "*using such criteria as bone thickness...to*

identify some fragments to the class level without first identifying the element." He suggests that the cortical thickness of unidentified fragments should be measured "*to allow the analyst to assign a size range for otherwise unidentifiable long bone fragments*" (Driver 1999: 7). Barba and Dominguez-Rodrigo (2005) used cortical thickness in combination with diagnostic mid-shaft features to identify the long bones of bovids to element. Pante and Blumenschine (2010) measured cortical thickness in their study of the hydraulic transportability of long bone fragments. Although cortical thickness was measured to gauge bone density, Blumenschine (personal communication) notes that the cortical thickness of identified bone correlated with animal size class.

Badenhorst (2008) in his study of the archaeofauna of the Puebloan sites of the San Juan Basin in the American Southwest, measured the cortical thickness of both identified and unidentified long bone. The data provided a check on the relative frequency of the identified small and large animal remains. Cortical thicknesses of 2mm or less indicated the presence of small animals such as birds, rodents and rabbits while measurements of more than 2mm suggested the occurrence of larger animals such as deer and large carnivores. His results indicated a higher frequency of larger animals in the unidentified bone sample which he attributed to either recovery bias or the intense processing and fragmentation of the long bones of larger animals. More recently Badenhorst and Henshilwood (2010) measured the cortical thickness of a sample of identified faunal remains from BBC. This sample includes commonly occurring small species such as Cape dune molerat (*Bathyergus suillus*) and rock hyrax (*Procavia capensis*) and large mammals such as eland (*Tragelaphus oryx*).

In my study, where possible, the cortical thickness of unidentified long bone fragments from BBC is correlated with the size class of the animal from which it derives. By assigning bone fragments to size classes, unidentified bone fragments can be compared to identified faunal remains to investigate whether the size classes of the unidentified fragments mimic the animal size classes represented in the identified fauna. The methodological implications are discussed further in Chapter 4.

2.3.3 Fracture patterns

Bone is a complex composite structure consisting of both mineral and organic materials (Carbone & Keel 1985; Steele & Bramblett 1988; Lyman 1994). Its mineral content imparts rigidity and hardness while the organic compounds give it resilience and elasticity (Carbone & Keel 1985; Gupta & Zouipos 2008). Living bone contains moisture and is ductile while, post-mortem, bone is dry and brittle. Fracture patterns therefore differ between bone fragmented ante or peri-mortem and bone fragmented post-mortem (Johnson 1985). Differentiating between green-bone or 'fresh' and brittle-bone or 'dry' fractures may suggest whether fragmentation was the result of pre- or post-depositional processes (Johnson 1985; Villa & Mahieu 1991; Lyman 1994; Marean *et al.* 2000). In addition, fracture angle and outline patterns are useful indicators of pre and post-depositional processes affecting faunal remains and may differentiate 'fresh' from 'dry' bone breakage (Shipman *et al.* 1981; Villa *et al.* 1986, Villa & Mahieu 1991; Lyman 1994; Marean *et al.* 2000).

While spiral fractures reflect green bone breakage and have been associated with human marrow processing activity (Pickering *et al.* 2005), this is not necessarily the case (Haynes 1983, Haynes & Stanford 1984; Myers *et al.* 1980). Both humans and carnivores, such as hyenas and jackals, break open and fragment 'fresh' bone to extract it's nutrients, in the process producing spirally-fractured bone fragments (Brain 1967a, 1974a, 1981; Marean 1991, Marean *et al.* 1992, Marean & Bertino 1994). The result is a classic case of equifinality: both human and non-human fragmentation processes result in the destruction of the diagnostic epiphysis and an increase in unidentified shaft fragments. Breakage patterns, therefore, would not reveal the actors involved the fragmentation process but in conjunction with other analytical methods they could confirm whether humans played a dominant role as the accumulators of fauna (Gifford 1981; Marean *et al.* 2000; Thompson 2008, 2010).

Extensive research has been undertaken on differentiating fresh and dry bone breakage patterns in zooarchaeology (e.g., Sadek-Karoos 1972, Noe-Nygaard 1977, 1989; Myers *et al.* 1980; Bunn 1983b; Todd & Rapson 1988; Villa & Mahieu 1991; Marean *et al.* 2000; Outram 2001, 2002, Thompson 2010, Thompson & Henshilwood 2011). Dart (1957) proposed that hominids, utilising a 'crack-and-twist' method of breaking bone, produced spiral fractures in extracting marrow and producing bone tools. This pattern was later shown to be the result of hyenas (Brain 1967a, 1981; Klein 1977; Maguire 1980). An early experimental study on the fragmentation patterns of identified long bone was done by Sadek-Karoos (1972). She looked at the fracture patterns of sheep metatarsals from Jaguar Cave in Idaho in order to devise a method of studying intentional breakage. Her research was one of the first attempts by

archaeologists to gain an empirical understanding of breakage patterns. Biddick and Tomenchuck (1975) developed a computer-aided co-ordinate system of recording fracture outlines. Johnson (1985) outlined a set of criteria used by many analysts to differentiate between dry and fresh bone breakage. In her extensive review of the properties and fracture mechanics of archaeological bone, she described the biomechanics of spiral fractures and how they differ from other types of breakage. She also noted that although spiral fractures reflect fresh bone breakage, they did not signify the agent(s) of fracture.

Villa and Mahieu (1991) modified Johnson's (1985) set of criteria in their investigation of human long bone fracture patterns. They analysed long bone breakage patterns from three prehistoric human burial sites in France, each with a unique taphonomic history. The Sarrians assemblage is a collective burial dating to about 2500 BCE with bones broken by sediment pressure. Conjoining fragments lay next to one another and incomplete fractures were noted in some specimens. The Fontbregoua cave site (~ 4000 BCE) is believed to be an assemblage of cannibalised long bones, broken for marrow extraction (i.e. green-bone fractures) (Villa *et al.* 1986). Twenty percent of the bones have impact notches and 30% have cut marks indicating human activity. The Bezouc assemblage is a Stone Age collective burial with bones broken during excavation. The aim of their research was to analyse fresh versus dry bone breakage. In doing so they observed the fracture angle and the fracture outline or shape and measured the degree of shaft fragmentation by tabulating the shaft circumference versus the shaft length.

The Sarrians and Bezouc (dry fractured) assemblages were similar to one another and both differed from the freshly fractured Fontbregoua collection. Fracture angles from the 'dry' material tended to be perpendicular to the long bone axis (or 'right-angled') while those for the 'fresh' material were oblique (acute and obtuse) (Figure 2.1). For the 'dry' assemblages, fracture surfaces tended to be jagged as opposed to the smooth surfaces of 'fresh' fractured bones. Fracture outlines for the 'dry' bones were more transverse (i.e. straight and transverse to the long bone axis) while the Fontbregoua bones were oblique or V-shaped (i.e. spiral fractures) (Figure 2.2). Almost 80% of the Fontbregoua bone had splintered diaphysis with less than half the circumference remaining, in contrast to the almost complete shaft diameters of the 'dry' assemblages.

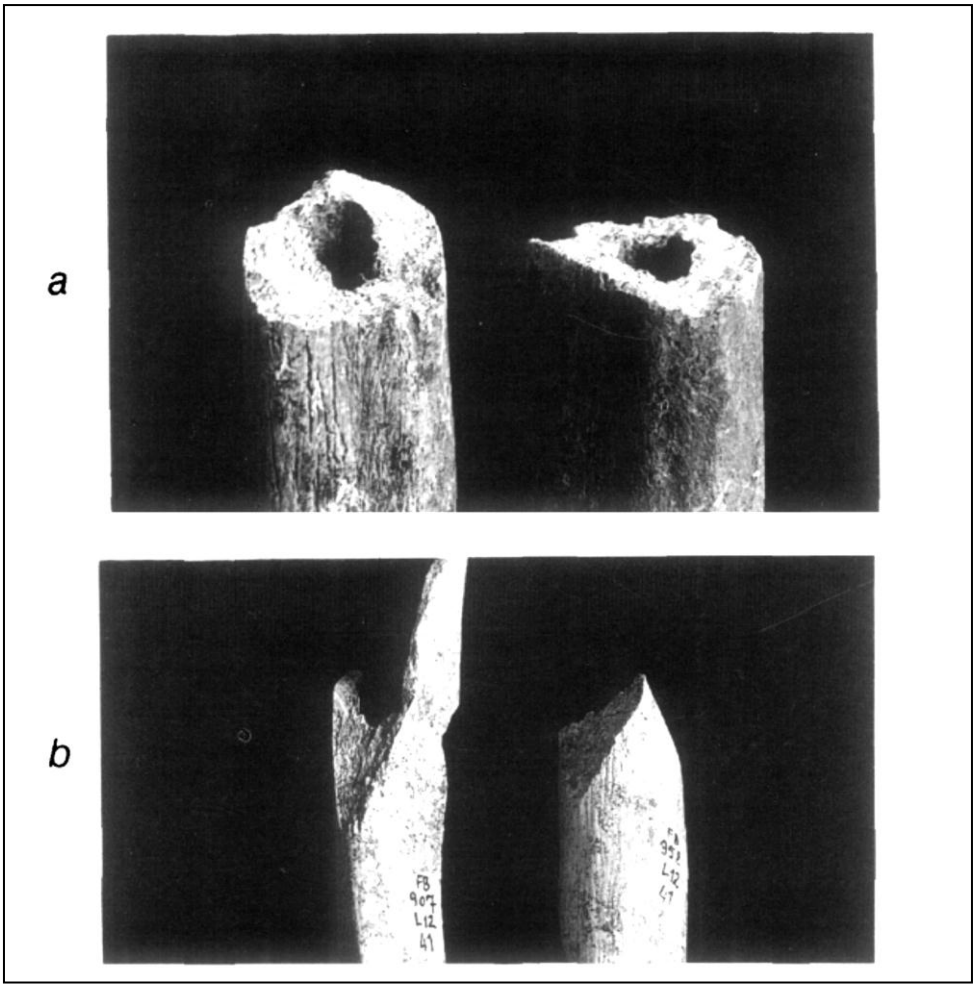


Figure 2.1: Fracture angles. Dry bone breakage results in perpendicular fracture angles in long bone shafts (a). Fresh bone breakage results in oblique fracture angles (b). Note the roughness of the dry fractured specimen (a) versus the smooth surface of the fresh fractured specimen (b) (Image from Villa & Mahieu 1991)

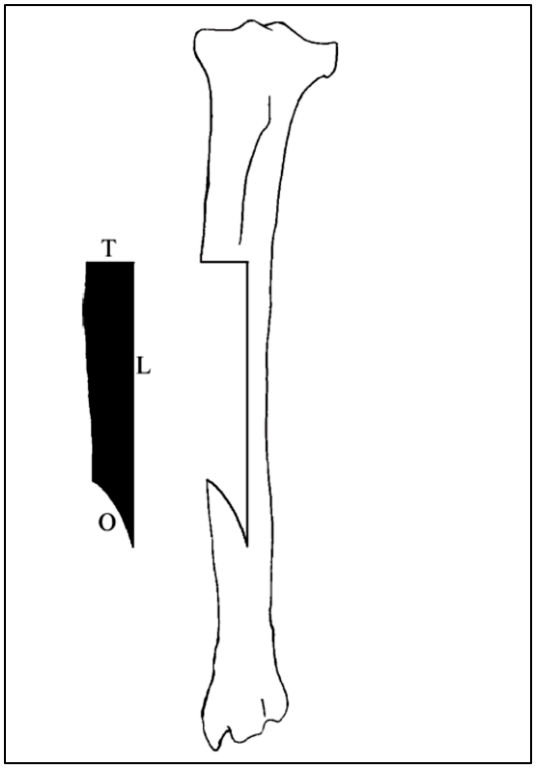


Figure 2.2: **Fracture outlines.** Dry bone breakage results in longitudinal (L) and transverse (T) fractures outlines on long bone fragments. Fresh bone breakage results in spiral or oblique (O) fractures. (Figure from Pickering *et al.* 2005)

Outram (2001) in his review of bone fat exploitation methods proposes models for expected patterns in bone fracture and fragmentation. While he found no accounts of bone grease production in people from warm climates, he noted that marrow exploitation was ubiquitous amongst hunting peoples. Like previous researchers, such as Noe-Nygaard (1977) and Villa and Mahieu (1991), he found that fracture patterns can be assessed from unidentified shaft fragments and devised an index to determine whether fresh or dry breakage dominated faunal assemblages.

The analyses of bone breakage patterns have also been used to investigate subsistence activities in Pleistocene and Late Quaternary sites in southern Africa. For example, Marean *et al.* (2000) utilised Villa and Mahieu's (1991) procedures in their analysis of the fracture patterns of the Die Kelders MSA fauna in the south-western Cape. They found that the frequencies of breakage types varied between body size class in Layer 10 and 11, dating to around Marine Isotope Stage (MIS) 4. Layer 11 had a higher frequency of breaks indicative of green bone fractures while the frequency of dry bone breaks was not significantly different

between the two layers. The frequencies of 'right-angled' and transverse bone breakage suggests that about 10 to 15% of the breaks in Layer 10 and 11 were likely the result of post-depositional breakage (Marean *et al.* 2000: 208). Pickering *et al.* (2005) used an alternative method of analysing fracture patterns to explain the role of hominids as bone accumulators. They observed the fracture plane and angle of ungulate limb bones from Member 3 of the Plio-Pleistocene Swartkrans site. Their research indicated that statistically significant differences exist between fracture planes caused by hammer-stones (dynamic loading) and those caused by chewing activities (static loading). They found that carnivores were probably responsible for the majority of the faunal collection. Like most other research, the above studies were undertaken to confirm hominid or carnivore activity from the assemblages. These studies involved only identifiable bone, unlike Brain's (1969, 1981) studies.

The analysis of long bone fragmentation patterns alludes to the taphonomic history of the assemblage (Brain 1981; Klein & Cruz-Uribe 1984; Marean 1991; Marean *et al.* 2000; Outram 2001, Outram *et al.* 2005). Bone breakage patterns resulting from these processes could indicate marrow extraction activity (Brain 1974a, 1981; Noe-Nygaard 1977; Binford 1981, 1984; Todd & Rapson 1988; Blumenschine 1991; Enloe 1993; Outram 2001; Pickering *et al.* 2005; Bar-Oz & Munro 2007) but would not differentiate between human and non-human fracturing agents (Johnson 1985; Lyman 1994).

2.3.4 Taphonomic agents associated with bone fragments

Taphonomic processes are the agents responsible for any alteration to faunal remains, including the production of unidentified bone fragments. Taphonomy has been defined as "*the study of processes that operate on organic remains after death to form fossil deposits*" (Gifford 1981: 366). Exposure to the elements (weathering), gnawing by rodents or carnivores, trampling, burning and butchering all act as agents of modification and fragmentation of bone (Behrensmeyer 1978; Bunn 1983b; Hill 1983; Bunn *et al.* 1988; Marean & Spencer 1991; Lyman 1994; Selvaggio 1994, 1998; Reitz & Wing 1999; O'Connor 2000; Conard *et al.* 2008). Burned bone, for example, is commonly fragmented in archaeological assemblages (cf. Stiner *et al.* 1995; Cain 2005; Clark 2009; Clark & Ligouis 2010). Chemical changes to the bone caused by water percolation, gastric acids, penetration

of roots, chemical composition of soil and natural decomposition could result in their further fragmentation (Behrensmeyer 1978; Gifford 1981). These diagenetic processes have to be taken into account if the fragmentation of a faunal assemblage is to be assessed (Johnson 1985; Behrensmeyer *et al.* 2000; O'Connor 2000).

There is extensive documentation on the role of taphonomy in the formation of bone assemblages and bone fragmentation. Brain (1967a, 1967b) noted that trampling and the effects of weathering and sand abrasion are significant contributors to the production of 'pseudo-tool' bones. These bone fragments, believed to be tools by Dart, were more likely produced by natural taphonomic processes (Brain 1981). In his seminal publication on cave taphonomy, Brain (1981) demonstrated the significance of both human and natural processes in the fragmentation of bone. He collected a wide range of ethnographic and actualistic data as well as documenting the activities of large carnivores and weathering in the modification of bone.

Burning also plays a significant role in bone fragmentation (Brain 1981; McKinley 1994; Stiner *et al.* 1995, 2005; Costamagno *et al.* 2005; Cain 2005; Clark & Plug 2008; Clark 2009; Clark & Ligouis 2010). Clark (2009), in her study of the MSA fauna from Sibudu Cave, noted that the majority of remains were burned, constituting more than 95% of fauna in some layers. She argued that the high degree of fragmentation of the Sibudu Cave assemblage was probably related to burning since burning desiccates bone, making it brittle and more likely to fragment. Considering the number of hearths, evidence of cut marks and the associated bone and stone tool collections, humans, as opposed to natural bush fires were the likely bone collectors at Sibudu Cave.

In the southern Cape, the study of the taphonomy of MSA long bone fragments has had a significant impact on the interpretation of human subsistence models (Binford 1984; Klein 1989; Milo 1998; Bartram & Marean 1999; Klein et al. 1999b). In particular, it has been suggested that the exclusion of long bone fragments has biased the interpretations of skeletal part frequencies from southern Cape sites (Marean *et al.* 1992; Marean 1998, 2005; Marean & Kim 1998; Bartram & Marean 1999). For example, in his analysis of the Klasies River fauna, Klein (1976) attributed the under-representation of large bovid proximal long bone elements relative to smaller bovids to the 'schlepp effect' (Perkins & Daly 1968). The schlepp effect suggests that carcasses were dragged back to camps or home bases with the hides still attached, using the feet as handles. This pattern, however, has been argued to be the

result of excavator bias (Turner 1989; Bartram & Marean 1999). Turner (1989: 5) noted that taxonomically 'undiagnosable' bone did not form part of Klein's (1976) analysis. Bartram & Marean (1999: 10) have argued that the fragmentation of upper-limb bones for marrow by both humans and carnivores have contributed to this pattern, which they call the 'Klasies pattern'. The taphonomic analysis of unidentified long bone fragments has been accepted as a significant aspect of Pleistocene zooarchaeological studies (Brain 1981; Marean 1991, Marean *et al.* 1992, Marean & Bertino 1994). Research in the 'refitting' of long bone fragments, for example, has attempted to eliminate these unidentified fragments and increase the number of identifiable specimens (e.g., Marean *et al.* 2000; Pickering 2002, Ogola 2003, 2009; Pickering *et al.* 2003; Yeshurun *et al.* 2007; Yravedra & Dominguez-Rodrigo 2009).

Anthropogenic modification to bone. Anthropogenic modifications on bone such as cut marks and percussive marks are good indicators of human subsistence activity (Noe-Nygaard 1977, 1989; Binford 1981, 1984; Bunn 1981, 1983a, Potts & Shipman 1981; Shipman 1983, 1986a; Bunn & Kroll 1986; Fisher 1995; Marean 1998, Marean & Kim 1998, Milo 1998; Marean *et al.* 2000; Pickering 2002). Long bones more commonly exhibit surface modification consistent with human activity (Binford 1981; Brain 1981; Bunn & Kroll 1986; Shipman 1986b; Blumenschine & Madrigal 1993; Enloe 1993; Capaldo 1997; Dominguez-Rodrigo 2002). Cut and percussion marks are therefore likely to occur on long bone fragments (Binford 1981; Brain 1981; Enloe 1993; Fisher 1995; Thompson 2010; Thompson & Henshilwood 2011). Researchers agree that percussion and carnivore tooth marks are indicative of marrow extraction activities (Binford 1981, 1984; Brain 1981; Bunn 1981; Potts & Shipman 1981; Blumenschine 1986; Davis 1987; Blumenschine & Selvaggio1988; Lyman 1994, 2008; Reitz & Wing 1999; Pickering & Engeland 2006). Some researcher's caution that human and animal-produced marks may be difficult to differentiate (Bunn & Kroll 1986; Villa & Mahieu 1991; Lyman 1994) and that cut marks may be the result of natural processes such as animal trampling (Shipman 1981a; Shipman & Rose 1984; Andrews & Cook 1985; Behrensmeyer *et al.* 1986; Olsen & Shipman 1988). Percussion-marked long bone shafts, however, appear to be significantly indicative of human activity (Johnson 1985; Villa *et al.* 1986; Blumenschine & Selvaggio 1988; Villa & Mahieu 1991; Marean *et al*. 2000; Pickering & Egeland 2006).

The above research indicates that the analysis of surface modification caused by taphonomic processes on bone reveals both human and carnivore subsistence strategies. The stratigraphic prevalence of taphonomic marks in MSA faunal assemblages, such as those from BBC, can

be used to explore hunting behaviour during the Still Bay period. In the next chapter, the significance of this period and BBC is explored.

CHAPTER 3: BACKGROUND TO BLOMBOS CAVE

This chapter focuses on BBC and describes the site's depositional history, geology and stratigraphy. I discuss first the chronology of the deposits within BBC and the palaeoenvironment of the surrounding area at the time the site was occupied during the MSA. I then review the archaeological background of BBC with particular emphasis on the Still Bay techno-complex, the focus period for this study, and describe the BBC faunal assemblage and taphonomy.

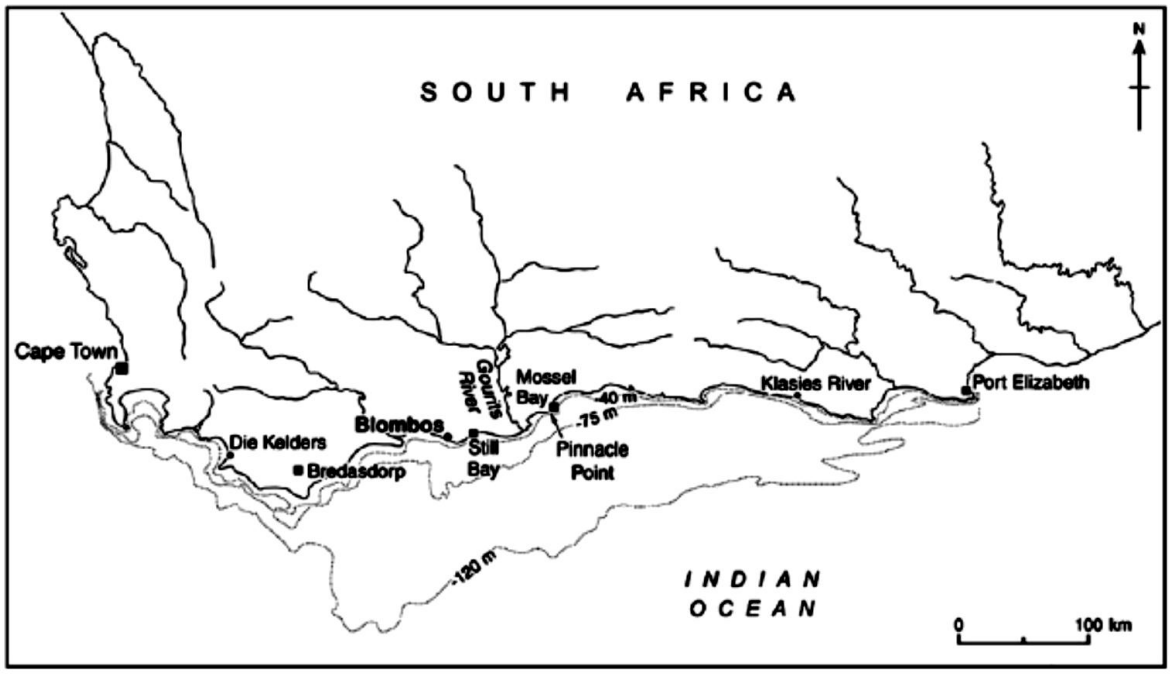


Figure 3.1: Map showing Blombos Cave, Die Kelders, Pinnacle Point and Klasies River (Image from Jacobs *et al.* 2006)

3.1 Site Description

BBC lies on the southern Cape coast about 300 km east of Cape Town and 25 km west of the town of Still Bay (Figure 3.1). It is located at 34˚25´S, 21˚13´E approximately 100 m from the Indian Ocean and 34.5 m above sea level. The entrance to the cave is about 10 m long and

1.5 m high and 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 cave under the Bredasdorp Group sediments (Henshilwood *et al.* 2001b). These sediments consist of shelly conglomerate and marine sands of the De Hoopvlei Formation which, in turn, is overlain by the aeolian sands of the Pliocene-aged Wankoe Formation that represents the volumetric bulk of the Bredasdorp Group. (Malan 1989; Henshilwood 2008a). The interior of the cave is small, compared to other MSA cave sites along the southern Cape coast such as Pinnacle Point and Klasies River, with the surface area of the cave floor behind the drip line about $55m^2$ in size. Within the cave, the 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.* 2001b). Ground waters rich in $CaCO_3$ (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: 442).

Excavations commenced in 1991 and regular excavation seasons have occurred between 1991 and the present. The surface area of BBC is divided into square metres and further divided into 0.5 m quadrates. The word 'layer' has been used to describe a single stratum that has accumulated through natural and /or human deposition. Layers may differ from each other with regard to texture, colour, or composition (Henshilwood *et al.* 2001b: 424). At BBC, layers have been grouped into phases. Henshilwood *et al.* (2001b: 425) define a phase as "*a chronologically limited cultural unit within a local cultural sequence. Each phase is made up of a number of different layers with similar diagnostic traits that sets it apart from other phases.*"

The BBC stratigraphic sequence consists of three LSA and four MSA occupation phases. When excavations began, the mouth of the cave was almost completely sealed by dune sand. Approximately 20 cm of aeolian sand overlaid the surface of the LSA layer suggesting that the contents of the cave had not been disturbed since the final LSA occupation at around 290 years ago (Henshilwood 2005). The LSA deposits have been dated using accelerator mass spectrometry (AMS) radiocarbon dating to between 290 and 2000 years BP (Henshilwood 2008a). A sterile layer of yellow dune sand between five and 50 cm thick separated the LSA and MSA layers. This layer, named BBC Hiatus, most likely blew into the unoccupied cave during lowered sea levels at ~ 70 ka. Soon afterward the entrance to the cave was blocked by a sand dune and likely only re-opened during the mid-Holocene when the base of the dune

was eroded by higher sea levels (Henshilwood 2008a). The MSA layers are composed mostly of aeolian, marine-derived dune sand blown in through the entrance of the cave (Henshilwood 2005).

The MSA layers are divided into four phases based on their stratigraphic position and composition: an M1 phase; an upper and lower M2 phase; and a M3 phase in the bottom layers. The four upper most layers below BBC Hiatus have been assigned to the M1 phase (Henshilwood *et al.* 2001b). This phase consist of medium brown sands surrounding lenses of shell, stone and bone, and numerous small basin-shaped hearths (Henshilwood *et al.* 2001b; Henshilwood 2005). The M1 and upper M2 phases contain bifacially worked lanceolate points, the *fossile directeurs* of the Still Bay techno-complex, and end and side scrapers (Figure 3.2) (Goodwin & Van Riet Lowe 1929; Henshilwood *et al.* 2001b; Villa *et al.* 2009; Mourre *et al.* 2010). Two engraved ochre plaques, about 40 perforated shell beads, formal bone tools and an engraved bone fragment have also been recovered from these phases, in addition to three human teeth (Henshilwood & Sealy 1997; Grine *et al.* 2000; Henshilwood *et al.* 2001a, 2001b, 2002, 2004; Grine & Henshilwood 2002; d'Errico *et al.* 2003, d'Errico & Henshilwood 2007). The lower M2 phase contains small quantities of flakes, blades and cores, a few pieces of ochre and hearths. Shell beads, bifacial points and bone tools are absent from this phase (Thompson & Henshilwood 2011).

In my study, the stratigraphy of the MSA has been consolidated into broad units. For example, Layer CFA and CFC are grouped into Layer CF while Layers CAA and CAB become Layer CA. The M1 phase consists of Layers CA, CB, CC, CD while the upper M2 phase consist of Layer CF. The pre-Still Bay lower M2 phase consist of Layer CG (Figure 3.3).

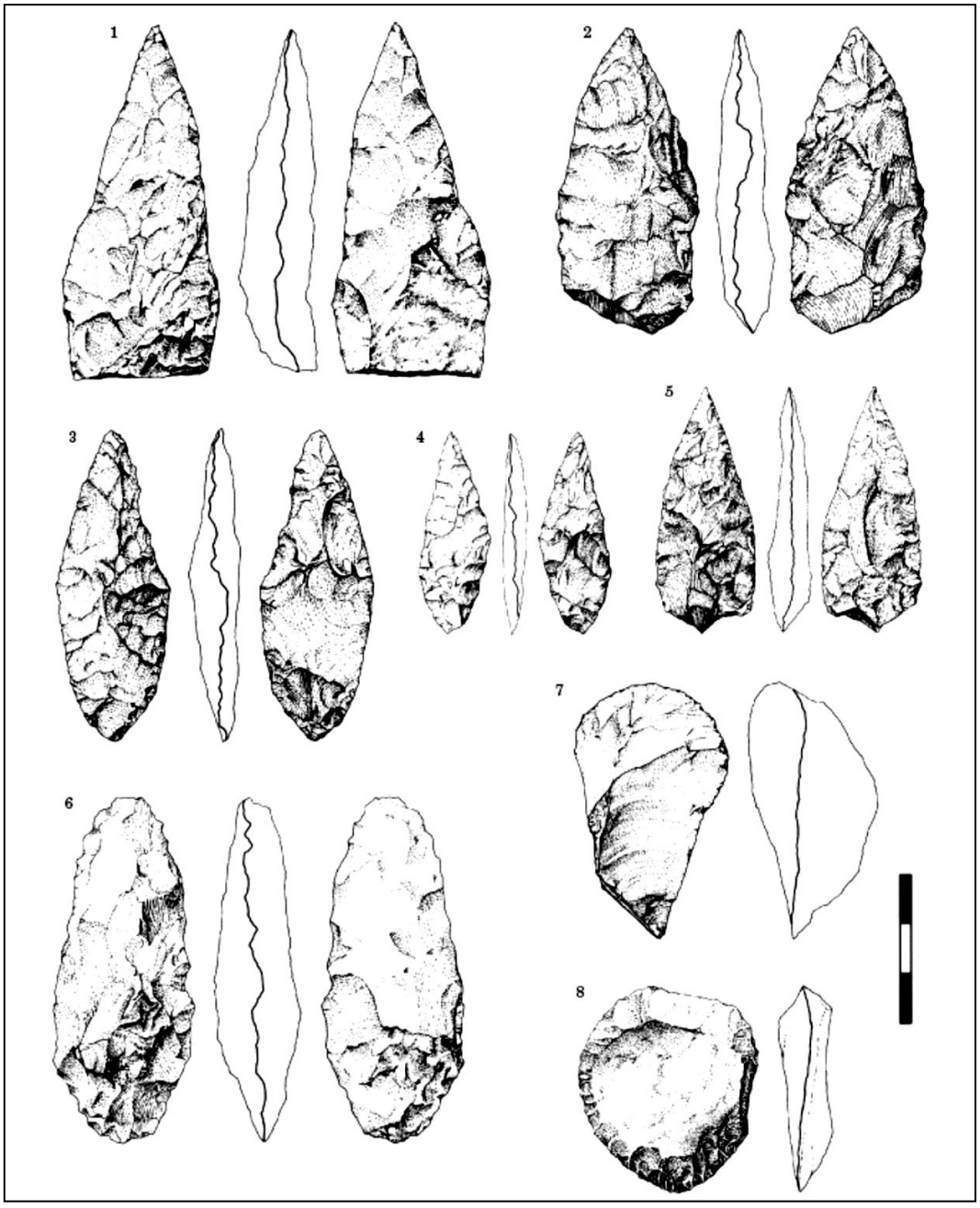


Figure 3.2: Stone tools from the M1 at BBC. Numbers 1 – 6 are lanceolate bifacial ('Still Bay') points and 7 and 8 are convex scrapers (Figure from Henshilwood *et al.* 2001b)

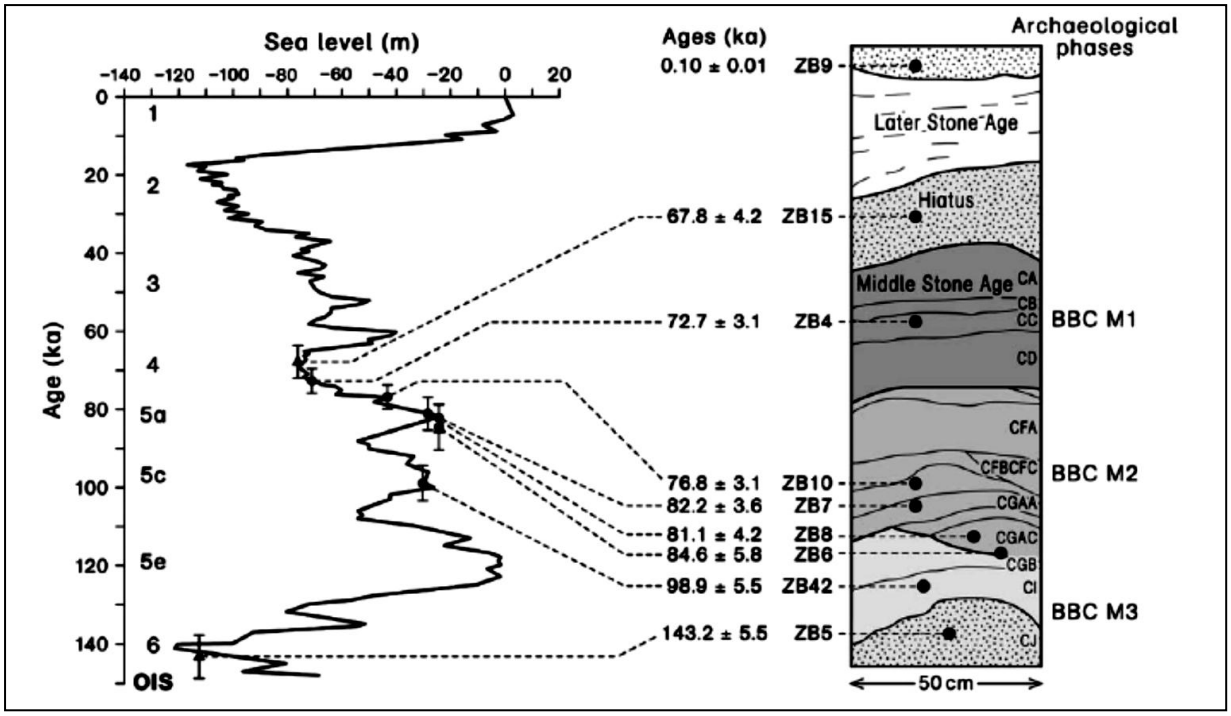


Figure 3.3: Stratigraphy and OSL ages at BBC (Figure from Jacobs *et al.* 2006)

3.2 Dating and Chronology

BBC has been extensively dated using a number of methods (Jacobs *et al.* 2003a, 2003b, 2006; Tribolo *et al.* 2005, 2006; Henshilwood 2008a). Current evidence indicates that the Still Bay occurred between ~ 77 and 72 ka (Henshilwood 2008b, Henshilwood & Dubreuil 2011). An optically stimulated luminescence (OSL) age of 72.7 ± 3.1 ka was obtained for the upper level of the M1 phase from Layer CC (Jacobs *et al.* 2003a, 2003b). Thermoluminescence (TL) age estimates suggest that between 74 ± 5 ka and 78 ± 6 ka are the likely time period for the M1 layers (Tribolo *et al.* 2006). Jacobs *et al.* (2006) place the M2 phase between 84.6 ± 5.8 ka and 76.8 ± 3.1 ka. An OSL age of 76.8 ± 3.1 ka was obtained from the upper M2 (Layer CF), while the lower M2 (Layer CG) yielded an OSL date of 84.6 ± 3.1 ka (Jacobs *et al.* 2006; Henshilwood 2008b) (Figure 3.3).

3.3 Palaeoenvironment

The southern Cape is a region of dynamic climatic variability (Carr *et al.* 2007). The vegetation near BBC comprises mostly fynbos; evergreen sclerophyllous shrubland that dominants the Western Cape Province of South Africa, including most of the southern coastal region (Goldblatt 1997; Henshilwood *et al.* 2001b). BBC occurs at the interface of two major climatic regions, the winter and summer rainfall zones, and has year-round precipitation (Carr *et al.* 2006, 2007; Chase & Meadows 2007; Roberts *et al.* 2008). In addition, this area is also situated near the convergence of the cold Benguela and warm Agulhas oceanographic systems (Barrable *et al.* 2002; Carr *et al.* 2006, 2007; Roberts *et al.* 2008).

The MSA II industry preceded the Still Bay techno-complex in the southern Cape and occurs at sites such as Klasies River (Singer & Wymer 1982; Wurz 2002). The MSA II was prevalent during a cool climatic period (Carr *et al.* 2007; Chase & Meadows 2007; Henshilwood 2008b) and coincided with one of the driest periods in the African Quaternary between 101 – 70 ka (MIS 5c – MIS 5b) (Deacon *et al.* 1988; Pinot *et al.* 1999; Cohen *et al.* 2007; Scholz *et al.* 2007; Barham & Mitchell 2008; Jacobs & Roberts 2008; Compton 2011). The pre-Still Bay lower M2 phase (Layer CG) at BBC is broadly contemporaneous with the MSA II Upper industry at Klasies River but it may also correlate to the time period where there was no occupation at this site, as indicated in the RF Member (Wurz 2002).

MIS 5a generally correlates with the lower M1 and upper M2 phase at BBC with the upper M1 layers corresponding to the beginning of MIS 4 (Thompson & Henshilwood 2011: 13). The early Still Bay period at BBC (the upper M2 phase) occurred during a temperate environment with climatic conditions in southern Africa during the early and middle stages of MIS 5a likely to have been mild and warm (Henshilwood 2007, 2008b: 42). Sea-levels were about 25m lower than present with the coastline less than 3km from the present shore (Henshilwood 2007). The M1 Still Bay phase occurred during a cooler period (MIS 5a/ 4) when sea-levels dropped to 60 – 70 m below present and the shore extended 10 – 25km from the current shoreline (Carr *et al.* 2007; Henshilwood 2007, 2008b; Compton 2011). Following the MIS 5a/ 4 transition, MIS 4 was cool and arid (Chase 2010; Jacobs & Roberts 2008). Chase (2010), however, has recently proposed that, rather than being dry, MIS 4 was a moist period. He suggests that increased interaction between temperate and tropical climatic systems resulted in more humid condition along the southern Cape coast during MIS 4 (Chase 2010: 1364). Speleothem data from Pinnacle Point suggests that ~72 to 63 ka was a period of climatic and environmental instability and that a major climatic and environmental event occurred at about 72 ka, concordant with the end of the Still Bay. The Speleothem

records also show that summer-rainfall and C4 grasses were more abundant along the southern Cape coast during the Still Bay time period than they are today (Bar-Matthews *et al.* 2010: 2143).

Analyses of the BBC fauna also suggest that the MSA environment was moister and grassier in the M1 and upper M2 phases than it is today (Henshilwood *et al.* 2001b: 438). Bergmann's Rule states that "*races of warm blooded vertebrates from cooler climates tend to be larger than races of the same species from warmer climates*" (Mayr 1956: 105). Studies by Klein (1991; Klein & Cruz-Uribe 1996), however, suggest that variation in the mean adult size of small mammals, such as molerats, is more closely linked to precipitation than to temperature. Molerats that live in moist conditions tend to be larger than those that live in drier environments. On average, the BBC MSA molerats were significantly larger than those living during the LSA. Although Klein (Henshilwood *et al.* 2001b) did not differentiate between the upper and lower M2, he notes that during the M2 molerats were slightly larger (although not significantly so) than their M1 successors (Henshilwood *et al.* 2001b). The presence of solitary, highly territorial browsers such as steenbok (*Raphicerus campestris*) and common duiker (*Sylvicapra grimmia*) also supports a bushy environment (Thompson & Henshilwood 2011). This confirms palaeoclimatic evidence that the M2 was wetter and more temperate than the M1 period (Henshilwood 2008b).

3.4 Archaeological Context: The Still Bay

The archaeology of the M1 phase at BBC is dominated by the Still Bay cultural stratigraphic period (Henshilwood *et al.* 2001b; Henshilwood 2008a). The term 'Still Bay' was first used by C. Heese at the beginning of the 20th century to describe lanceolate-shaped bifacial points he discovered near the village of Still Bay in the early 1900s (Goodwin 1933). The term was refined by Goodwin and Van Riet Lowe (1929) to also include 'oak-leafed' shaped 'spear points' on the basis of lithics discovered at a number of MSA sites on the Cape Peninsula (Wadley 2007). Goodwin suggested that the Still Bay represented the end of a long development "*which gave the makers an amazing control over their material*" (Goodwin 1933: 521). Later, Still Bay was also used to include other lithic stages such as the 'Mossel Bay' (Malan 1955).

By the 1970's, however, Sampson (1974) questioned the validity of the Still Bay as a material culture. The term fell into disuse and was not included in Volman's (1981, 1984) review of the southern African MSA. Excavations at Hollow Rock Shelter in the Western Cape and at BBC in the 1990's uncovered lithics conforming to the Still Bay type as defined by Goodwin and Van Riet Lowe (1929; see also Evans 1994; Henshilwood 1995, 2008a). Henshilwood *et al.* (2001b: 429) proposed that the term be reinstated in their site report as a "*regional, cultural-stratigraphic term for assemblages with fully bifacially flaked, lanceolate shaped points.*" In the past two decades, Still Bay lithics have also been recovered at Diepkloof in the Western Cape and Sibudu in KwaZulu- Natal (Parkington *et al.* 2005; Wadley 2007).

The Still Bay is regarded as an archaeologically significant period in the emergence of modern human behaviour (d'Errico 2003, d'Errico *et al.* 2001, 2003; Henshilwood *et al.* 2001b, 2002, 2004; Minichillo 2005; Mellars 2006; McCall 2007; Wadley 2007; Lombard & Clark 2008; d'Errico & Stringer 2011; Henshilwood & Dubreuil 2011). Behavioural modernity has been characterised as behaviour mediated by symbolism and, in extant societies, includes the expression of personal or group identity through personal ornamentation (Chase & Dibble 1987; McBrearty & Brooks 2000; Wadley 2001; Henshilwood & Marean 2006). Other characteristics include innovative technologies (such as increased artefact diversity) (Klein 1995), demographic expansion (Powell *et al.* 2009) and resource intensification (for a detailed review see McBrearty & Brooks 2000). The evolution of 'modern' human behaviour, and what defines it, is a contentious issue (Noble & Davidson 1993; McBrearty & Brooks 2000; Shennan 2001; Stringer 2002; Phillipson 2005; Mellars 2005; Ambrose 2006; Henshilwood & Marean 2006; Minichillo 2006; Coolidge & Wynn 2007; Szathmary & Szamado 2008; Wynn 2009; Henshilwood & Dubreuil 2011; Wynn & Coolidge 2011). Much of the debate regarding behavioural modernity focuses on when it first occurs in the archaeological record (Klein 2000; McBrearty & Brooks 2000; d'Errico *et al.* 2003; Henshilwood & Marean 2006), whether symbolic artefacts equate with modern behaviour (Wynn & Coolidge 2007; Malafouris 2008; Wynn 2009) and whether these behaviours were the result of a neuro-cognitive adaptation in the Late Pleistocene (Klein 2000, 2009; Enard *et al.* 2002; Coolidge & Wynn 2007; Henshilwood & Dubreuil 2011). Personal ornaments are regarded as definitive indicators of behavioural modernity (Klein 1995; d'Errico *et al.* 2003, 2005; Henshilwood *et al.* 2004; Mellars 2006; Henshilwood & Dubreuil 2011). The engraved bone and perforated shell beads recovered from the c. 78 – 72

ka Still Bay units and the ochre plagues from the c. 100 – 73 ka units at BBC (Figure 3.4) show that by at least 100 ka, southern African people imbued artefacts with symbolic meaning and were, for all intents and purposes, 'modern' (Henshilwood *et al.* 2002, 2004, 2009; d'Errico *et al.* 2003; Wadley 2007, but see Klein 2000, 2001, 2003, 2009; Wynn & Coolidge 2007; Malafouris 2008; Wynn 2009 and comments on Henshilwood & Dubreuil 2011 for counter-arguments).

