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INTERPRETATIVE TOOLS FOR STUDYING STONE AGE HUNTING TECHNOLOGIES: EXPERIMENTAL ARCHAEOLOGY, MACROFRACTURE ANALYSES AND MORPHOMETRIC TECHNIQUES.

Justin Pargeter

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

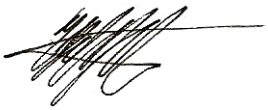
Johannesburg, 2011

DECLARATION

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

Signed

Justin Harry Pargeter



On this the 05 day of April 2011

ABSTRACT

This dissertation contains an assessment and use of the macrofracture and morphometric methods for detecting Later Stone Age hunting weaponry. Two sets of replicated unretouched stone artefacts were trampled by cattle and humans to determine the formation of impact fractures under these, and knapping conditions. The results suggest that small frequencies (c. 3 %) of certain impact fracture types do occur on flakes subject to trampling and knapping forces. Macrofracture and morphometric data were recorded for stone artefacts (bladelets, backed artefacts and convergent pieces) from Robberg (c. 18 000 - 12 000 years ago) and Wilton (c. 8000 - 2000 years ago) Later Stone Age assemblages on the southern Cape coast. Impact fracture frequencies were similar in these two samples, but were significantly higher than in the trampling experiments. The morphometric data suggests, on average, congruence between Later Stone Age tools with impact fractures and experimental, archaeological and ethnohistoric spear and arrow tips. Based on these results it appears likely that Wilton backed artefacts, specifically segments, were used as arrowheads and it is unclear at present what weapon types were used during the Robberg phase although the use of spears seems probable.

ACKNOWLEDGMENTS

This dissertation is dedicated to all the hooves and feet that made the experiments possible. I would like to thank all my family and friends who gave support, advice and input into this project and I would especially like to thank my supervisors, post-graduate support staff and the PAST and NRF foundations for financial and academic assistance during this project.

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CHAPTER 1: INTRODUCTION

In this dissertation, I use experimental archaeology to assess whether the macrofracture method is suitable for identifying stone tools used as weaponry during the Later Stone Age in southern Africa. In particular, hunting technologies during the Wilton and Robberg phases of the Later Stone Age (LSA) are investigated.

1.1 Macrofracture analysis and trampling/knapping experiments

The types, frequencies and patterns of fractures on stone tools, especially diagnostic impact fractures (DIFs), are employed in macrofracture analysis to detect whether a stone tool was used for hunting (Fischer *et al.* 1984; Lombard 2005a). A *macrofracture* can be defined as fracture visible with the naked eye or with a hand lens. *Diagnostic impact fractures* are macrofractures that have been shown, through experiments, to be associated with stone artefacts used as impact weapon tips. The assumption is that these fractures are caused by impact during use (e.g. hunting), and that different variations of this use will leave different breakage patterns on the tools (Dockall 1997). A hand lens is required to detect these fractures.

In this dissertation, fracture types are compared to experimental and archaeological materials to form working hypotheses about the potential hunting function of stone artefacts. By studying and interpreting macrofracture patterns and frequencies archaeologists have, for example, initiated discussions into prehistoric risk management strategies (Lombard & Parsons 2008) and the origins of food production in the Levant (Yaroshevich *et al.* 2010) among other topics.

The limitations of this method and its applicability to archaeology have been only partially assessed (see Fischer *et al.* 1984; Odell 1988; Lombard 2005a). It is unclear at present if certain DIFs form only during hunting and are therefore

characteristic of hunting alone. Post-depositional processes are perhaps also responsible for the formation of some DIFs.

1.1.1 *Research aim*

The primary aim of this study is to assess the advantages and the limits of the macrofracture method. This is done by determining whether the types of macrofractures used as diagnostic criteria for Stone Age hunting weapons can also occur under circumstances other than hunting, for example as a result of the knapping process and through trampling by humans and cattle.

1.1.2 *Research design*

For this dissertation a series of human and cattle trampling experiments were conducted to observe the formation of macrofractures under non-hunting conditions. Experimental flakes were manufactured from locally available rock types, such as dolerite, milky quartz and quartzite, and were subjected to human and cattle trampling. After the trampling sessions the tools were examined for macrofractures

1.2 Assessing hunting weaponry using macrofracture analysis

There are contentious issues around when and where different hunting weapon types appear in the archaeological record (Lombard & Phillipson 2010; Villa & Soriano 2010). This is partially because few hunting weapons made on organic materials survive. We must therefore rely on contextual evidence to interpret prehistoric hunting technologies (Lombard & Phillipson 2010). The types of weapons used and people's reliance on these weapons have behavioural implications for how we perceive Stone Age capacities (Shea & Sisk 2010). For instance projectile weaponry (i.e. bow and arrow technology) may have assisted in diet and niche broadening and in the expansion of modern humans out of Africa after c. 50 ka by providing a flexible technology that would have allowed humans to focus more intensely on some food sources and more widely on others (Shea 2006, 2009). Establishing which artefacts were used for hunting, and which types

of hunting weapons were used are therefore important initial steps towards understanding prehistoric human behaviour and cognitive capacity.

At present there is a reliance on the use of the macrofracture method to assess whether certain stone artefacts were used as hunting weapons (Lombard & Pargeter 2008). There are numerous statements alluding to the use of LSA Wilton stone artefacts (a microlith-dominated industry dated to between 8 and 2 ka) as hunting weapons (e.g. Deacon, J. 1984; Turner 1986; Deacon, H. J. & Deacon, J. 1999). However, very little functional analysis has been done to formally assess these statements aside from the work done by Wadley and Binneman (1995). In this dissertation, I will address this issue by using macrofracture and morphometric techniques. As both the Howieson's Poort (HP) (characterised by backed artefacts such as segments and trapezes and dated to between c. 64 and 59 ka) and different LSA industries contain backed artefacts, initial assumptions about the HP backed artefacts were based on analogies with those of the LSA Wilton (Deacon, H. J. 1976, 1989; Phillipson 1976; Parkington *et al.* 1980; Mellars 1990). We now know more about the functions of HP artefacts and their role in sophisticated, flexible hunting technologies (Lombard 2008; Wadley & Mohapi 2008; Wadley *et al.* 2009; Villa *et al.* 2010). In this dissertation, LSA Wilton backed artefacts were formally analysed and compared to the HP pieces, to assess the similarities and differences in their macrofracture and morphometric attributes.