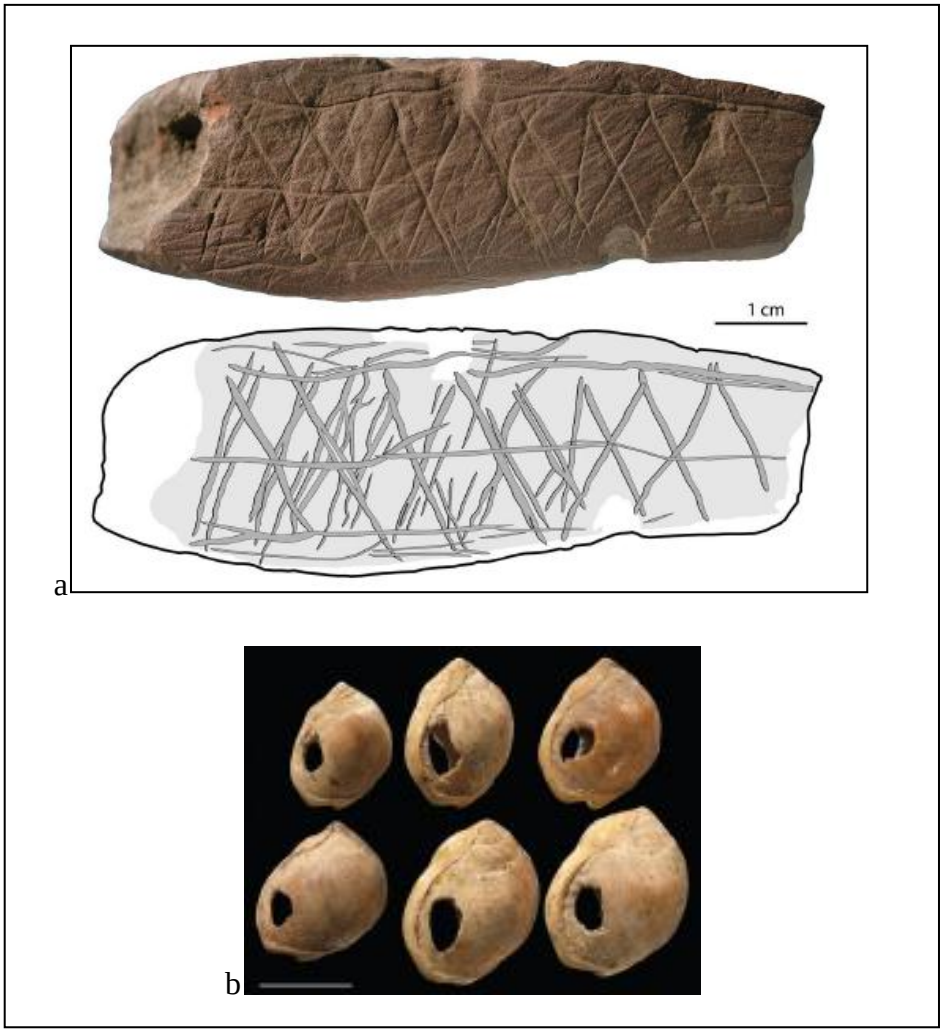


Figure 3.4: Engraved ochre (a) and pierced shell beads (b) from the Still Bay layers at BBC (Images from Henshilwood *et al.* 2009 [a] and Henshilwood *et al.* 2004 [b])

The lanceolate shaped bifacial points that define the Still Bay are associated with a period where innovative technologies are integrated with modern subsistence behaviour (for

example, fishing) and social practices during the Late Pleistocene (Henshilwood *et al.* 2001b, 2002; Henshilwood 2008a; Villa *et al.* 2009). This techno-complex coincided with both an increase in the complexity of cognitive behaviour amongst southern Cape coastal people (in the form of the emergence of symbolism), and a period of demographic expansion by modern humans out of Africa between ~ 80 and 60 ka (Lahr & Foley 1998; Henshilwood *et al.* 2002; Mellars 2006; Behar *et al.* 2008; Henshilwood 2008b; Villa *et al.* 2009; Mourre *et al.* 2010).

3.5 The Blombos Cave Fauna

3.5.1 Klein's analysis (1992 – 2000 excavations)

BBC is the first site where well preserved faunal remains have been recovered in association with Still Bay lithics. Klein (Henshilwood *et al.* 2001b) analysed the fauna from the MSA and LSA layers at BBC recovered between 1992 and 2000. He found that small mammals such as Cape dune molerats (*Bathyergus suillus*) and rock hyraxes (*Procavia capensis*) dominate the assemblage and angulate tortoises (*Chersina angulata*) remains are also common. Within the LSA layers, the charring on molerat incisors and premaxillae indicate that these animals were baked, an activity which appears to have continued to recent times (Henshilwood 1997). Some of the oldest known sheep (*Ovis aries*) bones in southern Africa were also recovered from the LSA layers (Henshilwood 1996). In the MSA layers, small browsers such as steenbok (*Raphicerus campestris*), grysbok (*Raphicerus melanotis*) and common duiker (*Sylvicapra grimmia*) were the most numerous ungulates while larger ungulates such as rhinoceros (*Rhinocerotidae* gen.) and eland (*Tragelaphus oryx*) were rarer. The principle carnivores during the M1 and M2 phases were the African wildcat (*Felis silvestris*), genets (*Genetta* sp.) and grey or small grey mongoose (*Galerella pulverulenta*). Cape fur seals (*Arctocephalus pusillus*) were also relatively common in all layers. Few large land-based carnivore bones such as hyaena (*Hyaenidae* gen.) were recovered from the MSA layers suggesting that people were most likely the accumulators of the fauna. For a list of taxa recovered from the M1 and M2 see Chapter 6.3 (Table 6.3).

Acid-etched bone was relatively rare suggesting that, while raptors may account for some of the small mammal fauna, humans were the main contributors to the small mammal faunal assemblage. Klein and Cruz-Uribe (1996) argue that the prevalence of eland (*Tragelaphus*

oryx) over buffalo (*Syncerus caffer*) remains in the MSA layers implies that humans favoured eland which were more placid and probably less common than the nearby, but more aggressive buffalo. This result appeared consistent with Klein's (1982, 1989, 1995, Klein & Cruz-Uribe 2000) hypothesis that MSA people were less effective hunters than their LSA counterparts (for counter-arguments, see Milo 1998; Faith 2008, 2011; Lombard & Clark 2008; Dusseldorp 2010).

3.5.2 Thompson's taphonomic analysis (2000 – 2004 excavations)

Thompson (2008) undertook a taphonomic study of the MSA BBC fauna from the 2000, 2002 and 2004 excavation seasons. Faunal specimens were not identified to species but to general taxonomic groups, at the family level and above, and to element and size class. Her analyses included 'less identifiable' fragments such as long bone shaft splinters and long bone flakes (Thompson & Henshilwood 2011: 751). Thompson (2008) notes that nearly 98% of the identified remains are bovids and that almost 50% of those bovid remains are from size class I. She found a significant difference in the size class distribution between the M1 and M2 phases with the upper and lower M2 showing a high proportion of size I bovids relative to the M1. While ungulate size classes are relatively evenly distributed in the M1, 65% of the M2 ungulate remains are of bovid size class I. The relative proportions of larger mammals, small mammals (< 4.5 kg) and tortoises is similar to that found at Die Kelders Cave 1 (Klein & Cruz-Uribe 2000) and Ysterfontein (Klein *et al.* 2004) in the Western Cape. Mid-shaft fragments are also highly represented at BBC with 67% of long bone fragment from the mid-shaft region. Unidentified long bone fragments would, therefore, be common in the BBC faunal assemblage.

Overall, Thompson and Henshilwood (2011) found a moderate degree of post-depositional fragmentation and believed that the majority of breakage occurred while bones were in a fresh state; implying human marrow extraction activities. Post-depositional fragmentation was more severe in the M1 and upper M2 than in the lower M2. They attribute this to more intensive occupations at BBC resulting from increased trampling and burning activities. Bones of larger animals also appear more heavily fragmented. A substantial amount of long bones were affected by density-mediated destruction with small ungulates less affected than large ungulates (Thompson & Henshilwood 2011: 756). This could imply that carnivore

ravaging may have occurred even though humans were the dominant accumulators. Similarly to Klein (Henshilwood *et al.* 2001b), they found few gastric-etched and rodent-gnawed bones indicating that raptors would have played little role in faunal accumulation at BBC. 'Exfoliated' bone (a destructive process attributed by Thompson to the crystallization of minerals on the bone surface) is relatively high, especially in the M1. Percussion, tooth and cut marks were noted although Thompson (2008) and Thompson and Henshilwood (2011) did not show the proportion of marked specimens, instead using the proportion of epiphyseal, near-epiphyseal or mid-shaft fragments. Their analysis suggests that percussion marks are common throughout all size classes in the lower M2 and M3 while cut marks occur more frequently in the larger size classes in the lower M2 and M3 layers. Burnt bone is relatively common at BBC with 27% of the identified bone showing evidence of burning.

In my study, 'identified BBC fauna' describes the BBC faunal remains analysed by both Klein (Henshilwood *et al.* 2001b), Thompson (2008) and Thompson and Henshilwood (2011). Their assessment is the comparative sample on which the analysis of the unidentified fauna is based. The criteria by which the unidentified faunal remains are analysed are discussed in the next chapter.

CHAPTER 4: METHODOLOGY

In this chapter, I discuss the materials, methods and criteria used to assess the unidentified faunal remains from BBC. In the first section, I provide a background to the BBC faunal material that I analysed and give reasons why I chose to investigate unidentified long bones. I then discuss the criteria used to diagnose and evaluate the unidentified long bone fragments in the dataset.

4.1 Methodological Framework

The initial stages of a zooarchaeological analysis typically involve separating identified from unidentified faunal material. Klein and Cruz-Uribe (1984:17) note that "*nonidentifiable bones are frequently sorted out at a very early stage of the analysis and ignored thereafter.*" Unlike identified faunal remains, unidentified bone fragments cannot be grouped within a zoological typology because they cannot be classified to a taxonomic level (Driver 1992). Since taxonomy cannot be used to identify them, the way unidentified bone fragments are classified is important for their evaluation. In this study each bone fragment was morphometrically measured and morphologically assessed so that the unidentified faunal remains from BBC could be placed within groups.

Bone terminology

Long bones are composed of an epiphysis at each end and a central, mid-shaft diaphysis. The diaphysis consist of a sheath of dense cortical bone (the cortex) surrounding a marrow-filled cavity. Epiphyses consist of trabecula cancellous bone (Figure 4.1) (Steele & Bramblett 1988). In this study, the outer surface of the cortex is referred to as the 'outer cortex'. The inner layer of the cortex (the surface in contact with the marrow) is referred to as the 'inner cortex' (Figure 4.2).

Macroscopic versus microscopic analysis

Some researchers have argued that it is sufficient to assess only 'conspicuous' marks on bone, i.e. human or animal-produced marks that are visible without the aid of microscopy, so as not to 'over-estimate' these behavioural indicators (Bunn 1981; Shipman 1986b; Cruz-Uribe & Klein 1994; Oliver 1994). Cruz-Uribe and Klein (1994: 42), for example, noted that

diagnosing inconspicuous marks was too time-consuming while Oliver (1994) argued that inconspicuous tooth marks could be confused with cut marks. Blumenschine *et al.* (1996: 496) suggest that the exclusion of 'inconspicuous' marks biases results. They argue that bone with conspicuous animal-produced marks are generally destroyed or consumed while those on 'non-identifiable' long bone fragments are ignored. 'Inconspicuous' marks, they propose, are just as significant indicators of human or animal activity as macroscopically visible marks and should not be ignored. In this study, bone fragments were assessed with the aid of a light microscope specifically to observe inconspicuous marks. In the case of percussion marks, for example, the micro-striations that differentiate percussion marks from carnivore tooth marks can only confidently be observed with the aid of a hand lens or microscope (Blumenschine & Salvaggio 1988; Blumenschine *et al.* 1996).

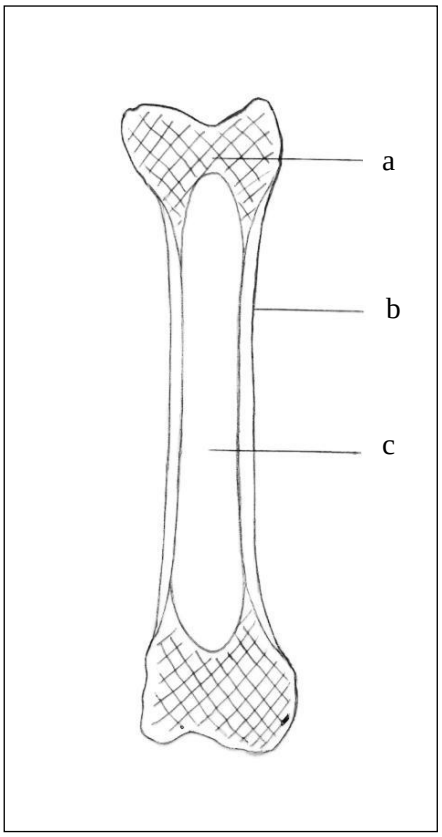


Figure 4.1: Structure of long bone. Epiphyses consist of cancellous bone (a). Diaphysis consist of dense cortical bone or cortex (b) surrounding the marrow cavity (c)

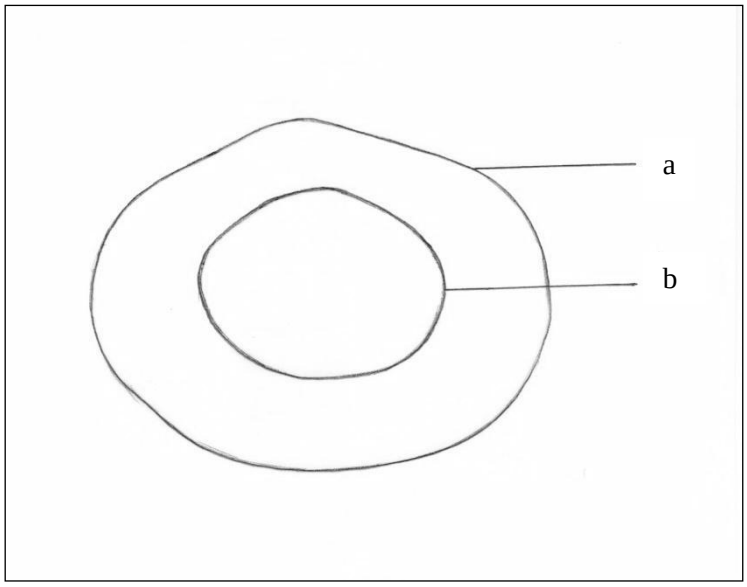


Figure 4.2: Cross-section of long bone shaft. In this study, the outer surface of the cortex is the outer cortex (a). The inner surface of the cortex (the medullary cavity) is the inner cortex (b)

4.2 The Blombos Cave Faunal Material

The faunal remains from BBC are curated at the Iziko Museum of Cape Town. The unidentified macro-mammalian long bone fragments from the M1 and upper M2 phases from BBC were analysed and compared to the faunal remains identified to element (Thompson 2008, Thompson & Henshilwood 2011) and to taxon by Klein (Henshilwood *et al.* 2001b). The macro-mammalian faunal remains excavated in 2000 were analysed by Thompson (2008). This collection is catalogued as 'large mammal identified' (Iziko Museum accession number SAM – AA 8990) because these post-cranial fauna were identified to skeletal element from size 1 to 5 mammals: equivalent of Brain's (1974) size classes. These faunal remains were excavated from squares D2 – D5, G4 – G6, H5 – H6 and I5 at BBC. Unidentified long bone fragments were bagged and catalogued as 'long bone' within the 'large mammal identified' boxes. It is these long bone fragments that I analysed in this study.

Thompson (2008) divided the BBC fauna into 'identified' and 'unidentified' bone. Following Driver's (1999) method, all bone was considered 'identified' if the skeletal elements could be determined. The method that defines the specimen as an element, or part thereof, is the presence of diagnostic landmarks on bone such as articular surfaces, major tuberosities or diagnostic foramen. Marean *et al.* (2000) define faunal material not identified to taxa but

identified to element as ‘unidentified’ while Thompson (2008) classifies bones identified to element as ‘identified’. In this study, cranial, rib and vertebral ‘unidentified’ fragments, as per the methodology of Marean *et al.* (2000), are considered ‘identified’ since they can be assigned to element (*contra* Brain 1974). In my study I analysed the long bone fragments not identified to element or taxonomic groups because:

1. Long bones are well represented in Pleistocene faunal assemblages (Bartram & Marean 1999; Dominguez-Rodrigo 2002; Pickering 2002: 131). Over 90% of the identified faunal remains from BBC are bovids and mid-shaft fragments are well represented (Henshilwood *et al.* 2001b; Thompson 2008, Thompson & Henshilwood 2011). Unidentified long bone fragments should, therefore, constitute a highly representative sample of the unidentified faunal remains at BBC.

2. Long bones are most likely to exhibit surface modification consistent with human activity (Brain 1981; Binford 1981; Bunn & Kroll 1986; Shipman 1986b; Blumenschine & Madrigal 1993; Enloe 1993; Capaldo 1997; Dominguez-Rodrigo 2002). The assessment of surface marks on unidentified long bones fragments could be used to explore aspects of subsistence behaviour during the Still Bay at BBC.

3. Long bone fragments are easy to distinguish because of the contrast between the dense outer cortical bone and sparse (or in the case of processed bone, nonexistent) trabecula inner marrow.

4.3 Bone Fragment Analysis

The four goals of this dissertation include determining the length, cortical thickness and animal size class, fracture patterns and surface modification of the bone fragments and to discuss the behavioural implications of the results. The approach that I follow in analysing these aspects is discussed below.

4.3.1 Fragment length

The morphometric analysis of unidentified long bone fragments involves determining each fragments size. Fragment size, in turn, is a measure of the intensity of fragmentation (Lyman

1994). Different size parameters have been used by different researchers (e.g. Brain 1969; Voigt 1983; Lyman & O'Brien 1987; Lyman 1994; Outram 2001); all involved measuring the length of fragments. In order to limit the number of variables in the analyses, the breadth of cortical fragments was not measured. Only the length of specimens was recorded in this study since previous researchers have used fragment lengths, not breadth, as an indicator of fragmentation (e.g. Brain 1974b, 1975; Enloe 1993; Lyman & O'Brien 1987; Voigt 1983). The length of each fragment was measured to the nearest millimetre with a digital calliper and recorded according to Drivers (1999) coding scale (Table 4.1).

Table 4.1: Classification of fragment length

Code	Fragment length (mm)
1	<10
2	10 - 19.9
3	20 - 29.9
4	30 - 39.9
5	40 - 49.9
6	50 - 59.9
7	60 - 69.9
8	70 - 79.9
9	80 - 89.9
10	90 - 99.9

4.3.2 Cortical thickness and animal size class

The unidentified long bone fragments were measured and described using Driver's (1999) coded system. This was done to standardise the data, so that it can be compared to other faunal studies. Each bone fragment was recorded individually in an Excel database.

Cortical thickness was only measured when both the outer and inner surfaces of the cortex could be observed. Both the outer and inner surfaces of the cortex have distinctive features that can be used to identify them (Barba & Dominguez-Rodrigo 2005). The thickest portion between the outer and inner cortex was measured with a digital calliper to the nearest millimetre and assigned a reading error of +/- 0.01mm (Table 4.2). Each fragment was categorised according to the following codes:

Table 4.2: Classification of cortical thickness

Code	Cortical thickness (mm)
1	<2
2	2 - 3.9
3	4 - 5.9
4	6 - 7.9
5	8 - 9.9
6	10 - 11.9
7	12 - 13.9
8	14 - 15.9
9	16 - 17.9
10	18 - 19.9

The above cortical thickness codes were used to group bone fragments according to the animal size classes. Cortical thickness of unidentified long bone fragments were measured and placed into size codes devised by Driver (1999). These size codes were grouped into small, medium and large animal size classes and correlated to the size classes devised by Brain (1974) and used by Thompson (2008) and Thompson and Henshilwood (2011). Although Brain's (1974a) size classes were intended to categorise the post-crania of bovids, his classification scheme was applied to all fauna from BBC since it is difficult, if not impossible, to differentiate bovid from other long bone fragments.

Cortical bone thickness varies both between and within species (Currey & Alexander 1985; Barba & Dominguez-Rodrigo 2005; Croker *et al.* 2009) and in relation to sexual dimorphism and age (Stein *et al.* 1998; Peacock *et al.* 1998). To assess the variation of cortical thickness within a species, I used digital callipers to measure the cortical thicknesses of humeri, femora, radii, tibia, metapodia and phalangial bones from the Gobabeb goat (*Capra hircus*) bone collection at the Ditsong National Museum of Natural History in Pretoria (formerly the Transvaal Museum). This collection was used because it is well documented with a known taphonomic history (Brain 1967a, 1967b, 1981). In addition, most of the long bone elements are broken and it was possible to measure their cortical thickness. Cortical measurements recorded by Badenhorst and Henshilwood (2010) of known species from BBC were also used to correlate animal size classes with cortical thickness. These measurements were utilised as a reference sample and compared to measurements obtained from unidentified long bone fragments from BBC in order to group the unidentified BBC specimens to animal size class. The results of this comparison and the classification of animal sizes from cortical thickness are presented in Chapter 5 and discussed in Chapter 6.3.

4.3.3 Fracture patterns

Long bone fracture patterns have been observed and studied by a number of researchers (e.g. Dart 1949a, 1949b; Sadek- Karoos 1972; Biddick & Tomenchuck 1975; Noe-Nygaard 1977; Johnson 1985; Villa & Mahieu 1991; Outram 2001; Pickering *et al.* 2005). Researchers agree that both the fracture shape or outline and the fracture angle (the angle of the cortex to the longitudinal axis) can be used to differentiate fresh from dry bone specimens. Fracture angles from dry bone specimens tend to be perpendicular to the long bone axis (or 'right-angled'), while those for fresh specimens are oblique (acute and obtuse). Fracture surfaces of assemblages consisting of dry bone tend to be jagged as opposed to the smooth surfaces of fresh or spiral fractured bones. Fracture outlines for dry bones are transverse (i.e. straight and transverse to the long bone axis) while fresh or spiral fractures are mostly curved or V-shaped. In addition to fracture shape, colour and texture was also used to differentiate fresh from dry bone breaks (Johnson 1985).

Among the various methods used by researchers to record bone fracture morphology (e.g., Villa & Mahieu 1991; Outram 2001), the simplest is arguably Driver's (1999) system. Using

this method, each longitudinal end of unidentified long bone fragments is observed and recorded as either ‘s’ (spiral), ‘t’ (transverse) or ‘v’ (an irregular or ‘zig-zag’ break denoting a dry fracture) (Figure 4.3). Each fragment has two coded values and is classified as either ‘ss’ (fresh fracture), ‘st’ (intermediate), ‘sv’ (intermediate), ‘tv’ (dry fracture) or ‘tt’ (dry fracture).

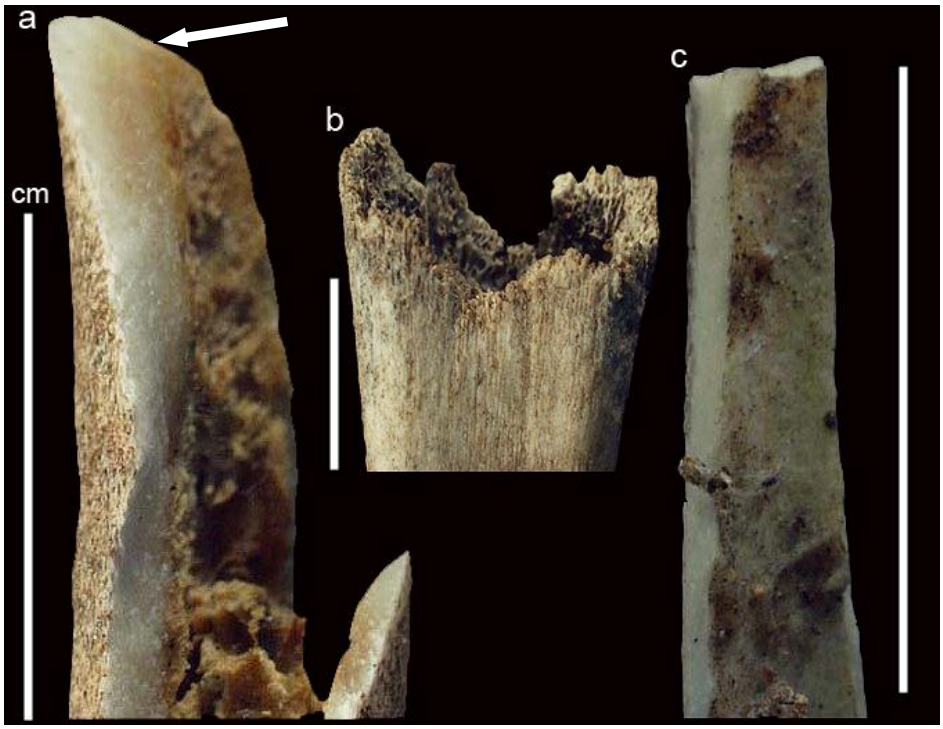


Figure 4.3: Examples of fracture patterns. Spiral (a); irregular (b); and transverse (c) breakage. Note the curved fracture angle of the spiral fracture (arrow)

4.3.4 Surface modifications

Any anthropogenic or animal-produced marks on bone were recorded in addition to weathering and rootlet etching. All bone fragments were examined with the aid of a Nikon binocular light microscope (10 – 40x magnification) under oblique, unidirectional, incandescent lighting. The following modifications were assessed:

Cut marks. Cut marks are characterised by fine, V-shaped incisions or striations on the bone surface and are indicative of butchery activity (Binford 1981; Bunn 1981; Potts & Shipman 1981; Blumenschine 1986, Blumenschine & Selvaggio 1988; but see Andrews & Cook 1985;

Behrensmeyer *et al.* 1986) (Figure 4.4). They are usually distinguishable as straight, geometric lines or in 'birds' feet' shaped patterns (Walker & Long 1977; Lyman 1994; Fisher 1995)

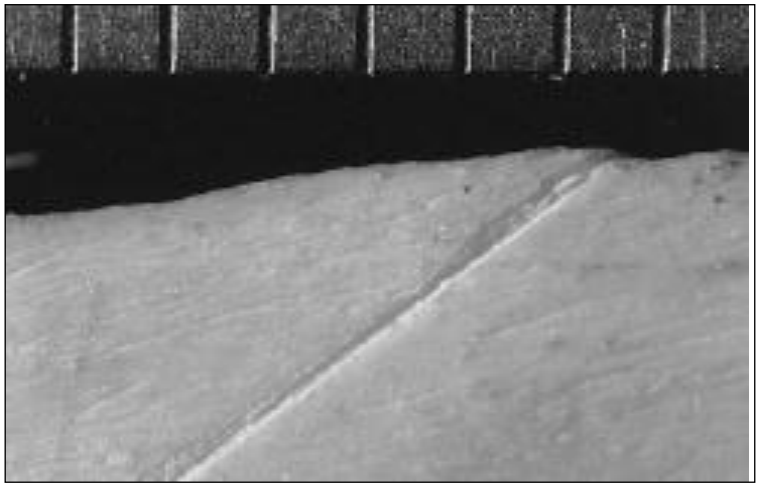


Figure 4.4: Cut marks on bone. (Image from Blumenschine *et al.* 1996)

Percussion marks. These are characterised by either depressed fractures (or 'pits') on the bone surface or dynamic impact scars or 'notches' (Blumenschine & Salvaggio 1988; Noe-Nygaard 1989; Villa & Mahieu 1991; Lyman 1994; Blumenschine *et al.* 1996; Outram 2001; Pickering & Egeland 2006). Depressed fractures can appear similar to carnivore bite marks (Binford 1981; Haynes 1983; O'Connor 2000) but are distinguishable from tooth marks by the appearance of fine 'micro-striations' at the edge of the 'pits' or notches (Blumenschine & Salvaggio 1988; Blumenschine *et al.* 1996) (Figure 4.5). Impact notches can also be confused with large carnivore bite marks but are also generally associated with micro-striations. In this study, percussion marks were recorded but only if they were associated with micro-striations.

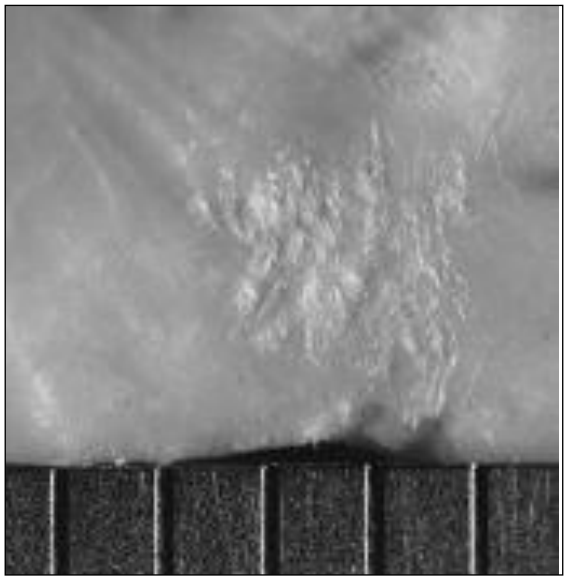


Figure 4.5: Percussion mark on bone. (Image from Blumenschine *et al.* 1996)

Chop marks. Chop marks are broad, V-shaped 'notches' on bone that are generally associated with butchery (Lyman 1987) (Figure 4.6). However, ambiguity can arise between 'genuine' chop marks and percussion impact 'notches' which, in turn, resemble carnivore bite 'punctures' (Binford 1981; Fischer 1995). Because they reflect the same butchery process, chop marks were grouped together with cut marks.

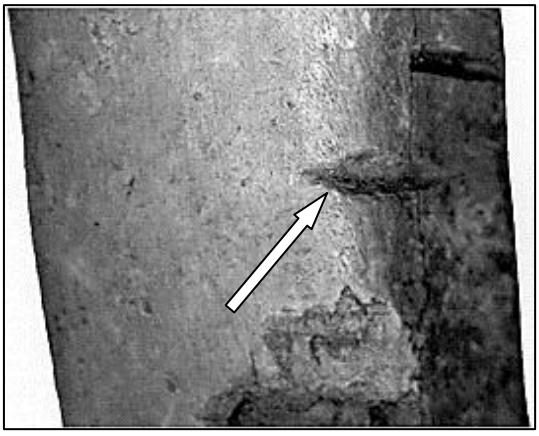


Figure 4.6: Chop marks on bone. Note the deep V-shaped notches. (Image from Noe-Nygaard 1989)

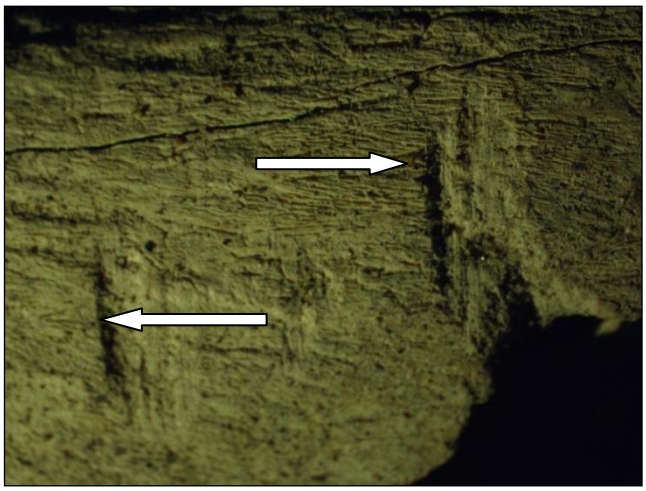
Polish. Polish refers to the removal of minute amounts of the bone surface through the process of abrasion (Fisher 1995: 33). Although polished bones generally imply human activity, sand abrasion or fluvial activity may mimic polishing (Brain 1967a, 1967b). Polish was recorded only if the surface of the bone exhibited a glossy sheen and microscopic observation revealed parallel or near parallel micro-striations on the surface of the outer cortex (Henshilwood *et al.* 2001a).

Burning. Excessive heat modifies and damages the surface of bone (Shipman *et al.* 1984; Lyman 1994). Although burnt bone generally indicates human activity (Oakley 1954; Brain 1981), burnt bone may be the result of veldt fires or other natural agents (Lyman 1994). De Graaff (1961) and Stiner *et al.* (1995) observed that bone deposited below hearths became charred and Stiner *et al.* (1995, 2011) noted that bone calcination was most likely the result of fires made in hearths and therefore indicative of human activity. Shipman *et al.* (1984) incorporated a five-stage colour method when defining bone fragments as burnt. This colour coding is also used to categorise the BBC fauna by Thompson (2008) and Thompson and Henshilwood (2011). Shipman *et al.* (1984) noted that the micromorphology of bone can be used to categorise various stages of burning. To assess bone micromorphology, they used a high-powered scanning electron microscope (SEM). Because I used a low resolution light microscope to assess the unidentified bone fragments from BBC, only colour was used to evaluate burning. Assessing burnt bone based on colour alone has been found to be an effective means of determining damage caused by excessive heat (Taylor *et al.* 1995; Bennett 1999; Clark & Ligouis 2010). I defined specimens as 'burnt' based on Brain's (1981: 54) simpler two stage colour system. Bone was considered burnt if they were black (charred or 'carbonised') and/or white ('calcined'). The criteria I used to assess burning is more conservative than the method used by Thompson (2008) and Thompson and Henshilwood (2011) because only two colours (black and white) are used and specimens were thus less likely to be misdiagnosed as 'burnt'.

Non-human modification. The effects of carnivore damage (tooth marks), rodent damage (gnaw marks) and root etchings were also recorded. Tooth marks are defined as furrows with a U-shaped profile (Figure 4.7a) or localised 'punctures' (Figure 4.7b) on the surface of the bone (Binford 1981; Brain 1981). Although these marks can appear similar to cut marks, their pathways tend to be wider and curved (U or S-shaped) as opposed to the narrower and more straight or geometric pathways of cut marks. Tooth-marked bone furrows are also

characteristically U-shaped compared to the V-shaped furrows of cut marks (Figure 4.8). The ‘punctures’ are also not associated with micro-striations (Blumenschine *et al.* 1996). Gnaw marks are characterised by small, shallow, parallel markings caused by rodents or small carnivores (Figure 4.9) and generally affect the edges of bone surfaces (Lyman 1994; Reitz & Wing 1999). Acids associated with plant roots leave characteristic striations on the surface of the bone and are often confused with other forms of modification such as tooth marks (Behrensmeyer 1978; O’Connor 2000). Weathered bone fragments were categorised according to Behrensmeyer’s (1978) six stage scheme and classified as either not present (stage 0), mild (stages 1 and 2), moderate (stages 3 and 4) or heavy (stage 5).

Except for weathering which was classified in stages, the above modifications were noted as either ‘present’ or ‘absent’ on each bone fragment. The frequencies of modification for each fragment were not recorded.



a

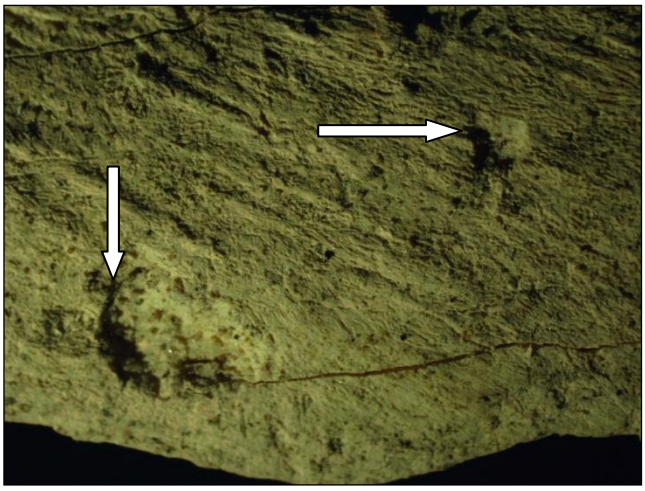


Figure 4.7: Carnivore tooth marks. U-shaped furrows are associated with tooth marks (a) and depressed fractures denote bite marks (b).

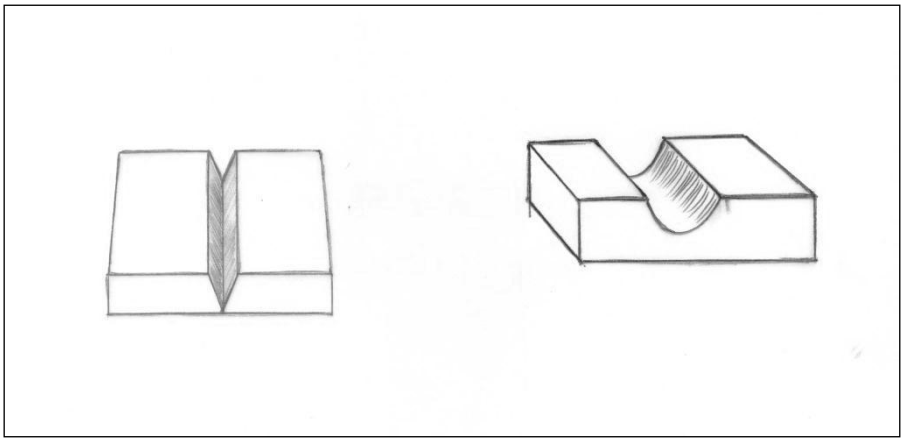


Figure 4.8: Cut and tooth marks. V-shaped cut marks (left) compared to U- shaped tooth mark furrows (right)



Figure 4.9: Rodent gnaw marks. Parallel markings characterise gnaw marks

4.4 Analyses of Quantitative Data

The analysed BBC assemblage was divided into size classes defined by both cortical thickness and fragment length. These size classes were quantified by number and displayed using histograms. All quantitative data in this study was compared and datasets from previous research were included so that differences and/ or relationships between variables could be inferred. Pearson product-moment correlation coefficients (r), coefficients of determination (r^2) and regression scatterplots were used to establish the correlation between variables. Student's *t*-tests were used to test whether the means of groups were significantly different to one another and chi-squared tests were used to test the significance of sampling distributions (Langley 1968; Shennan 1988; Fletcher & Lock 1991; Drennan 1996). Morphological and morphometric bone fragment data from each layer of the sampled squares within the M1 and upper M2 phases were analysed and compared to one another.

Badenhorst (2008) suggests that the use of statistical testing in zooarchaeology is problematic. He argues that (particularly in the case of MSA archaeofaunal assemblages) it is virtually impossible to prove or disprove whether specimens are from the same individual or even the same time period. Because of the scattering and dispersal of faunal remains through time (Hill 1979), identified remains of the same species may not belong to the same individual or associated bone group (ABG). The remains of faunal specimens belonging to the same ABG are dependent on each other while those not in the same ABG would be

statistically independent of each other (Morris 2010). The independence or dependence of random variables (specimens) would be even more problematic with regard to unidentified specimens. Therefore, in my study, the results of statistical tests and correlations are only used as a guide to show tendencies – rather than as actual proof – of distribution.

CHAPTER 5: RESULTS

In this chapter the results of the analysis of the unidentified long bone fragments from the M1 and upper M2 phases at BBC are presented. After a brief description of the specimens, I discuss their spatial and stratigraphic distributions. The first section contains the results of the analysis of the length and cortical thickness of the bone fragments. The next section includes an assessment of the breakage patterns and surface modifications of the specimens. Where appropriate, I have applied Students' *t* and chi-squared test statistics to test the significance of sampling distributions and means.

5.1 Sample Size and Spatial Distribution

In this study, 2305 unidentified long bone fragments were analysed and assessed for breakage patterns and surface modifications. The lengths of 2302 specimens were measured as three specimens were discarded because they were incorrectly noted or corrupted. It was not possible to measure the cortical thickness of some fragments because they lacked inner or outer surfaces resulting in 2042 specimens being measured. Only specimens recovered during the 2000 BBC field season were assessed in this study. Specimens were recovered from either the north western border of the cave interior (squares D2 – D5) or the south eastern section of the excavation (squares G4, G5, G6, H5 and H6) (Figure 5.1). None of the specimens in this sample was recovered from the central region of the excavation.

Of the ten quadrates at BBC assessed in this study, five are associated with hearths or 'ashy' sediment. The South East corner of the site (Squares G4, G5, G6, H5 and H6) encompasses a series of hearths from Layers CA to CF. Most of the burnt bone was recovered from the remains of these hearths. There is a close relationship between the frequency of recovered unidentified burnt bone (48.5%, n = 1117) and the frequency of quadrates associated with hearths (50%, n = 5). This is discussed in detail in Chapter 6.5.

The following calculations are based on unidentified long bone fragments where lengths could be determined (n = 2302). Sixty four percent of bone fragments (n = 1568) were recovered from four squares in the South East section of the site (G5, G6, H5 & H6) (Table 5.1). With the exception of Layer CE, bone fragments were recovered from all layers in the

M1 and upper M2. Over two- thirds of fragments occurred in Layers CD and CF in the lower M1 and upper M2, respectively (67%, n = 1643).

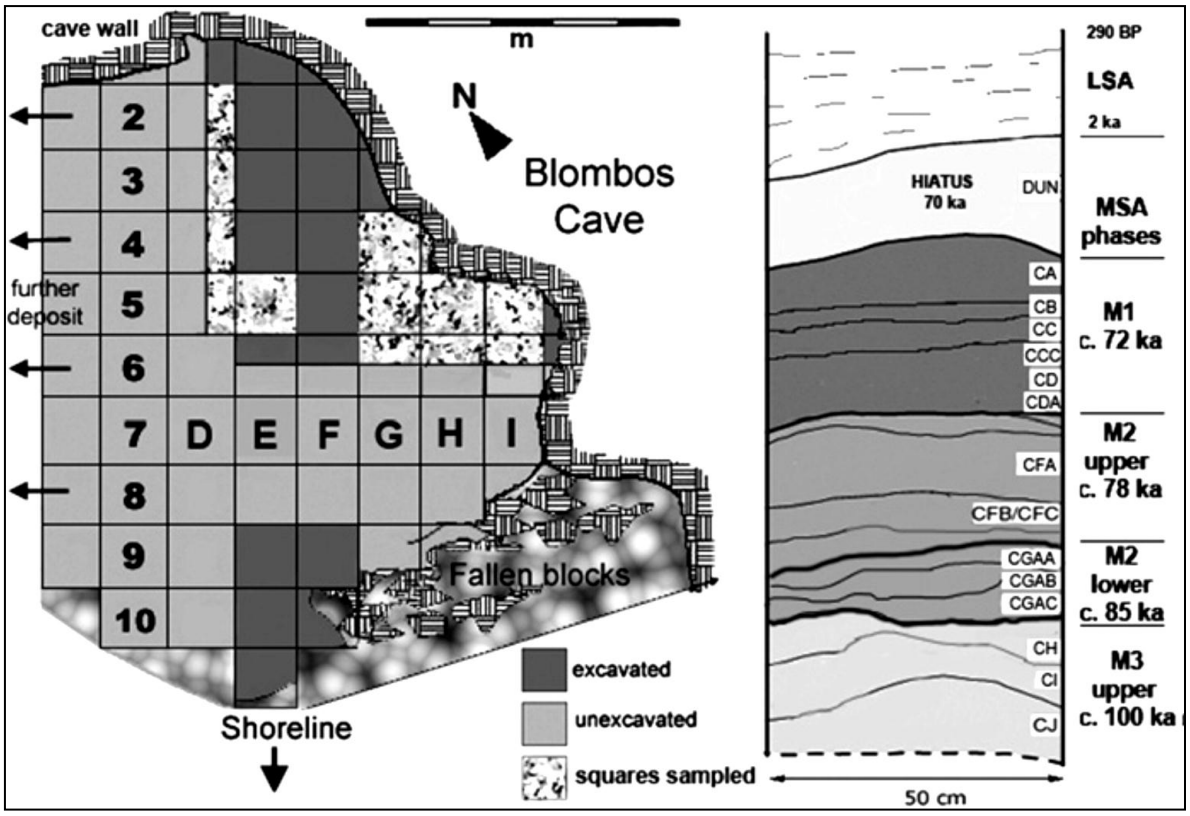


Figure 5.1: the spatial distribution and stratigraphy of BBC (from Thompson & Henshilwood 2011)

In all the following tables, the letters SD represents 'standard deviation' and CV is the 'coefficient of variation'. Specimens referred to as 'undamaged' are bone fragments that do not exhibit any surface modification. 'Unburnt' fragments are specimens that do not show any evidence of burning as defined in this study (i.e. black or white colouring).

Table 5.1: The spatial distribution of bone fragments at BBC by square

Square	n	%	Mean length	SD	CV
D2	110	4.8	17.7	12.2	0.69
D3	118	5.2	18.9	12.5	0.66
D4	363	15.7	17.1	10.7	0.63
D5	21	0.9	19.7	14.0	0.71
G4	160	7.0	21.5	15.8	0.74

G5	444	19.3	21.2	13.4	0.63
G6	237	10.3	17.2	9.2	0.54
H5	455	19.8	26.4	16.3	0.62
H6	321	13.9	20.0	12.6	0.63
I5	73	3.2	26.1	23.0	0.88
Total	**2302**	**100.1**	**20.9**	**14.1**	**0.68**

Table 5.2: The stratigraphic distribution of bone fragments at BBC by layer and phase

Phase	Layer	n	%
M1	CA	298	13.0
	CB	199	8.7
	CC	162	7.0
	CD	706	30.7
M2 upper	CF	937	40.7
Total		**2302**	**100.1**

5.2 Fragment Lengths

Of the entire sample (n = 2305), the lengths of 2302 specimens were used in the analyses. The mean length is 20.9 mm with a standard deviation of 14.1 mm. Mean bone fragment length for the M1 is 22.5 ± 15.3 mm and 18.6 ± 11.6 mm for the upper M2 (Table 5.3). Although the median of the lengths of the M1 and upper M2 fragments are similar (Figure 5.2), there is a general trend towards a reduction of fragment length down through the layers. On average, the shortest bone fragments (18.6 ± 11.6 mm) occur in the lowest layer (CF or the upper M2) while the mean longest fragments (23.7 ± 15.7 mm) were recovered from the top-most layer (CA) (Table 5.4). Spatially, Square D4 contained the shortest average specimens (17.1 ± 10.7 mm) while the longest average specimens (26.4 ± 16.3 mm) occur in Square H5. The majority of specimens (82.0%, n = 1887) are less than 30 mm in length (Driver's codes 1 – 3) while almost a third (60.1%, n = 1383) are between 10 and 20 mm long (code 2) (Table 5.5; Figure 5.3).

Table 5.3: Length of bone fragments at BBC by phase (mm)

Phase	n	Mean length	SD	CV

M1	1365	22.5	15.3	0.68
M2 upper	937	18.6	11.6	0.62
Total	**2302**	**20.9**	**14.1**	**0.68**

Table 5.4: Length of bone fragments at BBC by layer (mm)

Phase	Layer	n	Mean length	SD	CV
M1	CA	298	23.7	15.7	0.66
	CB	199	21.6	14.0	0.65
	CC	162	22.8	14.0	0.61
	CD	706	22.1	15.7	0.71
M2 upper	CF	937	18.6	11.6	0.62

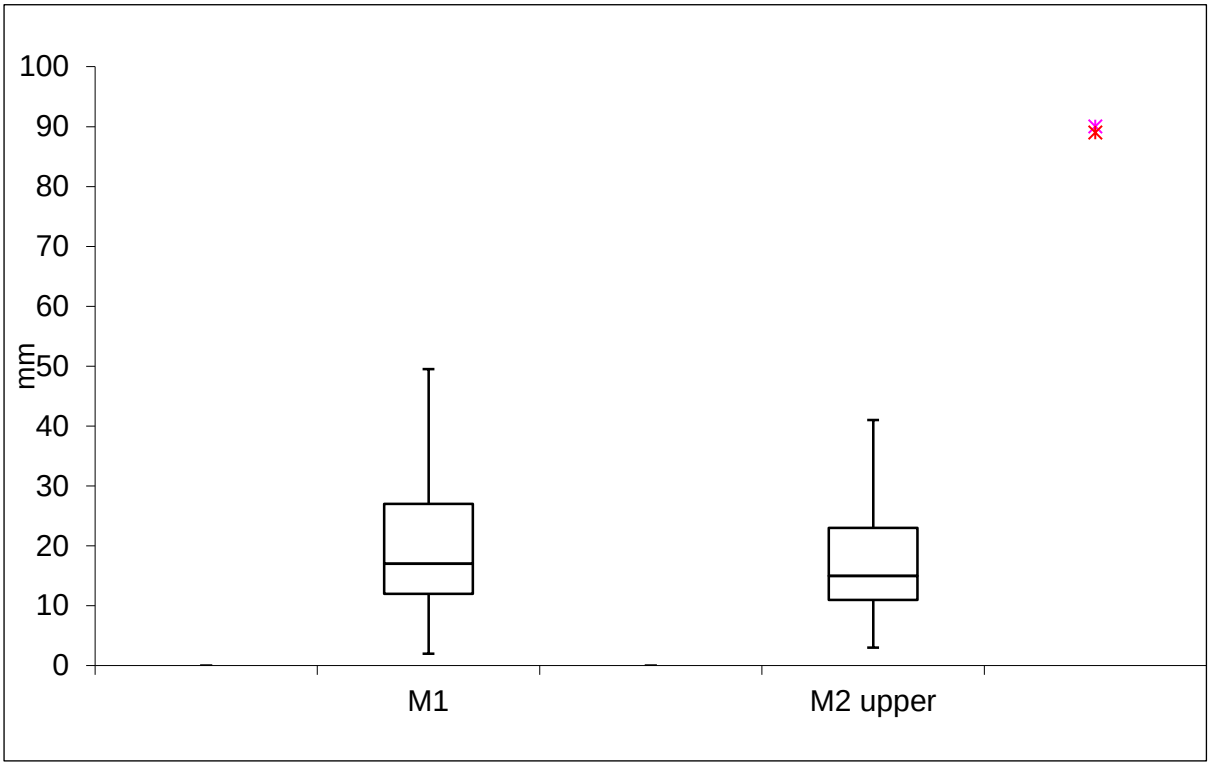


Figure 5.2: Unidentified long bone fragment lengths at BBC by phase

Table 5.5: Length codes of bone fragments at BBC

Code	M1	%	M2 upper	%	Total	%
1	125	9.1	149	15.9	274	11.9
2	646	47.3	463	49.4	1109	48.2

3	303	22.2	201	21.5	504	21.9
4	134	9.8	73	7.8	207	9.0
5	71	5.2	25	2.7	96	4.1
6	37	2.7	15	1.6	52	2.3
7	21	1.5	7	0.8	28	1.2
8	12	0.9	2	0.2	14	0.6
9	8	0.6	1	0.1	9	0.4
10	2	0.2	0	0.0	2	0.1
11	4	0.3	1	0.1	5	0.2
12	2	0.2	0	0.0	2	0.1
Total	**1365**	**100.0**	**937**	**100.1**	**2302**	**100.0**

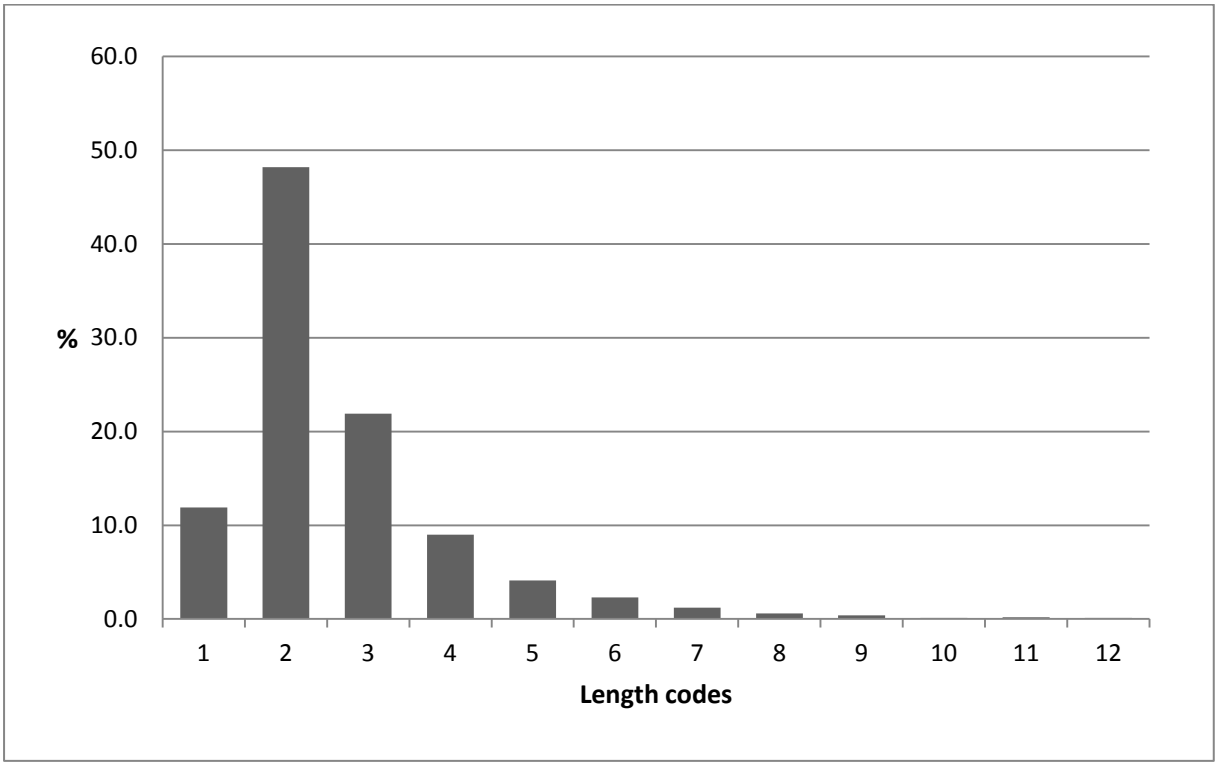


Figure 5.3: Size distribution of unidentified long bone fragments from the M1 and upper M2 at BBC

Burnt fragments, on average, are 18.9 ± 11.5 mm long (Table 5.6). Carbonised (charred) bone fragments (19.9 ± 12.5 mm) (Table 5.7) are generally longer than calcined fragments (14.8 ± 6.8 mm) (Table 5.8). A Students' *t* test was applied between calcined and unburnt specimens because this class seemed one in which a possible meaningful difference was apparent in the average statistic. Calcined fragments are significantly shorter than unburnt specimens (22.8 ±

15.8 mm) (Students' *t* critical value = 1.976; df = ∞; α = 0.05) (Table 5.9; Figure 5.4). Bone fragments exhibiting cut or chop marks (27.3 ± 19.2 mm) (Table 5.10) are generally longer than those with percussion marks (24.0 ± 15.7 mm) (Table 5.11). Specimens with tooth and gnaw marks (39.3 ± 23.0 mm) (Table 5.12) are longer than all other fragments, while polished fragments (18.9 ± 11.0 mm) (Table 5.13) are shorter than undamaged specimens (20.2 ± 13.1 mm) (Table 5.14; Figure 5.5).

The above datasets show that, except for tooth-marked specimens, differences between lengths are minimal. The longer tooth-marked fragments and the differences between the lengths of burnt and unburnt specimens may be important and these are discussed in Chapter 6.

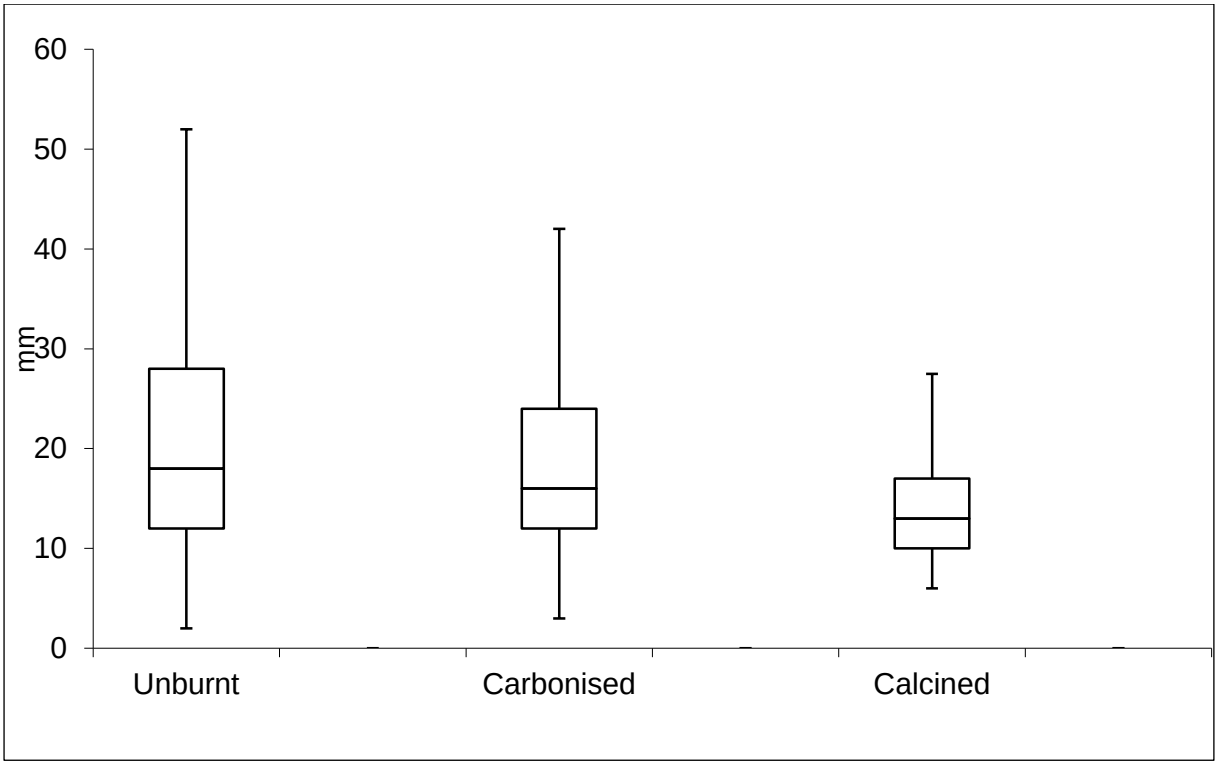


Figure 5.4: Comparison between the lengths of burnt and unburnt fragments from the M1 and upper M2 at BBC

Table 5.6: Length of burnt fragments at BBC by phase (mm)

Phase	n	Mean length	SD	CV
M1	618	19.9	12.4	0.62
M2 upper	499	17.5	10.2	0.58
Total	**1117**	**18.9**	**11.5**	0.61

Table 5.7: Length of carbonised fragments at BBC by phase (mm)

Phase	n	Mean length	SD	CV
M1	467	20.7	13.3	0.64
M2 upper	334	18.8	11.2	0.60
Total	**805**	**19.9**	**12.5**	0.63

Table 5.8: Length of calcined fragments at BBC by phase (mm)

Phase	n	Mean length	SD	CV
M1	73	15.4	6.6	0.43
M2 upper	130	14.4	6.9	0.48
Total	**203**	**14.8**	**6.8**	**0.46**

Table 5.9: Length of unburnt fragments at BBC by phase (mm)

Phase	n	Mean length	SD	CV
M1	747	24.6	17.1	0.70
M2 upper	438	19.8	13.0	0.66
Total	**1185**	**22.8**	**15.8**	**0.69**

Table 5.10: Length of cut and chop-marked fragments at BBC by phase (mm)

Phase	n	Mean length	SD	CV
M1	112	31.7	21.9	0.69
M2 upper	69	20.4	10.8	0.53
Total	**181**	**27.3**	**19.2**	**0.70**

Table 5.11: Length of percussion-marked fragments at BBC by phase (mm)

Phase	n	Mean length	SD	CV
M1	172	27.2	18.3	0.67
M2 upper	222	21.4	12.7	0.59
Total	**394**	**24.0**	**15.7**	**0.66**

Table 5.12: Length of tooth and gnaw-marked fragments at BBC by phase (mm)

Phase	n	Mean length	SD	CV
M1	60	42.8	23.3	0.55
M2 upper	31	32.4	21.1	0.65
Total	**91**	**39.3**	**23.0**	**0.59**

Table 5.13: Length of polished fragments at BBC by phase (mm)

Phase	n	Mean length	SD	CV
M1	205	19.7	12.1	0.62
M2 upper	222	18.1	9.8	0.54
Total	**427**	**18.9**	**11.0**	**0.58**

Table 5.14: Length of undamaged fragments at BBC by phase (mm) *

Phase	n	Mean length	SD	CV
M1	483	21.6	13.9	0.64
M2 upper	249	17.3	10.6	0.61
Total	**732**	**20.1**	**13.0**	**0.65**

*Undamaged fragments are specimens that do not exhibit surface modification

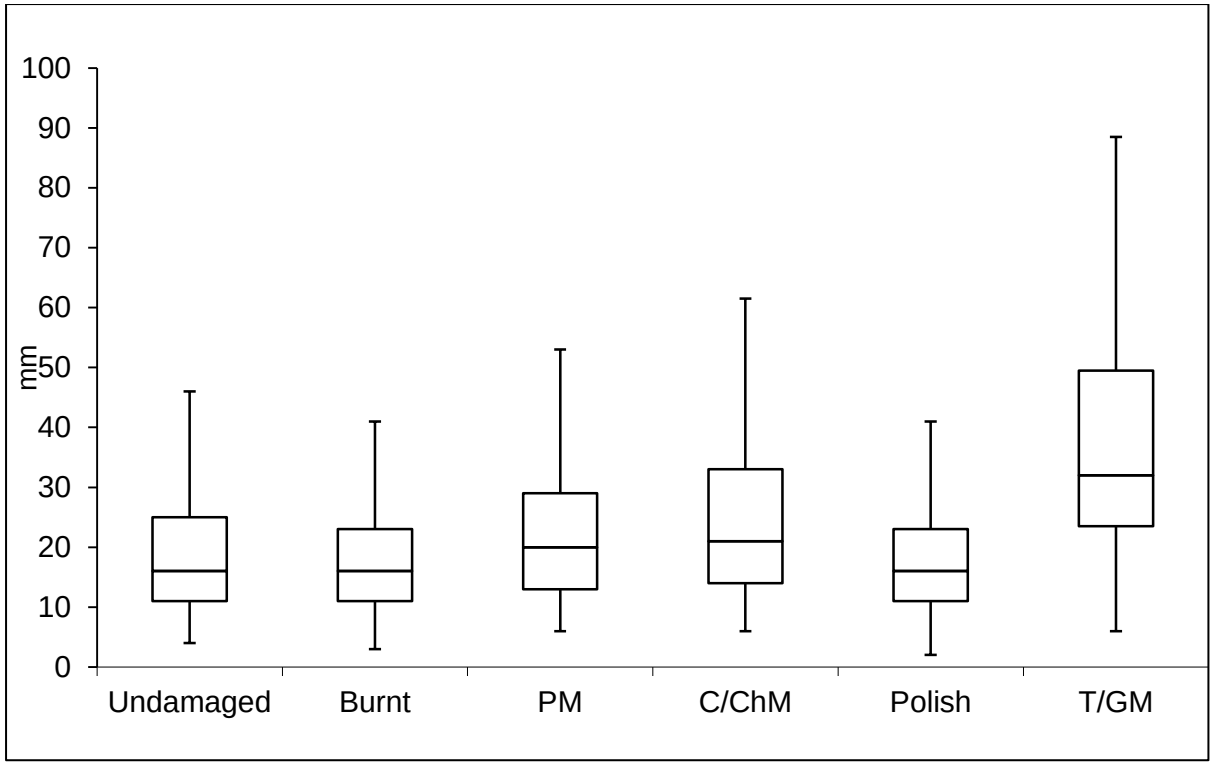


Figure 5.5: Surface modifications and the lengths of bone fragments from the M1 and upper M2 at BBC. PM = Percussion marks. C/ChM = Cut and chop marks. T/GM = Tooth and gnaw marks.

5.3 Cortical Thickness

The mean cortical thickness for all fragments is 3.5 ± 2.7 mm (n = 2042). As with the lengths of unidentified long bone fragments, the largest cortical measurements also occur in the M1 phase (3.9 ± 3.0 mm) (Table 5.15; Figure 5.6). Stratigraphically, the thickest cortical bones were recovered from Layer CB (4.7 ± 3.5 mm) while the thinnest mean cortical measurements are from the lowest layer, CF (2.9 ± 1.8) (Table 5.16). Square I5, in the South East corner of the cave produced the thickest cortical measurements (4.8 ± 3.1 mm) while Square D2, in the most Northerly corner, produced the thinnest (2.6 ± 1.1 mm) (Table 5.17). The majority of bone fragments (88.2%, n = 1800) had a cortical thickness less than 6 mm (Driver's code 1 – 3), although a few fragments were classified as code 10 or more (Table 5.18; Figure 5.7). The cortex of one fragment, for example, was 30 mm thick (code 16).

I investigated whether the cortical thickness of the various types of modified fragments display a meaningful pattern. The mean cortical thickness of all burnt fragments is 3.4 ± 2.4 mm (Table 5.19). The average cortical thickness of carbonised bone fragments (3.6 ± 2.6 mm) (Table 5.20) is thicker than calcined fragments (2.6 ± 1.3 mm) (Table 5.21) and unburnt

specimens (3.5 ± 2.9 mm) (Table 5.22; Figure 5.8). Variation in the cortical thickness of burnt specimens will be discussed in Chapter 6. Percussion-marked bones (3.8 ± 2.9 mm) (Table 5.23) are slightly thinner than cut- and chop-marked bones (4.4 ± 3.4 mm) (Table 5.24). Fragments displaying tooth and gnaw marks have the thickest cortices (5.9 ± 5.0 mm) (Table 5.25). The mean cortical thickness for polished bone fragments is 2.9 ± 2.1 mm (Table 5.26) and undamaged specimens are on average 3.2 ± 2.5 mm (Table 5.27; Figure 5.9).

Like fragment lengths, cortical thickness also decreases slightly down through the layers at BBC. The implications of this and the relationship between taphonomy and cortical thickness are discussed in detail in Chapter 6.

Table 5.15: Cortical thickness of bone fragments at BBC by phase (mm)

Phase	n	Mean thickness	SD	CV
M1	1194	3.9	3.0	0.77
M2 upper	848	2.9	1.8	0.62
Total	**2042**	**3.5**	**2.7**	**0.77**

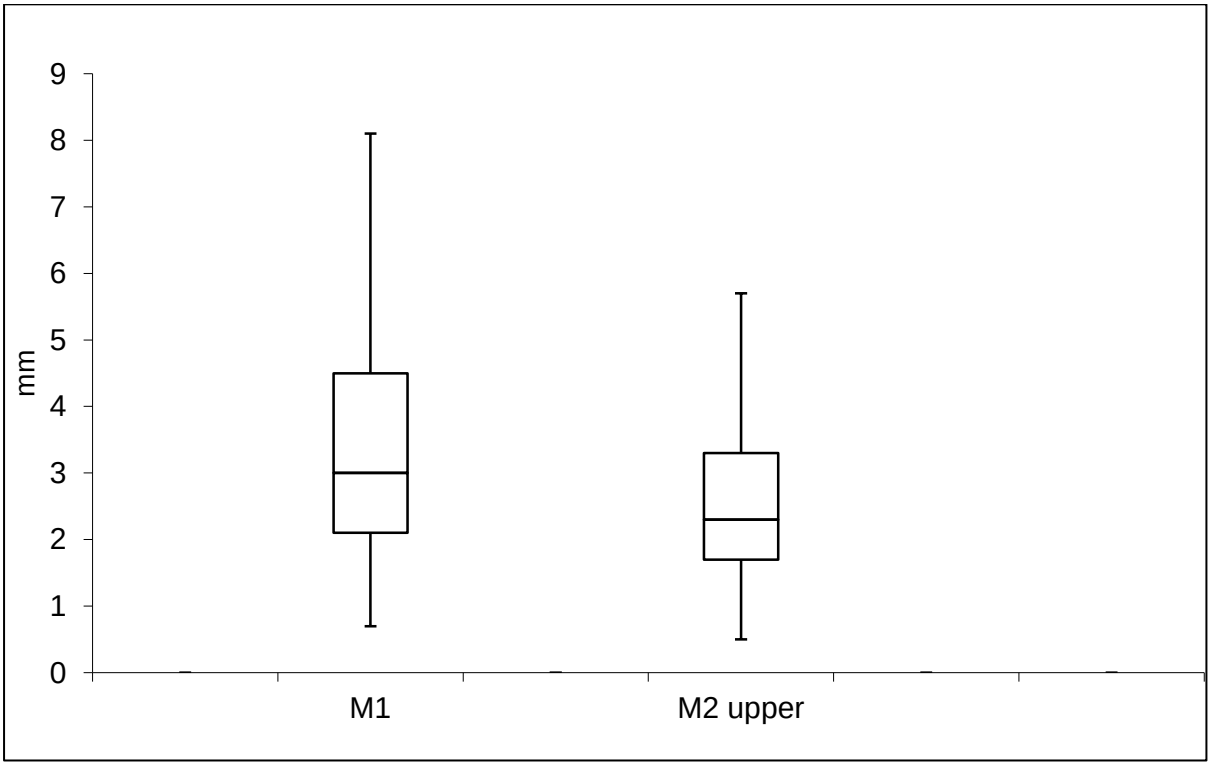


Figure 5.6: Cortical thickness of bone fragments at BBC from the M1 and upper M2 phases

Table 5.16: The stratigraphic distribution of cortical thickness at BBC by layer (mm)

Phase	Layer	n	Mean thickness	SD	CV
M1	CA	272	3.8	3.1	0.82
	CB	150	4.7	3.5	0.75
	CC	134	4.6	3.7	0.8
	CD	638	3.6	2.6	0.72
M2 upper	CF	848	2.9	1.8	0.62

Table 5.17: The spatial distribution of cortical thickness at BBC by square (mm)

Square	n	%	Mean thickness	SD	CV
D2	102	5.0	2.6	1.1	0.42
D3	100	4.9	2.9	1.6	0.55
D4	315	15.4	2.8	1.9	0.68
D5	18	0.9	3.2	2.2	0.69
G4	137	6.7	3.7	2.7	0.73
G5	376	18.4	3.4	2.4	0.71
G6	214	10.5	2.8	1.8	0.64
H5	430	21.1	4.2	3.1	0.74
H6	287	14.0	3.8	3.5	0.92
I5	63	3.1	4.8	3.1	0.65
Total	**2042**	**100.0**	**3.5**	**2.7**	**0.77**

Table 5.18: Cortical thickness codes of bone fragments at BBC

Code	M1	%	M2 upper	%	Total	%
1	230	19.2	305	36.0	535	26.2
2	569	47.6	388	45.8	957	46.9
3	209	17.5	99	11.7	308	15.1
4	88	7.4	30	3.5	118	5.7
5	44	3.7	19	2.2	63	3.1
6	20	1.7	3	0.4	23	1.1
7	14	1.2	2	0.2	16	0.8
8	6	0.5	2	0.2	8	0.4
9	7	0.6	0	0.0	7	0.3
10	1	0.1	0	0.0	1	0.1
11	1	0.1	0	0.0	1	0.1
12	3	0.2	0	0.0	3	0.2

13	1	0.1	0	0.0	1	0.1
14	0	0.0	0	0.0	0	0.0
15	0	0.0	0	0.0	0	0.0
16	1	0.1	0	0.0	1	0.0
Total	**1194**	**100.0**	**848**	**100.0**	**2042**	**100.1**

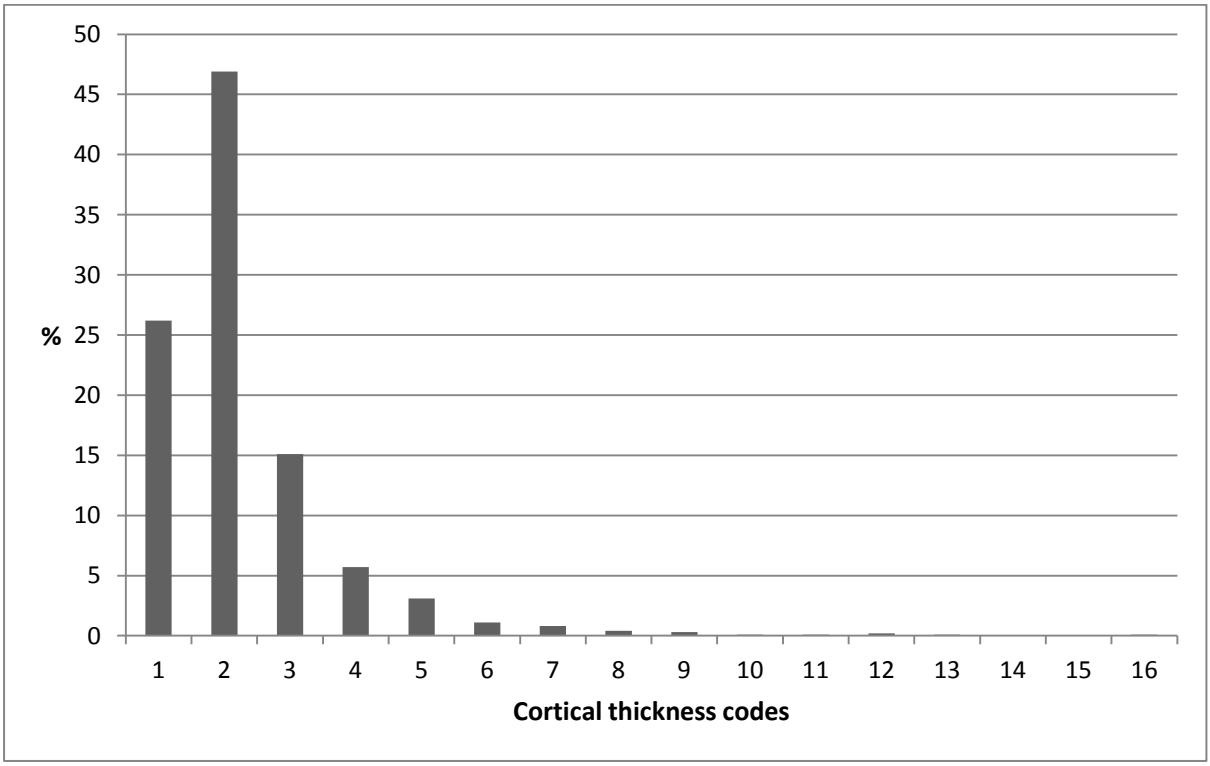


Figure 5.7: Cortical thickness of unidentified long bone fragments from the M1 and upper M2 at BBC

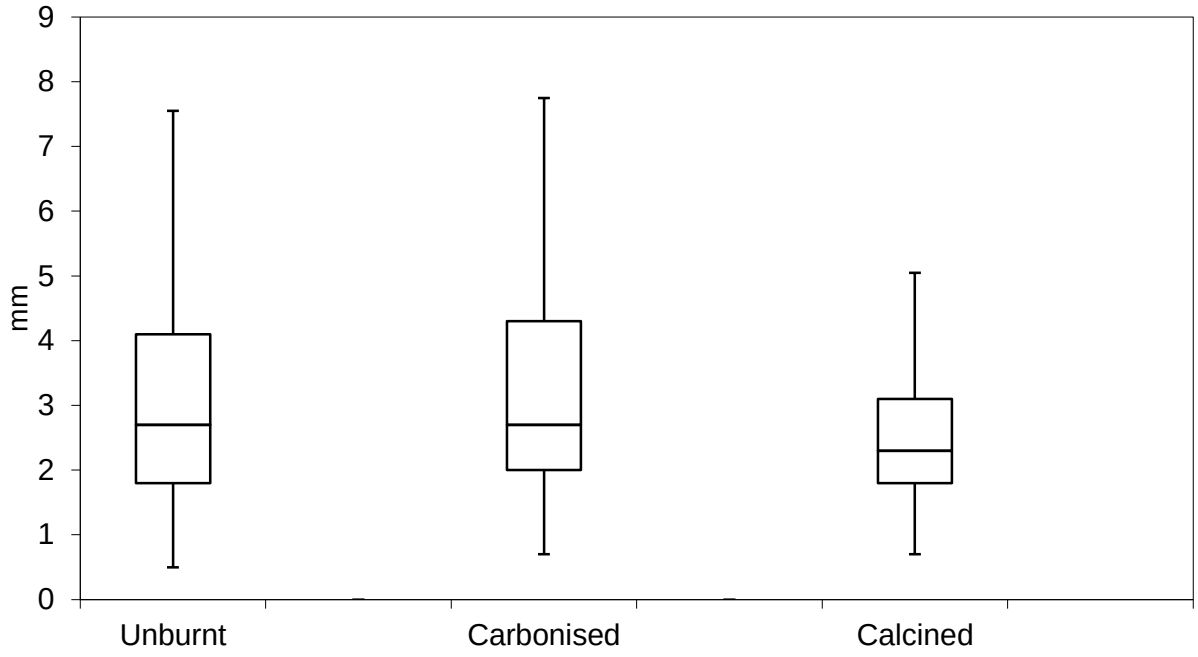


Figure 5.8: Cortical thickness of burnt bone fragments from the M1 and upper M2 at BBC

Table 5.19: Cortical thickness of burnt fragments from BBC by phase (mm)

Phase	n	Mean thickness	SD	CV
M1	554	4.0	2.8	0.70
M2 upper	465	2.8	1.7	0.60
Total	**1019**	**3.4**	**2.4**	**0.71**

Table 5.20: Cortical thickness of carbonised fragments from BBC by phase (mm)

Phase	n	Mean thickness	SD	CV
M1	408	4.1	2.9	0.7
M2 upper	307	2.9	1.8	0.62
Total	**715**	**3.6**	**2.6**	**0.72**

Table 5.21: Cortical thickness of calcined fragments from BBC by phase (mm)

Phase	n	Mean thickness	SD	CV
M1	73	2.8	1.3	0.46
M2 upper	127	2.5	1.2	0.48
Total	**200**	**2.6**	**1.3**	**0.50**

Table 5.22: Cortical thickness of unburnt fragments from BBC by phase (mm)

Phase	n	Mean thickness	SD	CV
M1	639	3.8	3.2	0.84
M2 upper	383	2.9	2	0.69
Total	**1022**	**3.5**	**2.9**	**0.83**

Table 5.23: Cortical thickness of percussion-marked fragments from BBC by layer (mm)

Layer	n	Mean thickness	SD	CV
CA	17	4.2	3.0	0.71
CB	22	6.0	4.3	0.72
CC	18	5.8	3.5	0.60
CD	109	4.1	3.1	0.76
CF	214	3.2	2.6	0.81
Total	**394**	**3.8**	**2.9**	**0.76**

Table 5.24: Cortical thickness of cut and chop-marked fragments from BBC by layer (mm)

Layer	n	Mean thickness	SD	CV
CA	23	4.8	2.7	0.56
CB	18	6.1	4.7	0.77
CC	10	6.6	3.8	0.56
CD	63	4.6	3.8	0.83
CF	66	3.1	2.0	0.65
Total	**181**	**4.4**	**3.4**	**0.77**

Table 5.25: Cortical thickness of tooth and gnaw-marked fragments from BBC by phase (mm)

Phase	n	Mean thickness	SD	CV
M1	57	6.4	5.5	0.86
M2 upper	30	4.9	3.6	0.74
Total	**87**	**5.9**	**5.0**	**0.85**

Table 5.26: Cortical thickness of polished fragments from BBC by phase (mm)

Phase	n	Mean thickness	SD	CV
M1	206	3.5	2.6	0.74
M2 upper	222	2.4	1.5	0.63
Total	**428**	**2.9**	**2.1**	**0.72**

Table 5.27: Cortical thickness of undamaged fragments from BBC by phase (mm)*

Phase	n	Mean thickness	SD	CV
M1	384	3.4	2.9	0.85
M2 upper	183	2.9	1.7	0.59
Total	**567**	**3.2**	**2.5**	**0.78**

***Undamaged bone fragments are bone fragments that do not exhibit surface markings

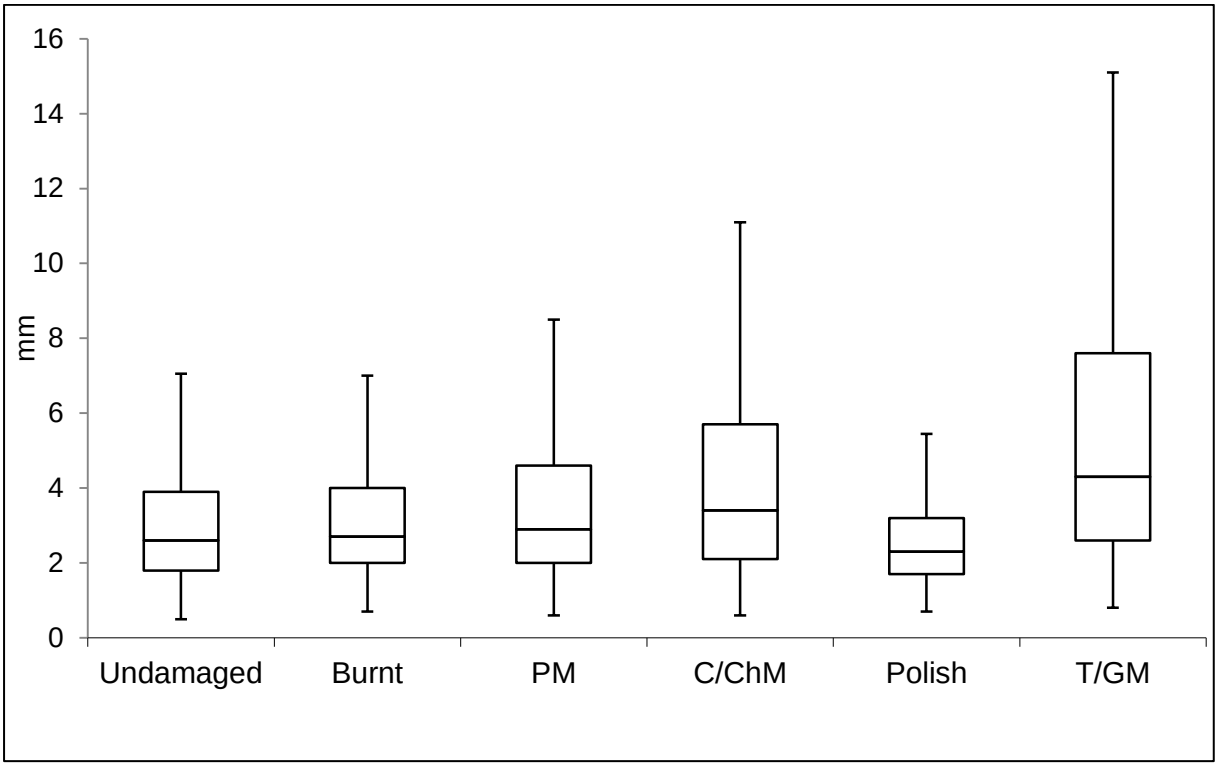


Figure 5.9: Surface modifications and the cortical thickness of bone fragments from the M1 and upper M2 at BBC. PM = Percussion marks; C/ChM = Cut and chop marks; T/GM = Tooth and gnaw marks

5.3.1 Cortical thickness and animal size

Cortical thickness variation in a known bovid species (*Capra hircus* [goat]) and that of the identified fauna from BBC was determined so that the relationship between cortical thickness and bovid size could be investigated. To assess variation between long bone cortical thickness within a species, 561 cortical measurements from 6 elements were taken from the Gobabeb goat bone collection at the Ditsong National Museum of Natural History (formerly the Transvaal Museum) in Pretoria. These goat long bones represent a Bovid II size animal (Brain 1974a) or a small- medium size mammal (Klein 1976). The mean cortical thickness of all the long bones is 2.3 ± 0.8 mm with a range of between 0.6 and 4.7 mm (Table 5.28). The majority specimens were classified as adult (71.8%, n = 404), with 20.2% sub-adult (n = 114) and 8% (n = 45) of indeterminate age. However, because the age class of the long bones could not be definitively determined, all specimens were used in the analyses. Due to their similarity, metacarpals and metatarsals were grouped together as metapodia. The mid-shaft of the tibia produced the thickest mean cortical measurement at 3.4 ± 0.5 mm while the thinnest measurement came from the proximal phalanges (1.4 mm). Humeri display the greatest variability in cortical measurements (0.6 mm – 4.5 mm). The majority of cortical measurements (37%, n = 209) taken from this element. The mean cortical thickness of the goat long bones were categorised as code 2 (2.0 mm – 3.9 mm).

Table 5.28: Cortical thickness of goat long bones from Gobabeb

Element	Anatomical zone*	n	Range	Mean thickness	SD	Code
Femur	P	15	1.8 - 4.4	2.7	0.8	2
	M	33	1.9 - 3.5	2.8	0.4	2
	D	8	1.4 - 3.7	2.3	0.9	2
Humerus	P	32	1.4 - 2.7	2	0.3	2
	M	103	1.6 - 4.2	2.9	0.5	2
	D	74	0.6 - 4.5	2.8	0.6	2
Metapodia	P	35	1.4 - 3.3	2.3	0.5	2
	M	42	1.7 - 3.8	2.8	0.5	2
	D	36	1.5 - 3.3	2.2	0.5	2
Phalanges	P	2	1.4	1.4	0	1
	M	3	1.4 - 1.6	1.5	0.1	1
	D	0	0	0	0	0
Radius/Ulna	P	19	1.8 - 2.8	2.3	0.3	2
	M	60	2.2 - 3.6	2.8	0.4	2

	D	11	1.7 - 3.1	2.5	0.4	2
Tibia	P	9	1.4 - 3.4	2.6	0.6	2
	M	56	2.2 - 4.7	3.4	0.5	2
	D	23	1.8 - 3.8	2.6	0.5	2

*****P = proximal; M = mid-shaft; D = distal

To investigate the variability of the cortical thicknesses between species, the cortices of elements from a sample of known taxa from BBC were measured (Badenhorst & Henshilwood 2010). Of the 15 taxa identified to species, genus or size class, 251 measurements were obtained from seven long bone elements (Table 5.29). The cortices of the majority of taxa (71.7%, n = 180) were categorised as code 1 (less than 2 mm). Almost half (44.6%, n = 112) of all measurements were taken from either the Cape dune molerat (*Bathyergus suillus*) or the rock hyrax (*Provacia capensis*). Less than 10% (9.2%, n = 23) of all cortical measurements were categorised between code 4 and 8 (6.0 mm – 15.9 mm). A metapodial and metatarsal bone from an eland (*Tragelaphus oryx*) was classified as code 5 and code 8, respectively. This suggests that larger long bone elements of eland, such as the femur and tibia, would have thicker cortices and, therefore, higher codes (possibly 10 and above). There appears to be much variability in the cortical thicknesses of the identified elements, specifically tibia. Tibia from Bovid size class I fauna, for example, have been classified as code 1, 2 and 3 while tibia from Bovid III specimens occur in codes 3 and 6. The implications of these results are discussed further in Chapter 6.

Table 5.29: Cortical thickness measurements of identified bones from BBC. Identified bones are bones classified to element

Code	n	Taxa	Element*
1	22	BOV I	FE, RA, MP, HU, MT, MC, TI
	1	BOV II	RA
	37	*Bathyergus suillus* (Cape dune molerat)	FE, RA, MP, HU, TI
	75	*Provacia capensis* (Rock hyrax)	FE, RA, MP, HU, TI, MC
	4	*Raphicerus* sp. (Cape grysbok)	RA, MP, MC
	31	Small mammal	FE, RA, MP, HU, TI
	1	Small carnivore	RA

	3	Small-medium carnivore	MP
	3	*Lepus* sp. (Hare)	RA, HU
	3	Small bird	HU, TI
2	12	BOV I	FE, RA, MP, HU, TI, MT, MC
	15	BOV II	FE, RA, MP, HU, TI, MT, MC
	6	*Raphicerus* sp. (Cape grysbok)	RA, HU, TI, MC, UL
	1	Small mammal	TI
	1	Medium mammal	TI
	1	Large mammal	TI
	1	*Bathyergus suillus* (Cape dune molerat)	TI
	1	*Procavia capensis* (Rock hyrax)	HU
	1	*Lepus* sp. (Hare)	TI
3	1	BOV I	TI
	3	BOV II	MP
	4	BOV III	FE, TI
	1	Large mammal	TI
4	2	BOV III	HU, MP
	1	BOV III/ IV	MP
	3	BOV IV	HU, RA, TI, MP, MT, MC
	2	Large mammal	FE, HU, TI
5	1	*Tragelaphus oryx* (Eland)	MP
	3	BOV IV	MP, MT, MC
	3	Large mammal	FE, HU
6	2	BOV III	TI, MP
	3	BOV IV	TI, MP
7	1	BOV IV	MT
	1	Large mammal	HU
8	1	*Tragelaphus oryx* (Eland)	MT

*****FE = Femur, RA = Radius, MP = Metapodia, MC = Metacarpal, MT = Metatarsal, HU = Humerus, TI = Tibia.

Returning to the unidentified BBC fauna; the similarity between the distributions of the lengths and that of cortical thickness of the unidentified BBC fragments suggests that a relationship exists between these two variables (Fig. 5.10). Plotting the length against the cortical thickness of the bone fragments produces a Pearson's correlation coefficient of 0.947 (Fig. 5.11). The coefficient of determination ($r^2 = 0.897$) indicates that almost 90% of the variation in length relates to cortical thickness suggesting that a close relationship exists between length and cortical thickness. This relationship is addressed in Chapter 6.3.