The Robberg industry, an unretouched bladelet-dominated techno-tradition dated to between 18 and 12 ka, is a poorly understood expression of the LSA (Mitchell 2000, 2008). The functions of Robberg bladelets are assumed, including the suggestion that they were used as hunting weapon inserts (Parkington 1984; Mitchell 1988: 214; Lombard & Parsons 2008). Other suggested uses for Robberg bladelets, based on the results of microwear analyses, include cutting, slicing and sawing (Mitchell 1988; Wadley & Binneman 1995; Wadley 1996). Bladelets could have been hafted as lateral inserts along the sides of projectile weapons in order to increase their reliability as weapons (Lombard & Parsons 2008). In this

dissertation I address the issue of the use of Robberg bladelets as hunting weapons with macrofracture and morphometric techniques.

1.2.1 *Research aim*

The secondary aim of this study is to investigate Wilton and Robberg hunting technologies by examining the bladelets, backed stone tools (particularly segments) and convergent pieces that are characteristic stone tool types associated with this period.

1.2.2 *Research design*

Macrofracture and morphometric data from Wilton and Robberg assemblages at Nelson Bay Cave (NBC) and Byneskranskop 1 (BNK 1), and Wilton deposits at Blombosfontein Nature Reserve site 4 (BBF 4) are examined and recorded in this dissertation. I will carry out the first analysis of Wilton and Robberg stone artefacts and relate these results to those from existing database for use-related macrofractures (e.g. Fischer *et al.* 1984; Odell & Cowan 1986; Shea 1988; Lombard *et al.* 2004; Lombard & Pargeter 2008; Villa *et al.* 2010; Yaroshevich *et al.* 2010).

The results obtained from the archaeological samples are then compared to the HP backed artefacts and late Holocene bladelets from the archaeological sites Jagt Pan 7 and Melkboom, both located in the northern Cape, to determine whether flexible hunting technologies were present during the Wilton and Robberg phases. Through this approach, I can use the high-quality data recorded for stone artefacts from other periods for interpreting the functions of LSA tools from South Africa (see Mitchell 2008: 59).

1.3 Dissertation structure

Chapters 2, 3 and 4 provide background information to the macrofracture and morphometric methods and to experimental archaeology. Chapter 5 contains an

introduction to the functional analysis of the 3 artefact types in this work, whilst Chapter 6 previews the archaeological sites and samples selected for analysis.

The experimental, macrofracture and morphometric methodologies employed in this study are presented in Chapters 7 and 8. Chapter 9 provides the results of the trampling and knapping experiments, whilst Chapters 10 and 11 present the macrofracture and morphometric results obtained from the archaeological materials studied.

A general discussion and conclusion of these results, an assessment of the macrofracture method based on the experiments and a contextualisation of the archaeological macrofracture and morphometric data are presented in Chapters 12 and 13. Chapter 13 also provides recommendations for future research on similar topics.

CHAPTER 2: MACROFRACTURE METHOD BACKGROUND

Previous experiments, as well as archaeological data, show that fractures can be potentially good indicators of the uses of stone tools (e.g. Barton & Bergmann 1982; Bergman & Newcomer 1983; Odell & Cowan 1986; Shea 1988, 1989, 1990; Nuzhnyi 2000; Lombard & Pargeter 2008; Mussi & Villa 2008; Villa *et al.* 2009; Villa & Soriano 2010; Yaroshevich *et al.* 2010). There are distinct macrofracture types that are characteristic of the use of impact, stabbing or thrusting weapons (Dockall 1997). These are known as diagnostic impact fractures (DIFs) (Fischer *et al.* 1984; Lombard 2005a). They are usually understood to include four main breakage types: step terminating bending fractures; spin-off fractures > 6 mm; bifacial spin-off fractures and impact burinations (The Ho Ho committee 1979; Fischer *et al*. 1984; Lombard 2005a). The method that is used to detect these fracture types is known as the macrofracture method. These fracture types can grade from one to another throughout the life-cycle of a single tool and delimiting them based on the criteria below is merely a heuristic device to help analysts (Hayden 1979, Lawrence 1979).

The macrofracture method cannot be used alone to determine hunting functions. It can only give conclusive results about the hunting function of stone artefacts when combined with other strands of archaeological data such as microresidue and microwear analyses, morphometric studies and faunal data (Shea *et al.* 2001; Lombard 2008; Villa *et al.* 2009). This is in part because we do not know the precise limits of macrofracture formation and cannot be certain that all macrofractures were formed in a particular way. By combining macrofracture information with other strands of archaeological data, we begin to build stronger analogies to help interpret aspects of the archaeological record (see Section 4.3). Other researchers have conducted similar macrofracture analyses, but use different nomenclature. These included impact scar analyses (Soriano *et al.* 2007; Villa *et al.* 2009), projectile damage analyses (Yaroshevich *et al.* 2010) and impact damage analyses (Barton & Bergman 1982). The principles are the same:

certain macrofractures identified in the analyses provide possible indicators that a tool was used during hunting (Dockall 1997).

2.1 Fracture types, nomenclature and variables

The nomenclature used to describe macrofractures is derived from the work of Cotterell and Kamminga (1979) and The Ho Ho committee (1979) and is also used in other areas of lithic research (cf. Andrefsky 1998). Fractures are classified with respect to how they initiate and how they terminate, and there is meant to be a relationship between the two (Crabtree 1972; Speth 1972; Cotterell & Kamminga 1979).

Two main sets of fracture initiations are recognised: cone (hertzian or point) and bending initiations. *Cone initiations* result when a force is directed onto the tip of a tool. These fracture types tend to leave a concave fracture profile in the area of initiation (The Ho Ho committee 1979). *Bending initiations* originate from stresses that act to pull fractured pieces away from the edges of tools in a direction perpendicular to the long axis of the piece. These fracture types tend to have convex or straight profiles (Cotterell & Kamminga 1979; see Table 2.1).

Flake terminations describe the shape of the area where the fracture ends. Three main bending fracture terminations are recognised: feather, hinge and step terminations (see Table 2.1). *Feather terminations* are characterised by a smooth fracture profile and tend to be associated with cone initiating forces (Crabtree 1972; Cotterell & Kamminga 1979). *Hinge terminations* are associated with bending forces acting across the surface of the tool leaving a fracture profile with a small lip at its distal end (Cotterell & Kamminga 1979). Both feather and hinge terminating fractures are without discontinuities in their profiles.

Step terminations, or longitudinal macrofractures (Dockall 1997: 325), as the name implies, terminate in an abrupt 90° step that should be easily felt with the finger (see Table 2.1). They are caused by either cone or bending forces (Crabtree

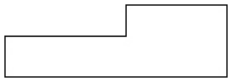
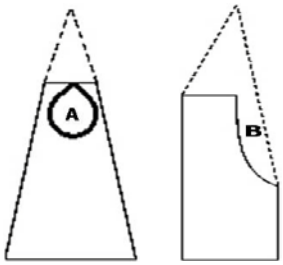
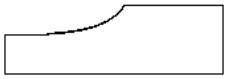
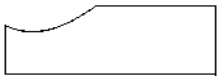
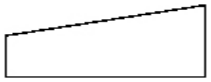
1972; Cotterell & Kamminga 1979) and are therefore associated with a variety of possible agents of formation (Hovers 2009). For example the bending forces associated with trampling tend to produce step terminating fractures as do the hertzian forces associated with knapping. Step terminating fractures are especially common on the proximal ends of flakes from knapping (Nuzhnyi 1990; Soriano *et al.* 2007; see Phillipson 2007 plates 3 and 7; Villa *et al.* 2010 supplementary online material: 8 – 10). It is, however, possible to distinguish between step terminating scars produced before and after tool retouching and therefore to distinguish between impact-related and accidental step terminations (Nuzhnyi 1990; Villa *et al.* 2010 supplementary online material: 8). Bending fractures have been recorded in association with medial and proximal ends of points from Sibudu Cave (see Figure 2.3) and are indicators that hafting can also cause these fractures to occur (Lombard *et al.* 2004). Projectiles lodged in live animals that are on the run might be subject to more bending fractures as the projectile knocks against brushwood and trees (e.g. Odell & Cowan 1986: 202 and Phillipson 2007: 22).

Fractures that terminate in a *burin-like step termination*, a fourth macrofracture termination type, have very similar characteristics to step terminating fractures except they tend to occur on the lateral edges of tools rather than across the face of a tool (Epstein 1960, 1963; Bergman & Newcomer 1983; Odell & Cowan 1986: 204; Lombard 2005a) (see Table 2.1). These fractures are known as impact burinations or lateral macrofractures (Dockall 1997: 324; Ahler 1971; Schimelmitz *et al.* 2004). They are sometimes confused with deliberate burination or fractures resulting from knapping processes. Impact burin spalls commonly lack the small percussion bulbs seen on knapping spalls and the negative percussion bulbs seen on deliberate burin removals (Epstein 1963; Shea 1988; Lombard 2005a). Deliberate burination also reveals characteristic crushing and edge damage not seen on impact burinations (Shea 1988: 443 – 444; Lombard 2005a). Fischer *et al*. (1984) include another fracture type in their DIF categories, these being spin-off fractures (see Table 2.1). *Spin-off fractures*, both bifacial and unifacial are secondary fracture types that originate from bending fractures, such as step terminating or snap fractures. They tend to have a feather-like termination

profile and are considered to be the most diagnostic of DIFs (Fischer *et al.* 1984; Lombard 2005a). These fracture types are also sometimes referred to in the literature as "flute-like fractures" (Frison *et al.* 1976: 46; Barton & Bergman 1982; Bergman & Newcomer 1983: 241; Holdaway 1989).

Snap fractures are bending fractures that cause a clean break across the face or side of a tool (see Table 2.1). Snap, feather and hinge terminating fractures and tip crushing are recorded during macrofracture analyses to describe the complete range of damage seen on a tool. Such damage can result from a variety of other activities (such as human and cattle trampling) and should not be used alone as potential indicators of projectile impact (Ahler 1971; Frison 1974; Shea 1988; Crombé *et al.* 2001; Lombard 2005a; Villa *et al.* 2009: 855; but see Casper & De Bie 1996: 445 for an alternative perspective).

Table 2.1: Primary macrofractures and DIFs recognised in this study
(Source: Fischer et al. 1984; Lombard 2005a; DIF: diagnostic impact fracture)

Fracture type	Description	Illustration
Step terminating fracture (DIF)	A bending fracture terminating in a 90° step. Cone (hertzian) forces can also result in step terminating fractures.	
Spin-off fracture (DIF)	A secondary fracture type originating from bending fractures such as step terminating or snap fractures (see doted lines in figure). Spin-off fractures tend to have a feather-like termination and are concave in profile. These can be bifacial or unifacial. Only spin-off fractures > 6 mm are considered diagnostic in this analysis. **A:** spin-off flake in plan view; **B:** spin-off flake in profile view	
Impact burination (DIF)	A bending fracture terminating in a 90° step on the lateral side of a tool.	
Feather terminating fracture	A bending fracture terminating in an acute angle or in a curve less than 90°.	
Hinge terminating fracture	A bending fracture terminating in an upturned curve or lip.	
Snap fracture	A bending fracture in which the bending forces act to snap the tool in a clean break.	
Impact notch	Smooth semi-circular, unretouched notches found in association with the cutting edges of tools, especially backed artefacts.	