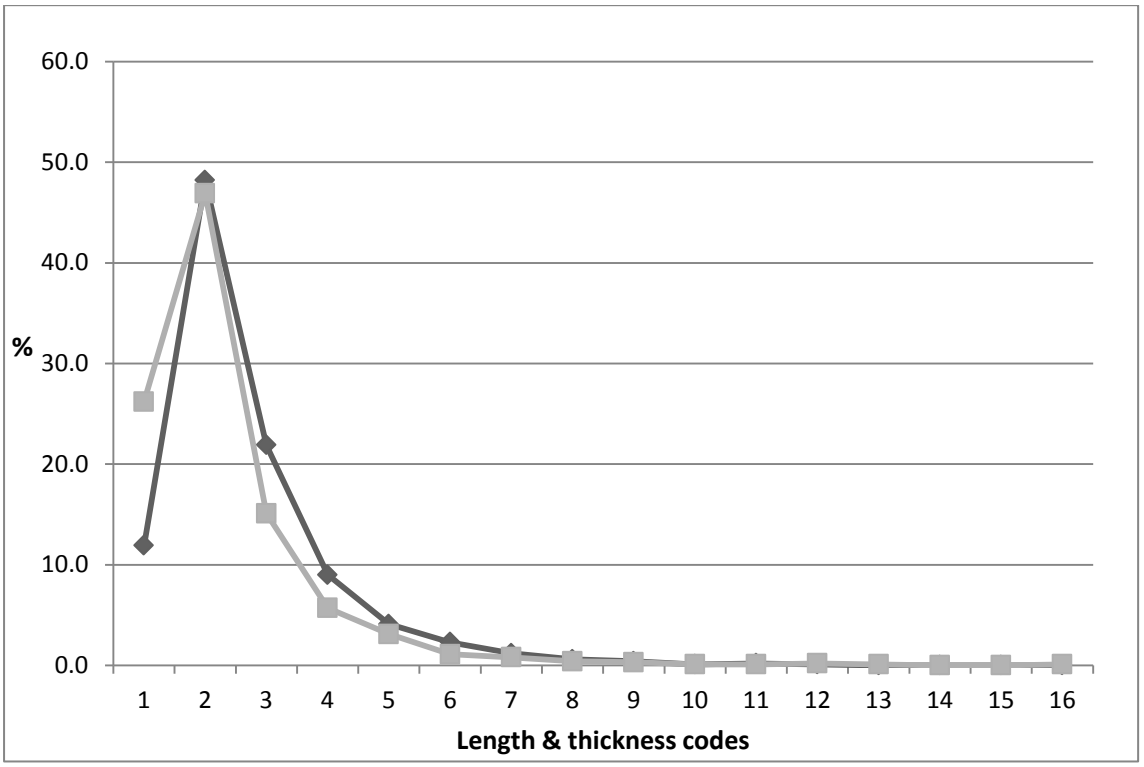


Figure 5.10: Comparison between the length and cortical thickness of unidentified long bone fragments. Black line = Length of bone fragments; Gray line = Cortical thickness of bone fragments

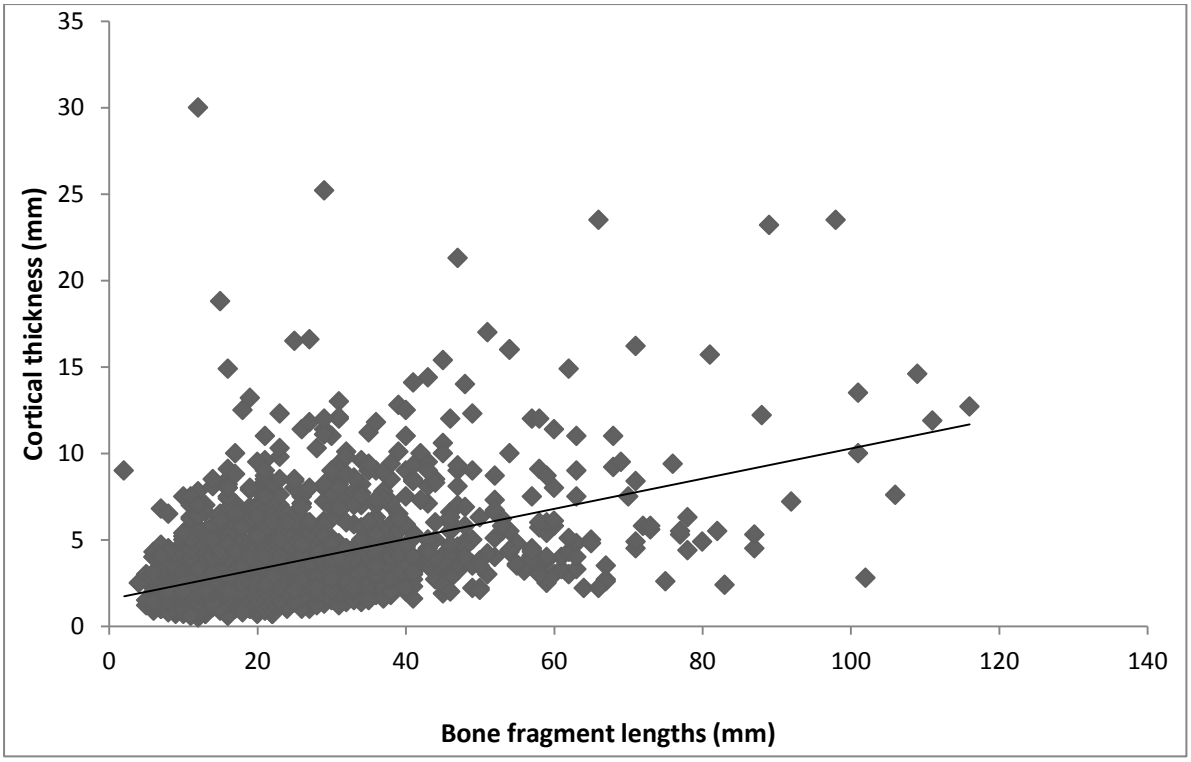


Figure 5.11: Mean bone fragment lengths plotted against mean cortical thickness.

5.4 Fracture Patterns

Each longitudinal end of the 2305 fragments was assessed for fracture patterns (n = 4610). The majority of all fractures were the result of spiral or fresh breaks (Figure 5.12) (62.8%, n = 2896). A third of fractures were transverse or the result of dry breakage (34.2%, n = 1575) while only three percent (n = 139) of fractures were irregular (Table 5.30).



Figure 5.12: Fragment with spiral fractures

Table 5.30: Fracture patterns of bone fragments from the M1 and upper M2 at BBC

Fracture	M1	%	M2 upper	%	Total	%
Spiral	1719	62.9	1177	62.7	2896	62.8
Transverse	923	33.8	652	34.7	1575	34.2
Irregular	90	3.3	49	2.6	139	3.0
Total	**2732**	**100.0**	**1878**	**100.0**	**4610**	**100.0**

Bone fragments resulting from spiral fractures are generally longer than those resulting from transverse fractures (23.1 ± 15.4 mm versus 15.6 ± 8.3 mm, respectively) (Table 5.31). Burnt fragments exhibit more transverse fractures (47.0%, n = 1050) and less spiral fractures (50.4%, n = 1125) than the combined sample (Table 5.32). Unburnt bone fragments have more spiral fractures (74.6%, n = 1767) and less dry breaks (22.0%, n = 521) than the combined sample (Table 5.33).

Table 5.31: Comparison between the lengths of spirally and transversely-fractured fragments at BBC (mm)*

Fracture	n	Mean length	SD	CV

Spiral	1158	23.1	15.4	0.7
Transverse	519	15.6	8.3	0.5

*****Only the lengths of fragments with both ends spirally or both ends transversely fractured were assessed

Table 5.32: Fracture patterns of burnt fragments from the M1 and upper M2 at BBC

Fracture	n	%
Spiral	1125	50.4
Transverse	1050	47.0
Irregular	59	2.6
Total	**2234**	**100.0**

Table 5.33: Fracture pattern of unburnt fragments from the M1 and upper M2 at BBC

Fracture	n	%
Spiral	1767	74.6
Transverse	521	22.0
Irregular	80	3.4
Total	**2368**	**100.0**

5.5 Surface Modifications

5.5.1 Burning

Almost half the analysed specimens display evidence of burning (48.5%, n = 1117). The majority of burnt fragments are carbonised (35.2%, n = 805), while only 8.8% (n = 203) of all fragments are calcined (Figure 5.13). Stratigraphically, the majority of burnt specimens occurred in Layer CF (44.7%, n= 499) and CD (32.5%, n = 363) while the least burnt specimens are in Layer CC (6.2%, n = 69) (Fig. 5.14). More burnt bone fragments were recovered in Squares D4 (18.8%, n = 211) and G5 (18.1%, n = 203) while Square D5 yielded the least amount of burnt bone (1.5%, n =17). Calcined bone also occurred most frequently in Square D4 (41.4%, n= 84) and the least frequently in Square I5 where no calcined specimens were recovered. Although Square G5 yielded a high percentage of burnt fragments, only 6.9% (n = 14) of calcined fragments were recovered from this square. G5, however, yielded

the most carbonised fragments (21.2%, n= 171) while the least amount of carbonised fragments occurred in D5 (1.6%, n= 13).

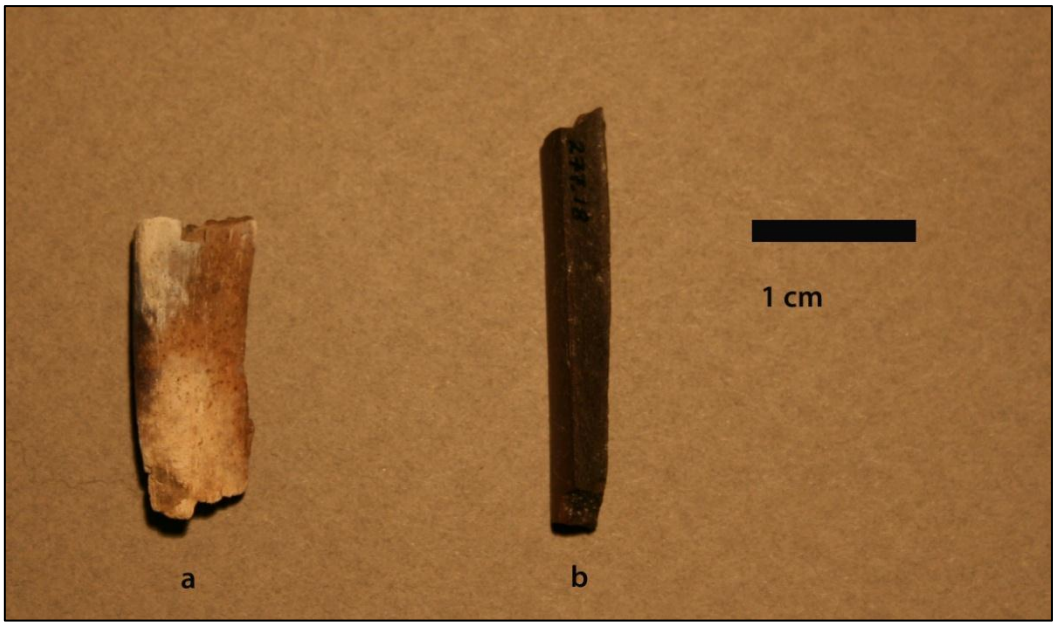


Figure 5.13: Calcined (a) and carbonised (b) fragments. Both specimens have transverse fractures at both ends

Many of the unidentified long bone fragments from BBC display percussion marks on or near burnt regions (Figure 5.15**)**. There is a strong correlation between the frequency of percussion-marked bone per layer and that of burnt bone (Pearson's correlation coefficient r = 0.918; $\alpha = 0.01$) (Figure 5.16). Almost a quarter (23.9%, n = 267) of burnt specimens exhibit percussion marks. I investigated whether similar frequencies of burning and percussion marks occurred in the M1 and upper M2 phases. The null hypothesis is that there is no difference between the frequency of unburnt and burnt bone with percussion marks between the M1 and upper M2. This assumption was tested using a chi-squared test which rejected the null hypothesis at the 5% level. A significant difference, therefore, exists between burnt fragments with percussion marks and unburnt fragments with percussion marks between the M1 and upper M2 (Chi-squared = 9.138; df = 1; $\alpha = 0.05$) (Table 5.34a & 5.34b). The relevance of percussion-marked burnt bone is discussed in Chapter 6.

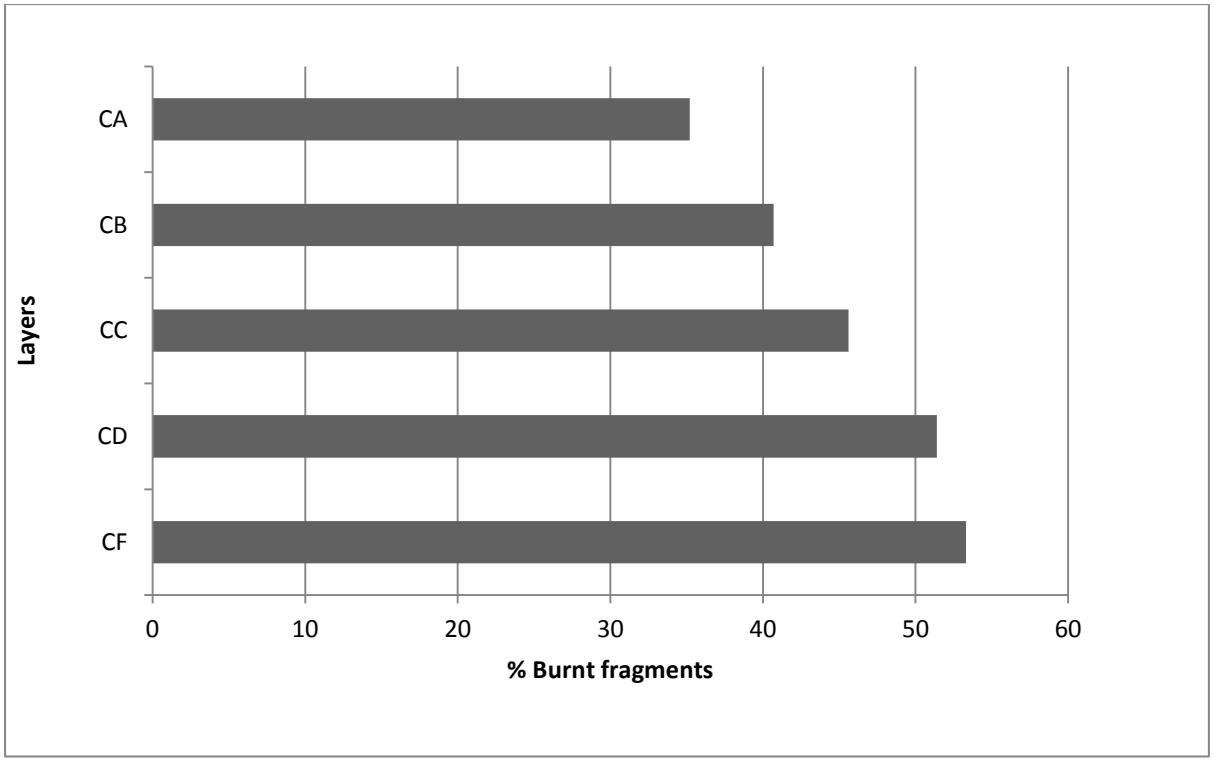


Figure 5.14: Stratigraphic distribution of burnt fragments at BBC

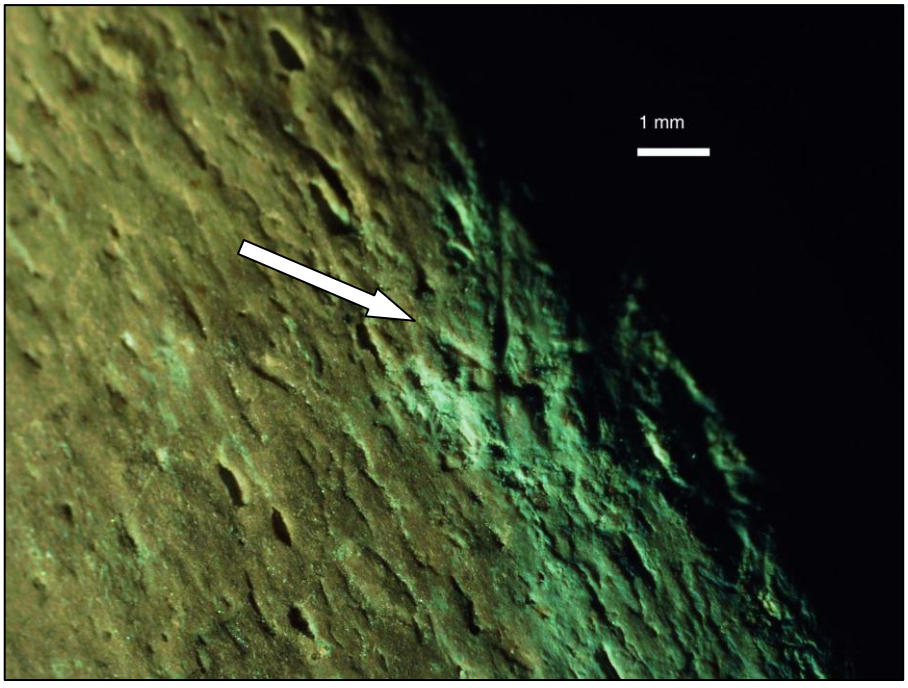


Figure 5.15: Percussion mark on a calcined section of bone

Table 5.34a: Observed frequencies of percussion-marked burnt bone from BBC

Phase	Burnt specimens with PM*	Unburnt specimens with PM*	Total
M1	106	71	177
M2 upper	161	56	217
Total	**267**	**127**	**394**

*PM = percussion mark

Table 5.34b: Expected frequencies of percussion-marked burnt bone from BBC

Phase	Burnt specimens with PM*	Unburnt specimens with PM*	Total
M1	119.95	57.05	177
M2 upper	147.05	69.95	217
Total	**267**	**127**	**394**

Chi-squared = 9.138

*PM = percussion mark

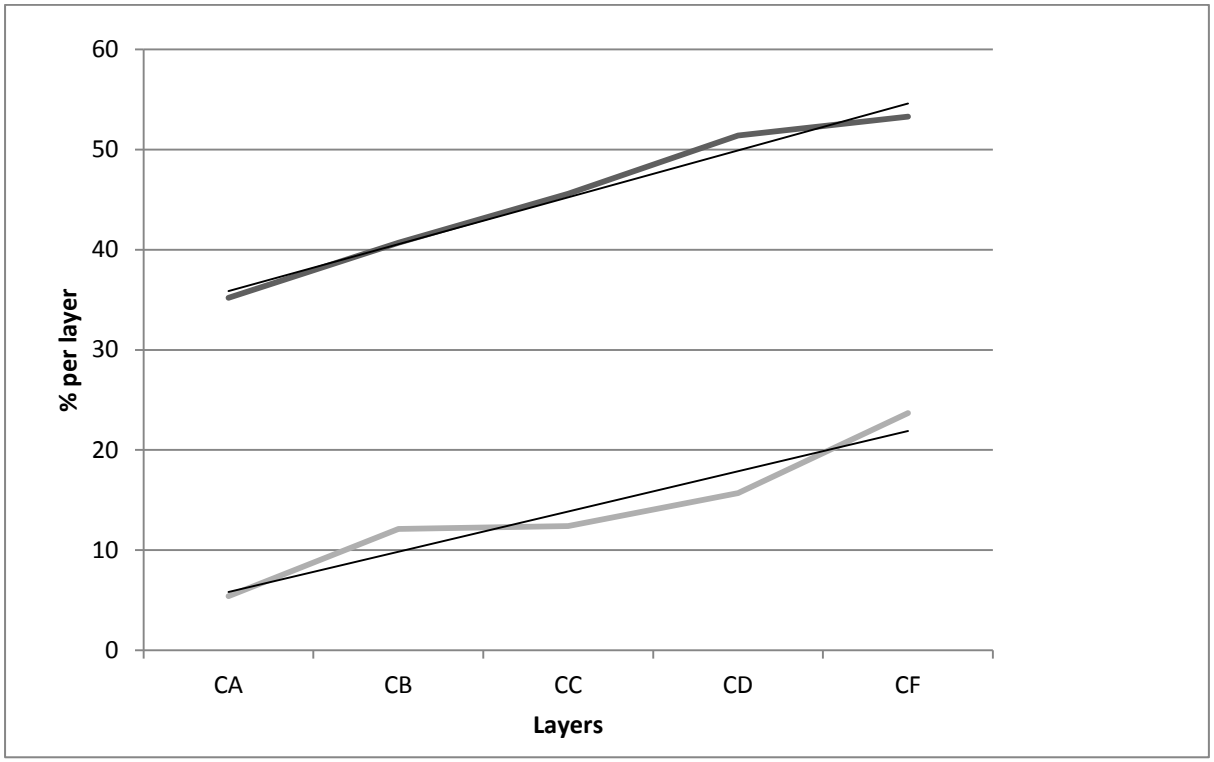


Figure 5.16: Comparison of the frequencies of burnt and percussion-marked bone fragments at BBC. Grey line = percussion-marked bone; Black line = burnt bone. Trend lines represent Pearson's correlation coefficient r = 0.918

5.5.2 Anthropogenic modifications

Just under a quarter of all specimens (22.6%, n = 519) exhibit cut, chop or percussion marks (Figure 5.17). These marks are distributed almost evenly between the M1 (48.6%, n = 252) and the upper M2 (51.5%, n = 267) phases. In contrast, undamaged bone fragments are more common in the upper layers than in the lower layers (Figure 5.18). Square G5 yielded the most human-marked specimens (31.1%, n= 173) while D5 yielded the least (0.7%, n = 4).

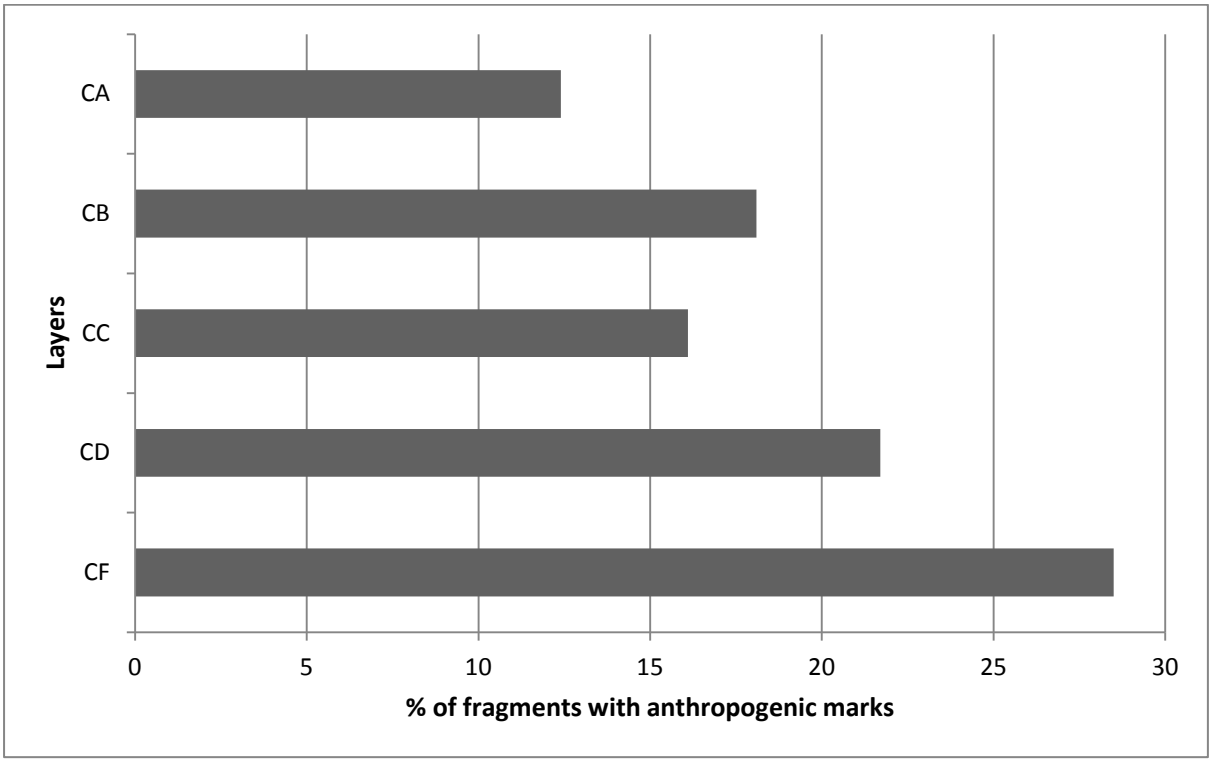


Figure 5.17: Stratigraphic distribution of bone fragments with anthropogenic marks at BBC. Anthropogenic marks are classified as cut, chop and percussion marks.

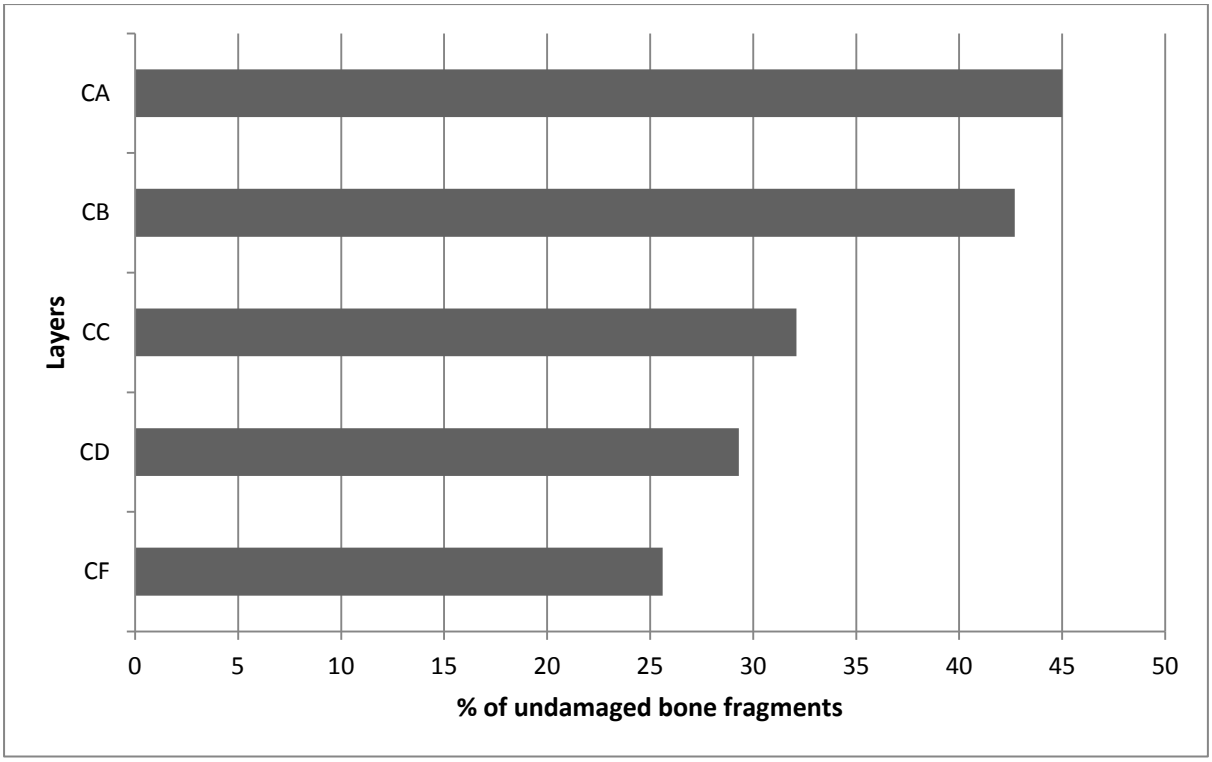


Figure 5.18: Stratigraphic distribution of undamaged bone fragments at BBC

Cut and chop marks occur on less than 10% of the unidentified long bone fragments (7.9%, n = 181) (Figure 5.19). The majority of these specimens were recovered from Layers CF (38.1%, n= 69) and CD (34.3%, n = 62). The proportion of cut and chop-marked fragments is relatively constant throughout the layers at BBC (Figure 5.20). Square G5 yielded the most cut and chop-marked fragments (21.6%, n = 39) while no cut-marked specimens were recovered from Square D5.

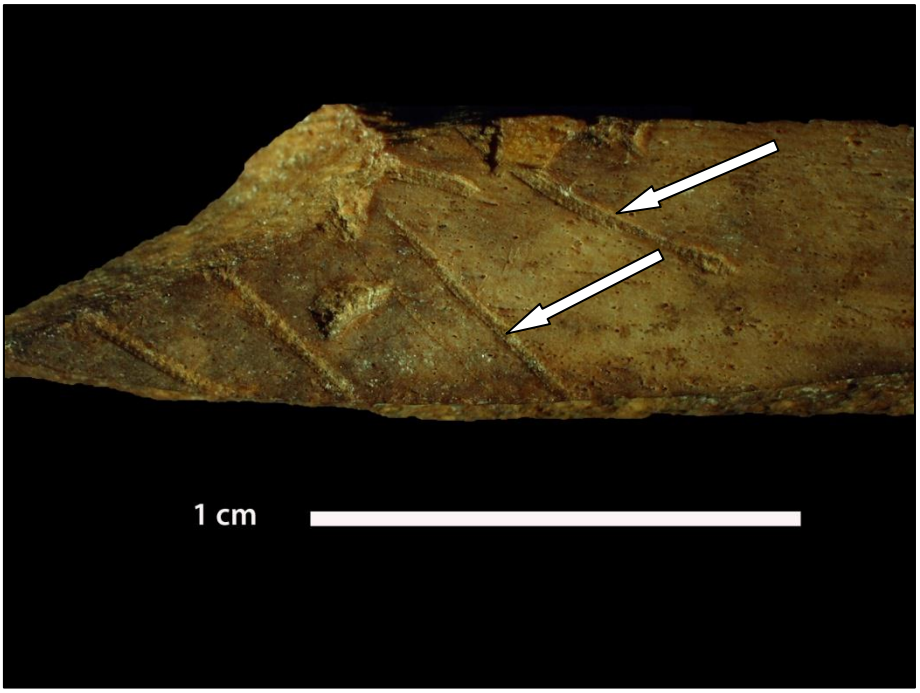


Figure 5.19: A cut-marked fragment. Note the straight, geometric striations

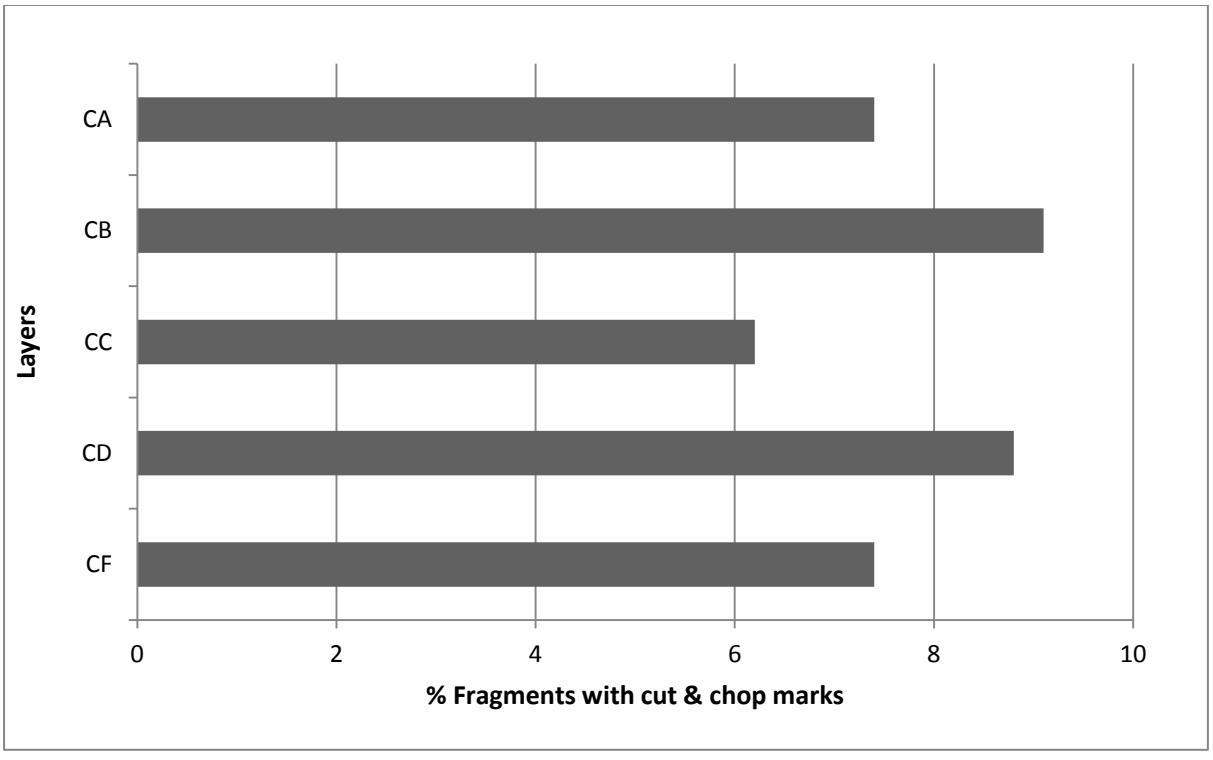


Figure 5.20: Stratigraphic distribution of bone fragments with cut and chop marks at BBC

Just under a fifth of specimens display percussion marks (17.1%, n = 394) (Figure 5.21). The largest proportion of these fragments were recovered from Layers CF (56.4%, n = 222) and CD (28.4%, n = 112) while the least were recovered from Layer CA (4.1%, n = 16) (Figure 5.22). More percussion-marked fragments occurred in Square G5 (36.0%, n = 142) than in any other square, while D5 yielded the least percussion-marked fragments (1.0%, n = 4).

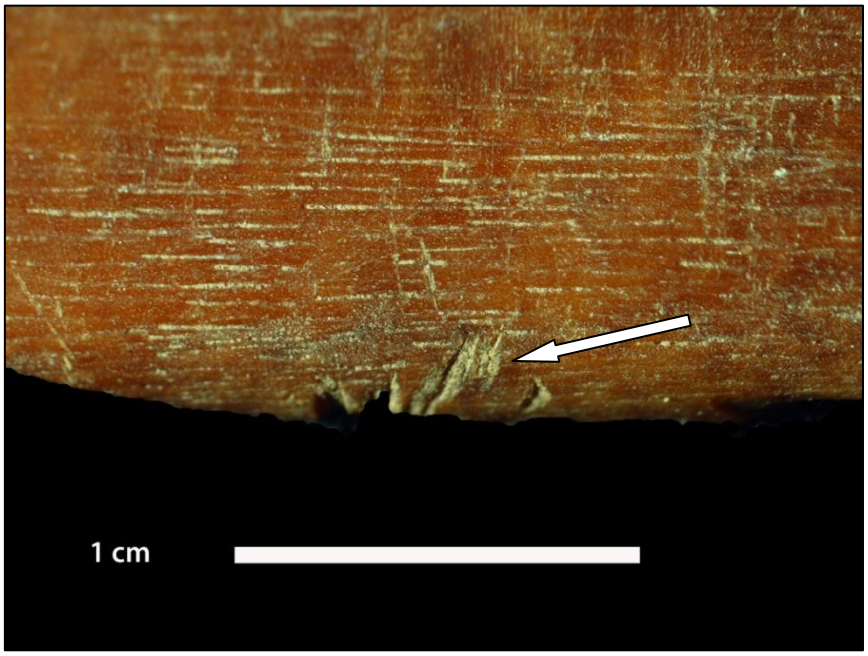


Figure 5.21: Percussion mark. The striations and glossy sheen above the percussion mark indicates polishing

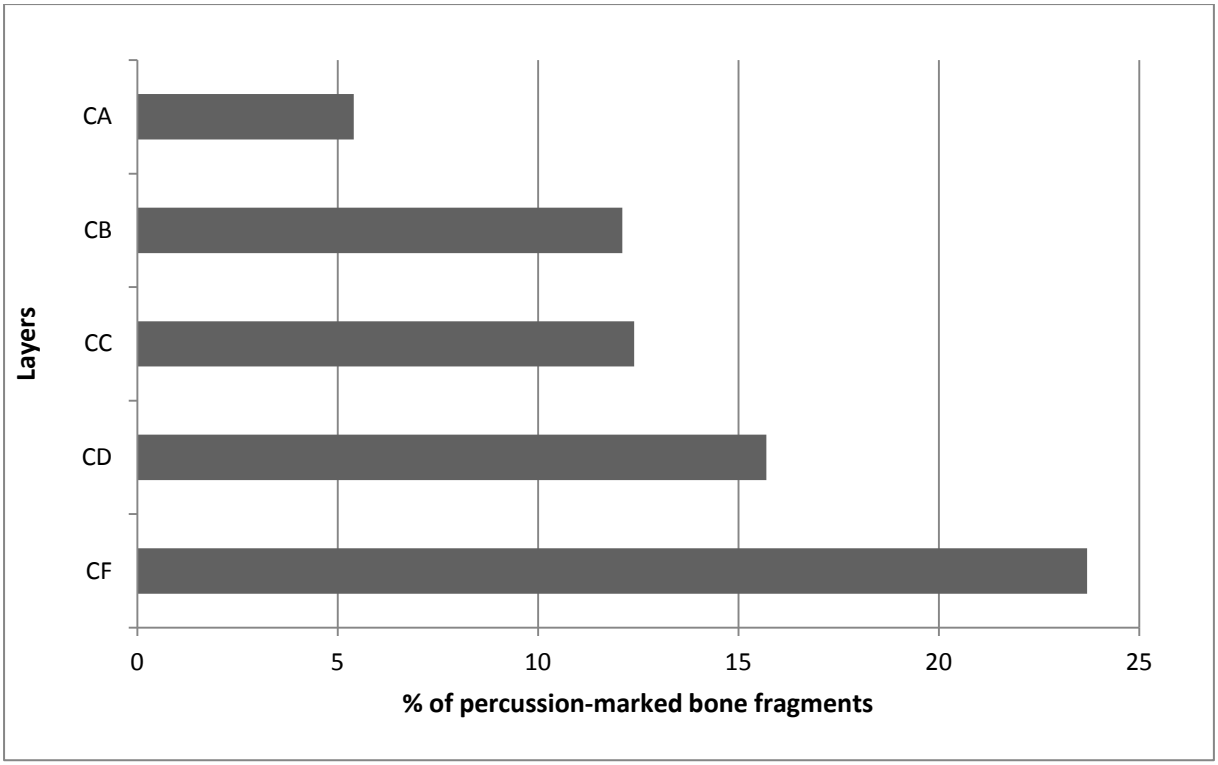


Figure 5.22: Stratigraphic distribution of bone fragments with percussion marks at BBC

5.5.3 Polish

A fifth of all bone fragments display evidence of polish (20.5%, n = 472) (Figure 5.23). Polished fragments are slightly more prevalent in the upper M2 (52.0%, n = 222) than in the M1 (48.0%, n= 205) phase. Almost half of all polished specimens occur in Layer CF (52.0%, n = 222) while Layer CC yields the least amount of polished fragments (4.0%, n = 17) (Figure 5.24). Spatially, Squares G6 (23.0%, n = 98) and D4 (19.0%, n = 81) contain the most polished specimens while the least specimens with polish were recovered from G4 (1.2%, n = 5).

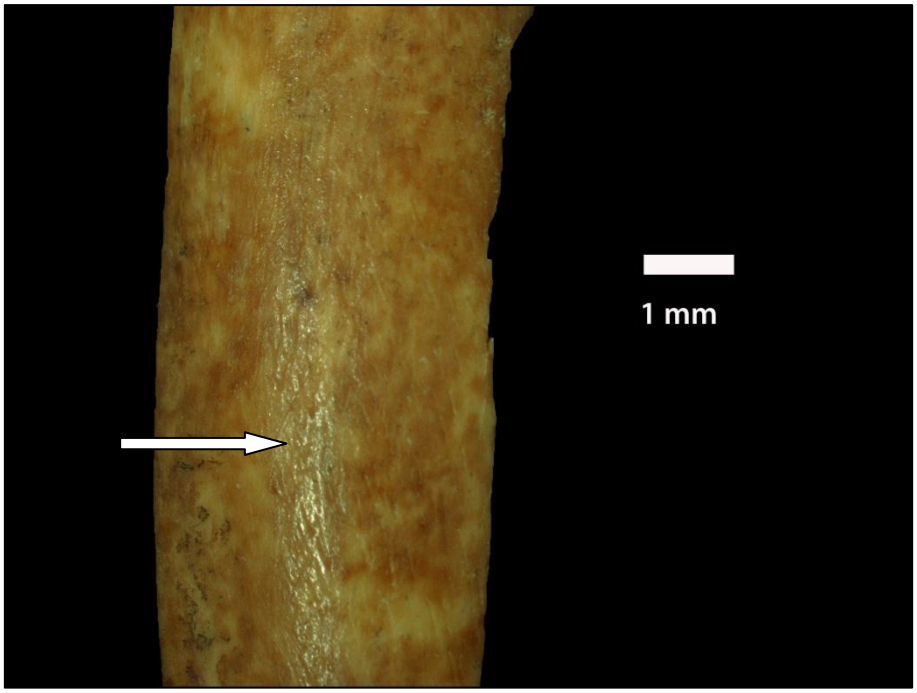


Figure 5.23: Polished specimen. 'Criss-cross' striations are visible on the polished surface

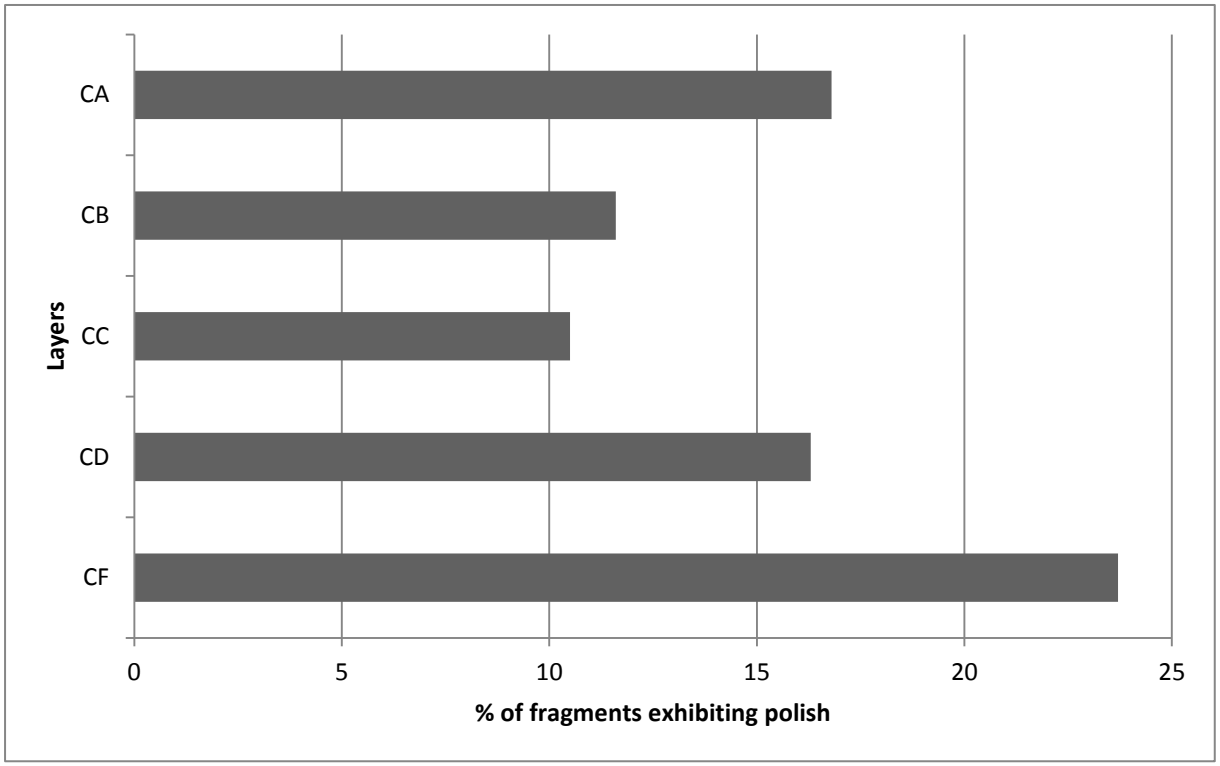


Figure 5.24: Stratigraphic distribution of bone fragments with polish at BBC

5.5.4 Tooth and gnaw marks

Relatively few bone fragments exhibited tooth or gnaw marks (4.0%, n = 91) (Figure 5.25) with the majority recovered from the M1 phase (65.9%, n = 60). Layer CF yielded the most specimens (34.1%, n = 31) while the least specimens were recovered from Layer CB (9.9%, n = 9) (Figure 5.26). Square G4 yielded the most tooth or gnaw-marked fragments (20.9%, n = 19) while no specimens occur in D5 and only two fragments were recovered from both D2 and D3 (2.2%, n = 2).