A recent potential addition to the list of DIFs is the impact notch (Lombard and Pargeter 2008; Yaroshevich *et al.* 2010) (see Table 2.1). Impact notches are smooth, unretouched and semi-circular in shape and are often found on the cutting

edges of backed pieces. Retouched notches have been noted on backed pieces from Klasies River Cave (Singer & Wymer 1982; Wurz 2000) and in a smooth unretouched form on the Rose Cottage Cave (Soriano *et al.* 2007) Umhlatuzana and Sibudu Cave HP backed pieces (Lombard & Pargeter 2008: 2528) (see Figure 2.3). Smooth semi-circular notches on backed pieces from the HP levels at Sibudu Cave dated to c. > 60 ka were also found in association with bone, fat, collagen and animal tissue microresidues that suggest their association with hunting or cutting/slicing (Lombard & Pargeter 2008). This fracture type is not considered diagnostic of hunting at present as notches have been known to form as a result of human trampling (McBrearty *et al.* 1998), hafting (Soriano *et al*. 2007) and edge modification (Phillipson 2007). Recent experimental work with transversely-hafted backed artefacts has shown that smooth semi-circular notches do occur more often with this hafting arrangement on the cutting edges of backed pieces (Pargeter 2007; Yaroshevich *et al.* 2010). Thus there is compelling evidence that if macrofractures are identified in association with specific areas of tools (i.e. cutting edges opposite backed edges and not proximal ends) this fracture type could be a useful indicator of hunting and transverse hafting. Other possible functions for these edges, such as cutting and slicing, and the associated notches cannot at present be ruled out.

The formation of macrofractures is suggested to be independent of raw material type (Fischer *et al*. 1984; Odell & Cowan 1986; Lombard *et al.* 2004), artefact shape (Fischer *et al.* 1984; Shea 1988; Lombard 2004) and size (Odell & Cowan 1986). Differences in hafting positions, propulsion velocity and mode of propulsion (thrusting vs. throwing) may have an effect on the patterns and combinations of macrofractures on tools (Casper & De Bie 1996; Lombard 2006; Pargeter 2007; Lombard & Pargeter 2008; Yaroshevich *et al.* 2010; Lombard & Phillipson 2010). Hutchings & Bruechert (1997) have shown that various microscopic fracture features, such as wallner lines, fracture wings and fracture parabolas, can be used to determine the velocity at which flakes and fractures form. Paying attention to these micro-indicators could prove useful for understanding the velocities at which macrofractures form.

Raw material type and artefact size are not variables in macrofracture formation, but some rock types (e.g. flint) and larger artefact sizes do make it easier to detect the presence of macrofractures (see Odell & Cowan 1986; Pargeter 2007). It has also been shown that DIFs form on tools that not only impact animal hide but also hard substances such as bone or wood (Barton & Bergman 1982: 238; Huckell 1982; Lombard *et al.* 2004). Initially some concern was raised over the fact that bipolar knapping could imitate the kinds of stresses exerted when a tool impacts a target. Bipolar knapping tends to produce recognisable scars such as ripples, fissures and crushing associated with platforms. These features are not usually seen in combination with impact fractures that result from hunting and if found in association with DIFs, are not included in the analysis (Odell & Cowan 1986).

Identifying predictable patterns in macrofracture formation has proven to be quite difficult (Lombard & Pargeter 2008). This is because macrofractures occur in a variety of combinations, positions and frequencies that are potentially influenced by the types of targets weapons are aimed at, the speeds at which the weapons are projected and the various angles of impact (Odell 1981; Bergman & Newcomer 1983). Understanding the basic aspects of fracture mechanics, which is how fractures form and under what conditions they form, has helped eliminate other possible causes for macrofracture formation (Dockall 1997).

2.2 Macrofracture experiments and archaeological uses outside of Africa

Although DIFs are present on tools recovered from known animal-kill sites (Haurey 1953; Agogino & Frankforter 1960; Frison 1971, 1974, 1991, *et al.* 1976; Frison & Zeimens 1980; Bradley 1991; Villa *et al.* 2009), the macrofracture method is largely an experimentally derived method. It is therefore important to discuss the experimental background to the macrofracture method.

Fischer *et al.* (1984) were some of the first to experimentally establish the macrofracture method for the identification of stone tools used as projectile tips. Their experiments made use of a variety of points of differing shapes and sizes

used to tip spears and arrows that were either thrust by arm or projected using a bow into an animal carcass (Fischer *et al.* 1984). Diagnostic impact fractures were present on 40 % of the arrowheads and on 55 % of the spearheads in their sample (see Table 2.2). Thus the lower limit of DIFs, when all the tools in a sample are used for hunting purposes (irrespective of tip morphology or the species into which the tip is projected), is said to be about 40 % of a sample (Fischer 1985; Lombard 2005a). The types of DIFs obtained on tools during the Fischer *et al.* (1984) experiments were irrespective of the shape or size of the tools used as tips. They also analysed a number of variable Holocene flint points (n = 397) known to have been used as arrow components and also found DIFs on these pieces. The DIF frequencies noted on their Holocene assemblages ranged from five % at Bromme in Denmark to 42 % in the upper levels at Stellmoor, Germany (Fischer *et al.* 1984) (see Table 2.2). These results made it clear that even though pieces were used as projectile components, they will not necessarily accumulate DIF fracture frequencies to the same degree.

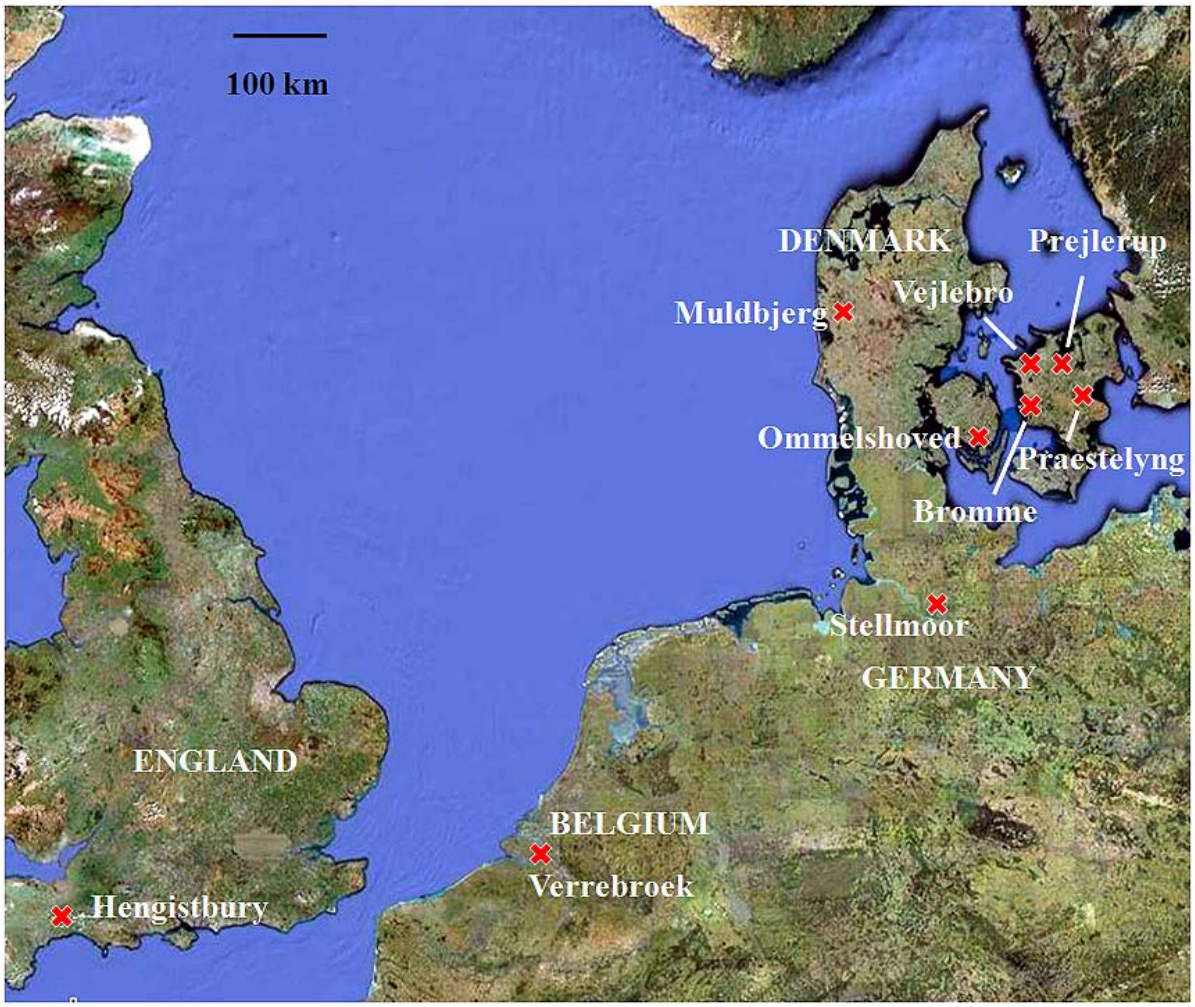


Figure 2.1: European archaeological sites with macrofracture data
(Map of Europe, retrieved and modified on Aug 13, 2010 from www.googlemaps.com)

Table 2.2: Summary of experimental and archaeological samples mentioned in the text *(KRM 2: Klasies River Cave 2; UMZ: Umhlatuzana rock shelter; M1: Blombos phase 1; M2: Blombos phase 2; M3: Blombos phase 3; DIF: diagnostic impact fracture; LSA: Later Stone Age; HP: Howieson's Poort)*

Site/Sample	Sample	DIFs	DIF %	Ages
Experimental Samples				
Fischer *et al.*(1984) spears	11	6	55	Current
Fischer *et al.*(1984) arrows	137	54	39	Current
Odell & Cowan (1986) spears	40	10	25	Current
Odell & Cowan (1986) arrows	40	9	24	Current
Lombard *et al.*(2004) spears	35	21	57	Current
Pargeter (2007) backed pieces (small spears)	30	12	40	Currrent
Crombe *et al.* (2001) arrows	87	22	25	Current
Crombe *et al.* (2001) barbs on arrows	96	3	3	Current
Yaroshevich *et al.* (2010) transverse points	20	8	40	Current
Yaroshevich *et al.* (2010) single straight points	44	15	34	Current
Yaroshevich *et al.* (2010) oblique points	25	6	24	Current
Yaroshevich *et al.* (2010) double oblique points	16	4	25	Current
Yaroshevich *et al.* (2010) barbs on arrows	144	34	23.6	Current
Yaroshevich *et al.* (2010) lateral blades on arrows	16	2	12.5	Current
Late Holocene Northern Cape LSA				
Melkboom 1 (Lombard & Parsons 2008)	330	30	9	c. 0.23 ± 60 ka
Jagt Pan 7 (Lombard & Parsons 2008)	919	111	12	c. 2.55 ± 60 ka
European Holocene				
Ommelshoved (Fischer *et al.* 1984)	110	22	10	c. 2.8 ka
Bromme (Fischer *et al.* 1984)	65	3	5	c. 3.2 ka
Stellmoor, upper level (Fischer *et al.* 1984)	45	19	42	c. 3.5 ka
Prejlerup Aurochs (Fischer *et al.* 1984)	15	6	40	c. 6.5 ka
Vejlebro, levels 8 & 9 (Fischer *et al*. 1984)	66	7	10	c. 6.5 ka
Praestelyng (Fischer *et al.* 1984)	57	8	14	c. 13 ka
Muldbjerg (Fischer *et al.* 1984)	30	9	30	c. 13 ka
European Early Mesolithic				
Verrebroek backed points (Crombé *et al.*2001)	30	7	28	c. 7.02 – 9.49 ka
Verrebroek retouched bases points (Crombé *et al.*2001)	38	19	56	c. 7.02 – 9.49 ka
Levantine Late and Middle Epipalaeolithic				
el-Wad Terrace (Yaroshevich *et al*. 2010)	246	25	8.4	c. 14.5 – 11.5 ka
Neve David (Yaroshevich *et al.* 2010)	334	21	5.3	c. 16.5 – 14.5 ka
Southern African late Pleistocene MSA				
Sibudu Cave post-HP points (Lombard *et al.* 2004)	50	21	42	c. 50 – 60 ka
UMZ post-HP retouched points (Lombard 2007a)	53	23	36.5	c. 40 ka
KRM 2 HP backed tools (Wurz & Lombard 2007)	85	18	21	c. 60 ka
Sibudu Cave HP backed tools (Lombard & Pargeter 2008)	132	29	32	c. < 60 ka
UMZ HP backed tools (Lombard & Pargeter 2008)	101	24	24	c. 60.0 ± 3.5 ka
Blombos M1 retouched points (Lombard 2007a)	115	20	17	c. 73 ka
Sibudu Still Bay retouched points (Lombard 2007a)	22	4	18	c. 75 ka
UMZ Pre-HP retouched points (Lombard 2007a)	73	9	12	c. 70.5 ± 4.7 ka
Blombos M2 convergent flakes (Lombard 2007a)	46	1	2	c. 85 – 77 ka
Blombos M3 convergent flakes (Lombard 2007a)	180	38	21	c. 99 ka