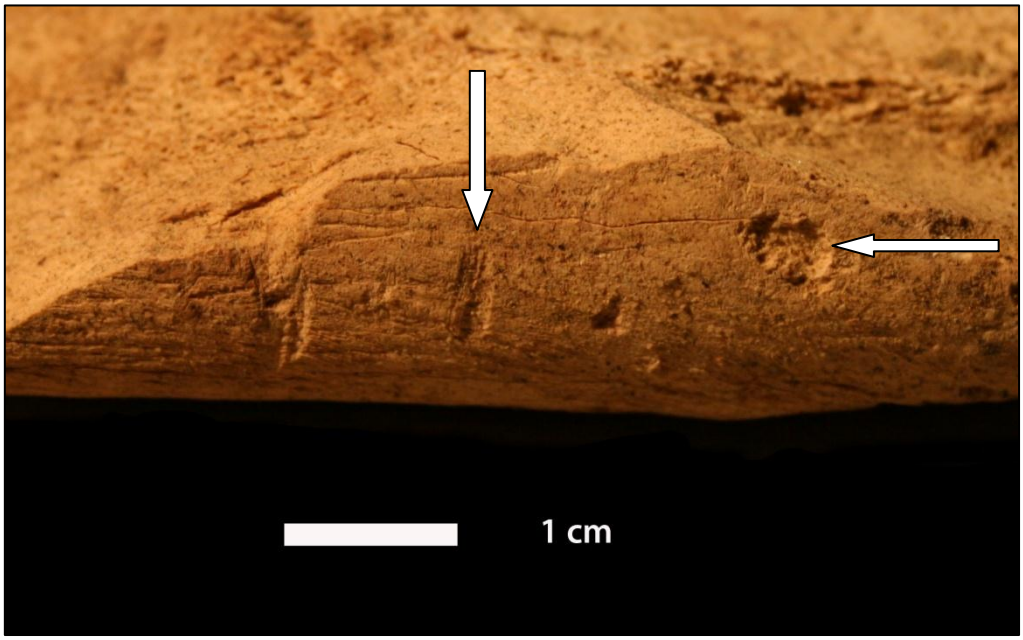


Figure 5.25: Tooth marks (left arrow) and a carnivore bite mark (right arrow)



Figure 5.26: Stratigraphic distribution of tooth and gnaw-marked bone fragments at BBC

In my analyses, the percentage of taphonomically altered fragments per layer was measured (Table 5.35; Figure 5.27). These percentages are based on the number of specimens with surface modifications from the total number of specimens within each layer. The frequency per layer reflects the relative importance of taphonomic variables to each other within each layer and negates the effects of the sediment volume of layers. It also indicates the temporal prevalence of taphonomic processes.

The majority of the unidentified long bone fragments from the BBC sample was recovered from Layers CD and CF (71.4%, n = 1643) with almost 40% of all specimens occurring in Layer CF. However, in comparing the number of unidentified fragments (NUSP) to the estimated volume per layer, we can see that although Layer CF yields the most specimens it has the lowest numbers of fragments per volumetric unit because it has the greatest volume (Table 5.36; Figure 5.28). A more appropriate measurement is the numbers of specimens per volumetric unit which is an assessment of bone fragment density. Layer CA has the highest density at 5.41 numbers of unidentified specimens (NUSP) per mm^3, followed by Layer CB and CC (4.33 and 4.63 NUSP per mm^3, respectively) (Table 5.36). In contrast, Layer CD and CF yielded the lowest suggesting that bone fragment density decreases with depth.

Table 5.35: Surface modifications per layer at BBC

Layer	NUSP*	Burnt		Tooth & gnaw marks		Cut marks	
		n	%	n	%	n	%
CA	298	105	35.2	23	7.7	22	7.4
CB	199	81	40.7	9	4.5	18	9.1
CC	162	69	45.6	11	6.8	10	6.2
CD	706	363	51.4	17	2.4	62	8.8
CF	937	499	53.3	31	3.3	69	7.4
Layer	**NUSP***	**Percussion marks**		**Undamaged**		**Polish**	
		n	%	n	%	n	%
CA	298	17	5.7	134	45.0	50.0	16.8
CB	199	24	12.1	85	42.7	23	11.6
CC	162	19	11.7	54	33.3	17	10.5
CD	706	111	15.7	210	29.8	115	16.3
CF	937	222	23.7	249	26.6	222	23.7

*NUSP = Number of Unidentified Specimens

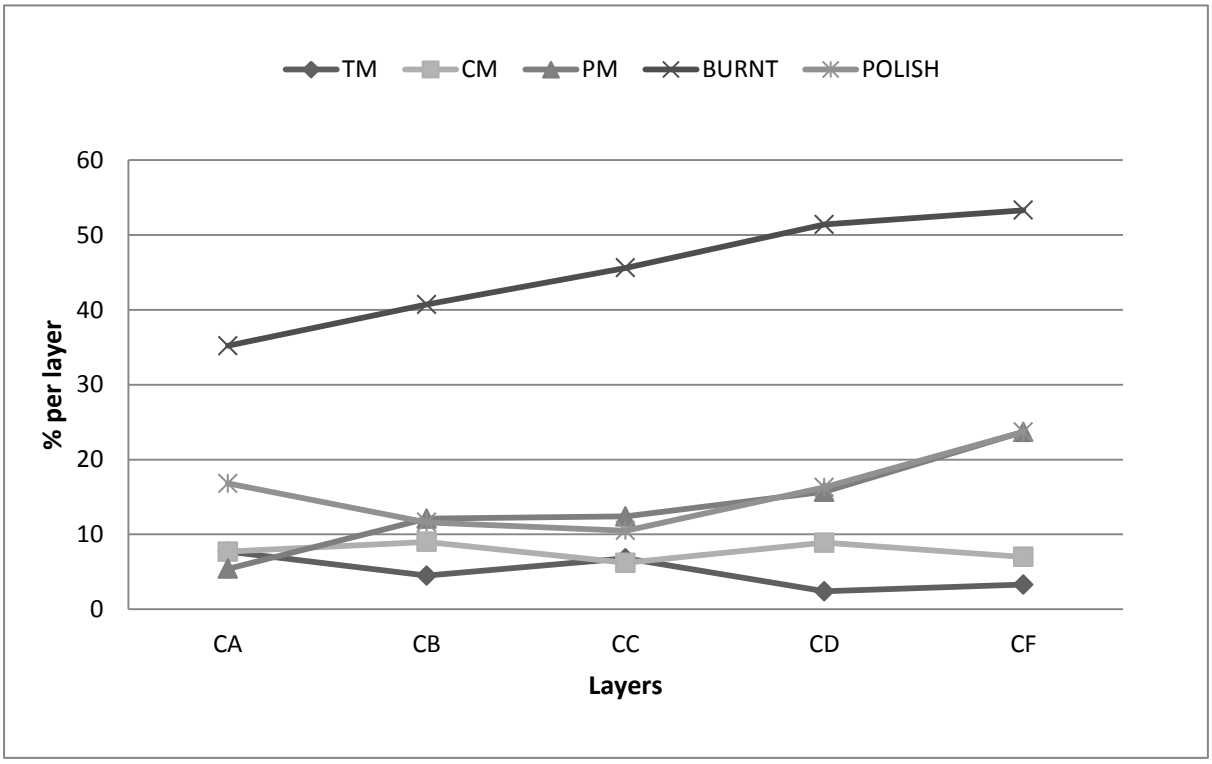


Figure 5.27: Relative frequency of surface modifications per layer at BBC. TM = tooth & gnaw marks; CM = cut & chop marks; PM = percussion marks

Table 5.36: Density of bone fragments at BBC per layer

Layer	Volume (m^3)	NUSP	NUSP per mm^3
CA	0.055	298	5.418
CB	0.046	199	4.326
CC	0.035	162	4.628
CD	0.362	706	1.950
CF	0.608	937	1.541

*NUSP = Number of Unidentified Specimens

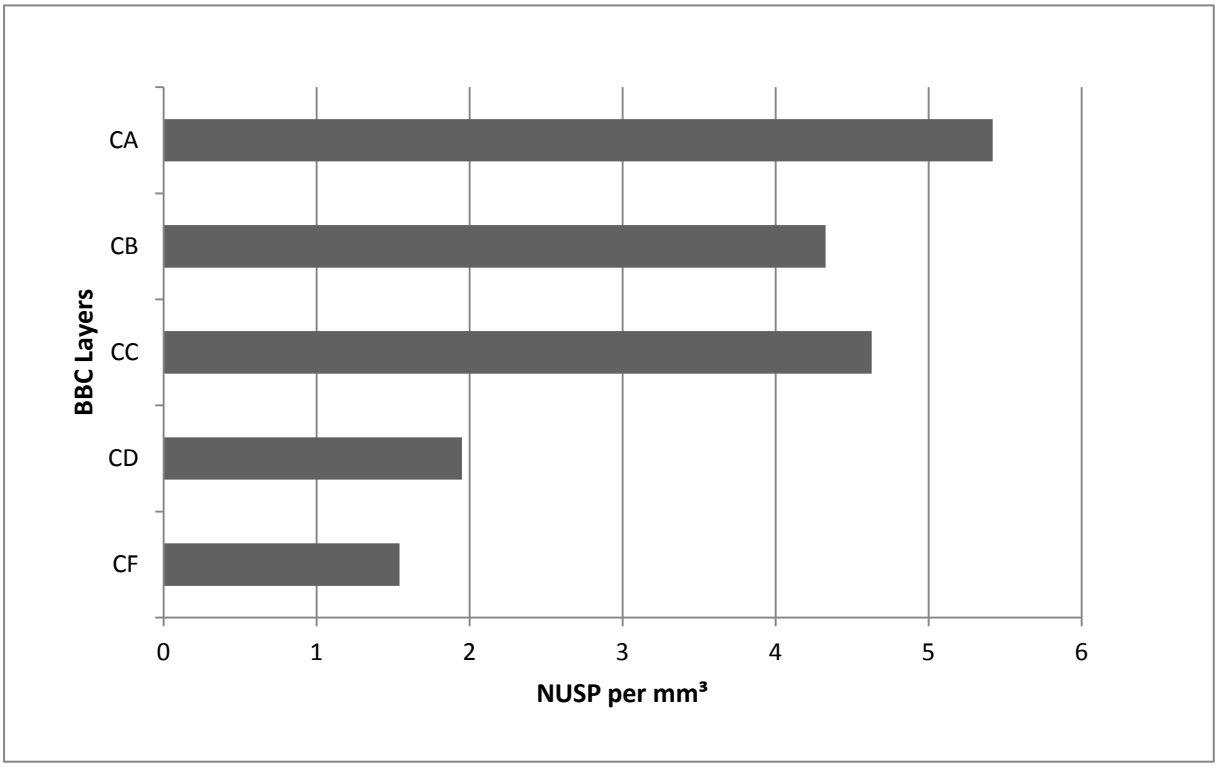


Figure 5.28: Bone fragments per volume at BBC

*NUSP = Number of Unidentified Specimens

5.6 Summary

Of the 2305 specimens assessed, the lengths of 2302 and the cortical thickness of 2042 specimens were measured. The majority of these bone fragments were recovered from Layer CF while Layer CC yielded the least amount of specimens. All specimens were recovered from either the North West border or the South East corner of the excavation area. Bone fragments generally become smaller down through the layers. The average cortical thickness

of specimens is thicker in Layer CB and CC and thinnest in Layer CF, lower down in the sequence. Burnt specimens are slightly smaller than unburnt specimens although calcined specimens are significantly smaller than unburnt specimens. Cut- and chop-marked, and percussion-marked specimens are, on average, longer and thicker than undamaged specimens. Tooth and gnaw marked fragments are generally longer and thicker than all other specimens. Over 80% of specimens are less than 30 mm in length (code 1 – 3) and almost 90% have a cortex less than 6 mm thick (code 1 – 3). The 561 measurements from the Gobabeb goat bone collection at the Ditsong National Museum of Natural History in Pretoria suggests that the cortical thickness of these Bovid II animals all fall within code 2 of Driver's (1999) classification system. As discussed above, this indicates that cortical thickness may be used to infer animal size class.

The majority of fractures from the total sample were the result of spiral or 'fresh' breaks and a third were transverse or the result of dry breakage. While burnt bone displayed significantly more transverse fractures than the total sample, undamaged specimens exhibit significantly more spiral fractures. Bone fragments spirally fractured are also, on average, longer than those broken transversely. Almost half the total sample exhibit evidence of burning while just under a quarter display cut, chop or percussion marks. Less than 8% of specimens display cut and chop marks while just over 17% have percussion marks. Polish occurred on 20.5% of specimens and tooth and gnaw- marked fragments are relatively rare (4%). Most of the modified specimens occurred in Layer CF but this could be attributed to sample size because almost 40% of all specimens were recovered from this layer. However, the numbers of unidentified fragments (NUSP) per volumetric unit indicates that bone density was greater in the top three layers (CA, CB and CC) and lowest in the upper M2 (Layer CF).

In Chapter 6, I discuss the implications of these results in terms of trends in subsistence behaviour during the Still Bay at BBC. In particular, I explore variability in hunting strategies and the effects of fragmentation on the above dataset.

CHAPTER 6: DISCUSSION AND CONCLUSION

In this chapter, the results of the analyses of unidentified faunal specimens are discussed and compared to other archaeofaunal assemblages; specifically those from MSA sites in southern Africa (Figure 3.1). In the first section I discuss the implications of the sample distribution and fragment density. I then consider the lengths and cortical thickness of specimens, with particular emphasis on the correlation of cortical thickness to element/animal size. The next section deals with breakage patterns and surface modification. Surface modification is divided into burning, percussion and cut marks, polish and non-anthropogenic modification. Finally, I discuss the taphonomy and faunal density patterns at BBC in the context of the Still Bay.

6.1 Sample Density and Distribution

Spatially, all specimens were recovered from either the North West margin or the South East corner of the excavation (Figure 5.1). The dataset for this research, therefore, represents only a sample of the unidentified fauna present at BBC. Stratigraphically, the volume per unit measurements indicates that fragment density decreases with depth, dropping abruptly from Layer CC to Layer CF (Table 5.36; Figure 5.22). The reason for the higher number of bone fragments in the upper layers may be the result of either:

1) An increase in species abundance or diversity. More species may have occurred at BBC during the periods contemporaneous with Layers CA to CC. Alternatively, improved human hunting methods (or, less likely, increased carnivore activity) may have also resulted in an increase in the number of faunal material deposited in those layers.
2) An increase in the fragmentation of the assemblage with fewer bones classified as shafts. If the number of species remained constant, then fragmentation, caused by taphonomic processes such as trampling, root etching and sedimentation, may have increased the number of unidentified specimens (NUSP) within layers. In addition, human activities related to food processing strategies such as marrow extraction,

burning and butchering and carnivore activities may also have increased fragmentation and the NUSP within the layers.

Bone fragment densities may not only imply human or animal occupation but may also be related to sedimentation. Brain (1975: 111 – 112), for example, in his review of the southern African australopithecine bone accumulations, suggests that high concentrations of bone in faunal assemblages is the result of low rates of sedimentation. By contrast, 'rapid' sedimentation results in 'diluted' faunal assemblages. However, the Plio-Pleistocene dolomite cave-sites he discusses are located in the Gauteng Highveld interior and involve a different sedimentological aetiology to the coastal BBC site. Klein (1975: 285), in his study of the Pleistocene faunal assemblage at Swartklip along the False Bay coast argues that fragmentation in southern Cape cave sites is most likely the result of 'slow' sedimentation and human activity. He argues that "[w]*ithin a single cave, changes in occupational intensity or in sedimentation rates generally correlate with changes in bone fragmentation.*" In proposing models for variation in the densities of fossil assemblages, Kidwell (1985, 1986) argues that if fossil (lithics, shell or bone) deposition within a stratum is constant, an increase of fossil density as stratigraphic depth decreases is the result of a decrease in sedimentation over time. This form of fossil concentration (which she terms a Type I model), corresponds to the stratigraphy of BBC where bone fragment density decreases with increased depth. She suggests that this type of stratum would result in higher frequencies of fossil fragmentation in shallower levels. This may not be the case at BBC where fragmentation may increase with depth, albeit only slightly. As a reflection of fragmentation, bone fragment length is discussed in the next section.

6.2 Fragment Length

The length of bone fragments has been used as a proxy for the evaluation of the fragmentation of faunal assemblages (Brain 1969, 1974b, 1975, 1981; Voigt 1983; Lyman & O'Brien 1987; Enloe 1993; Lyman 1994; Outram 2001; Clark 2009). Published studies where the lengths of unidentified bone fragments have been measured are rare and even fewer studies have involved MSA faunal material. The exceptions are the Apollo 11 site in Namibia where the mean unidentified bone fragment length is 24.0 ± 3.8 mm (Thackeray 1979). In the Howieson's Poort and Post-Howieson's Poort faunal assemblage from Sibudu, the majority

of unidentified bone was less than 20 mm long (Driver's codes 1 and 2) (Clark 2009). The mean fragment length at BBC (20.9 ± 14.1 mm) falls well within the range of the Sibudu (Clark 2009) and Apollo 11 measurements (Thackeray 1979) and is also within the range of measurements from the MSA/LSA layers at Bushman's Rock Shelter (Brain 1969) and LSA sites such as the Wilton Rock Shelter (Thackeray 2007). The average length of long bone fragments from early Pleistocene sites such as Kromdraai and Swartkrans, however, are longer than those from BBC (Brain 1981) (Table 6.1).

The BBC data was compared to 'bone flake' distribution histograms from the Iron Age sites of Mapungubwe, K2, Nkope, Matope Court (Voigt 1983) and Great Zimbabwe (Brain 1974b). Bone fragments from K2 peak in the 20 – 30mm (Driver's code 3) and the 30 – 40mm (code 4) size classes, while at Nkope, specimen's peak in the 0 – 25 mm (codes 1, 2 and 3) size classes. At Matope Court, bone fragments peak in the 20 – 40 mm (codes 3 and 4) size class while at Great Zimbabwe they occur more often in the 51 – 76 mm (codes 6 to 8) group. By contrast, specimens from BBC are smaller, peaking in the code 2 (10 – 19.9 mm) size class (Figure 5.3). However, differences in occupational age and sedimentation aetiology must be taken into account when comparing data from the above Iron Age sites to MSA coastal cave-sites such as BBC.

Except for the mean fragment lengths from the Wilton Rock Shelter, bone fragments from BBC are, on average, shorter than specimens from both MSA and LSA sites (Table 6.1). The mean fragment lengths from southern African Iron Age sites are also greater than those from BBC. However, bone fragments from the upper Level 1 at K2 peak in the 10 – 20 mm size class and specimens from the heavily fragmented Nkope assemblage "*came from a shallow, hard deposit*" (Voigt 1983: 98). Voigt (1983) suggests that both Nkope and the upper levels of the K2 deposit were more susceptible to trampling and weathering, resulting in smaller fragments.

There is a significant difference between the mean fragment length in Layer CA and that of Layer CF at the 5% level (Students' *t* critical value = 1.965; df = ∞; $\alpha = 0.05$) suggesting that, although only by a small margin, the average lengths of bone fragments from BBC decrease from the upper to the lower layers. Diagenetic processes such as soil compaction may have been an important factor (cf. Brain 1981; Gifford 1981; Lyman 1994; Behrensmeyer *et al.* 2000). Shipman (1981) suggests that rapid sediment deposition results in the fragmentation of faunal remains. Klein and Cruz-Uribe (1984: 71 – 73) note that the southern African faunal

assemblages they have analysed are highly fragmented. At the Late Pleistocene site of Boomplaas, for example, they suggest that "*intense post-depositional pressure was the principle cause of fragmentation*". Villa and Mahieu (1991) propose that conjoining bone fragments lying next to each other, at the Late Neolithic Sarrians site in France, are the results of sediment compaction. In his analysis of the fauna from McEachern's Cave in South-eastern Australia, Kos (2003: 791) notes that limb bones demonstrates increasing fragmentation with depth: a process he associates with sediment compression, trampling and rock-fall. However, unlike BBC, McEachern's Cave is a pitfall trap where the remains of terrestrial fauna have been accumulating since the Late Quaternary. Henshilwood *et al.* (2001b) indicate that roof spall is more common in Layers CC and CD than in the upper Layers CA and CB. As opposed to soil compaction, rock-fall was probably not a significant factor in bone fragmentation at BBC.

Thompson and Henshilwood (2011) measured the lengths of identified long bone fragments from BBC. They found the median fragment lengths to be 23 mm for the M1 and 17 mm for the upper M2. The median length for unidentified fragments from the M1 is 17 mm and 15 mm from the upper M2. On average, identified long bones fragments are likely longer than unidentified fragments because longer bone fragments retain more taxonomically identifiable characteristics than shorter ones. Thompson and Henshilwood (2011: 752) argue that bone fragments are longer in the M1 because "*the fragment size differences between the phases are likely attributable to differences in body size representation.*" They note that the M1 has a larger proportion of size 3 and above faunal remains than the upper M2 and that smaller fragment sizes in the lower layers were likely the result of smaller animals. The lengths of the unidentified fragments mirror the pattern recorded by Thompson and Henshilwood (2011) and suggest that fragment length may relate to animal or element size. However, the effects of sediment pressure and burning (as discussed below) may have affected specimen lengths.

Burning may also have contributed to the relatively shorter fragments in the lower layers at BBC. As noted in Chapter 5, burnt fragments in general, and calcined fragments in particular, are significantly shorter than unburnt specimens. Costamagno *et al.* (2005) suggest that burnt bone is likely to be more intensively fragmented than unburnt bone. Stiner *et al.* (1995) also note that bone fragments from Palaeolithic and early Mesolithic sites in Italy that exhibit evidence of burning are consistently shorter than unburnt fragments. They suggest that burnt bone is generally smaller than unburnt bone because burnt bone is "*more easily broken*." (Stiner *et al.* 1995: 235). Burning weakens the structure of bone making it more susceptible

to breakage by other means (Marean *et al.* 2000). The prevalence of burnt bone in the lower M1 and upper M2 may account for the relatively shorter fragments in these layers.

Researchers have proposed that the relatively long unidentified limb-bone fragments from early Pleistocene assemblages are related to carnivore activity (Brain 1981; Thackeray 2007). This corresponds to measurements obtained from the unidentified BBC faunal sample indicating that bone fragments with tooth marks are generally longer than undamaged specimens (Figure 5.5). Mean long bone fragment lengths from faunal assemblages accumulated by hyenas are significantly higher than those from human-accumulated assemblages (Brain 1981; Thackeray 2007). Percussion-marked specimens are also longer than undamaged fragments in the BBC sample (24 mm versus 20.1 mm, respectively) (Table 5.11 & 5.14). Blumenschine (1995: 25), in describing his marrow extraction model argues that "[b]*reakage is aimed at exposing* [marrow] *and puts a premium on finesse over strength.*" He suggests that "*experience in this breakage technique...obviates the need to batter bones, thus minimizing the degree of fragmentation.*"

Thackeray (2007) notes that the standard deviations for mean 'bone flake' lengths from MSA and LSA assemblages are generally lower than those from early Pleistocene sites. He attributes these higher standard deviations to carnivore activity. Other researchers have also suggested that hyena dens have a wider range of unidentified bone fragments sizes in comparison to the narrower range of human-induced assemblages (Brain 1981; Villa *et al.* 2004). While the small unidentified bone fragments at BBC could indicate fragmentation associated with human activities, the high degree of variability of fragment lengths may be attributed to the effects of carnivores on the faunal assemblage (Brain 1981; Thackeray 2007) (Table 6.1).

Table 6.1: Mean unidentified bone fragment lengths from early Pleistocene and Late Quaternary faunal assemblages

Period	Faunal assemblage	n	Mean fragment length (mm)	Standard deviation	Data source
ESA	Kromdraai:				Brain 1981; Thackeray 2007
	KA(D13)	3016	25.2	10.1	
	KB1	1512	24.8	11.6	
	KB2	627	27.3	4.4	

	KB3	748	27.9	4.5	
	Swartkrans:				Brain 1981; Watson 1993
	SK M1	6171	28.7	4.6	
	SK M2	6835	27.4	4.4	
	SK M3	8923	30.0	4.8	
	SK M5	757	39.0	5.9	
	Sterkfontein:				Brain 1981; Pickering *et al.* 2004; Thackeray 2007
	M5	89	54.7	31.2	
MSA	Apollo 11	1879	20.0	9.0	Thackeray 1979
	BBC (M1 &upper M2)	**2302**	**20.9**	**14.1**	**This study**
LSA	Wilton	33891	13.9	1.4	Brain 1981; Thackeray 2007
	Bushman Rock Shelter	2723	37.5	5.7	Brain 1969; Thackeray 2007
Modern	Spotted hyaena (*Crocuta crocuta*)	270	72.0	8.6	Brain 1981; Thackeray 2007
	Brown hyaena (*Hyaena brunnea*)	2887	110.5	10.4	Brain 1981; Thackeray 2007

6.3 Cortical Thickness

The majority of unidentified long bone fragments from the dataset occur in Driver's code 2 (2 – 3.9 mm) cortical size class (46.4%, n = 1010). To test whether these cortical codes, and therefore the cortical thickness of long bone fragments, can be correlated with animal size class, the cortices of goat (*Capra hircus*) long bones from the Gobabeb collection (Brain 1967a) was measured (cf. Uerpman 1973; Driver 1992). In addition, the cortical thickness of a sample of identified fauna from BBC had also been measured by Badenhorst and Henshilwood (2010). These measurements were not only used to test for the variability of cortical thickness within and between species, but also to check the validity of applying Driver's (1999) coding system to archaeofaunas from southern Africa. Compared to North America, where the system was developed (Driver 1999), southern Africa has a more extensive faunal diversity (Swanepoel *et al.* 2008).

Cortical measurements from the identified fauna from BBC indicate that variability in cortical thickness exists, not only between species, but within species as well. Rock hyrax (*Procavia capensis*) and eland (*Tragelaphus oryx*), for example, have cortical measurements that occur in both code 1 and 2, and code 5 and 8, respectively (Table 5.29). The Gobabeb goat bone sample, however, indicates that, regardless of element, cortical thickness clusters within a single code (Table 5.28). Although variation within species does occur, cortical measurements from the BBC identified fauna indicate that this variation is slight (Badenhorst & Henshilwood 2010). Of the 77 cortical measurements of rock hyrax, for example, 75 were classed as code 1, while only two were in code 2. Various factors such as element size, sexual dimorphism and age affect the size and therefore the cortical thickness of bone (Alexander 1977; Biewener 1983a, 1983b; Currey & Alexander 1985; Ruff *et al.* 1991; Croker *et al.* 2009). Variation in the cortical thickness of the BBC identified fauna, for example, can be the results of age differences since both juveniles and very mature individuals have cortices thinner than prime aged adults (Stein *et al.* 1998). The cortices of individual elements also vary in thickness (Barba & Dominguez-Rodrigo 2005) and females likely have thinner cortices than males (Peacock *et al.* 1998). In general, however, despite the variation in cortical measurements, the data suggests that species can be accommodated within the cortical thickness codes.

The value of the cortical thickness codes is not in identifying species, however, but in deriving animal size groups from within faunal assemblages. The relevance of the cortical coding system is not in individual measurements but as an assemblage statistic. The clustering of the cortical measurements in the reference samples suggests that the unidentified bone from BBC can also be accommodated into size classes. Therefore, Driver's (1999) cortical thickness codes have been used to group the unidentified BBC specimens into small, medium and large animal size classes.

Cortical measurements from the identified BBC fauna indicate that rodents and small-mammals such as the common duiker (*Sylvicapra grimmia*) can be categorised within code 1. Goats from the Gobabeb collection have been used as a proxy for medium-sized fauna. Since the cortical measurements from this collection fall (with one or two exceptions) within code 2, medium-sized animals have consequently been grouped in the code 2 and 3 categories. Badenhorst and Henshilwood's (2010) data reveal that cortical measurements for large animals, such as those defined as Bovid IV, were categorised in codes 4 and above. Thus, the cortical thickness of unidentified long bones has been classified as code 1 for small, codes 2

and 3 for medium, and codes 4 and above for large animal size classes. For comparative reasons, the identified fauna from BBC (Henshilwood *et al.* 2001b; Thompson 2008) was also grouped into animal sizes classes based on both Brains' (1974a) and Klein's (1976) method for bovid size classification (Table 6.2). Therefore, Bovid I (or 'small') was classified as small fauna, Bovid II and III (or 'small-medium' and 'large-medium') was medium and Bovid IV and V (or 'large' and 'very large') was grouped in the large fauna category.

Table 6.2: Animal size classes based on cortical thickness codes

Unidentified size class	Code	Equivalent bovid size classes		Weight range (kg)
Small		Brain (1974a)	Klein (1976)	
	1	Bovid I	Small	4.5 – 19
Medium	2	Bovid II	Small-medium	18 – 84
	3	Bovid III	Large-medium	77 – 299
Large	4	Bovid IV	Large	367 – 900
	≥ 5	-	Very large	> 900

The majority of identified fauna from BBC, as described by Klein (Henshilwood *et al.* 2001b) was classified as 'small' fauna (Table 6.3; Figure 6.1). Size classes of identified large-mammal fauna categorised by Thompson (2008) and Thompson and Henshilwood (2011) also indicate that most of the upper M2 fauna consist of small species (Figure 6.2). Although a significant proportion of species from the M1 was classified as 'small', the majority of M1 species were 'medium-sized'. However, Thompson's dataset excludes small-mammals such as rock hyrax (*Procavia capensis*) and Cape dune molerat (*Bathyergus suillus*) which dominate the BBC faunal assemblage. By contrast, most of the unidentified specimens from both the M1 and upper M2 were grouped in the 'medium' size class category (Table 6.4; Figure 6.3). The data indicates that there are more medium-sized animals present in the faunal assemblage at BBC than could be identified. This discrepancy between the size distribution of identified and unidentified fauna suggests that the unidentified fauna may reveal patterns not conspicuous in the identified faunal remains (cf. Badenhorst 2008). The reasons for this discrepancy may be the result of three factors:

1) The majority of the small fauna identified at BBC are rodents and small-mammals such as the Cape dune molerat and rock hyrax. These animals are common in

southern Cape archaeofaunal assemblages and easier to identify relative to their size and morphology (Thompson 2010). Faunal analysts are, thus, more likely to identify these specimens than, for example, medium-sized bovids that are difficult to distinguish from one another (Driver 1992).

2) Pressure from sediment weight over a large surface area results in greater loading forces per square centimetre than the same force over a smaller surface area (Johnson 1985; Herrmann *et al.* 2006). Long bones with narrower diameters, such as those from smaller elements or species, tend to resist fragmentation better than those with larger diameters (Johnson 1985; Marean 1991). The bones of smaller animals would be less likely to fragment. Consequently, the remains of these animals would be more likely to be identified, resulting in their dominance in the numbers of identified specimens (NISP) in faunal assemblages. Although Thompson (2008) and Thompson and Henshilwood (2011) indicate that larger fauna is more common in the M1 than the upper M2 (Figure 6.2), sediment weight and fragmentation may be a factor in the prevalence (and, possibly, 'identifiability') of smaller species in the deeper, upper M2 phase.
3) Because of their low caloric value, the bones of small fauna were less likely to be fragmented in order to extract marrow. Therefore, smaller animals are likely to be more complete in the assemblage and more easily identifiable.

Table 6.3: Size class of identified fauna at BBC (data from Henshilwood *et al.* 2001b)

Animal size class	Equivalent Bovid size class	Species	M1 NISP* (%)#	M2 NISP* (%)#	Total
Small (code 1)	Bov I	Hedgehog (*Erinaceus frontalis*)	6	10	
		Cape hare (*Lepus capensis*)	11	4	
		Scrub hare (*Lepus saxatilis*)	25	15	
		Cape dune molerat (*Bathyergus suillus)*	419	303	
		Porcupine (*Hystrix africaeaustralis)*	1	0	
		Chacma baboon (*Papio ursinus*)	1	0	
		Black backed jackal (*Canis mesomelas)*	1	0	
		Jackal (*Canis* sp.)	1	0	
		Striped polecat (*Ictonyx*	3	2	

		striatus)			
		Honey badger (*Mellivora capensis*)	1	1	
		Genet (*Genetta* sp.)	2	4	
		Small grey mongoose (Galerella *pulverulenta*)	3	4	
		Wildcat (*Felis silvestris*)	16	1	
		Rock hyrax (*Procavia capensis*)	169	190	
		Common duiker (*Sylvicapra grimmia*)	0	2	
		Steenbok (*Raphicerus campestris*)	0	1	
		Grysbok or Steenbok (*Raphicerus* sp.)	101	48	
		Grysbok (*Raphicerus melanotis*)	10	2	
		Small bovids (Bov I)	382	360	
		Small fauna total	**1152 (54.7)**	**947 (45.3)**	**2099 (100.0)**
Medium (code 2 & 3)	Bov II & III	Cape fur seal (*Arctocephalus pusillus*)	126	32	
		Dolphin (*Delphinidae* indet.)	2	1	
		Blue antelope (*Hippotragus leucophaeus*)	6	6	
		Southern reedbuck (*Redunca arundinum*)	14	4	
		Wildebeest (*Connochaetes gnou*)/ Hartebeest (*Alcelaphus buselaphus*)	5	0	
		Springbok (*Antidorcas* sp.)	0	1	
		Vaalribbok (*Pelea capreolus*)	6	2	
		Small-medium bovids (Bov II)	74	51	
		Large-medium bovids (Bov III)	91	50	
		Medium fauna total	**324 (68.8)**	**147 (31.2)**	**471 (100.0)**
Large (code 4 & above)	Bov IV &V	Black rhinoceros (*Diceros bicornis*)	3	0	
		Rhinoceros (*Rhinocerotidae* gen. et sp. indet.)	13	6	
		Hippopotamus (*Hippopotamus amphibius*)	3	1	
		Eland (*Tragelaphus oryx*)	48	8	
		Cape buffalo (*Syncerus caffer*)	2	0	
		Large bovids (Bov IV)	183	58	
		Large fauna total	**252 (77.5)**	**73 (22.5)**	**325 (100.0)**

* NISP = Number of Identified Specimens

Percentage of animal size class per phase in brackets

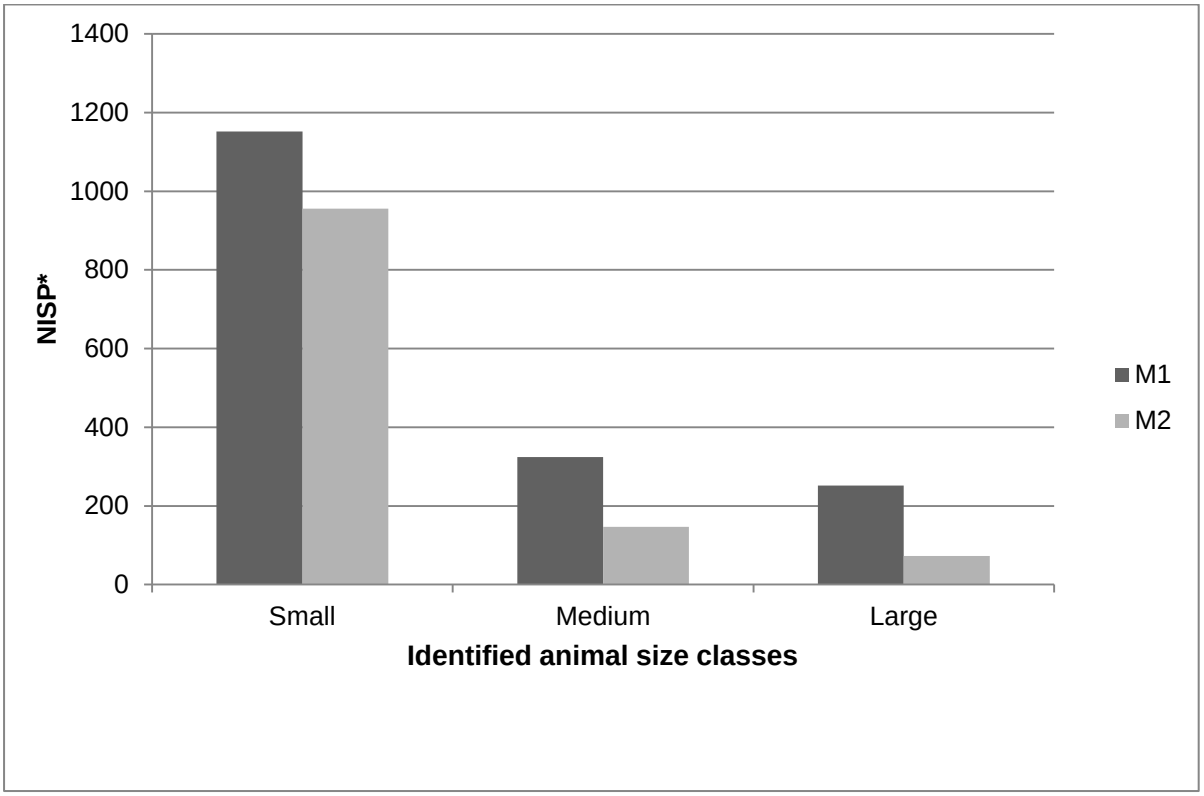


Figure 6.1: Distribution of animal size classes for identified fauna at BBC. Small = Bov I; Medium = Bov II & III; Large = Bov IV & V (data from Henshilwood *et al.* 2001b)

*NISP = Numbers of Identified Specimens

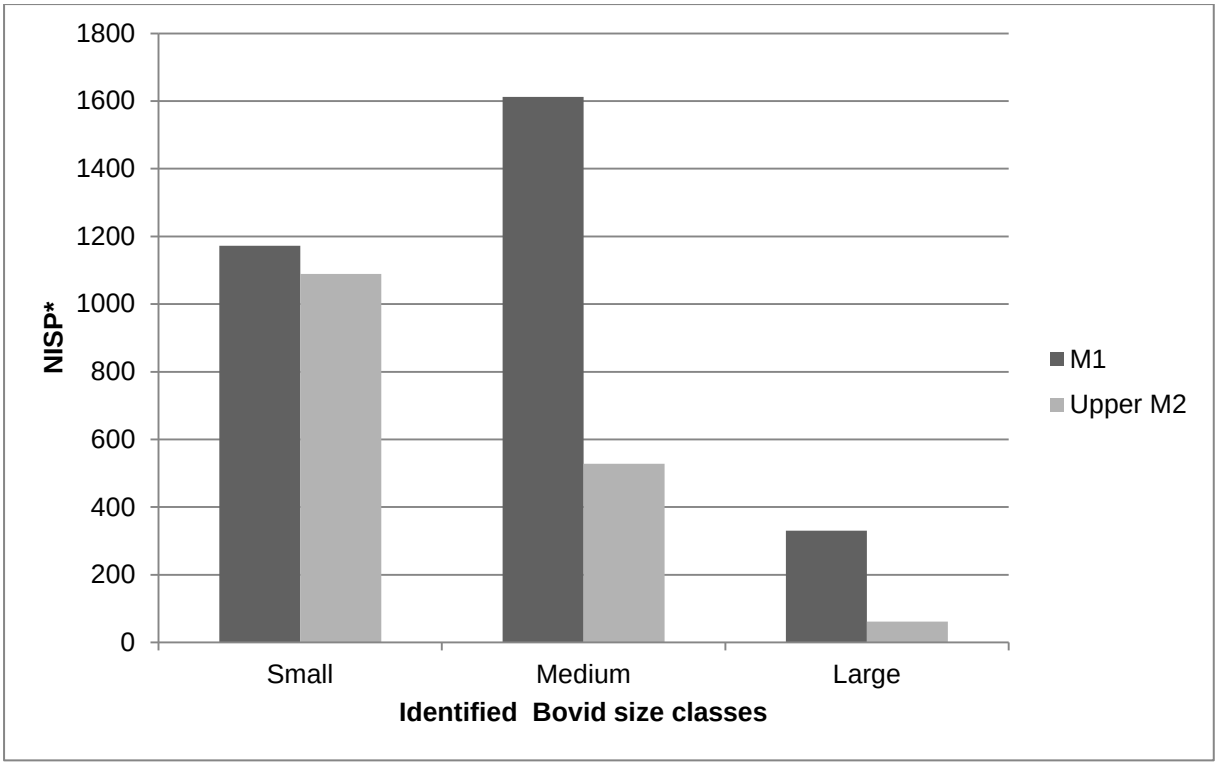


Figure 6.2: Distribution of bovid size classes for large-mammal identified fauna at BBC. Small = Bov I (size 1); Medium = Bov II & III (size 2 & 3); Large = Bov IV & V (size 4 & 5) (data from Thompson & Henshilwood 2011)

*NISP = Numbers of Identified Specimens

Table 6.4: Size class of unidentified fauna at BBC

Animal size class	M1		Upper M2	
	n	%	n	%
Small (code 1)	230	19.2	305	36.0
Medium (codes 3 & 4)	778	65.1	487	57.5
Large (codes 4 & above)	186	15.7	56	6.5
Total NUSP*	1194	100.0	848	100.0

*NUSP = Number of Unidentified Specimens

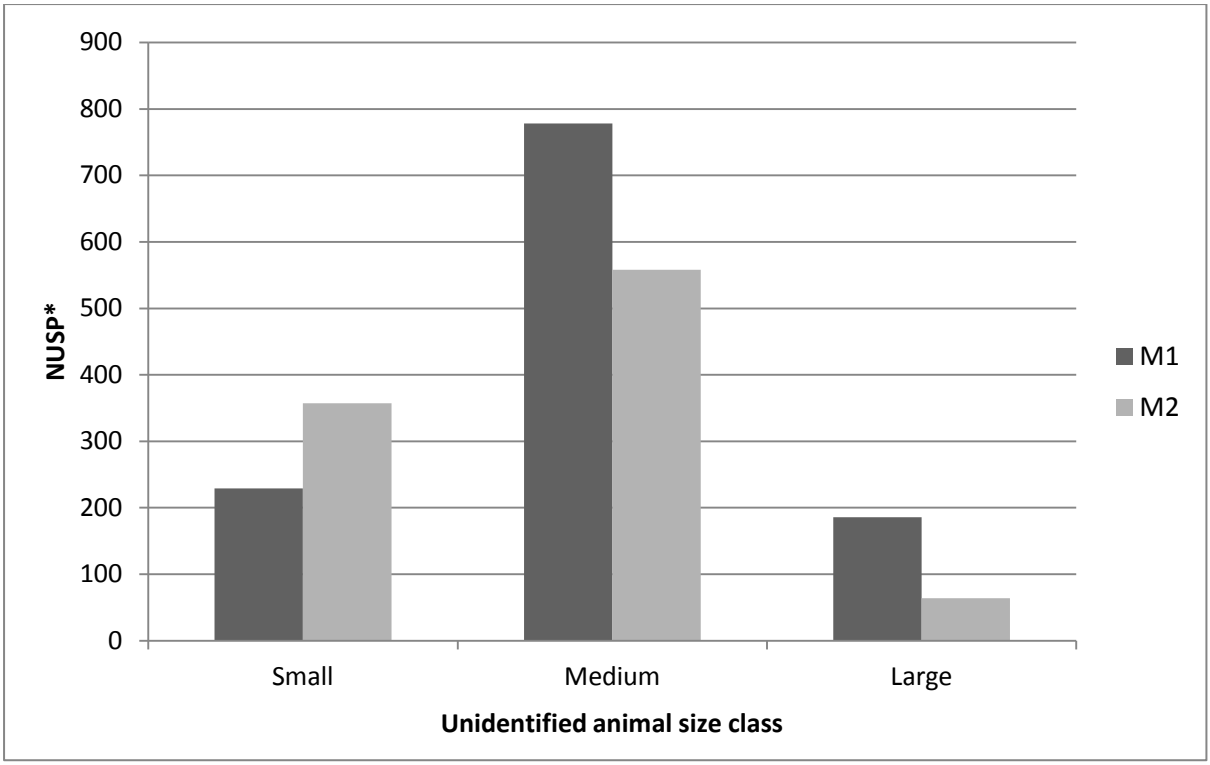


Figure 6.3: Distribution of animal size classes for unidentified fauna at BBC. Small = code 1; Medium = codes 2 & 3; Large = codes 4 & above

*NUSP = Number of Unidentified Specimens

Variability in cortical thickness within a species, or even an individual, precludes using these measurements to correlate cortical thickness to a particular species. However, cortical thickness is related, not only to the size range of animals, but to element size as well. Cortical thickness may also be indicative of the caloric value of the specimen: thicker cortical measurements imply larger animals or meat-bearing elements and, therefore, more meat, as well as more marrow. At BBC, cortical thickness is greatest in Layer CB and CC (the M1) and thinnest in Layer CF (the upper M2). This confirms Thompson's (2008) and Thompson and Henshilwood's (2011) research that indicate that the upper M2 had a higher representation of size I bovids than the more recent M1. On average, bone fragments with the thinnest cortical measurements were recovered from the lower Still Bay (Layer CF) (2.9 ± 1.8 mm). This layer also yielded the most percussion-marked bone fragments per layer (23.7%, n = 222) suggesting that either smaller fauna or the smaller elements of larger animals were more intensively exploited.