Barton and Bergman (1982) conducted a series of experiments to investigate attributes of 70 microlithic points excavated from the site of Hengistbury in southern England (see Figure 2.1). They used reconstructed flint microliths to tip a series of arrows, which were then shot into a fallow deer carcass from a distance of 8 m using a calibrated bow (Barton & Bergman 1982). Impact fractures, such as burin-like breaks (impact burinations) and flute-like breaks (step terminating fractures, spin-off fractures), were present on both the experimental, as well as the archaeological, samples indicating the presence of hunters at this site during the Mesolithic period of southern England (Barton & Bergman 1982: 242). They do not dismiss the possibility that these tools could also have functioned as cutting implements. Unfortunately, their publication does not mention the specific frequencies in which these fracture types occur on the experimental weapons. Not all of the fractures on their sample occurred on the tips of points; many were located along lateral edges and close to the proximal ends of tools and some points, with very successful penetrations, did not accumulate any fractures (Barton & Bergman 1982).

Crombé *et al.* (2001) conducted a further set of experiments with microliths used as hunting weapons. In this replication, experimental flint microliths (n = 183), in the forms of segments, triangles, truncated pieces and points, were fired into a sheep carcass from a distance of approximately 20 m using a calibrated bow (Crombé *et al*. 2001: 258). Geometrically shaped pieces, such as segments, triangles and obliquely truncated points were used as barbs, and microlithic points with retouched bases and unilaterally backed points were used as tips (Crombé *et al*. 2001: 258). Of their experimental arrowhead sample, 25 % had DIFs at the apex or close to the intersection between the haft and the tip. This is considerably larger than the 3.13 % DIFs present on their barb sample (see Table 2.2). These frequencies were calculated as fractures divided by the total tip sample, and it is not clear whether or not multiple fractures occurred on single tips (see Lombard *et al.* 2004 for an example). Their barb sample showed mainly lateral cone fractures (impact burinations) (40 %). These data show that barbs do, as one would assume, accumulate DIFs to a different and much smaller degree than projectile tips.

The Crombé *et al*. (2001) replicated microliths were then compared to an assemblage of microliths (n = 467) from the Verrebroek site, East Flanders, Belgium (see Table 2.2 and Figure 2.1). Of the points with retouched bases, 56 % had macroscopic impact damage compared to 28 % of the unilaterally backed points in their sample (mean = 44 %). There are some slight differences between these frequencies and those present in the experiments. The crescents (segments), triangles and truncated points in their sample showed only limited macro- and microwear traces more comparable to their experimental barb sample. Their suggestion is that two different functional groups of artefacts existed at the Verrebroek site: points functioned as arrow tips whereas segments and other backed and geometric microliths would have served as barbs (Crombé *et al.* 2001). This conclusion seems to suggest that artefact morphology does, in some ways, affect macrofracture formation, if only in that humans tend to haft different shaped pieces in different ways.

Some of the earliest projectile experiments with a new world focus were those conducted by Odell and Cowan (1986) (but also see Browne 1940; Evans 1957; Peets 1960; Ahler 1971, 1979; Butler 1975; Flenniken 1978; Flenniken & Raymond 1986 and Titmus & Woods 1986). In these experiments, 80 chert flakes were used to tip both arrows and spears, which were projected into freshly dead dog carcasses. Half of the chert tips were bifacially worked and the other half were left unretouched. These tips were hafted onto slotted hafts and attached with natural hemp bindings and Elmer's glue. Two meter long spears were thrown from a distance of 4 – 5 m whilst the arrows were shot with a 20 kg pull strength bow from a distance of 10 – 12 m (Odell & Cowan 1986: 199). The weapons were fired once, retrieved, de-hafted, cleaned and examined for macro-impact damage using a low-power microscope. This cycle was repeated eight times and the weapons were fired a total of 230 times.

In their experiment with spears (n = 40), c. 40 % of the weapons failed to penetrate the carcasses whereas 44 % of their unretouched arrowhead sample and 12 % of their retouched arrowhead sample did not penetrate. They argue that

retouched points are more effective at penetrating an animal than unretouched points (see Jones 1980 for a similar discussion).