As implied above, surface modification may be related to animal or element size. Although percussion-marked specimens are relatively common in the upper M2, Student's *t* tests indicate that percussion marked fragments are slightly (yet significantly) thicker than undamaged fragments (Student's *t* critical value = 1.963; df = ∞; α = 0.05). Cut-marked fragments were significantly thicker than undamaged specimens (Student's *t* critical value = 1.967; df = ∞; α = 0.05) suggesting the processing of larger fauna or elements. Burnt fragments were also significantly thinner than unburnt specimens (Student's *t* critical value = 1.961; df = ∞; α = 0.05) probably because burning shrinks bone (Shipman *et al.* 1984; Nicholson 1993). Despite the border-line significance of these tests at the 5% level, the differences suggest that an increased number of surface modifications are associated with element size. This is discussed further in Chapter 6.5.

The stratigraphic distribution of bone fragments may be related to its cortical thickness. Specimens with larger cortices are bigger (longer) and trampling may have resulted in greater vertical displacement of smaller specimens with thinner cortices. As a consequence, larger fragments (with thicker cortices) may be prevalent in the upper MSA layers while smaller specimens (with thinner cortices) may have settled in the bottom layers (Gifford-Gonzalez *et al.* 1985; Olsen & Shipman 1988). However, research by Henshilwood (2005) and colleagues (Henshilwood *et al.* 2001a, d'Errico & Henshilwood 2007) on the stratigraphic integrity of BBC has investigated the provenience of archaeological material at the site and found that no vertical dispersal occurred between layers. Other possible explanations include severe fragmentation of long bones in the pre-M1 layers. Fragmentation may have been so extreme that bone from long bone shafts cannot be identified as 'long bone fragments' only as 'unidentifiable' bone fragments.

6.4 Fracture Patterns

The analysis of breakage patterns is indicative of the level of post-depositional fragmentation of a faunal assemblage (Villa & Mahieu 1991; Lyman 1994). Breakage patterns suggest the extent of human or carnivore predatory exploitation of bone assemblages (Johnson 1985; Marean *et al.* 2000). The breakage patterns of the unidentified long bone fragments from the BBC sample was compared to both the breakage patterns of identified specimens from BBC and those from other MSA sites. Previous analyses of the breakage patterns from BBC and

other MSA faunal assemblages used the method of Johnson (1985) adapted by Villa and Mahieu (1991), where both the fracture outline and the fracture angle were assessed (e.g., Marean *et al.* 2000; Thompson 2008, 2010). Fracture outlines or shapes were classified as curved or v-shaped, denoting a spiral or 'fresh' fracture while a 'transverse' fracture represented a 'dry' break. Fracture angles are defined as "*the angle formed by the fracture surface and the bone cortical surface.*" (Villa & Mahieu 1991: 34). These were either oblique for spiral or perpendicular ('right-angled') for transverse fractures. In contrast, the unidentified fauna was assessed using Driver's (1999) method where spiral and transverse fractures were denoted and no 'intermediate' or 'indeterminate' breakages were recorded. In comparing these studies to the unidentified BBC sample, these methodological differences in fracture assessment had to be considered. Consequently, the evaluation of fracture outlines and angles from the unidentified BBC sample were grouped together in a combined 'fracture edge' category. For comparative purposes, the 'fracture edge' of the unidentified BBC sample was compared only to the fracture outlines of other datasets.

More than 73% of fractures from the identified fauna in the M1 (73.3%, n = 2112) and just over 70% in the upper M2 (70.6%, n = 1259) show curved or v-shaped fracture outlines indicating that the majority of bone was broken in a 'fresh' state (Thompson & Henshilwood 2011). Almost two-thirds (62.8%, n = 2896) of the unidentified BBC specimens from the M1 and upper M2 displayed spiral fractures. There is a clear difference in the frequencies of spiral fractures between the identified and unidentified fauna from the M1 and upper M2 phases at BBC (Table 6.5). However, many of the unidentified specimens are burnt and because burning desiccates bone (Shipman *et al.* 1984; Thompson 2005), the likelihood of spiral fractures decreases (Lyman 1994; Bennett 1999). In comparison, the ends of unidentified unburnt bone fragments (n = 2368) exhibit more spiral fractures (74.6%, n = 1767). This discrepancy in the breakage pattern between the identified and unidentified datasets is likely the result of the prevalence of burnt bone in the unidentified sample since burning increases the frequency of transverse or 'dry' fractures (Stiner *et al.* 1995; Costamagno *et al.* 2005).

Compared to Die Kelders and Pinnacle Point, the unidentified long bone fragments from BBC display the lowest frequency of spiral fractures (Table 6.5). Again, this is most likely due to the high incidence of burnt bone at BBC. Sediment compaction may also have resulted in higher frequencies of transverse fractures in both the identified and unidentified BBC sample (cf. Villa & Mahieu 1991). In addition, methodological differences in the assessment

of fracture patterns between those sites and the unidentified BBC sample may have also contributed to variability in the frequencies of fracture patterns. For example, as discussed above, a different method was used to analyse breakage patterns from the identified BBC fauna than was used to assess the unidentified BBC fauna (see Chapter 4.3) and this may account for the discrepancies between the datasets. Individual variation between analysts can also be a factor since decisions to record fracture patterns as 'oblique', 'intermediate' or 'right-angled' are, to some extent, subjective.

Alternatively, while the identified BBC dataset includes all faunal elements, the unidentified BBC sample represents only long bones. The higher incidence of transverse breakage within the unidentified BBC sample may imply more post-depositional breakage of long bones in relation to other elements. Despite these differences, the general pattern at BBC is similar; spiral fractures dominate the overall breakage pattern indicating either human, or carnivore, within-bone nutrient exploitation.

Table 6.5: Comparisons between the fracture patterns at BBC and other MSA sites

Faunal assemblage	n	Fracture outline*		Data source
		Curved/V-shaped (%)	Transverse (%)	
Die Kelders	5600	4130 (73.8)	1076 (19.2)	Marean *et al.* 2000
Pinnacle Point	4879	3762 (77.1)	1006 (20.6)	Thompson 2010
BBC Identified#	4666	3375 (72.3)	1112 (23.8)	Thompson 2008
BBC Unidentified	**4610**	**2896 (62.8)**	**1575 (34.2)**	**This study**

***'Curved/V-shaped' fracture outlines are equivalent to 'spiral' fracture patterns in this study. Only 'Curved/V-shaped' and 'Transverse' fracture outlines were used in this table. 'Inter mediate' and 'Curved/V-shaped/ Transverse' categories from other studies were ignored.

BBC Identified consists of M1 and upper M2 only.

The fragment length data indicate that the lengths of unidentified long bone fragments decrease with depth, albeit only slightly. If this was the result of sediment compaction then transverse fractures would be more prevalent in the lower layers than in the upper layers at BBC. This is not the case, however, since the incidence of spiral fractures is marginally higher in the upper M2 than in the M1 (Table 5.30). Burning, which produces less spiral-fractured specimens, is more common in the upper M2 than in the M1 (Figure 5.12). Carnivore activity may account for the higher frequencies of spiral breakage in the upper M2.

However, the frequency of tooth-marked bone, which reflects carnivore activity, is low throughout the dataset; particularly in the upper M2 (Figure 5.20). If greater bone fragment density per volume is equated with a higher prevalence of human occupation then this could be reflected in the breakage patterns. Thompson and Henshilwood (2011) argue that the relatively higher proportion of transverse fractures in the M1 is a result of post-depositional breakage caused by trampling and burning. The prevalence of burnt fragments in the upper M2 and the longer fragments in the upper layers at BBC, however, appear to contradict this. The solution to this conundrum may lie in the frequency of percussion marks, which are relatively more common in the upper M2. As an indicator of human activity, percussion marks may be related to the higher incidence of spiral fractures (and the more intense fragmentation) in the early Still Bay layers, in particular Layer CF. This is discussed further in the next section.

6.5 Surface Modification

Burning. The most common modification to the bone fragments was burning. While just over a quarter (27.4%) of the identified BBC faunal assemblage exhibited evidence of burning (Thompson 2008, Thompson & Henshilwood 2011), almost half (48.5%, n = 1117) the unidentified BBC specimens assessed were classified as burnt. Thompson (2008) used a five-stage method utilised by previous researchers to describe burning (Shipman *et al.* 1984). For the unidentified BBC sample, burnt specimens were defined by Brain's (1981) simpler two-stage analysis. The criteria for analysing burning in the unidentified sample was more conservative because only two colours (black and white) were used and specimens were thus less likely to be misdiagnosed as 'burnt'.

The spatial distribution of burnt specimens relates to the distribution of hearths at BBC (Table 6.6). In particular, the prevalence of carbonised fragments in squares G4 to H6 correlates to the occurrence of hearths in those squares. This association suggests that human activity accounts for the burnt bone at BBC and these fragments were probably the remnants of food, refuse or fuel. Burnt bone may not only have resulted from bone being heated in hearths but also as a result of bone deposited below hearths (De Graaff 1961; Stiner *et al.* 1995). A large proportion of calcined fragments were recovered from square D4 in the North West margin of the site (14.2%, n = 114). Calcined bone is usually associated with hearths

and human activity (Brain 1981; Cain 2005; Costamagno *et al.* 2005; Stiner *et al.* 2011) and square D4 is not associated with any hearths. Stiner *et al.* (2011) suggest that burnt (and especially, calcined) bone in caves is evidence of the remnants of hearth features. The presence of calcined bone in square D4 may, therefore, imply that hearths may once have occurred in this section of BBC.

Table 6.6: Spatial distribution of unidentified burnt bone and hearths

Presence of hearths	Square	Burnt fragments		Carbonised fragments*		Calcined fragments*	
		n	%	n	%	n	%
No	D2	80	7.2	33	4.1	41	20.2
No	D3	67	6.0	37	4.6	21	10.3
No	D4	211	18.9	114	14.2	84	41.4
No	D5	17	1.5	13	1.6	2	1.0
Yes	G4	71	6.4	53	6.6	10	4.9
Yes	G5	203	18.2	171	21.2	14	7.0
Yes	G6	110	9.9	91	11.3	9	4.4
Yes	H5	175	15.6	138	17.1	8	3.9
Yes	H6	149	13.3	124	15.4	14	6.9
No	I5	34	3.0	31	3.9	0	0.0
Total		**1117**	**100.0**	**805**	**100.0**	**203**	**100.0**

*Fragments classified as 'carbonised and calcined' have been excluded from these datasets

Studies on the Sibudu MSA faunal assemblage suggest that 'localised' burning may be indicative of bone fragments being burnt as fuel or as refuse (Cain 2005; Clark 2009). Cain (2005: 881) proposes that bone fragments in which the interior of the specimen is more extensively burnt than the exterior indicates that "*the elements were broken before the final burning to allow consistent burning around the fragment and that many of the fragments were dry or slightly green when they were burned.*" An almost identical pattern exists within the unidentified long bone sample at BBC where many of the specimens display a similar 'localised' burning distribution (Figure 6.4). This pattern, in addition to the high incidence of fragmented bone, suggests that perhaps long bone fragments were also burnt as refuse or possibly used as fuel (cf. Costamagno *et al.* 2005). In her study of the cooking patterns of contemporary Kutse foragers in the Kalahari, for example, Kent (1993) observed very few charred bones as a result of food processing, regardless of whether meat was roasted or

boiled. She noted that, in most cases, burnt bones were the result of post-depositional processes where bones were tossed onto fires as refuse. In his study of the use of bone as fuel during the lower Aurignacian at the Pataud Rock Shelter in France, Théry-Parisot (2002) argues that combining wood with bone is a more effective source of fuel than using wood alone. However, Driver (1999: 29) suggests that localised burning is the result of roasting where the exterior of the bone, covered in meat, is less burnt than the exposed interior.

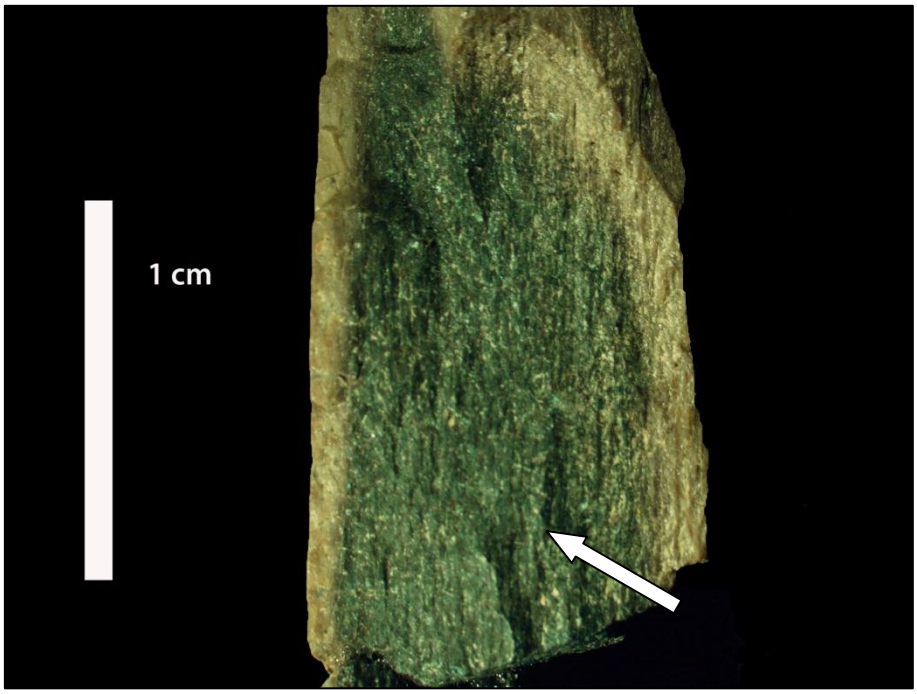


Figure 6.4: Localised burning. The interior of the cortex (arrow) is carbonised while the exterior is unburnt.

There is a strong correlation between burnt bone and percussion marks in the BBC dataset (Table 5.34a & b). This suggests that, in some cases, long bones were possibly heated before they were broken. Ethnographic accounts confirm that bones were heated prior to fragmentation (Zierhut 1967; Binford 1981; Yellen 1991; Kent 1993; Outram 2002). In Karen Lupo's (1998) experimental study on the caloric costs of long bone marrow processing, for example, limb bones were lightly roasted over a small charcoal grill for a few minutes before they were broken open in order to aid marrow extraction. Yellen (1991) notes that the !Kung San from Botswana warm bones by boiling rather than roasting them. This warming makes it easier for marrow to be extracted since roasting long bone "*makes the marrow 'thin' while boiling the entire bone thickens* [the marrow] *to a desirable*

consistency." (Yellen 1991: 13). Zierhut (1967: 34) in his study of the bone-breaking activities of the Calling Lake Cree from Alberta records that the long bones of hunted animals were thrown onto coals 'for a short time' in order to facilitate bone breakage. Likewise, Binford (1981) observes Nunamiut people from Alaska also warming bones before extracting marrow. Outram (2002) argues that the most effective pre-marrow extraction treatment involves heating bone slightly. By melting the outer marrow, mild heat facilitates the extraction of marrow. In contrast, extreme heating, which results in bone charring, destroys marrow. Because the unidentified fragments at BBC were recorded as either 'burnt' or 'unburnt', it was not possible to assess the extent of 'slight' burning or whether bones were boiled and to observe how they relate to percussion marks. Nevertheless, with the prevalence of carbonised and calcined specimens at BBC, it is unlikely that the incidence of burnt bone with percussion marks is related to bone being heated prior to marrow extraction.

The strong correlation between burnt and percussion-marked bone may suggest that burning may have been used as an aid to tool manufacture. Half the MSA bone tools (n = 14) recovered in the 1992 to 2000 field season at BBC show evidence of burning (Henshilwood *et al.* 2001a). One is completely burnt, seven are partially burnt and six are burnt at the tip. Henshilwood *et al.* (2001a: 661) argue that 'tip burning' was most likely intentional and done to harden the tip after being shaped by scraping. Burning also increases the likelihood of transverse fractures and may have been used as a method to control the manufacturing process in tool construction. Burning bone may have 'dried out' potential bone tool blanks, reducing the chance of spiral fractures and making it easier for tool-makers to fashion tools.

Percussion marks. The ubiquity of bone marrow extraction amongst foraging groups suggests the importance of marrow as a nutritional source (Binford 1981; Speth 1987; Bunn *et al.* 1988; Bar-Oz & Munro 2007). Although the caloric value of marrow varies between faunal elements and amongst individuals (Blumenschine & Madrigal 1993; Bar-Oz & Munro 2007), large long bone elements such as the femur and tibia of ungulates have been shown to yield the most nutritional fatty acids (Brink 1997; Munro & Bar-Oz 2005). Percussion marks are indicative of subsistence processes since they represent attempts by humans to recover this nutritional food source (Blumenschine & Selvaggio 1988; Lyman 1994; Blumenschine 1995). They may also infer butchery patterns and the attempts by hominins to reduce large meat-bearing elements into more manageable pieces (Binford 1981; Lyman 1994). In addition, carnivores have been shown to have little interest in shaft fragments broken by

hammer-stones since humans would have already extracted the nutrient-rich marrow (Brain 1981; Blumenschine 1988; Marean & Bertino 1994). Marean *et al.* (2000: 214) suggest that "[p]*ercussion-marked long bone shafts provide unambiguous documentation of hominids collecting and breaking long bones at the location the bone fragments were discovered.*"

Compared to other MSA assemblages, relatively few unidentified BBC bone fragments exhibit percussion marks (Table 6.6). Thirty-eight percent of the identified BBC faunal remains, for example, display percussion marks as opposed to 17.1% of the unidentified fauna (Thompson 2008). However, there is a strong inverse correlation between the frequency of percussion-marked and burnt specimens at southern African MSA sites (Pearsons' coefficient $r = -0.999$; $\alpha = 0.01$) (Figure 6.5). This suggests that the more burnt fragments there are, the less likely percussion marks are observed. Burning appears to negatively affect the diagnoses of surface modifications, such as percussion marks, on bone fragments by damaging the outer cortex (Nicholson 1993; Clark & Ligouis 2010). Percussion-marked specimens were also longer, on average, than undamaged fragments (Table 5.11 & 5.14). This may be related to observer bias since percussion marks are more likely to be observed on longer fragments. Mean lengths, however, are well within the range of an experimental study untaken by Pickering and Egeland (2006) on the effects of hammer-stone percussion damage on bones, which produced bone splinters with a mean length of 29.6 mm. These lengths support suggestions by previous researchers that marrow processing may produce longer bone fragments (Enloe 1993; Noe-Nygaard 1977).

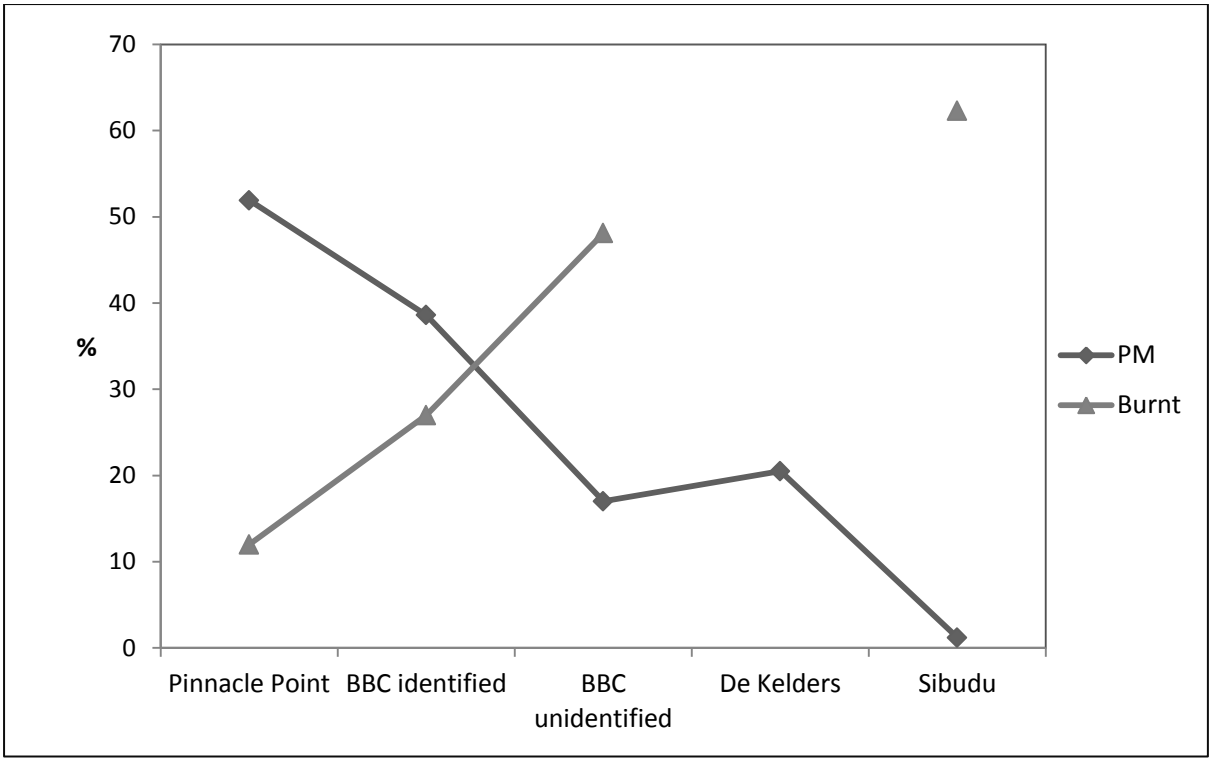


Figure 6.5: Relationship between percussion marks and burning at southern African MSA sites

Percussion-marked fragments are also slightly thicker than undamaged specimens (3.8 mm versus 3.2 mm, respectively) (Table 5.23 & 5.27). Despite the small margin, this supports Thompson's (2008: 247) suggestion that "*the incidence of percussion-marking increases with animal size*." This is a reasonable suggestion since larger animals yield more marrow (Blumenschine & Madrigal 1993) and are likely to be butchered into more manageable pieces than smaller species (Binford 1981; Lyman 1994). The thickest mean percussion-marked cortical measurements were obtained from Layer CB suggesting that during this later Still Bay period larger animals were likely more often butchered. This also supports arguments by Thompson (2008) and Thompson and Henshilwood (2011) who propose that larger bovids were more common in the earlier M1 phase. The cortical thickness of percussion-marked fragments from Layers CF are, on average, thinner (3.2 mm), possibly indicating that during those periods smaller fauna or elements were processed (Table 5.23). In addition, the proportion of percussion-marked fragments by layer is also highest in Layer CF (23.7%) (Figure 5.18). This could imply that marrow processing occurred more frequently during this period at BBC but involved smaller fauna or elements.

Cut marks. Cut mark frequencies vary extensively within faunal assemblages and can be affected by such factors as the skill of the butcher, the size of the body part processed, the condition of the carcass and the number of butchers involved (Binford 1981; Bunn 1983b, 1991; Lyman 1987; Fisher 1995; Dominguez-Rodrigo 2003; Dominguez-Rodrigo & Yravendra 2009). For example, Milo (1998: 102) notes that cut marks on occipital condyle specimens from Klasies River range from between 21% and 100% in large bovids. Data from southern African MSA assemblages appear to support substantial variations in cut mark frequencies (Table 6.7). In addition, the methods used by the analyst to assess cut marks such as microscopic or macroscopic evaluation also affect cut mark frequencies. In their macroscopic analysis of the identified BBC bone, for example, Henshilwood *et al.* (2001b: 435) note that cut mark frequencies were low (0.1%, n = 3) but suggest that this would rise "*significantly if the bone surfaces were examined microscopically*." Compared to their data, the relatively high incidence of cut-marked specimens in my study confirms this.

Ethnographic accounts and actualistic studies of butchery activities indicate that not all butchery strokes leave cut marks on bone (Fisher 1995; Parsons & Badenhorst 2004). Conversely, researchers have suggested that the frequencies of cut-marked bone from modern hunter/ gatherer butchery activities (27% in some cases [Bunn 1983b]) should be adjusted to take into account the difference between the effects of metal knives and stone tools on bone fragments (Binford 1981; Brain 1974b, 1981; Bunn 1983b, Bunn & Kroll 1986). Bunn (1991: 448) has proposed that "*frequencies of cut marks in individual Plio-Pleistocene assemblages, extending up to 5% or so, were consistent with observations of modern human butcheries and were thus evidence of hominid butchery as a dominant factor in the formation of the ancient bone assemblages.*" Although the cut mark frequency for the unidentified BBC fauna is only 7.9% (n = 193), it is more than the 5% threshold suggested by Bunn (1991). In this regard, the cut mark frequencies from the unidentified sample still indicate the importance of human butchery in the taphonomic history of BBC.

As discussed previously, the macroscopic assessment for cut marked specimens from the identified BBC fauna yielded low frequencies (Henshilwood *et al.* 2001b). However, no data for the frequency of microscopically assessed cut-marked bone fragments per total numbers of identified specimens (NISP) were available from the identified BBC assemblage analysed by Thompson (2008) or Thompson and Henshilwood (2011). Thompson (2008), however, notes that the majority of cut marks occur on the mid-shaft of long bones. The relatively low

incidence of cut marks from the unidentified BBC fauna appears incongruous with this since most, if not all, unidentified long bone specimens are fragmented diaphyses. Most likely, the high frequency of burnt specimens at BBC, once again, affected the assessment of surface modification resulting in only 7.9% (n = 193) of specimens exhibiting cut marks.

Specimens with cut marks are also, on average, thicker than undamaged fragments at BBC (4.4 mm versus 3.2 mm, respectively) (Table 5.24 & 5.27). This is consistent with Milo's (1998) assertion that cut marks increase with body size at Klasies River. Cut-marked bone fragments were thickest in Layers CB and CC (6.1 and 6.6 mm, respectively) while the thinnest cut-marked specimens were recovered from Layer CF (3.1 mm) (Table 5.24). Variation in the cortical thickness of cut-marked fragments between layers may imply changes in hunting strategies (Lombard & Clark 2008) or the effects of seasonality (Klein 1977, 1981) when younger animals were hunted. The thinner cortices at Layer CF, for example, may be related to a prevalence of juveniles or very mature individuals. However, it may also imply that smaller animal size-groups or elements were more commonly processed during these periods. Prevailing palaeoenvironmental conditions, for example, may have affected encounters between hunters and their prey or influenced animal migratory patterns. This may have resulted in the prevalence of younger/older or smaller (possibly more solitary) bovids in the faunal assemblage (Klein 1983, Klein *et al.* 1999c).

Many possibilities could explain the differences in cortical thickness of cut-marked fragments between layers at BBC. Yet, as with percussion-marked specimens, the evidence suggests that larger fauna was more prevalent in the M1 (particularly Layers CB and CC) than in the upper M2. The cortical thickness of cut-marked specimens appears to follow a significantly similar distribution to that of percussion-marked specimens down through the layers (Pearson's correlation coefficient $r = 0.969$; $\alpha = 0.05$). Despite a myriad of possibilities, with regard to animal size class; butchery and marrow extraction processes appear to be broadly similar to one another.

Table 6.7: Cut mark frequencies in southern African MSA assemblages

Faunal assemblage	Cut marks		Source
	n#	%*	
Sibudu (non-id bone)	21	0.9	Clark 2009

Die Kelders	821	13.8	Marean *et al.* 2000
Duinefontein 2	20	1.0	Klein *et al.* 1999a; Cruz- Uribe *et al.* 2003
BBC unidentified	**193**	**7.9**	**This study**
BBC identified	3	0.1	Henshilwood *et al.* 2001b
Klasies River	983	18.1	Milo 1998

* Percentage of cut-marked fragments per total number of specimens

Number of cut-marked specimens

Polish. Polish and abrasion can be distinguished by whether bone surface modification is intentional or unintentional (Brain 1967b; Fisher 1995; Lyman 1994). In this regard, the term 'polish' has been used to differentiate intentional manufacturing modification, or use-wear, from accidental or unintentional abrasion (Lyman 1984). A fifth (20.5%, n = 472) of unidentified bone fragments from BBC display abrasive wear defined as 'polish'; that is, exhibiting a macroscopic sheen in addition to parallel or near-parallel microscopic striations (Shipman & Rose 1988; Henshilwood *et al.* 2001a). While Shipman and Rose (1983) suggests that natural abrasion does not appear to produce the glossy sheen apparent in use-wear specimens, Brain (1967b, 1981) argues that 'polish' can result from the abrasion of sand and the effects of trampling. The majority of the Gobabeb goat bone specimens collected in the 1960's by Brain (1967a, 1967b, 1981), for example, exhibit, not only a sheen, but parallel striations as well (personal observation). These 'striations' may be the result of sand particles infiltrating and widening the vascular grooves on the bones' outer cortex. Thus, the parallel striations used to classify abraded bone from BBC as 'polished' in this study, may be vascular grooves widened by sediment movement. Burning also causes a glossy sheen that may be mistaken for polish (Shipman *et al.* 1984). Experimental studies by Bromage (1984) indicate that sediment pressure may produce the smoothing associated with polish on the cortices of bone. Much of the glossy sheen attributed to polish in the unidentified BBC faunal sample may be as a result of the effects of sediment pressure, movement or burning. This may explain why some specimens appear to exhibit cut marks or percussion marks on 'polished' bone (e.g., Figure 6.6; see also Figure 5.21).

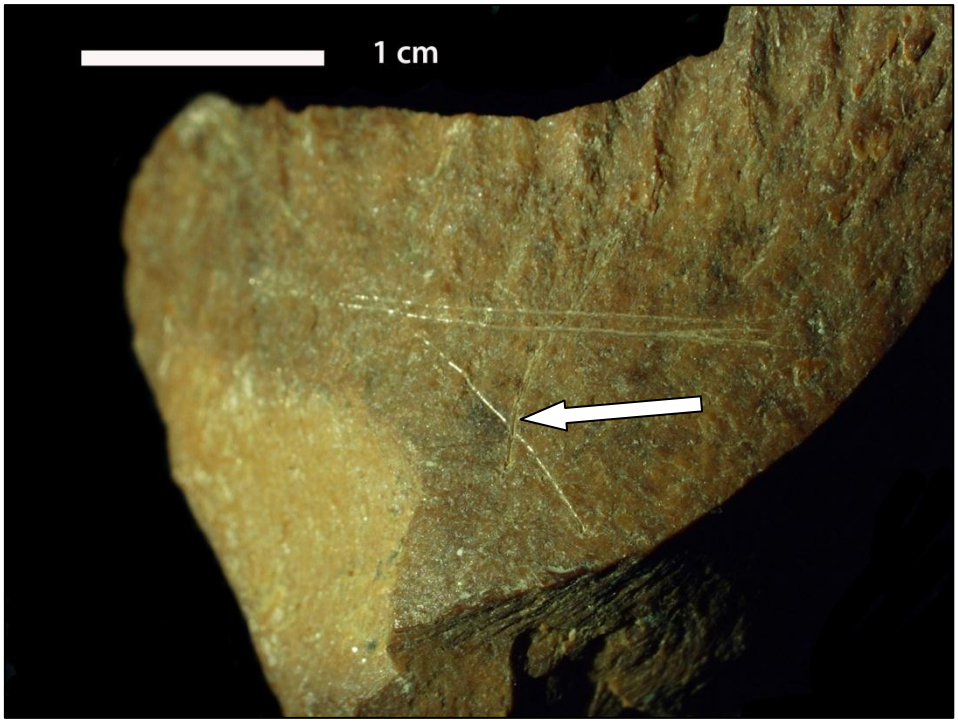


Figure 6.6: Cut marks on polished bone

Not all polishing on bone fragments may be the result of natural or non-anthropogenic processes. There is, for example, a weak correlation between the proportion of undamaged specimens and bone fragments displaying polish through the layers (Pearsons' coefficient r = -0.473; $\alpha = 0.01$) suggesting that sediment compaction, burning or wind abrasion are not only responsible for polished bone fragments. In addition, many specimens in the dataset exhibit striations, which are not only parallel, but in 'a preferred axis of motion' (Shipman & Rose 1988: 329) that strongly implies intentional polishing (Figure 5.21). Parallel striations, especially along vascular grooves, may be less reliable a criteria for polish than criss-cross striations, which more likely suggest intentional modification.

Bone tools at Blombos Cave. Henshilwood *et al.* (2001a: 668; d'Errico & Henshilwood 2007) suggest that intentional polish indicates the presence of bone tools. Polish, they argue, may not just be the result of use-wear, but as an 'added value' in the final stages of bone tool manufacture. Polish is taphonomically significant in that bone tools were an important factor in the early Still Bay techno-complex. 'Formal' bone tools are also rare in the MSA and their frequent occurrence at BBC indicates the importance of this site in the study of behavioural modernity (Henshilwood *et al.* 2001a).

Twenty-eight bone tools were discovered in the MSA layers at BBC (Henshilwood *et al.* 2001a). Fourteen could be securely placed within the upper M2 phases, six were recovered from the M1, five came from either the M1 or M2 and three, recovered from the M3, were probably derived from the M2. These tools consisted of 'awls' and 'projectile points' and were mostly constructed from long bone shaft fragments. Lombard (2006, 2007) suggests that some of these projectile points were not only used as tips for hunting weapons but were also hafted and used as butchering knives. In comparing the cortical thickness of MSA versus LSA bone tools, Henshilwood *et al.* (2001a) found that MSA tools tended to have thicker cortices than LSA tools (3 mm versus 2 mm, respectively); well within the range of mean cortical thickness measurements of unidentified BBC long bone fragments. Also, the mean cortical thickness of polished bone in the unidentified BBC sample is 2.9 mm, which closely corresponds to the mean cortical thickness of MSA tools. Two of the criteria used to differentiate MSA from LSA bone tools are polishing and colour: MSA bone tools are more polished and darker than the LSA variety (Henshilwood *et al.* 2001a: 661). Darker, more polished bone fragments are common in the unidentified BBC sample. While they may be the result of burning, they may also be indicative of bone tools. Bone tools are also more prevalent in the upper M2 than in the M1 and this distribution is reflected in higher incidence of polished bone in Layers CF. However, spatially, the quadrates where the bone tools were recovered from is almost mutually exclusive to those that yielded unidentified bone fragments, with only squares G4, G6 and H5 overlapping (Figure 6.7). Although the evidence suggests that polished bone fragments represent the remains of bone tools, some 'polished' bone may be the result of post-depositional abrasive processes. To what degree 'polished' bone is the result of intentional human behaviour or natural processes is difficult to assess without high-resolution microscopic analysis. Future research using scanning electron microscopy may resolve this question.

2	110	**(1)**	**(1)**
3	122	**(5)**	**(5)**

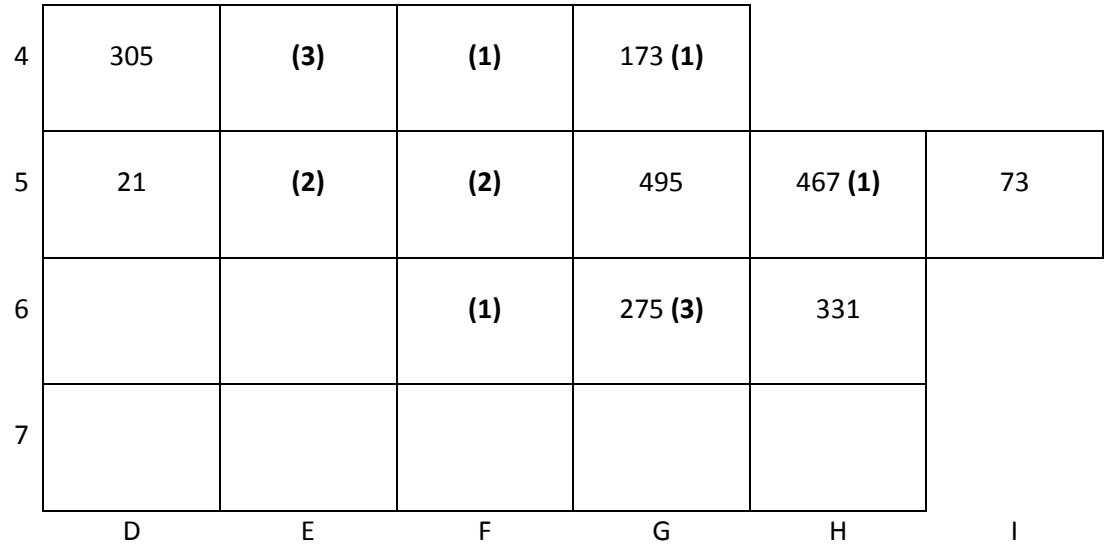


Figure 6.7: Spatial distribution of bone tools and bone fragments in the M1 and M2 at BBC. Numbers of bone tools are in bold and in parentheses (bone tool data from Henshilwood *et al.* 2001a)

Non-anthropogenic modification. Tooth marks and gnaw marks are relatively rare in the dataset (4.0%, n = 99) implying that carnivores contributed little to the faunal assemblage (Table 6.8) (c.f. Henshilwood *et al.* 2001b; Thompson 2008). Of the 99 specimens, 36 (1.5%) exhibited only gnaw marks, slightly higher than the frequency from the identified BBC fauna (<0.6%) (Thompson & Henshilwood 2011). However, the rarity of tooth marks may be due to the difficulty in discerning them. Root etchings, for example, can mimic tooth marks (Figure 6.8). Dominguez-Rodrigo and Barba (2006: 173) note that percussion and tooth marks are easily confused with each other and suggest that the misdiagnoses of tooth marks can lead to the misrepresentation of carnivore and human influences in archaeofauna. In addition, when humans chew or gnaw bones they also leave tooth marks and contribute towards bone fragmentation (Brain 1981). Human tooth marks are difficult to differentiate from other carnivore marks and may also affect tooth mark frequencies (Brain 1981; Fernandez-Jalvo & Andrews 2011)

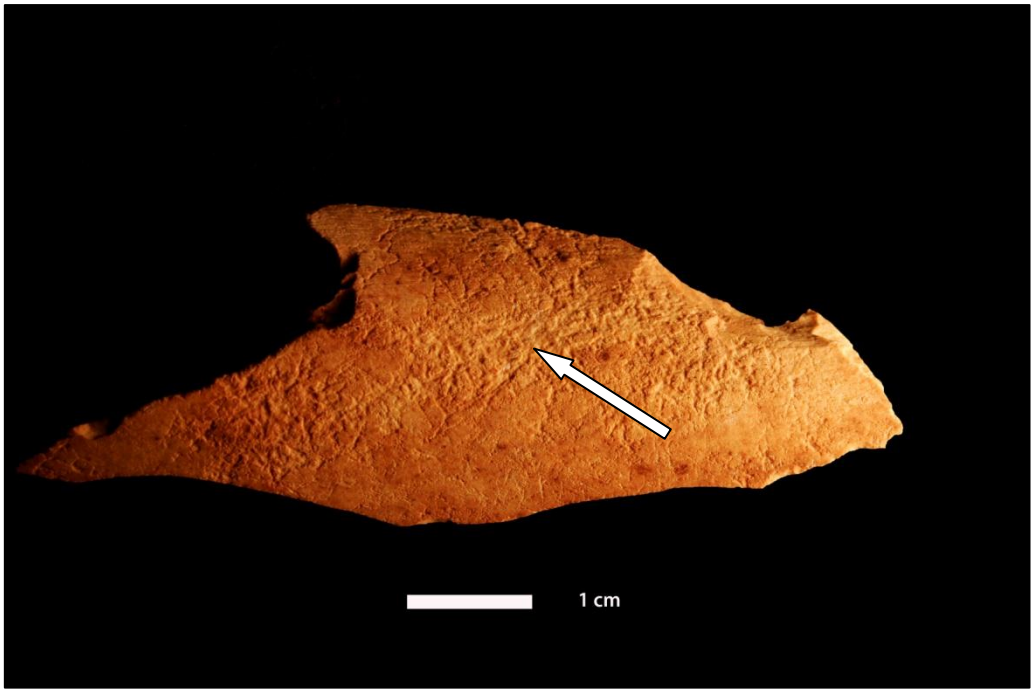


Figure 6.8: Root etchings resembling tooth marks. Root etching furrows (arrow) can be confused with tooth mark 'scouring'

The small size of the tooth marks from BBC, suggests that small carnivores, such as mongoose, were more common than hyena, leopard or other large carnivores (e.g., Figure 5.23). Over 10% of animal-marked specimens (11.1%, n = 11) exhibit anthropogenic marks (cut/chop and percussion marks) while eight tooth-marked fragments are burnt. This indicates that, occasionally, both humans and carnivores had access to the same faunal remains at BBC. The prevalence of anthropogenic marks and burning at BBC makes it likely that this interaction took the form of primary human access to the remains followed by carnivore/rodent scavenging (cf. Capaldo 1997, 1998; Selvaggio 1998; Dominguez-Rodrigo 1999; Lupo & O'Connell 2002; Norton & Goa 2008). However, one specimen from Layer CFA displayed a possible cut mark over a possible tooth mark (Figure 6.9). The specimen was burnt, however, making a definitive diagnosis problematic. In addition, the tooth mark may in fact be a cut mark resembling a furrow caused by tooth marks. Another possibility is that the 'tooth mark' may be a furrow caused by root etching with the 'edges' or plateau of the furrow damaged through burning or abrasion. Assuming no misdiagnosis, it would indicate that carnivores had primary access to the bone and that humans may have engaged in scavenging activities during this period (Binford 1984; Blumenschine 1988; Capaldo 1998; Selvaggio 1994, 1998; Shipman 1986a). Although evidence indicates that hunting was the

primary strategy employed by humans accumulating fauna during the MSA (Klein 1976, 1989; Marean & Kim 1998; Milo 1998; Klein *et al.* 1999b; Klein & Cruz-Uribe 2000; Marean *et al.* 2000; Thompson 2008, 2010; Thompson & Henshilwood 2011), ethnographic research suggests that modern, small-scale foragers still scavenge, given the opportunity (Bunn *et al*. 1988; O'Connell *et al.* 1988; Lupo & O'Connell 2002).

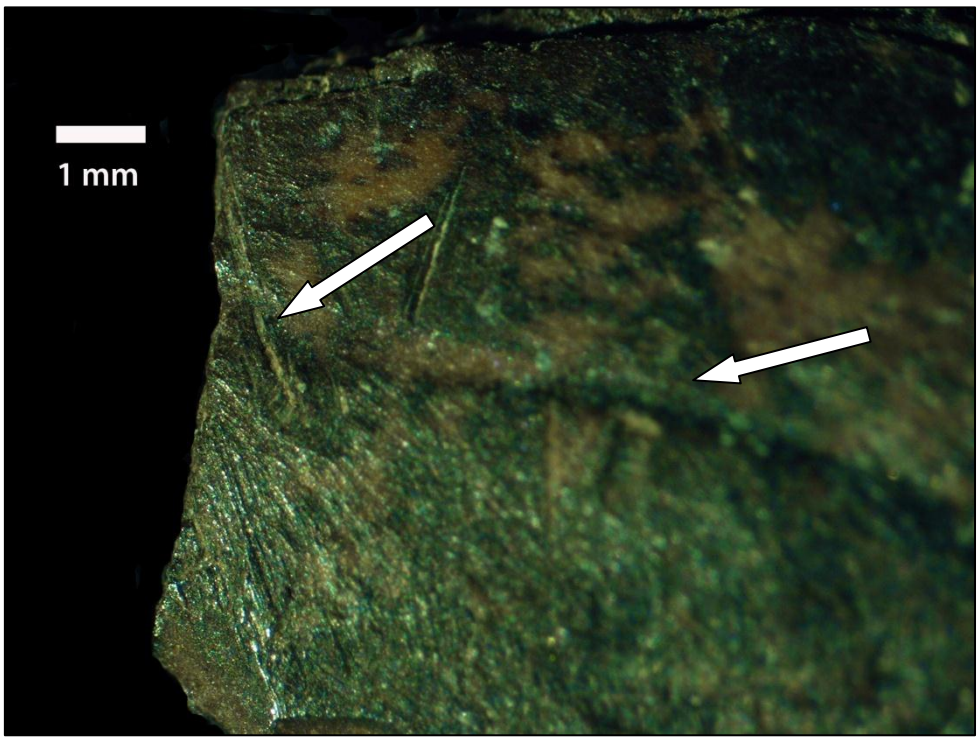


Figure 6.9: Possible tooth mark over a cut mark. A cut mark (left arrow) appears to overlay a furrow resembling a tooth mark (right arrow)

Only five specimens were classified as 'mildly weathered'. The identified fauna from BBC produced similar results (one 'weathering stage 1' fragment) indicating that weathering played virtually no role in the taphonomy of BBC (Thompson & Henshilwood 2011). This is most likely due, in part, to the fact that BBC is not an open site but relatively sheltered and fragments were not exposed to the elements for long periods (Behrensmeyer 1978; Henshilwood *et al.* 2001b; Thompson 2008).

Dendritic or root etching occurred on only 3.6% of specimens (n = 83) (e.g., Figure 6.10). Although occurring more often on unidentified specimens than on the identified BBC faunal

remains (<1% [Thompson 2008, 2010]), it still indicates that root damage contributed little to the fragmentation of BBC's fauna. The majority of dendritically-etched fragments were recovered from the upper M2 (59%, n = 49) compared to the M1 (41%, n = 34), possibly because root activity is more prevalent in the deeper sediment layers. Grayson (1988: 30), however, in his analyses of the fauna from Palaeoindian cave sites, notes that the deepest stratum of a Utah cave site contains no etched bones. This he attributes to the 'extremely low organic content' within the deeper levels.



Figure 6.10: Root etchings (arrow). The green/black hue of the specimen is the result of burning

Root etchings may negatively affect the assessment of surface modification on bone fragments. When root etchings occur over tooth, cut or percussion marks, for example, those modifications become difficult to discern and may lead to misdiagnoses (Blumenschine *et al.* 1996; O'Connor 2000). As discussed previously, root etchings can mimic tooth marks, in particular, because both modifications produce u-shaped furrows (Behrensmeyer 1978; Lyman 1994; O'Connor 2000). In root etching these furrows are the result of humic acids secreted by plants (Behrensmeyer 1978) or acids secreted by fungi associated with decomposing plant material (Grayson 1988). Furrows produced by tooth marks, on the other

hand, are the result of abrasion caused by teeth being dragged across the bone surface (Haynes 1980; Maguire *et al.* 1980; Binford 1981; Gifford 1981).

Table 6.8: Frequency (%) of surface modification at southern African MSA sites

Modification*	Pinnacle Point	BBC identified	BBC unidentified	Die Kelders	Sibudu#
PM	51.9	38.6	17.0	20.5	1.2
TM	13.2	12.4	4.0	11.6	0.3
Burnt	12.0	27.0	48.1	-	62.3

*TM = tooth mark; PM = percussion mark

Sibudu TM data includes both carnivore bite and gnaw marks

6.6 Implications for Human Behaviour during the Still Bay at Blombos Cave

The analyses of both the identified and unidentified fauna indicate that humans were the dominant accumulators of bone at BBC during the Still Bay period (Henshilwood *et al.* 2001b; Thompson 2008; Thompson & Henshilwood 2011). The prevalence of spiral fractures indicates either human or carnivore activity. However, the taphonomic data suggest that carnivores contributed minimally to the faunal assemblage and natural processes such as weathering had little role in the fragmentation of bone. In addition, the high frequency of burnt bone is particularly indicative of human activity at BBC (cf. Thackeray 1979; Binford 1981; Brain 1981; Stiner *et al.* 1995, 2011).

Fragmentation of the faunal assemblage in the M1 and upper M2 may relate to subsistence patterns and periods of human occupation during the Still Bay at BBC. Human occupation was sporadic at BBC fluctuating from medium during the upper M2 (Layer CF), to high during the upper M1 (Layer CA and CB) (Thompson & Henshilwood 2011). As discussed previously, volumetric estimates indicate that the top three layers (CA, CB and CC) contain the highest bone fragment density per volume. Age estimates obtained through OSL methods place Layer CC at 72.7 ± 3.1 ka; well within the Still Bay period (Jacobs *et al.* 2006). The bone fragment density of Layer CC was 4.63 NUSP per mm^3. An OSL age of 76.8 ± 3.1 ka was obtained from Layer CF (Jacobs *et al.* 2006) which "*should be regarded as the terminus post quem for the Still Bay levels at BBC*" (Henshilwood 2008b: 38). Bone fragment density

in Layer CF is 1.54 NUSP per mm³, substantially lower than the CA, CB or CC layers (Table 6.9). In contrast, the mean bone density at Die Kelders is 1.35 bones per mm³ for Layer 10 and 0.57 bones per mm³ for Layer 11; considerably less than at BBC (Marean *et al.* 2000). Lithic debitage volumetric density is also higher in the top two layers of the M1 (Layer CA and CB) than in the lower M1 layers (Layer CC to CD) and higher in the lower M1 than the M2 (Table 6.9). There is a significant correlation between lithic and faunal volumetric density in the M1 and M2 at BBC (Pearson's correlation coefficient $r = 0.970$; $\alpha = 0.05$). This suggests that, although sediment compaction played a role, fragmentation of the faunal assemblage at BBC was predominantly the result of human activities.

Differences in the bone fragment densities between the top and bottom layers of the Still Bay phases may be related to subsistence behaviour at BBC. Lombard and Clark (2008) argue that faunal and lithic evidence indicates a shift in hunting technologies within the Still Bay. The relative prevalence of bone tools in the upper M2, for example, contrasts with the scarcity of pointed stone artefacts from the same period (Lombard & Clark 2008: 50; Henshilwood *et al.* 2001b). The reverse is true for the M1 where retouched stone tools and bifacial points are prominent while bone tools are rare (Henshilwood *et al.* 2001b). Spiral fracture patterns are also more prevalent in the upper M2 than in the M1 despite a higher proportion of burnt bone fragments in the upper M2. In addition, the frequency of percussion-marked bone fragments is higher in the lower M1 and upper M2 than in the upper M1 suggesting that marrow-extraction strategies may have been more common in the early Still Bay. This may imply a change in the intensity of faunal exploitation patterns during the Still Bay.

Variation in bone fragment densities during the Still Bay may also be the result of environmental or ecological factors. Faunal density at BBC remains low during the early Still Bay (Layer CF to CD) and only increases in the CC layer. The OSL date from Layer CC corresponds to the advent of MIS 4 which Chase (2010) proposes was a relatively cool period with moist climates. This increase in bone density coincides with the MIS 5a/4 transition. Thus, the increase in faunal density in Layer CC likely relates to the environmental changes that would have occurred with the onset of MIS 4. Higher faunal density frequencies during the later Still Bay may then be the result of ecological factors such as an increase in species abundance/diversity or changes in animal migration patterns.

The intensity of fragmentation of a faunal assemblage may affect debates on hunting success during the MSA. Taxonomically quantitative data, such as NISP values, are how researchers

measure species abundance and diversity and assess subsistence strategies. Initially, fragmentation of faunal specimens increases NISP values by increasing the number of identifiable bone fragments (Grayson 1984). Severe fragmentation, however, decreases the NISP by reducing the area on bone on which diagnostic features occur (cf. Lyman 1994). A larger proportion of bone, therefore, becomes too small to be identified to element and taxa (Lyman & O'Brien 1987; Grayson & Fey 2004). At BBC, the length of bone fragments becomes shorter with increased depth, albeit only slightly. As a measure of the intensity of fragmentation, this progressive reduction in bone fragment length suggests that fragmentation increases with depth at BBC. Indeed, this increased fragmentation may have affected NISP values from the BBC faunal assemblage. The NISP at BBC (Henshilwood *et al.* 2001b) is slightly more in the M1 (n = 1547) than in the deeper M2 (n = 1096) suggesting that this difference may, in part, be due to different levels of fragmentation between the phases.

Much zooarchaeological debate has centred on the proficiency of MSA hunters (e.g., Klein 1974, 1976, 1989, 1995; Binford 1984; Turner 1989; Thackeray 1990; Klein & Cruz-Uribe 1996, 2000; Milo 1998; Marean & Assefa 1999; Assefa 2006; Faith 2008, 2011, Dusseldorp 2010, 2011; Weaver *et al.* 2011). In particular, the relative abundance of eland (*Tragelaphus oryx*) and buffalo (*Syncerus caffer*) has been used to argue that MSA hunters preferred more docile bovids such as eland and were less effective hunters than their LSA counterparts (e.g., Klein 1974, 2000; Klein & Cruz-Uribe 1996; Klein et al. 1999b, for counter arguments, see Faith 2008, 2011, Lombard & Clark 2008, Wadley 2010, Dusseldorp 2010). Fragmentation, however, may affect species abundance and diversity values, especially with regard to single taxa. Lyman and O'Brien (1987: 497), for example, caution that "*analysts who interpret element frequency of a single taxon must...be cognizant of the possibility that some elements may be analytically absent despite their actual presence in a collection.*" Badenhorst (2009: 36), in his faunal analyses of sites dating from the Middle Period and early Plateau Pithouse Tradition (*ca.* 7000 – 35000 BP) in British Columbia, argues that fragmentation results in 'identification bias' where certain elements are more easily identified in archaeofaunal assemblages than others. 'Excavator bias' often results in researchers collecting more familiar or identifiable bone fragments in the field. The assemblage is then further distorted as analysts ignore hard-to-identify specimens in the laboratory (Bartram & Marean 1999): a process called 'laboratory taphonomy' by Bartram (1993). In many archaeofaunal assemblages larger bovids are more poorly represented by proximal long bones than smaller bovids (Klein et al. 1999b). Due to its prevalence at Klasies River, Bartram and Marean

(1999) called this pattern the 'Klasies pattern' which they argue exists because analysts failed to take long bone mid-shaft fragments into account. Klein (1989) and colleagues (1999b), on the other hand, suggests that carcass size influences the transportation and identifiability of skeletal elements. Either way, this discussion demonstrates that skeletal-part profiles and the relative diversity or abundance of species within MSA assemblages may, in part, be a result of extensive fragmentation (Shipman 1981b; Hesse & Wapnish 1985). Fragmentation, in turn, is the result of taphonomic processes. Consideration of these factors should inform the use of taxonomically quantitative data measurements in the analyses of archaefaunal assemblages. Fragmentation and the taphonomic history of bone collections must be taken into account in the debate on hunting proficiency during the MSA.

Variability in taphonomic and faunal density patterns and subsistence behaviour during the Still Bay, however, may be more complex than assemblage fragmentation, environmental determinism or identification bias. Intermittent human occupation, seasonal hunting behaviour and taphonomically-unrecognised carnivore activity may all have affected bone fragment density at BBC. More abstract motives such as individual or group choice may have also played a role in transient human occupation during the Still Bay at BBC.

Table 6.9: Bone fragment and lithic density in the M1 and M2 at BBC

Phase	Layer	Bone density (per m^3)	Lithic density (per m^3) *
M1a	CA	5418	30208
	CB	4326	
M1b	CC	4628	13443
	CD	1950	
M2	CF	1541	2935
	CG	314	

* Number of all flaked stone pieces per volumetric unit (data from Henshilwood *et al.* 2001b)

6.7 Conclusion

The ubiquity of unidentified bone within archaeofaunal assemblages contrasts with the lack of published research undertaken on unidentified faunal remains. The prevalence of unidentified bone fragments from archaeological sites makes this an under-utilised source of information for research into early modern human subsistence strategies. While useful

information has been gleaned from the analysis of identified fauna, limited research has compared unidentified with identified archaeofaunal remains. Few published studies have been conducted on whether patterns suggested by identified fauna are similar to those suggested by unidentified samples. In comparing the unidentified to the identified fauna from BBC, I have attempted to assess the similarities and differences between the two. My study was a 'pilot study' to categorise and group fauna within archaeofaunal assemblages that were previously not identified.

If humans are known to be the predominant accumulators of faunal material in MSA archaeological assemblages then bone fragment density values may compliment taxonomic quantitative measurements such as NISP values as a means of assessing hunting success. In particular, severe fragmentation may lower NISP values and skew skeletal-part profiles affecting the evaluation of hunting proficiency in early modern human societies. At BBC, similarities between the stratigraphic distributions of bone and lithic volumetric densities suggest that higher bone fragment density can imply more intensive human occupation. Like lithic debitage density, bone fragment volumetric density is considerably higher in the upper than in the lower layers at BBC. This suggests that human occupation was more intensive in the later than in the earlier Still Bay period.

Bone fragment lengths may also reflect the intensity of human occupation, in addition to animal size. Mean fragment lengths from BBC is well within the range of other MSA and LSA sites and considerably shorter than either ancient or modern carnivore assemblages (Brain 1981; Klein 1975; Thackeray 2007). Tooth-marked fragments were, on average, the longest fragments measured. Percussion-marked fragments were also relatively long suggesting that marrow extraction activities may not necessarily result in shorter fragment lengths. Although slight, the reduction in fragment length deeper in the sequence is statistically significant and confirms Thompson's (2008) and Thompson and Henshilwood's (2011) finding that larger animals were more common in the M1 than in the upper M2. The reduction of bone fragments also correlate to an increase in the frequency of burnt bone in the lower layers. This suggests that burning may have also played a role in the shorter fragments in the lower layers at BBC. However, I would argue that the gradual reduction in fragment length through the layers also suggests that the effects of sediment compaction should be taken into account.

Although cortical thickness varies within and between species, virtually all measurements obtained from the Gobabeb goat reference sample clustered within the code 2 size class. Cortical measurements from a sample of identified fauna from BBC indicate that cortical thickness can be used to group unidentified long bone fragments into animal size classes. Cortical measurements, however, cannot be used to classify individual specimens to taxon. They are an assemblage statistic used to group unidentified faunal remains to size categories. The evidence indicates that the sample of unidentified fauna in this study consists of animals from a larger size class than the identified fauna. In this study, I suggest that the cortical measurements show that the unidentified fauna does not mimic the identified faunal remains. This implies that more medium or large-sized animals or elements are present in the BBC assemblage than those that could be identified. However, other factors such as sediment weight or 'excavator bias' may also have contributed to the discrepancy between the distributions. Cortical measurements also indicate that larger fauna (or elements) dominated the M1 and confirm Thompson's (2008) and Thompson and Henshilwood (2011) argument that smaller size 1 fauna were more prevalent in the upper M2 at BBC.

The majority of specimens exhibit spiral fractures indicating that they broke while in a fresh state. The breakage patterns of the unidentified fauna reflect that of the identified faunal remains. However, the identified faunal remains from BBC displayed higher frequencies of spiral fractures than the unidentified sample. This is most likely because the unidentified fauna is more burnt and burning increases the frequencies of transverse breakage.

Taphonomic evidence from the unidentified faunal remains indicates that humans rather than carnivores were the dominant contributors to the faunal assemblage at BBC. In this regard, this study confirms the research undertaken by Henshilwood *et al.* (2001b) and Thompson (2008). Non-anthropogenic modification such as tooth marks, weathering and root etchings is rare and conforms to the low frequencies found in the identified BBC fauna. Burning is the most common modification in the unidentified BBC faunal sample. The incidence of burnt bone is considerably higher in the unidentified faunal sample than in the identified sample (48% and 27.4%, respectively). A likely reason is because half the quadrates from which the unidentified fauna were recovered are associated with hearths. Burnt long bone fragments were probably the result of roasting, being discarded into fires as refuse or, possibly, for use as fuel.

Percussion and cut/chop marks are not as common in the unidentified sample as they are in the identified BBC fauna analysed by Thompson (2008) and Thompson and Henshilwood (2011) or other MSA assemblages. This may be due to the effects of burning on the diagnosis of surface marks. Burning may destroy the upper layers of the cortex where these marks occur; or these modifications may be more prevalent on the epiphysis of long bones. Especially in the case of cut/chop marks, this may indicate that filleting was less common than suggested by Thompson (2008, 2010). On average, both percussion- and cut/chop-marked bone fragments with the thinnest cortical measurements were recovered from Layers CF. The CF layer also produced the highest percentage of burnt and percussion-marked specimens.

Bone fragment density values and variation in the taphonomic frequencies per layer suggest a complex occupational and subsistence history at BBC during the Still Bay. Higher frequencies of spiral fractures, the low bone fragment density and the relatively high proportion of burnt and percussion-marked specimens in the early Still Bay period (Layer CF) contrasts with the late Still Bay (Layers CA and CB) where the reverse is true. This implies that some form of subsistence resource intensification may have occurred during the early Still Bay period at BBC. The increase of bone fragment density during the later Still Bay (Layer CC) correlates to the onset of MIS 5a/4 and to the climatic and environmental instability between ~73 and 63 ka reflected in Speleothem records (Bar-Matthews *et al.* 2010). I would argue that environmental conditions may have led to changes in occupational and subsistence behaviour during the Still Bay at BBC.

6.8 Future Avenues of Research

Within zooarchaeology, taphonomy plays an important role in revealing the depositional history of faunal assemblages but is restricted by the research scope of the analyses. The limited scope of this study warrants further analyses with extended scope in the future. Although many possibilities of continued research exist, four main avenues for future study stand out:

1) ***Spatial Distribution.*** The sample of unidentified fauna used in this dissertation consists of a dataset with limited spatial distribution: only specimens from the north-western and south-eastern margins of the BBC site were available for analysis. My

study should be regarded as a 'pilot study' since the vast majority of unidentified bone fragments from the central quadrates at BBC remains unexamined. An analysis of these specimens would confirm whether my pilot study reflects the 'true' distribution of unidentified fauna at BBC and whether any differences with the identified fauna are valid.

2) ***Cortical Measurements.*** Cortical measurements from the Gobabeb goat bone collection all cluster within a single code. Other bovids, however, may exhibit more cortical variability. The cortices of long bones of representative species from each of the bovid size classes should be measured in order to determine the extent of this variability. Practically, however, it may be difficult to measure cortical thickness since long bones from archaeofaunal assemblages or reference collections may not be broken (thereby exposing the cortices for measurement). One possibility is to take radiographs of long bones from known species from bovid reference collections in order to ascertain the average cortical thickness of each element. These measurements could then be used as reference samples in any future studies.

3) ***Assessing Polish.*** Abraded bone fragments may be the result of natural or human agencies. Since a glossy sheen may be the result of sediment movement, compaction or wind abrasion, microstriations on abraded specimens may imply intentional polishing. My study suggests that, in addition to parallel striations like those seen on some bone tools (e.g. Brain & Shipman 1993; Backwell & d'Errico 2001) at Swartkrans, 'criss-cross' striations on bone fragments may also be indicative of human involvement although this may be mimicked by trampling (c.f. Shipman & Rose 1988). High resolution microscopic analysis such as SEM assessment or the use of quantifiable surface roughness techniques as applied by d'Errico and Backwell (2009) may resolve this issue by revealing 'preferred axis of motions'. By determining whether abraded bone fragments are the result of human activity, bone tool manufacturing processes can be explored without the presence of complete bone tools in archaeological assemblages.

4) ***Resource Intensification in the Still Bay.*** The Still Bay encompasses both the M1 and the upper M2 at BBC. The relatively higher density of bone fragments within the upper M1 compared to the lower M1 and upper M2, however, suggest that

palaeoenvironmental conditions, as opposed to technological variation, may have significantly influenced the accumulation of fauna at BBC. Nonetheless, the prevalence of percussion marks and bone fragment with thinner cortices in the upper M2 does suggest that smaller animals were more intensively exploited at the onset of the Still Bay at BBC. The question, then, is whether subsistence intensification may indicate the advent of this techno-cultural complex or be the result of resource stress brought about by palaeoenvironmental changes. A taphonomic assessment of the recently recovered fauna from the Still Bay levels at other MSA sites such as Sibudu and Diepkloof could reveal whether marrow extraction and the exploitation of smaller animals and/or elements is more prevalent at the onset of Still Bay technology or whether their prevalence is a consequence of climatic change.

REFERENCES

Alexander, R. McN. 1977. Allometry of the limbs of antelopes (*Bovidae*). *Journal of Zoology* 183: 125 – 146.

Alexander, R. McN. 1979. Allometry of the limb bones of mammals from shrews (*Sorex*) to elephant (*Loxodonta*). *Journal of Zoology* 189: 305 – 314.

Ambrose, S.H. 2006. Howiesons Poort lithic raw material procurement patterns and the evolution of modern human behaviour: a response to Minichillo (2006). *Journal of Human Evolution* 50: 365 – 369.

Andrews, P. & Cook, J. 1985. Natural modifications to bone in a temperate setting. *Man* 20(4): 675 – 691.

Assefa, Z. 2006. Faunal remains from Porc-Epic: Paleoecological and zooarchaeological investigations from a Middle Stone Age site in southeastern Ethiopia. *Journal of Human Evolution* 20: 1 – 26.

Backwell, L.R. & d'Errico, F. 2001. Evidence of termite foraging by Swartkrans hominids. *Proceedings of the National Academy of Sciences* 98(4): 1358 – 1363.

Badenhorst, S. 2008. The zooarchaeology of Great House sites in the San Juan Basin of the American Southwest. Unpublished Ph.D dissertation. Simon Fraser University: Vancouver.

Badenhorst, S. 2009. Artiodactyl skeletal part representation at Middle Period and Early Pithouse Tradition sites on the Interior plateau, British Columbia: a view from EdRh-31. *Canadian Zooarchaeology* 26: 25 – 41.

Badenhorst, S. & Henshilwood, C.S. 2010. Unpublished data. African Heritage Research Institute: Cape Town.

Barba, R. & Dominguez-Rodrigo, M. 2005. The taphonomic relevance of the analysis of bovid long limb bone shaft features and their application to element identification: study of bone thickness and morphology of the medullary cavity. *Journal of Taphonomy* 3(1): 29 – 42.

Bar-Matthews, M., Marean, C.W., Jacobs, Z., Karkanas, P., Fisher, E.C., Herries, A.I.R., Brown, K., Williams, H.M., Bernatchez, J., Ayalon, A. & Nilssen, P.J. 2010. A high resolution and continuous isotopic speleothem record of paleoclimate and palaeoenvironment from 90 to 53 ka from Pinnacle Point on the south coast of South Africa. *Quaternary Science Reviews* 29: 2131 – 2145.

Bar-Oz, G. & Munro, N.D. 2007. Gazelle bone marrow yields and epipalaeolithic carcass exploitation strategies in the southern Levant. *Journal of Archaeological Science* 34:946 – 956.

Barham, L. & Mitchell, P. 2008. *The First Africans: African archaeology from the earliest tool-makers to most recent foragers.* Cambridge University Press: Cambridge.

Barrable, A., Meadows, M.E. & Hewitson, B.C. 2002. Environmental reconstruction and climate modelling of the Late Quaternary in the winter rainfall region of the Western Cape, South Africa. *South African Journal of Science* 98: 611 – 616.

Bartram, L.E. 1993. An ethnoarchaeological analysis of Kua San (Botswana) bone food refuse. Unpublished Ph.D dissertation. University of Wisconsin: Madison.

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

Behar, D.M., Villems, R., Soodyall, H., Blue-Smith, J., Pereira, L., Metspalu, E., Scozzari, R., Makkan, H., Tzur, S., Comas, D., Bertranpetit, J., Quintana-Murci, L., Tyler-Smith, C., Spencer Wells, R., Rosset, S., & the Genographic Consortium. 2008. The dawn of human matrilineal diversity. *The American Journal of Human Genetics* doi:10.1016/j.ajhg.2008.04.002.

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

Behrensmeyer, A.K., Gordon, K.D. & Yanagi, G.T. 1986. Trampling as a cause of bone surface damage and pseudo-cutmarks. *Nature* 319: 768 – 771.

Behrensmeyer, A.K., Kidwell, S.M. & Gastaldo, R.A. 2000. Taphonomy and paleobiology. *Paleobiology* 26(4): 103 – 147.

Bennett, J.L. 1999. Thermal alteration of buried bone. *Journal of Archaeological Science* 26: 1 – 8.

Biddick, K.A. & Tomenchuck, J. 1975. Quantifying continuous lesions and fractures on long bones. *Journal of Field Archaeology* 2(3): 239 – 249.

Biewener, A.A. 1983a. Allometry of quadrupedal locomotion: the scaling of duty factor, bone curvature and limb orientation to body size. *Journal of Experimental Biology* 105: 147 – 171.

Biewener, A.A. 1983b. Locomotory stresses in the limb bones of two small mammals: the ground squirrel and chipmunk. *Journal of Experimental Biology* 103: 131 – 154.

Biewener, A.A. 1991. Musculoskeletal design in relation to body size. *Journal of Biomechanics* 24: 19 – 29.

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

Binford, L.R. 1984. *Faunal Remains from Klasies River Mouth.* Academic Press: Orlando, Florida.

Blasco, R., Rosell, J., Peris, J.F., Caceres, I. & Verges, J.M. 2008. A new element of trampling: an experimental application on the Level XII faunal record of Bolomor Cave (Valencia, Spain). *Journal of Archaeological Science* 35: 1605 – 1618.

Blumenschine, R.J. 1986. Carcass consumption sequences and the archaeological distinction of scavenging and hunting. *Journal of Human Evolution* 15: 639 – 659.

Blumenschine, R.J. 1988. An experimental model of the timing of hominid and carnivore influences on archaeological bone assemblages. *Journal of Archaeological Science* 15: 483 – 502.

Blumenschine, R.J. 1991. Hominid carnivory and foraging strategies and the socio-economic function of early archaeological sites. *Philosophical Transactions of the Royal Society of London (Biology)* 334: 211 – 221.

Blumenschine, R.J. 1995. Percussion marks, tooth marks and experimental determinations of the timing of hominid and carnivore access to long bones at FLK *Zinjanthropus*, Olduvai Gorge, Tanzania. *Journal of Human Evolution* 29: 21 – 51.

Blumenschine, R.J. & Madrigal, T.C. 1993. Variability in long bone marrow yields of East African ungulates and it's zooarchaeological implications. *Journal of Archaeological Science* 20: 555 – 587.

Blumenschine, R.J., Marean, C.W. & Capaldo, S.D. 1996. Blind tests of inter-analyst correspondence and accuracy in the identification of cut marks, percussion marks and carnivore tooth marks on bone surfaces. *Journal of Archaeological Science* 23: 493 – 507.

Blumenschine, R.J. & Selvaggio, M. 1988. Percussion marks on bone surfaces as a new diagnostic of hominid behaviour. *Nature* 333: 763 – 765.

Brain, C.K. 1967a. Hottentot food remains and their bearing on the interpretation of fossil bone assemblages. *Scientific Papers of the Namib Desert Research Station* 32: 1 – 11.

Brain, C.K. 1967b. Bone weathering and the problem of bone pseudo-tools. *South African Journal of Science* 63(3): 97 – 99.

Brain, C.K. 1969. Faunal remains from the Bushmans Rock Shelter, eastern Transvaal. *South African Archaeological Bulletin* 24(94): 52 – 55.

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

Brain, C.K. 1974b. Human food remains from the Iron Age at Zimbabwe. *South African Journal of Science* 70: 303 – 309.

Brain, C.K. 1975. An introduction to the South African australopithecine bone accumulations. In: Clason, A.T. (ed.) *Zooarchaeological Studies*. pp. 109 – 119. North Holland: Amsterdam.

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

Brain, C.K. & Shipman, P. 1993. The Swartkrans bone tools. In: C.K. Brain (ed.) *Swartkrans: A Cave's Chronicle of Early Man*. pp. 195 – 215. Transvaal Museum Monograph 8: Pretoria.

Brink, J.W. 1997. Fat content in leg bones of *Bison bison*, and applications to archaeology. *Journal of Archaeological Science* 24: 259 – 274.

Bromage, T.A. 1984. Interpretation of scanning electron microscopic images of abraded forming bone surfaces. *American Journal of Physical Anthropology* 64: 161 – 178.

Bunn, H.T. 1981. Archaeological evidence for meat-eating by Plio-Pleistocene hominids from Koobi Fora and Olduvai Gorge. *Nature* 291: 574 – 577.

Bunn, H.T. 1983a. Evidence on the diet and subsistence patterns of Plio-Pleistocene hominids at Koobi Fora, Kenya and at Olduvai Gorge, Tanzania. In: Clutton-Brock, J. & C. Grigson (eds.) *Animals and Archaeology: 1. Hunters and their prey*. pp. 21 – 30. BAR International Series 163: Oxford.

Bunn, H.T. 1983b. Comparative analysis of modern bone assemblages from a San hunter-gatherer camp in the Kalahari Desert, Botswana, and from a spotted hyena den near Nairobi,

Kenya. In: Clutton-Brock, J. & C. Grigson (eds.) *Animals and Archaeology: 1. Hunters and their prey*. pp. 143 – 148. BAR International Series 163: Oxford.

Bunn, H.T. 1991. A taphonomic perspective on the archaeology of human origins. *Annual Review of Anthropology* 20: 433 – 467.

Bunn, H.T. & Kroll, E.M. 1986. Systematic butchery by Plio/Pleistocene hominids at Olduvai Gorge, Tanzania. *Current Anthropology* 27(5): 431 – 442.

Bunn, H.T., Bartram, L.E. & Kroll, E.M. 1988. Variability in bone assemblage formation from Hadza hunting, scavenging and carcass processing. *Journal of Anthropological Archaeology* 7: 412 – 457.

Butler, V.L. & Lyman, R.L. 1996. Taxonomic identification and faunal summaries: what should we be including in our faunal reports. *Society for American Archaeology* 14(1): 1 – 3.

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

Calder, W.A. 1984. *Size, Function and Life History.* Harvard University Press: Boston.

Capaldo, S.D. 1997. Experimental determinations of carcass processing by Plio-Pleistocene hominids and carnivores at FLK 22 (*Zinjanthropus*), Olduvai Gorge, Tanzania. *Journal of Human Evolution* 33: 555 – 597.

Capaldo, S.D. 1998. Simulating the formation of dual-patterned archaeofaunal assemblages with experimental control samples. *Journal of Archaeological Science* 25(4): 311 – 330.

Carbone, V.A. & Keel, B.C. 1985. Preservation of plant and animal remains. In: Gilbert, R.I. & Mielke, J.H. (eds.) *The Analysis of Prehistoric Diets.* pp. 2 – 19. Academic Press: New York.

Carr, A.S., Thomas, D.S.G., Bateman, M.D. 2006. Climatic and sea level controls on Late Quaternary eolian activity on the Agulhas Plain, South Africa. *Quaternary Research* 65: 252 – 263.

Carr, A.S., Thomas, D.S.G., Bateman, M.D., Meadows, M.D. & Chase, B. 2007. Late Quaternary palaeoenvironments of the winter-rainfall zone of southern Africa: palynological and sedimentological evidence from the Agulhas plain. *Palaeogeography, Palaeoclimatology, Palaeoecology* 239: 147 – 165.

Chaplin, R.E. 1971. *The Study of Animal Bones from Archaeological Sites*. Seminar Press: London.

Chase, B.M. 2010. South African palaeoenvironments during marine oxygen isotope stage 4: a context for the Howiesons Poort and Still Bay industries. *Journal of Archaeological Science* 37: 1359 – 1366.

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

Chase, P.C. & Dibble, H.L. 1987. Middle Palaeolithic symbolism: a review of current evidence and interpretation. *Journal of Anthropological Archaeology* 6: 263 – 296.

Clark, J.L. 2009. Testing Models on the Emergence and Nature of Modern Human Behaviour: Middle Stone Age Fauna from Sibudu Cave (South Africa). Unpublished Ph.D dissertation. University Of Michigan: Ann Arbor.

Clark, J.L. & Ligouis, B. 2010. Burned bone in the Howieson's Poort and post-Howieson's Poort Middle Stone Age deposits at Sibudu (South Africa): behavioural and taphonomic implications *Journal of Archaeological Science* doi: 10.1016/j.jas.2010.06.001.

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

Clark, W.E. LeGros 1957. Humans and hominids. Review of: The osteodontokeratic culture of *Australopithecus prometheus* by Dart, R.A. *Nature* 180: 156.

Cohen, A.S., Stone, J.R., Beuning, K.R.M., Park, L.E., Reinthal, P.N., Dettmen, D., Scholz, C.A., Johnson, T.C., King, J.W., Talbot, M.R., Brown, E.T. & Ivory, S.J. 2007. Ecological consequences of early late Pleistocene megadroughts in tropical Africa. *Proceedings of the National Academy of Science* 104(42): 16422 – 16427.

Compton, J.S. 2011. Pleistocene sea-level fluctuations and human evolution on the southern coastal plain of South Africa. *Quaternary Science Reviews* 30: 506 – 527.

Conard, N.J., Walker, S.J. & Kandel, A.W. 2008. How heating and cooling and wetting and drying can destroy dense faunal elements and lead to differential preservation. *Palaeogeography, Palaeoclimitology, Palaeoecology* 266: 236 – 245.

Costamagno, S., Théry-Parisot, I., Brugal, J.-P. & Guibert, R. 2005. Taphonomic consequences of the use of bone as fuel. Experimental data and archaeological applications. In: O'Connor, T. (ed.) *Biosphere to Lithosphere: New Studies in Vertebrate Taphonomy. Proceedings of the 9th Conference of the International Council of Archaeozoology, Durham.* pp. 51 – 62. Oxbow Books: London.

Croker, S.L., Clement, J.G. & Donlon, D. 2009. A comparison of the cortical bone thickness in the femoral mid-shaft of humans and two non-human mammals. *Journal of Comparative Human Biology* 60: 551 – 565.

Coolidge, F.L. & Wynn, T. 2007. The working memory account of Neandertal cognition: how phonological storage capacity may be related to recursion and the pragmatics of modern speech. *Journal of Human Evolution* 52(6): 707 – 710.

Cruz-Uribe, K. & Klein R.G. 1994. Chew marks and cut marks on animal bones from the Kasteelberg B and dune field midden Later Stone Age sites, Western Cape Province, South Africa. *Journal of Archaeological Science* 21: 35 – 49.

Cruz-Uribe, K., Klein, R.G., Avery, G., Avery, M., Halkett, D., Hart, T., Milo, R.G., Sampson, C.G. & Volman, T. 2003. Excavation of buried Late Acheulean (Mid-Quaternary) land surfaces at Duinfontein 2, Western Province, South Africa. *Journal of Archaeological Science* 30: 559 – 575.

Currey, J.D. & Alexander, R. McN. 1985. The thickness of the walls of tubular bones. *Journal of Zoology – Supp. A* 206:453 – 468.

Dart, R.A. 1949a. The predatory implemental technique of *Australopithecus*. *American Journal of Physical Anthropology* 7: 1 – 38.

Dart, R.A. 1949b. The bone-bludgeon hunting technique of *Australopithecus*. *South African Journal of Science* 2: 38 – 40.

Dart, R.A. 1957. *The Osteodondokeratic Culture of* Australopithecus Prometheus. Memoirs of the Transvaal Museum, no. 10: 1 – 105.

Dart, R.A. 1958. Bone tools and porcupine gnawing. *American Anthropologist* 60(4): 715 – 724.

Dart, R.A. & Kitching, J.W. 1958. Bone tools at the Kalkbank Middle Stone Age site and the Makapansgat australopithecine locality, Central Transvaal. Part 2: The osteodontokeratic contribution. *The Archaeological Bulletin* 13(51): 94 – 116.

Davis, S.J.M. 1987. *The Archaeology of Animals.* Batsford Ltd: London.

Deacon, H.J. 1992. Southern Africa and modern human origins. *Philosophical Transactions of the Royal Society London (Biology)* 337(1280): 177 – 183.

Deacon, J., Talma, A.S. & Vogel, J.C. 1988. Biological and cultural development of Pleistocene people in an Old World southern continent. In: Prescott, J.R. (ed.) *Early Man in the Southern Hemisphere: S23 – S31*. pp. 523 – 531. Department of Physics and Mathematical Physics, University of Adelaide: Adelaide.

d'Errico, F. 2003. The invisible frontier: A multiple species model for the origin of behavioural modernity. *Evolutionary Anthropology* 12: 188 – 202.

d'Errico, F. & Backwell, L.R. 2009. Assessing the function of early hominin bone tools. *Journal of Archaeological Science* 38(8): 1764 – 1773.

d'Errico, F. & Henshilwood, C.S. 2007. Additional evidence for bone technology in the southern African Middle Stone Age. *Journal of Human Evolution* 52: 142 – 163.

d'Errico, F., Henshilwood, C.S. & Nilssen, P. 2001. An engraved bone fragment from *c.* 70 000-year-old Middle Stone Age levels at Blombos Cave, South Africa: implications for the origin of symbolism and language. *Antiquity* 75(288): 309 – 318.

d'Errico, F., Henshilwood, C.S., Lawson, G., Vanhaeren, M., Tillier, A., Soressi, M., Bresson, F., Maureille, B., Novell, A., Lakarra, J., Backwell, L. & Julien, M. 2003. Archaeological evidence for the emergence of language, symbolism and music – an alternative multidisciplinary perspective. *Journal of World Prehistory* 17(1): 1 – 70.

d'Errico, F., Henshilwood, C., Vanhaeren, M., van Niekerk, K. 2005. *Nassarius kraussianus* shell beads from Blombos Cave: evidence for symbolic behaviour in the Middle Stone Age. *Journal of Human Evolution* 48: 3 – 24.

d'Errico, F. & Stringer, C.B. 2011. Evolution, revolution or saltation scenario for the emergence of modern cultures. *Philosophical Transactions of the Royal Society B* 366: 1060 – 1069.

de Graaf, G. 1961. Gross effects of a primitive hearth on bones. *South African Archaeological Bulletin* 16(61): 25 – 26.

de Ruiter, D.J., Brophy, J.K., Lewis, P.J., Churchill, S.E. & Berger, L.R. 2008. Faunal assemblage composition and palaeoenvironment at Plover Lake, a Middle Stone Age locality in Gauteng Province, South Africa. *Journal of Human Evolution* 55: 1102 – 1117.

Dewar, G., Halkett, D., Hart, T., Orton, J. & Sealy, J. 2006. Implications of a mass kill site of springbok (*Antidorcas marsupialis*) in South Africa: hunting practices, gender relations and sharing in the Later Stone Age. *Journal of Archaeological Science* 33: 1266 – 1275.

Dominguez-Rodrigo, M. 1999. Distinguishing between apples and oranges: the application of modern cut-mark studies to the Plio-Pleistocene (a reply to Monahan). *Journal of Human Evolution* 37: 793 – 800.

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

Dominguez-Rodrigo, M. & Barba, R. 2006. New estimates of tooth mark and percussion mark frequencies at the FLK Zinj site: the carnivore-hominid-carnivore hypothesis falsified. *Journal of Human Evolution* 50: 170 – 194.

Dominguez-Rodringo, M. & Pickering, T.R. 2003. Early hominid hunting and scavenging: a zooarchaeological review. *Evolutionary Anthropology* 12: 275 – 282.

Dominguez-Rodrigo, M. & Yravendra, J. 2009. Why are cut mark frequencies in archaeological assemblages so variable? A multivariate analysis. *Journal of Archaeological Scienc*e 36(3): 884 – 894.

Drennan, R.D. 1996. *Statistics for Archaeologists: A Commonsense Approach.* Plenum Press: New York.

Driver, J.C. 1992. Identification, classification and zooarchaeology. *Circaea* 9(1): 35 – 47.

Driver, J.C. 1999. *Crow Canyon Archaeological Centre Manual for the Description of Vertebrate Remains.* Crow Canyon Archaeological Centre: Cortez.

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

Dusseldorp, G. L. 2011. Tracking the influence of technological change on the Middle Stone Age hunting strategies in South Africa. *Quaternary International* (2011), doi: 10.1016/ j.quaint.2011.02.011.

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

Enard, W., Przeworski, M., Fisher, S.E., Lai, C.S.L., Wiebe, V. Kitano, T. Monaco, A.P. & Paabo, S. 2002 Molecular evolution of FOXP2, a gene involved in speech and language. *Nature* 418: 869 – 871.

Enloe, J.G. 1993. Ethnoarchaeology of marrow cracking: implications for the recognition of prehistoric subsistence organization. In: Hudson. J. (eds.) *From Bones to Behaviour: Ethnoarchaeological and Experimental Contributions to the Interpretation of Faunal Remains.* pp. 82 – 97. Center for Archaeological Investigations, Occasional Paper No. 21. Southern Illinois University: Chicago.

Evans, U. 1994. Hollow Rock Shelter, a Middle Stone Age site in the Cederberg. *South African Field Archaeology* 3: 63 – 72.

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

Faith, J.T. 2011. Ungulate biogeography, statistical methods, and the proficiency of Middle Stone Age hunters. *Journal of Human Evolution* 60: 315 – 317.

Fernandez-Jalvo, J. & Andrews, P. 2011. When humans chew bones. *Journal of Human Evolution* 60: 117 – 123.

Fisher, J.W. 1995. Bone surface modification in zooarchaeology. *Journal of Archaeological Method and Theory* 2(1): 7 – 68.

Fletcher, M. & Lock, G.R. 1991. *Digging Numbers: Elementary Statistics for Archaeologists.* Oxbow Books: Oxford.

Garcia, G.J.M. & da Silva, J.K.L. 2006. Interspecific allometry of bone dimensions: a review of the theoretical models. *Physics of Life Reviews* 3: 188 – 209.

Grayson, D.K. 1984. *Quantitative Zooarchaeology: Topics in the Analysis of Archaeological Faunas.* Academic Press: Orlando, Florida.

Grayson, D.K. 1988. Danger Cave, Last Supper Cave and Hanging Rock Shelter: the faunas. *American Museum of Natural History Anthropological Papers* 66(1): 1 – 130.

Grayson, D.K. & Fey, C.J. 2004. Measuring skeletal part representation in archaeological faunas. *Journal of Taphonomy* 2(1): 27 – 42.

Gifford, D. 1981. Taphonomy and paleoecology: a critical review of archaeology's sister discipline. In: M. B. Schiffer (ed.) *Advances in Archaeological Method and Theory* 4: 365 – 437. Academic Press: New York.

Gifford-Gonzalez, D. 2007. Thoughts on a method of zooarchaeological study of quotidian life. *Treballs d'Arqueologia* 13: 5 – 27.

Gifford-Gonzalez, D.P., Damrosch, D.B., Damrosch, D.R., Pryor, J. & Thunen, R.L. 1985. The third dimension in site structure: an experiment in trampling and vertical dispersal. *American Antiquity* 50: 803 – 818.

Grine, F.E. & Henshilwood, C.S. 2002. Additional human remains from Blombos Cave, South Africa: (1999 – 2000 excavations). *Journal of Human Evolution* 42: 293 – 302.

Grine, F.E., Henshilwood, C.S. & Sealy, J.C. 2000. Human remains from Blombos Cave, South Africa: (1997 – 1998 excavations). *Journal of Human Evolution* 38: 755 – 765.

Grine, F.E., Pearson, O.M., Klein R.G., Rightmire, G.P. 1998. Additional human fossils from Klasies River Mouth, South Africa. *Journal of Human Evolution* 35: 95 – 107.

Goldblatt, P. 1997. Floristic diversity in the Cape Flora of South Africa. *Biodiversity and Conservation* 6: 359 – 377.

Goodwin, A. J. H. 1933. The Cape Flats Complex. *South African Journal of Science* 30: 515 – 523.

Goodwin, A. J. H. & Van Riet Lowe, C. 1929. The Stone Age cultures of South Africa. *Annals of the South African Museum* 27: 1 – 289.

Gupta, H.S. & Zioupos, P. 2008. Fracture of bone tissue: the 'hows' and the 'whys'. *Medical Engineering & Physics* 30: 1209 – 1226.

Haynes, G. 1983. Frequencies of spiral and green-break fractures on ungulate limb bones in modern surface assemblages. *American Antiquity* 48(1): 102 – 114.

Haynes, G. & Stanford, D. 1984. On the possible utilization of *Camelops* by Earl Man in North America. *Quaternary Research* 22: 216 – 230.

Hedges, R. 2009. Studying human diet. In: Cunliffe, B., Gosden, C. & R. A. Joyce (eds.) *The Oxford Handbook of Archaeology*. pp. 484 – 518. Oxford University Press: Oxford.

Henshilwood, C.S. 1995. Holocene archaeology of the coastal Garcia State Forest, southern Cape, South Africa. Unpublished PhD thesis. University of Cambridge: Cambridge.

Henshilwood, C.S. 1996. A revised chronology for the arrival of pastoralism in southernmost Africa: new evidence of sheep at ca. 2000 B.P. from BBC, South Africa. *Antiquity* 70: 945 – 949.

Henshilwood, C.S. 1997. Identifying the collector: evidence for human processing of the Cape dune mole rat, *Bathyergus suillus*, from Blombos Cave, southern Cape, South Africa. *Journal of Archaeological Science* 24: 659 – 662.

Henshilwood, C. S. 2004. The origins of human behaviour – exploring the African evidence. In: Oestigaard, T., Anfinset, N., & T. Saetersdal, (eds.). *Combining the Past and the Present*

Archaeological Perspectives on Society. pp. 95 – 106. Proceedings from the conference 'Pre-history in a global perspective' held in Bergen 31 August – 2 September 2001.

Henshilwood, C.S. 2005. Stratigraphic integrity of the Middle Stone Age levels at Blombos Cave. In: d'Errico, F & L. Backwell (eds.) *From Tools to Symbols: From Early Hominids to Modern Humans.* pp. 441 – 458. Witwatersrand University Press: Johannesburg.