Bending fractures (snap, step and hinge terminating fractures) were the most common macrofractures in the Odell and Cowan (1986) experiments (see Table 2.2). Unfortunately spin-off fractures were not recorded in their analysis, either because they were not present or because of the absence of this fracture type. Every tip in their assemblage exhibited some form of damage after experimentation versus 43 % of the bases. However, c. 62 % of the damage on their tips, mostly snap and hinge fractures, would be considered non-diagnostic damage according to the standards employed by Fischer *et al.* (1984) and Lombard (2005a). There does not appear to be a discernable difference in DIFs on their spear tips and arrowheads (c. 25 % DIFs for each category). In general, their experiments suggest that: bow and arrow is more accurate than spear hunting at distance; retouched arrows deflect less often and are more successful than unretouched arrows; spears penetrate deeper than arrows; retouched flakes penetrate deeper than unretouched flakes; tool longevity is not affected by the means of propulsion nor size and arrows and spears accumulate relatively similar macrofracture frequencies (Odell & Cowan 1986).

2.3 Macrofracture experiments in Africa and the Middle East

Hunting experiments were conducted using unretouched convergent flakes made from local South African rock types, such as hornfels, chert, mudstone and quartzite, to assess whether DIFs would form on these local African rock types (Lombard *et al.* 2004). The results showed that these rock types also develop DIFs when exposed to pressure during hunting (Lombard *et al.* 2004). Similar results for the presence of DIFs on chert have been noted by Odell and Cowan (1986). However, the ability to detect fractures is affected by the quality of rock types and different rock types may also have an effect on fracture sizes.

Of the spears used in the Lombard *et al.* (2004) experiments, 35 were examined for macrofractures and, of these, 57 % showed evidence of DIFs (Lombard *et al.* 2004). This frequency is comparable to the spear sample in the Fischer *et al.* (1984) experiments, is higher than their arrowhead sample (40 % DIFs) and only slightly higher than the DIF counts on post-HP points from Sibudu Cave (42 % DIFs) (Lombard *et al.* 2004) (see Table 2.2). These frequencies are higher than the DIF frequencies present on Still Bay points from Blombos (mean = 13.4 %); late Middle Stone Age (MSA) unifacial points from Sibudu Cave (8.9 %) or post-HP unifacial points from Rose Cottage Cave (8.3 %) (Villa *et al.* 2009) (see Table 2.2).

The results obtained from these archaeological samples, therefore, raise certain questions regarding the direct applicability of experimentally derived DIF frequencies to archaeological case studies. Villa *et al.* (2009) state that the relatively high fracture frequencies (c. 40 %) observed on experimental assemblages most resemble those found at known kill sites, such as at Stellmoor and Casper. They should not be expected at residential and manufacturing sites, such as Sibudu and Blombos Caves, because fewer broken hunting weapons would be returned to such sites as opposed to animal-kill sites. Other factors that may also affect macrofracture frequencies are haft weight, velocity of delivery, angle of impact, resistance upon impact, variations in hafting configurations or retouching impacted areas (Lombard & Pargeter 2008; Villa & Lenoir 2009). The modification of tools through other activities such as butchery and trampling may be a further possible cause for the variation in macrofracture (not necessarily DIF) frequencies (Shea *et al.* 2001; Lombard & Parsons 2008; Villa *et al.* 2009; Villa & Lenoir 2009).

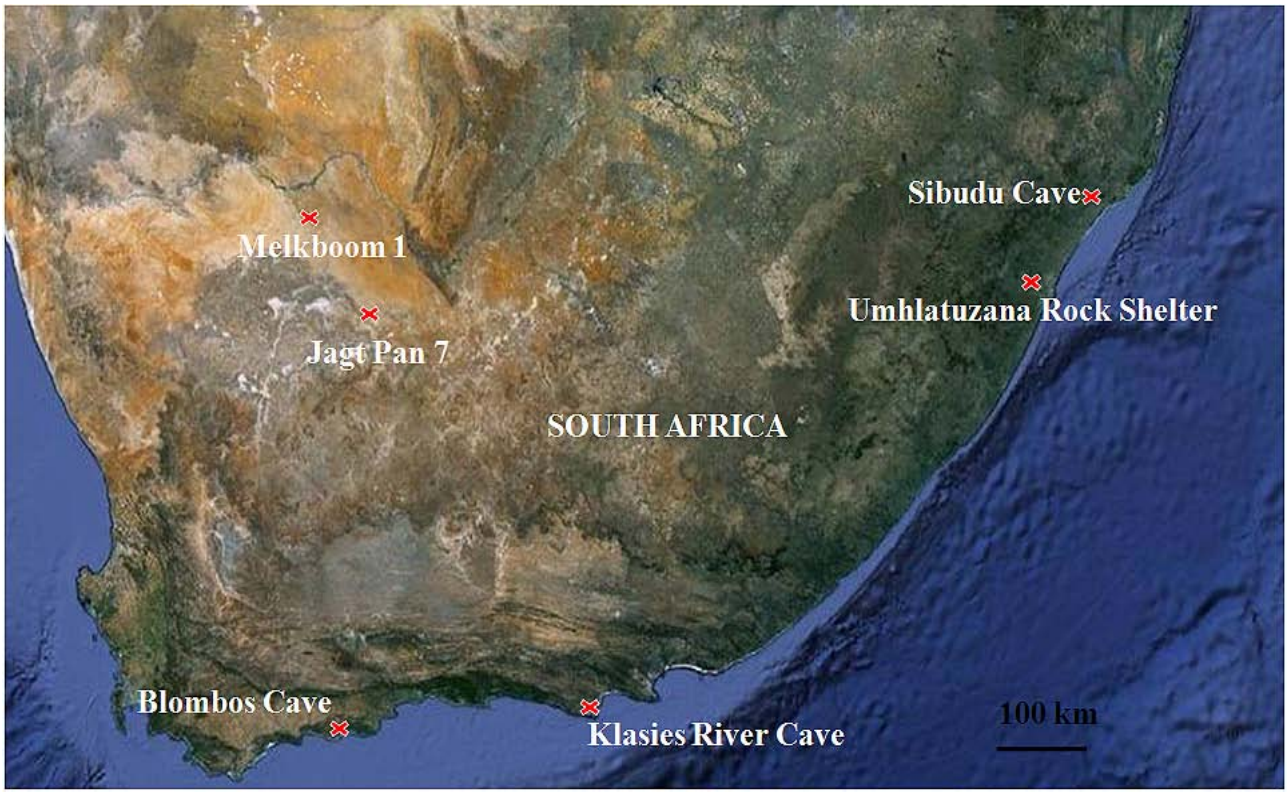


Figure 2.2: Some South African archaeological sites with macrofracture data
(Map of southern Africa, retrieved and modified on Aug 13, 2010 from www.googlemaps.com)