Henshilwood, C.S. 2007. Fully symbolic Sapiens behaviour: Innovation in the Middle Stone Age at Blombos Cave, South Africa. In: Mellars, P.A., Boyle, K., Bar-Yosef, O. & C.B. Stringer (eds.) *Rethinking the Human Revolution: New Behavioural and Biological Perspectives on the Origin and Dispersal of Modern Humans.* pp. 123 – 132. Oxbow books: London.

Henshilwood, C. S. 2008a. *Holocene Prehistory of the Southern Cape, South Africa: Excavations at Blombos Cave and the Blombosfontein Nature Reserve*. BAR International Series 1860, Cambridge Monographs in African Archaeology 75: Oxford.

Henshilwood, C. S. 2008b. Winds of Change: Palaeoenvironments, material culture and human behaviour in the Late Pleistocene (~77 ka – 48 ka ago) in the Western Cape Province, South Africa. *South African Archaeological Society Goodwin Series* 10: 35 – 51.

Henshilwood, C.S., d'Errico, F., Marean, C.W., Milo, R & Yates, R.J. 2001a. An early bone tool industry from the Middle Stone Age at Blombos Cave, South Africa: implication for the origins of modern human behaviour, symbolism and language. *Journal of Human Evolution* 41: 631 – 678.

Henshilwood, C.S., d'Errico, F., Yates, R., Jacobs, Z., Tribolo, C., Duller, G.A.T., Mercier, N., Sealy, J.C., Valladas, H., Watts, I & Wintle, A.G. 2002. Emergence of modern human behaviour: Middle Stone Age engravings from South Africa. *Science* 295: 1278 – 1280.

Henshilwood, C., d'Errico, F., Vanhaeren, M., van Niekerk, K. & Jacobs, Z. 2004. Middle Stone Age shell beads from South Africa. *Science* 304: 404.

Henshilwood, C.S., d'Errico, F. & Watts, I. 2009. Engraved ochres from the Middle Stone Age levels at Blombos Cave, South Africa. *Journal of Human Evolution* 57: 27 – 47.

Henshilwood, C.S. & Dubreuil, B. 2011. The Still Bay and Howiesons Poort, 77 – 59 ka: symbolic material culture and the evolution of the mind during the African Middle Stone Age. *Current Anthropology* 52(3): 361 – 400.

Henshilwood, C.S. & Marean, C.W. 2006. Remodelling the origins of modern human behaviour. In: Soodyall, H. (ed.) *The Prehistory of Africa: Tracing the Lineage of Modern Man.* pp. 31 – 46. Jonathan Ball: Cape Town.

Henshilwood, C.S. & Sealy, J.C. 1997. Bone artefacts from the Middle Stone Age at Blombos Cave, southern Cape, South Africa. *Current Anthropology* 38: 890 – 895.

Henshilwood, C.S., Sealy, J.C., Yates, R., Cruz- Uribe, K., Goldberg, P., Grine, F.E., Klein, R.G., Poggenpoel, C., van Niekerk, K. & Watts, I. 2001b. Blombos Cave, Southern Cape, South Africa: Preliminary Report on the 1992 – 1999 Excavations of the Middle Stone Age Levels. *Journal of Archaeological Science* 28: 421 – 448.

Herrmann, H.J., Wittel, F.K. & Kun, F. 2006. Fragmentation. *Physica A* 371: 59 – 66.

Hesse, B. & Wapnish, P. 1985. *Animal Bone Archaeology: From Objectives to Analysis. Manuals on Archaeology No. 5*. Taraxacum: Washington D.C.

Hill, A. 1979. Disarticulation and scattering of mammal skeletons. *Paleobiology* 5(3): 261 – 274.

Hill, A. 1983. Hyeanas and early hominids. In: Clutton-Brock, J. & C. Grigson (eds.) *Animals and Archaeology: 1. Hunters and their Prey*. pp. 87 – 92. BAR International Series 163: Oxford.

Hofman, R.R. 1989. Evolutionary steps of ecophysiological adaptation and diversification of ruminants: a comparative view of their digestive system. *Oecologia* 78(4): 443 – 457.

Isaac, G.L. 1983. Bones in contention: competing explanations for the juxtaposition of Early Pleistocene artifacts and faunal remains. In: Clutton-Brock, J. & C. Grigson (eds.) *Animals and Archaeology: 1. Hunters and their prey*. pp. 3 – 19. BAR International Series 163: Oxford.

Jablonski, D. 1996. Body size and macroevolution. In: Jablonski, D., Erwin, D.H. & J.H. Lipps (eds.) *Evolutionary Biology.* pp. 256 – 289. University of Chicago Press: Chicago.

Jacobs, Z., Duller, G.A.T., Wintle, A.G. & Henshilwood, C.S. 2006. Extending the chronology of deposits at Blombos Cave, South Africa, back to 140 ka using optimal dating of single and multiple grains of quartz. *Journal of Human Evolution* 51: 255 – 273.

Jacobs, Z. & Roberts, R.G. 2008. Testing times: old and new chronologies for the Howieson's Poort and Still Bay industries in environmental context. *South African Archaeological Society Goodwin Series* 10: 9 – 34.

Jacobs, Z., Wintle, A.G. & Duller, G.A.T. 2003a. Optical dating of dune sand from Blombos Cave, South Africa: I multiple grain data. *Journal of Human Evolution* 44: 599 – 612.

Jacobs, Z., Wintle, A.G. & Duller, G.A.T. 2003b. Optical dating of dune sand from Blombos Cave, South Africa: II single grain data. *Journal of Human Evolution* 44: 613 – 625.

Johnson, E. 1985. Current developments in bone technology. In: Schiffer, M.B. (ed.) *Advances in Archaeological Method and Theory Vol. 8*. pp. 157 – 235. Academic Press: New York.

Kappelman, J., Plummer, T., Bishop, L., Duncan, A. & Appleton, S. 1997. Bovids as indicators of Plio-Pleistocene paleoenvironments in East Africa. *Journal of Human Evolution* 32: 229 – 256.

Kent, S. 1993. Variability in faunal assemblages: the influence of hunting skill, sharing, dogs and mode of cooking on the faunal remains at a sedentary Kalahari community. *Journal of Anthropological Archaeology* 12: 323 – 385.

Kidwell, S.M. 1985. Paleobiological and sedimentological implications of fossil concentrations. *Nature* 318: 457 – 460.

Kidwell, S.M. 1986. Models for fossil concentrations: paleobiologic implications. *Paleobiology* 12: 6 – 24.

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

Klein, R.G. 1975. Middle Stone Age man-animal relationships in southern Africa: evidence from Klasies River Mouth and Die Kelders. *Science* 190: 265 – 267.

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

Klein, R.G. 1977. The ecology of early man in southern Africa. *Science* 8 (197): 115 – 126.

Klein, R.G. 1981. Stone Age predation on small African bovids. *The South African Archaeological Bulletin* 36(134): 55 – 65.

Klein, R.G. 1982. Age (mortality) profiles as a means of distinguishing hunted species from scavenged ones in Stone Age archaeological sites. *Paleobiology* 8(2): 151 – 158.

Klein, R.G. 1983. Palaeoenvironmental implications of Quaternary large mammals in the fynbos biome. *South African National Science Progress Report* 75: 116 – 138.

Klein, R.G. 1989. Why does skeletal part representation differ between smaller and larger bovids at Klasies River Mouth and other archeological sites? *Journal of Archaeological Science* 6: 363 – 381.

Klein, R.G. 1991. Size variation in the Cape dune molerat (*Bathyergus suillus*) and late Quaternary climatic change in southwestern Cape Province, South Africa. *Quaternary Research* 36: 243 – 256.

Klein, R.G. 1995. Anatomy, Behaviour and Modern Human Origins. *Journal of World Prehistory* 9(2) 167 – 198.

Klein, R.G. 2000. Archaeology and the evolution of human behaviour. *Evolutionary Anthropology* 9: 17 – 36.

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

Klein, R.G. 2003. Comment on: An early case of color symbolism. *Current Anthropology* 44: 491 – 522.

Klein, R.G. 2009. Darwin and the recent origin of modern humans. *Proceedings of the National Academy of Sciences USA* 106: 16007 – 16009.

Klein, R.G., Avery, G., Cruz-Uribe, K., Halkett, D., Hart, T., Milo, R.G. & Volman, T. 1999a. Duinefontein 2: an Acheulean site in the Western Province of South Africa. *Journal of Human Evolution* 37: 153 – 190.

Klein, R.G., Avery, G., Cruz-Uribe, K., Halkett, D., Parkington, J.E., Steele, T., Volman, T.P. & Yates, R. 2004. The Ysterfontein 1 Middle Stone Age site, South Africa, and early human exploitation of coastal resources. *Proceedings of the National Academy of Sciences USA* 101(16): 5708 – 5715.

Klein, R.G. & Cruz- Uribe, K. 1984. *The Analyses of Animal Bones from Archaeological Sites.* University of Chicago Press: Chicago.

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

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

Klein, R.G., Cruz-Uribe, K. & Milo, R.G. 1999b. Skeletal part representation in archaeofaunas: comments on "Explaining the 'Klasies Pattern': Kua ethnoarchaeology, the Die Kelders Middle Stone Age archaeofaunal, long bone fragmentation and carnivore ravaging" by Bartram & Marean. *Journal of Archaeological Science* 26: 1225 – 1234.

Klein, R.G., Cruz-Uribe, K., Halkett, D., Hart, T. & Parkington, J. 1999c. Paleoenvironmental and human behaviour implications of the Boegoeberg 1 Late Pleistocene hyena den, Northern Cape Province, South Africa. *Quaternary Research* 52: 393 – 403.

Kos, A.M. 2003. Characterisation of post-depositional taphonomic processes in the accumulation of mammals in a pitfall cave deposit from southeastern Australia. *Journal of Archaeological Science* 30: 781 – 796.

Lahr, M. & Foley, R.A. 1998. Towards a theory of modern human origins: Geography, demography and diversity in recent human evolution. *Yearbook of Physical Anthropology* 41: 137 – 176.

Langley, R. 1968. *Practical Statistics.* Pan Books: London.

Lombard, M. 2006. First impressions of the functions and hafting technology of Still Bay pointed artefacts from Sibudu Cave. *Southern African Humanities* 18(1): 27 – 41.

Lombard, M. 2007. Evidence for change in Middle Stone Age hunting behaviour at Blombos Cave: Results of a macrofracture analysis. *South African Archaeological Bulletin* 62: 62 – 65.

Lombard, M. & Clark, J.L. 2008. Variability and change in Middle Stone Age hunting behaviour: aspects from the lithic and faunal records. In: Badenhorst, S., Mitchell, P. & J.C. Driver (eds.) *Animals and People: Archaeozoological Papers in Honour of Ina Plug*. pp. 46 – 56. BAR International Series 1849: Oxford.

Lupo, K.D. 1998. Experimentally derived extraction rates for marrow: implications for body part exploitation strategies of Plio-Pleistiocene hominid scavengers. *Journal of Archaeological Science* 25: 657 – 675.

Lupo, K.D. & O'Connell, J.F. 2002. Cut and tooth mark distributions on large animal bones: ethnoarchaeological data from the Hadza and their implications for current ideas about early human carnivory. *Journal of Archaeological Science* 29: 85 – 109.

Lyman, R.L. 1984. Broken bones, bone expediency tools, and bone pseudotools: lessons from the blast zone around Mount St. Helens, Washington. *American Antiquity* 49: 315 – 333.

Lyman, R.L. 1987. Archaeofaunas and butchery studies: a taphonomic perspective. *Advances in Archaeological Method and Theory* 10: 249 – 337.

Lyman, R.L. 1994. *Vertebrate Taphonomy*. Cambridge Manuals in Archaeology. Cambridge University Press: Cambridge.

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

Lyman, R.L. & O'Brien, M.J. 1987. Plow-zone zooarchaeology: fragmentation and identifiability. *Journal of Field Archaeology* 14(4): 493 – 500.

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

McBrearty, S. & Stringer, C. 2007. The coast in colour. *Nature* 449: 793 – 794.

McCall, G.S. 2007. Behavioural ecological models of lithic technological change during the later Middle Stone Age of South Africa. *Journal of Archaeological Science* 34: 1738 – 1751.

McKinley, J.I. 1994. Bone fragment size in British cremation burials and it's implication for pyre technology and ritual. *Journal of Archaeological Science* 21: 339 – 342.

McMahon, T.A. 1975. Allometry and biomechanics: limb bones in adult ungulates. *American Naturalist* 109: 547 – 563.

Maguire, J.M., Pemberton, D. & Collett, M.H. 1980. The Makapansgat Limeworks Grey Breccia: hominids, hyaenas, hystricids or hillwash? *Palaeontologia Africana* 23: 75 – 98.

Malafouris, L. 2008. Beads for a plastic mind: the 'Blind Man's Stick' (BMS) hypothesis and the active nature of material culture. *Cambridge Archaeological Journal* 18(3): 401 – 414.

Malan, B.D. 1955. The archaeology of the Tunnel Cave and Skildergat Kop, Fish Hoek, Cape of the Good Hope. *South African Archaeological Bulletin* 10(37): 3 – 9.

Malan, J.A. 1989. *Lithostratigraphy of the Wankoe Formation (Bredasdorp Group).* Republic of South Africa, Department of Mineral & Energy Affairs, Geological Survey: Pretoria.

Malik, C.L., Stover, S.M., Martin, R.B. & Gibeling, J.C. 2003. Equine cortical bone exhibits rising R-curve fracture mechanics. *Journal of Biomechanics* 36: 191 – 198.

Marean, C.W. 1991. Measuring the postdepositional destruction of bone in archaeological assemblages. *Journal of Archaeological Science* 18: 677 – 694.

Marean, C.W. 1998. A critique of the evidence for scavenging by Neanderthals and early modern humans: New data from Kobeh Cave (Zagros mountains, Iran) and Die Kelders Cave 1, Layer 10 (South Africa). *Journal of Human Evolution* 35: 111 – 136.

Marean, C.W. 2005. From the tropics to the colder climates: contrasting faunal exploitation adaptations of modern humans and Neanderthals. In d'Errico, F & L. Backwell (eds.) *From Tools to Symbols: From Early hominids to Modern Humans.* pp. 333 – 371. Witwatersrand University Press: Johannesburg.

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

Marean, C.W. & Assefa, Z. 1999. Zooarchaeological evidence for the faunal exploitation behaviour of Neandertals and early modern humans. *Evolutionary Anthropology* 7: 22 – 37

Marean, C.W., Bar-Matthews, M., Bernatschez, J., Fisher, E., Goldberg, P., Herries, A.I.R., Jacobs, Z., Jerardino, A., Karkanas, P., Minichillo, T., Nilssen, P.J., Thompson, E., Watts, I. & Williams, H.M. 2007. Early human use of marine resources and pigment in South Africa during the Middle Pleistocene. *Nature* 449: 905 – 908.

Marean, C.W. & Bertino, L. 1994. Intrasite special analysis of bone: subtracting the effect of secondary carnivore consumers. *American Antiquity* 59: 748 – 768.

Marean, C.W. & Kim, S.Y. 1998. Mousterian large-mammal remains from Kobeh Cave: behavioural implications for Neanderthals and early modern humans. *Current Anthropology* 39(2): 79 – 113.

Marean, C.W. & Spencer, L.M. 1991. Impact of carnivore ravaging on zooarchaeological measures of element abundance. *American Antiquity* 56(4): 645 – 658.

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

Mayr, E. 1956. Geographical character gradients and climatic adaptation. *Evolution* 10(1): 105 – 108.

Mellars, P. 2005. The impossible coincidence. A single-species model for the origins of modern human behaviour in Europe. *Evolutionary Anthropology* 14: 12 – 27.

Mellars, P. 2006. Why did modern human populations disperse from Africa *ca.* 60 000 years ago: a new model. *Proceedings of the National Academy of Sciences USA* 103(25): 9381 – 9386.

Milo, R.G. 1998. Evidence for hominid predation at Klasies River Mouth, South Africa, and it's implication for the behaviour of early modern humans. *Journal of Archaeological Science* 25: 99 – 133.

Minichillo, T. 2005. Middle Stone Age Lithic Study, South Africa: An Examination of Modern Human Origins. Unpublished Ph.D dissertation. University of Washington: Seattle.

Minichillo, T. 2006. Raw material use and behavioural modernity: Howiesons Poort lithic foraging strategies. *Journal of Human Evolution* 50: 359 – 364.

Monahan, C.M. 1995. New zooarchaeological data from Bed II, Olduvai Gorge, Tanzania: implications for hominid behaviour in the Early Pleistocene. *Journal of Human Evolution* 31: 93 – 128.

Morris, J. 2010. The composition and interpretation of associated bone groups from Wessex. In Campana, D., Crabtree, P. deFrance, S.D., Lev-Tov, J. & A. Choyke (eds.) *Anthropological Approaches to Zooarchaeology*. pp. 259 – 269. Oxbow Books: Oxford.

Mourre, V., Villa, P. & Henshilwood, C.S. 2010. Early use of pressure flaking on lithic artifacts at Blombos Cave, South Africa. *Science* 330: 659 – 662.

Munro, N. & Bar-Oz, G. 2005. Gazelle bone fat processing in the Levantine Epipalaeolithic *Journal of Archaeological Science* 32: 223 – 239.

Myers,T. P., Voorhies, M.R. & Corner, R.G. 1980. Spiral fractures and bone pseudotools at paleontological sites. *American Antiquity* 45(3): 483 – 490.

Nicholson, R.A. 1993. A morphological investigation of burnt animal bone and an evaluation of its utility in archaeology. *Journal of Archaeological Science* 20: 411 – 428.

Noble, W. & Davidson, I. 1993. Tracing the emergence of modern human behaviour: methodological pitfalls and a theoretical path. *Journal of Anthropological Archaeology* 12: 121 – 149.

Noe-Nygaard, N 1977. Butchering and marrow fracturing as a taphonomic factor in archaeological deposits. *Paleobiology* 3(2): 218 – 237.

Noe-Nygaard, N. 1989. Man-made trace fossils on bone. *Human Evolution* 4(6): 461 – 491.

Norton, C.J. & Goa, X. 2008. Hominin-carnivore interactions during the Chinese Early Paleolithic: taphonomic perspectives from Xujiayao. *Journal of Human Evolution* 55: 164 – 178.

Oakley, K.P. 1954. Evidence of fire in South African cave deposits. *Nature* 174: 261.

O'Connell, J.F., Hawkes, K. & Blurton Jones, N. 1988. Hadza Scavenging: Implications for Plio/Pleistocene hominid subsistence. *Current Anthropology* 29: 356 – 363.

O'Connor, T.P. 1996. A critical overview of archaeological animal bone studies. *World Archaeology* 28(1): 5 – 19.

O'Connor, T.P. 2000. *The Archaeology of Animal Bones*. Sutton Publishing: Phoenix, Mill.

Ogola, C.A. 2003. Taphonomy of the Cave of Hearths Acheulean bone assemblage. Unpublished MSc. dissertation. University of Witwatersrand: Johannesburg.

Ogola, C.A. 2009. The taphonomy of the Cave of Hearths Acheulean faunal assemblage. In: McNabb, J. & A. Sinclair (eds.) *The Cave of Hearths: Makapan Middle Pleistocene Project.* BAR International Series 1940. University of Southhampton Series in Archaeology 1: Oxford.

Oliver, J.S. 1994. Estimates of hominid and carnivore involvement in the FLK *Zinjanthropus* fossil assemblage: some socioecological implications. *Journal of Human Evolution* 27: 267 – 294.

Olsen, S.L. & Shipman, P. 1988. Surface modification on bone: trampling versus butchery. *Journal of Archaeological Science* 15: 535 – 553.

Outram, A.K. 2000. Hunting meat and scavenging marrow? A seasonal explanation for Middle Stone Age subsistence at Klasies River Mouth. In: Rowley- Conwy, P. (ed.) *Animal Bones and Human Societies*. pp. 20 – 27. Oxbow books: Oxford.

Outram, A.K. 2001. A new approach to identifying bone marrow and grease exploitation: why the "indeterminate" fragments should not be ignored. *Journal of Archaeological Science* 28: 401 – 410.

Outram, A.K. 2002. Bone fracture and within-bone nutrients: an experimentally based method for investigating levels of marrow extraction. In: Miracle, P. & M. Milner (eds.) *Consuming Passions and Patterns of Consumption*. pp 51 – 64. MacDonald Institute for Archaeological Research: Cambridge.

Outram, A.K., Knusel, C.J., Knight, S. & Harding, A.F. 2005. Understanding complex fragmented assemblages of human and animal remains: a fully integrated approach. *Journal of Archaeological Science* 32: 1699 – 1710.

Pante, M.C. & Blumenschine, R.J. 2010. Fluvial transport of bovid long bones fragmented by the feeding activities of hominids and carnivores. *Journal of Archaeological Science* 37(4): 846 – 854.

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

Parsons, I. & Badenhorst, S. 2004. Analysis of lesions generated by replicated Middle Stone Age lithic points on selected skeletal elements. *South African Journal of Science* 100: 384 – 387.

Peacock, M., Lui, G., Carey, M., Ambrosius, W., Turner, C.H., Hui, S. & Johnson, Jr, C.C. 1998. Bone mass and structure at the hip in men and women over the age of 60 years. *Osteoporosis International* 8: 231 – 239.

Perkins, D. & Daly, P. 1968. A hunter's village in Neolithic Turkey. *Scientific American* 219(11): 97 – 106.

Phillipson, D.W. 2005. *African Archaeology*. Cambridge University Press: Cambridge.

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

Pickering, T.R., Clarke, R.J. & Moggi-Cecchi, J. 2004. Role of carnivores in the accumulation of the Sterkfontein Member 4 hominid assemblage: a taphonomic reassessment of the complete hominid fossil sample. *American Journal of Physical Anthropology* 125: 1 – 15.

Pickering, T.R., Dominguez-Rodrigo, M., Egeland, C.P. & Brain, C.K. 2005. The contribution of limb bone fracture patterns to reconstructing early hominid behaviour at Swartkrans Cave (South Africa): archaeological application of a new analytical method. *International Journal of Osteoarchaeology* 15: 247 – 260.

Pickering, T.R. & Egeland, C.P. 2006. Experimental patterns of hammerstone percussion damage on bones: implications for inferences of carcass processing by humans. *Journal of Archaeological Science* 33: 459 – 469.

Pickering, T.R., Marean, C.W. & Dominguez-Rodrigo, M. 2003. Importance of limb bone shaft fragments in zooarchaeology: a response to "On *in situ* attrition and vertebrate body part profiles" (2002) by M.C. Stiner. *Journal of Archaeological Science* 30: 1469 – 1482.

Pinot, S., Ramstein, G., Harrison, S.P., Prentice, I.C., Guiot, J., Stute, M. & Joussaume, S. 1999. Tropical paleoclimates at the Last Glacial Maximum: comparison of Paleoclimate Modelling Intercomparison Project (PMIP) simulations and paleodata. *Climate Dynamics* 15(11):857 – 874.

Plug, I. 1997. Late Pleistocene and Holocene hunter-gatherers in the Eastern Highlands of South Africa and Lesotho: a faunal interpretation. *Journal of Archaeological Science* 24: 715 – 727.

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

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

Powell, A., Shennan, S. & Thomas, M.G. 2009. Late Pleistocene demography and the appearance of modern human behaviour. *Science* 324: 1298 – 1301.

Reitz, E.J. & Wing, E.S. 1999. *Zooarchaeology*. Cambridge Manuals in Archaeology. Cambridge University Press: Cambridge.

Rightmire, G.P. 1984. Homo Sapiens in sub-Saharan Africa. In: Smith, F. & F. Spencer (eds.) *The Origins of Modern Humans: A World Survey of The Fossil Evidence.* pp. 295 – 325. Alan R. Liss: New York.

Roberts, D.L., Bateman, M.D., Murray-Wallace, C.V., Carr, A.S. & Holmes, P.J. 2008. Last interglacial fossil elephant trackways dated by OSL/AAR in coastal aeolianites, Still Bay, South Africa. *Palaeogeography, Palaeoclimatology, Palaeoecology* 257: 261 – 279.

Ruff, C.B., Scott, W.W. & Liu, A. Y-C. 1991. Articular and diaphyseal remodelling of the proximal femur with changes in body mass in adults. *American Journal of Physical Anthropology* 86: 397 – 413.

Sadek-Karoos, H. 1972. Primitive bone fracturing: a method of research. *American Antiquity* 37(3): 369 – 382.

Sampson, C.G. 1974. *The Stone age Archaeology of Southern Africa.* Academic Press: New York.

Schmitt, D.N. & Lupo, K.D. 1995. On mammalian taphonomy, taxonomic diversity, and measuring subsistence data in zooarchaeology. *American Antiquity* 60, 496–514.

Scholz, C.A., Johnson, T.C., Cohen, A.S., King, J.W., Peck, J.A., Overpeck, J.T., Talbot, M.R., Brown, E.T., Kalindekafe, L., Amoako, P.Y.O., Lyons, R.P., Shanahan, T.M., Casteneda, I.S., Heil. C.W., Forman, S.L., McHargue, L.R., Beauning, K.R., Gomez, J. &

Pierson, J. 2007. East African megadroughts between 135 and 75 thousand years ago and bearing on early-modern human origins. *Proceedings of the National Academy of Sciences* 104(42): 16416 – 16421.

Selker, F. & Carter, D.R. 1989. Scaling of long bone fracture strength with animal mass. *Journal of Biomechanics* 22: 1175 – 1183.

Selvaggio, M.M. 1994. Carnivore tooth marks and stone tool butchery marks on scavenged bones: archaeological implications. *Journal of Human Evolution* 20: 131 – 156.

Selvaggio, M.M. 1998. Evidence for a three-stage sequence of hominid and carnivore involvement with long bones at FLK *Zinjanthropus*, Olduvai Gorge, Tanzania. *Journal of Archaeological Science* 25: 191 – 202.

Shennan, S. 1988. *Quantifying Archaeology*. Edinburgh University Press: Edinburgh.

Shennan, S. 2001. Demography and cultural innovation: a model and its implications for the emergence of modern human culture. *Cambridge Archaeological Journal* 11: 5 – 16.

Shipman, P. 1981a. Applications of scanning electron microscopy to taphonomic problems. *Annals of the New York Academy of Science*. 376: 357-386.

Shipman, P. 1981b. *Life History of a Fossil: An Introduction to Taphonomy and Paleoecology.* Harvard University Press: Cambridge.

Shipman, P. 1983. Early hominid lifestyle: hunting and gathering or foraging and scavenging? In: Clutton-Brock, J. & C. Grigson (eds.) *Animals and Archaeology: 1. Hunters and their Prey*. pp. 31 – 50. BAR International Series 163: Oxford.

Shipman, P. 1986a. Scavenging or hunting in early hominids: Theoretical framework and tests. *American Anthropologist* 88(1): 27 – 43.

Shipman, P. 1986b. Studies of hominid-faunal interactions at Olduvai Gorge. *Journal of Human Evolution* 15: 691 – 706.

Shipman, P., Bosler, W. & Davis, K.L. 1981. Butchering of giant geladas at an Acheulian site. *Current Anthropology* 22: 257 – 268.

Shipman, P., Foster, G. & Schoeninger, M. 1984. Burnt bones and teeth: an experimental study of color, morphology, crystal structure and shrinkage. *Journal of Archaeological Science* 11: 307 – 325.

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

Shipman, P. & Rose, J. 1984. Cutmark mimics on modern and fossil bovid bones. *Current Anthropology* 25(1): 116 – 117.

Shipman, P. & Rose, J. 1988. Bone tools: an experimental approach. In: Olsen, S.L. (ed.) *Scanning Electron Microscopy in Archaeology*. pp. 303 – 335. BAR International series 452: Oxford.

Shockey, D.A. 1985. Discussion on "Mechanisms of dynamic fragmentation: factors governing fragment size." By D.E. Grady & M.E. Kipp. *Mechanics of Materials* 4: 321 – 324.

Singer, R. 1956. The "bone tools" from Hopefield. *American Anthropology* 58: 1127 – 1134.

Singer, R. & Wyman J. 1982. *The Middle Stone Age at Klasies River Mouth in South Africa.* Chicago University Press: Chicago.

Skedros, J.G., Bloebaum, R.D., Mason, M.W. & Bramble, D.M. 1994. Analysis of a tension/compression skeletal system: possible strain-specific differences in the hierarchical organisation of bone. *The Anatomical Record* 239(4): 396 – 404.

Speth, J.D. 1987. Early hominid subsistence strategies in seasonal habitats. *Journal of Archaeological Science* 14: 13 – 29.

Steele, D.G. & Bramblett, C.A. 1988. *The Anatomy and Biology of the Human Skeleton*. Texas A & M University: College Station.

Stein, M.S., Thomas, C.D.L., Feik, S.A., Wark, J.D. & Clement, J.G. 1998. Bone size and mechanics at the femoral diaphysis across age and sex. *Journal of Biomechanics* 31: 1101 – 1110.

Stiner, M.C., Gopher, A. & Barkai, R. 2011. Hearth-side socioeconomics, hunting and paleoecology during the late Lower Paleolithic at Qesem Cave, Israel. *Journal of Human Evolution* 60: 213 – 233.

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

Stringer, C. 2001. Dating the origin of modern humans. *Geological Society, London, Special Publications* 190: 265 – 274.

Stringer, C. 2002. Modern human origins: progress and prospects. *Philosophical Transactions of the Royal Society (London) B* 357: 563 – 579.

Straus, W.L. 1957. Saldanha man and his culture. *Science* 125: 973 – 974.

Swanepoel, E., Steyn, M. & Scheepers, M.D. 2008. A preliminary report on animal bone classification through computerized methods. *Annals of the Transvaal Museum* 45: 21 – 29.

Szathmary, E. & Szamodo, S. 2008. Being human: Language: a social history of words. *Nature* 456: 40 – 41.

Tavassoli, Z. & Shirvani, A.E. 2000. Models of fragmentation with power law log-normal distributions. *Physics A* 286: 29 – 44.

Taylor, J., Hare, P. & White T. 1995. Geochemical criteria for thermal alteration of bone. *Journal of Archaeological Science* 22: 115 – 119.

Thackeray, J.F. 1979. An analysis of faunal remains from archaeological sites in southern South West Africa (Namibia). *South African Archaeological Bulletin* 34(129): 18 – 33.

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

Thackeray, J.F. 2007. Hominids and carnivores at Kromdraai and other Quaternary sites in southern Africa. In: Pickering, T.R., Toth, N. & K. Schick (eds.) *Breathing Life into Fossils: Taphonomic Studies in Honor of C.K. (Bob) Brain.* pp. 67 – 73. Stone Age Institute Press: Bloomington.

Théry-Parisot, I. 2002. Fuel management (bone and wood) during the Lower Aurignacian in the Pataud Rock Shelter (Lower Palaeolithic, Les Eyzies de Tayac, Dordogne, France). Contribution of experimentation. *Journal of Archaeological Science* 29: 1415 – 1421.

Thompson, J.C. 2008. Zooarchaeological Tests for Modern Human Behaviour at Blombos Cave and Pinnacle Point Cave 13B, Southwestern Cape, South Africa. Unpublished Ph.D. thesis. Arizona State University: Tucson.

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

Thompson, J.C. & Henshilwood, C.S. 2011. Taphonomic analysis of the Middle Stone Age larger mammal faunal assemblage from Blombos Cave, southern Cape, South Africa. *Journal of Human Evolution* 60: 746 – 767.

Thompson, T.L. 2005. Heat-induced dimensional changes in bone and their consequences for forensic anthropology. *Journal of Forensic Science* 50 (5): 1008 – 1015.

Todd, L.C. & Rapson, D.J. 1988. Long bone fragmentation and interpretation of faunal assemblages: approaches to comparative analysis. *Journal Archaeological Science* 15: 307 – 325.

Tribolo, C., Mercier, N., Valladas, H. 2005. Chronology of the Howieson's Poort and Still Bay techno-complexes: assessment and new data from luminescence. In: d'Errico, F. & L. Backwell (eds.) *From Tools to Symbols: From Early Hominids to Modern Humans.* pp. 493 – 511. Witwatersrand University Press: Johannesburg.

Tribolo, C., Mercier, N., Selo, M., Valladas, H., Joron, J-L., Reyss, J-L., Henshilwood, C.S., Sealy, J.C. & Yates, R.J. 2006. TL dating of burnt lithics from Blombos Cave (South Africa): further evidence for the antiquity of modern human behaviour. *Archaeometry* 48: 341 – 357.

Turner, A. 1989. Sample selection, schlepp effects and scavenging: implications of partial recovery for interpretations of the terrestrial mammal assemblage from Klasies River Mouth. *Journal of Archaeological Science* 16:1 – 11.

Uerpmann, H-P. 1973. Animal bone finds and economic archaeology: a critical study of 'Osteo-Archaeological' method. *World Archaeology* 4(3): 307 – 322.

Villa, P., Bouville, C., Courtin, J., Helmer, D., Mahieu, E., Shipman, P., Belluomini, G. & Branca, M. 1986. Cannibalism in the Neolithic. *Science* 233: 431 – 437.

Villa, P., Castel, J-C., Beauval, C., Bourdillat, V. & Goldberg, P. 2004. Human and carnivore sites in the European Middle and Upper Palaeolithic: similarities and differences in bone modification and fragmentation. *Revue de Paleobiologie, Geneve* 23: 705 – 730.

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

Villa, P. Soressi, M., Henshilwood, C.S. & Mourre, V. 2009. The Still Bay points of Blombos Cave (South Africa). *Journal Archaeological Science* 36: 441 – 460.

Voigt, E.A. 1983. *Mapungubwe: An Archaeozoological Interpretation of an Iron Age Community.* Tranvaal Museum Monograph Number 1: Pretoria.

Volman, T.P. 1981. The Middle Stone Age in the southern Cape. Unpublished Ph.D. thesis. University of Chicago: Chicago.

Volman, T.P. 1984. Early prehistory of southern Africa. In: Klein, R.G. (ed.) *Southern African Prehistory and Palaeoenvironments.* pp. 169 – 220. Balkema: Rotterdam.

Vrba, E.A. 1976. The significance of bovid remains as indicators of environmental and predation patterns. In: Behrenmeyer, A.K. & A.P. Hill (eds.) *Fossils in the Making.* pp 247 – 271. University of Chicago Press: Chicago.

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

Wadley, L. 2007. Announcing a Still Bay industry at Sibudu cave, South Africa. *Journal of Human Evolution* 52: 681 – 689.

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

Walker, P.L. & Long, J.C. 1977. An experimental study of the morphological characteristics of tool marks. *American Antiquity* 42(4): 605 – 616.

Washburn, S.L. 1957. Australopithecines: The hunters or the hunted? *American Anthropologist* 59(4): 612 – 614.

Watson, V. 1993. Compositions of the Swartkrans bone accumulations, in terms of skeletal parts and animals represented. In: Brain, C.K. (ed.) *Swartkrans: A Cave's Chronicle of Early Man*. pp. 35 – 74. Transvaal Museum: Pretoria.

Weaver, T.D., Steele, T.E. & Klein, R.G. 2011. The abundance of eland, buffalo, and wild pig in Middle and Later Stone Age sites. *Journal of Human Evolution* 60: 309 – 314.

Wolberg, D.L. 1971. The hypothesized osteodontokeratic culture of the australopithecinae: a look at the evidence and the opinions. *Current Anthropology* 11(1): 23 – 37.

Woo, S.L.-Y., Kuei, S.C., Amiel, D., Gomez, M.A., Haynes, W.C. White, F.C., & Akeson, W.H. 1981. The effect of prolonged physical training on the properties of long bone: a study of Wolff's law. *Journal of Bone & Joint Surgery America* 63A: 780 – 787.

Wright, T.M. & Hayes, W.C. 1977. Fracture mechanic parameters for compact bone-effects of density and specimen thickness. *Journal of Biomechanics* 10: 419 – 430.

Wurz, S. 2002. Variability in the Middle Stone Age lithic sequence, 115,000 – 60,000 years ago at Klasies River, South Africa. *Journal of Archaeological Science* 29: 1001 – 1015.

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

Wynn, T. & Coolidge, F.L. 2007. Did a small but significant enhancement in working memory capacity power the evolution of modern thinking? In: Mellars, P., Boyle, K., Bar-Yosef, O. & C. Stringer (eds.), *Rethinking the Human Revolution.* pp 79 – 90. McDonald Institute Monographs: Cambridge.

Wynn, T. & Coolidge, F.L. 2011. The implications of the Working Memory Model for the evolution of modern cognition. *International Journal of Evolutionary Biology* 2011 doi:10.4061/2011/741357.

Yellen, J.E. 1991. Small mammals: !Kung San utilization and the production of faunal assemblages. *Journal of Anthropological Archaeology* 10: 1 – 26.

Yeshurun, R., Bar-Oz, G. & Weistein-Evron, M. 2007. Modern hunting behaviour in the early Middle Paleolithic: faunal remains from Misliya Cave, Mount Carmel, Israel. *Journal of Human Evolution* 53: 656 – 677.

Yravedra, J. & Dominguez-Rodrigo, M. 2009. The shaft-based methodological approach to the quantification of long limb bones and its relevance to understanding hominid subsistence in the Pleistocene: application to four Palaeolithic sites. *Journal of Quaternary Science* 4(1): 85 – 96.

Zhang, Y-Q., Lu, Y. & Hao, H. 2004. Analysis of fragment size and ejection velocity at high strain rate. *International Journal of Mechanical Sciences* 46: 27 – 34.

Zierhut, N.W. 1967. Bone breaking activities of the Calling Lake Cree. *Alberta Anthropologist* 1(3): 33 – 36.

APPENDIX A

Summary of statistics for fragment lengths from the M1 and M2 phases at BBC

Statistics	CA	CB	CC	CD	CF	CG
Mean	23.768456	21.592965	22.790123	22.092068	18.575240	17.453333
Standard Error	0.914726	0.993482	1.101735	0.592289	0.380233	0.885710
Median	19	16	19	17	15	14
Mode	16	15	12	11	12	13
Standard Deviation	15.790615	14.014788	14.022800	15.737520	11.639113	10.847687
Sample Variance	249.34351	196.41429	196.63891	247.66953	135.46896	117.67230
Kurtosis	4.043062	4.862662	2.356350	7.819053	7.812725	16.203282
Skewness	1.865147	2.021194	1.534751	2.380849	2.225645	3.234989
Range	96	85	70	112	106	86
Minimum	2	4	6	4	3	6
Maximum	98	89	76	116	109	92
Sum	7083	4297	3692	15597	17405	2618
Count	298	199	162	706	937	150
Largest(1)	98	89	76	116	109	92
Smallest(1)	2	4	6	4	3	6
Confidence Level(95.0%)	1.8001652	1.9591639	2.1757156	1.1628622	0.7462084	1.7501744

APPENDIX B

Summary of statistics for fragment lengths from the Still Bay (M1 & upper M2 phases) and for taphonomic modifications

Statistics	Total*	Undamaged	Burnt	Carbonised	Calcined
Mean	20.8836	20.9314	18.8478	19.8783	14.7783
Standard Error	0.2932	0.6480	0.3452	0.4390	0.4764
Median	16	16	16	16	13
Mode	12	12	12	13	12
Standard Deviation	14.0651	13.5462	11.5380	12.4569	6.7878
Sample Variance	197.828	183.500	133.126	155.174	46.074
Kurtosis	7.1598	3.0178	10.6555	9.7948	3.0075
Skewness	2.2494	1.6424	2.5015	2.4555	1.5527
Range	114	78	113	113	39
Minimum	2	4	3	3	6
Maximum	116	82	116	116	45
Sum	48074	9147	21053	16002	3000
Count	2302	437	1117	805	203
Largest(1)	116	82	116	116	45
Smallest(1)	2	4	3	3	6
Confidence Level(95.0%)	0.57487	1.27360	0.67737	0.86182	0.93938

*Total dataset includes the M1 and upper M2 (excludes the CG layer)

APPENDIX B. continued

Summary of statistics for fragment lengths from the Still Bay (M1 & upper M2 phases) and for taphonomic modifications

Statistics	Cut marks	Percussion marks	Tooth marks	Polish
Mean	27.3812	23.9188	43.1127	18.8665
Standard Error	1.4290	0.7893	2.9781	0.5310
Median	21	20	34	16
Mode	11	15	41	11
Standard Deviation	19.2257	15.6668	25.0939	10.9719
Sample Variance	369.626	245.449	629.701	120.384
Kurtosis	3.3037	4.2703	0.4102	5.7030
Skewness	1.7166	1.8898	1.0562	1.9209
Range	105	95	103	86
Minimum	6	6	6	2
Maximum	111	101	109	88
Sum	4956	9424	3061	8056
Count	181	394	71	427
Largest(1)	111	101	109	88
Smallest(1)	6	6	6	2
Confidence Level(95.0%)	2.81981	1.55174	5.93962	1.04365

APPENDIX C

Summary of statistics for cortical thickness of fragments from the M1 and M2

Statistic	CA	CB	CC	CD	CF	CG
Mean	3.75257	4.662	4.63308	3.61364	2.84605	2.87462
Standard Error	0.18700	0.28833	0.31999	0.10439	0.06316	0.17159
Median	2.7	3.5	3.2	2.9	2.3	2.1
Mode	2	3	3	2.5	2	2
Standard Deviation	3.08410	3.53133	3.69026	2.63677	1.84029	1.95644
Sample Variance	9.51165	12.47029	13.61799	6.95255	3.38666	3.82765
Kurtosis	11.60961	10.13269	7.26407	21.16332	7.09666	6.20056
Skewness	2.86926	2.65362	2.14884	3.53492	2.28840	2.15869
Range	22.8	22.8	24.5	29.2	14.1	12.1
Minimum	0.7	0.7	0.7	0.8	0.5	0.9
Maximum	23.5	23.5	25.2	30	14.6	13
Sum	1020.7	699.3	616.2	2305.5	2416.3	373.7
Count	272	150	133	638	849	130
Largest(1)	23.5	23.5	25.2	30	14.6	13
Smallest(1)	0.7	0.7	0.7	0.8	0.5	0.9
Confidence Level(95.0%)	0.36816	0.56975	0.63296	0.20499	0.12397	0.33950

APPENDIX D

Summary of statistics for cortical thickness of fragments from the Still Bay (M1 & upper M2 phases) and for taphonomic modifications

Statistic	Total*	Undamaged	Burnt	Carbonised	Calcined	Unburnt
Mean	3.45642	3.25820	3.42198	3.57444	2.58400	3.48532
Standard Error	0.05856	0.107452	0.07512	0.097343	0.088971	0.089752
Median	2.7	2.7	2.7	2.75	2.3	2.7
Mode	2	2	2	2	2.3	2
Standard Deviation	2.64622	2.55862	2.39797	2.59744	1.25824	2.86925
Sample Variance	7.0025	6.5465	5.7502	6.7467	1.5832	8.2326
Kurtosis	16.3775	33.4989	10.6958	9.7305	9.1567	18.3583
Skewness	3.1644	4.4602	2.6212	2.5324	2.2344	3.4293
Range	29.5	29.5	22.8	22.8	9.3	29.5
Minimum	0.5	0.5	0.7	0.7	0.7	0.5
Maximum	30	30	23.5	23.5	10	30
Sum	7058	1847.4	3487	2545	516.8	3562
Count	2042	567	1019	712	200	1022
Largest(1)	30	30	23.5	23.5	10	30
Smallest(1)	0.5	0.5	0.7	0.7	0.7	0.5
Confidence Level(95.0%)	0.11484	0.21105	0.14741	0.19111	0.17545	0.17612

*Total dataset includes the M1 and upper M2 (excludes the CG layer)

APPENDIX D continued

Summary of statistics for cortical thickness of fragments from the Still Bay (M1 & upper M2 phases) and taphonomic modifications

Statistic	Cut marks	Percussion marks	Tooth marks	Polish
Mean	4.4150	3.8126	5.8828	2.9121
Standard Error	0.2532	0.1479	0.5307	0.1031
Median	3.4	2.9	4.3	2.3
Mode	2	1.8	3	2
Standard Deviation	3.3976	2.8867	4.9496	2.1332
Sample Variance	11.5439	8.3331	24.4987	4.5507
Kurtosis	7.2510	8.2740	3.7069	8.4537
Skewness	2.2780	2.3917	1.8286	2.5733
Range	22.9	22.9	22.7	15.9
Minimum	0.6	0.6	0.8	0.7
Maximum	23.5	23.5	23.5	16.6
Sum	794.7	1452.6	511.8	1246.4
Count	180	381	87	428
Largest(1)	23.5	23.5	23.5	16.6
Smallest(1)	0.6	0.6	0.8	0.7
Confidence Level(95.0%)	0.4997	0.2908	1.0549	0.2027