In 2007, I carried out a pilot set of experiments to investigate the formation of macrofractures on replicated HP-type segments manufactured from European flint (Pargeter 2007). The primary aim of these experiments was to explore suitable hafting positions for the use of segments, therefore the rock types used were not important in this study. A total of 33 segments were hafted in four different configurations (vertical, horizontal, diagonal and transversal) to form 27 projectile weapons resembling small spears. These spears were then fired using a calibrated propulsion machine built especially for the experiments into an Impala (*Aepyceros melampus*) carcass from a distance of c. 4 m away for a maximum of 10 shots each or until the weapons were deemed unusable (for more details on the propulsion machine see Pargeter 2007).

At the conclusion of the firing experiment the edges of the segments were examined for macrofractures. On these segments 40 % had DIFs, with a particularly high frequency of impact burination fractures (Lombard & Pargeter 2008) (see Table 2.2). The different hafting configurations developed DIFs to

different degrees, with the diagonally hafted segments showing the highest frequencies. The frequencies of DIFs in my experiments are the same as the Fischer *et al.* (1984) arrow sample, but higher than those observed on the backed artefact HP samples from Sibudu (22 %), Umhlatuzana (24 %) and Klasies River Cave (21 %) (Lombard & Pargeter 2008) (see Figure 2.1). One possible explanation for this discrepancy is that these archaeological analyses included all broken pieces and whole tools with potentially variable functions, whereas the experimental samples are largely whole pieces and were all used for hunting purposes. Other possibilities include the use of segments as barbs, which have been shown to accumulate DIFs to a lesser degree (e.g. Crombe *et al.* 2001; Yaroshevich *et al.* 2010). Smooth semi-circular notches formed on the cutting edge of one of the transversely hafted segments in these experiments (Lombard & Pargeter 2008). Similar notches have been noted on segments from Sibudu and Umhlatuzana Caves and are thought to possibly represent a fracture type resulting from the impact of a transversally hafted weapon (Lombard 2005b, 2006; Yaroshevich *et al.* 2010) (refer to Section 2.1).

Shea (1988) conducted a study of the impact wear evident on unretouched Levantine Mousterian Levallois points, flakes and blades and confirmed the presence of DIFs on these tools. This reinforces the notion that tool morphology does not affect the formation of DIFs (Shea 1988). The majority of macrofractures were step and hinge terminating fractures located near to the tips of the tools and single large step/hinge terminating fractures near the tips on larger points. Shea also notes that feather terminating bending fracture clusters, along the laterals edges of tools, tended to occur when points were hafted with bindings, and not mastics. Based on this evidence he proposes that tools hafted with mastics could be recognisable, among other things, through the absence of these fracture clusters on their margins.

Yaroshevich *et al.* (2010) recently conducted archery experiments with different microlith types (n = 265), approximating types made and used during the Epipalaeolithic period in the Levant, hafted onto commercial wooden dowel sticks

(n = 102) in a variety of positions. Some of the arrows (n = 69) were hafted using beeswax and resin mixed with either gypsum powder or ochre. The remaining 33 arrowheads were hafted using reed fragments and water-based glues (Yaroshevich *et al.* 2010). The arrows, weighing between 20 and 40 g, were then shot, in two separate experiments, into sheep and goat carcasses with a recurved wooden sports bow with a 17.5 kg pull.

Yaroshevich *et al.* (2010) use their own classification scheme to record macrofractures on their sample focused on the orientation of the fracture, its location on the tool and the corresponding hafting configuration. Although their analysis uses different names for the different DIF types (to reflect their orientation and location on the tool), they do recognise the four fundamental DIF types outlined in the work of Fischer *et al.* (1984). Their DIF frequencies are therefore comparable to other analyses conducted using the original macrofracture protocol (Fischer *et al.* 1984). In the Yaroshevich *et al*. (2010) experiments, transverse points show the highest DIF frequencies (40 %) followed by single straight points (34.1 %) (see Table 2.2). The DIF frequencies on transverse points accord well with the Fischer *et al.* (1984) arrowheads as well as the Pargeter (2007) total projectile sample. Some of the impact fractures on transversally hafted microliths appear very similar to 'impact notches' noted in the Pargeter (2007) projectile experiments (refer to Section 12.2.1).

Only two (12.5 %) of the 16 laterally hafted blades showed any DIFs (Yaroshevich *et al.* 2010: 378) (see Table 2.2 and Figure 2.3). Of their barb sample, 23.6 % showed some form of DIF. This result suggests that pieces protruding from the lateral sides of a haft (i.e. obliquely hafted segments) are more likely to accumulate DIFs, although to a lesser degree than tips, as opposed to pieces hafted straight down a lateral edge (i.e. blades/bladelets). They also show, somewhat expectedly, that the longer the protruding part of a barb, the more likely it is to accumulate DIFs. These results reinforce the observation that variations in hafting configuration do have an effect on macrofracture formation patterns and frequencies (Lombard & Pargeter 2008).

A relevant focus in these experiments is explaining the reasons for differences in macrofracture frequencies. Yaroshevich *et al.* (2010) acknowledge that not all used hunting weapon tips and barbs would end up at living sites. Therefore we should expect to find lower DIF frequencies at residential versus kill sites (also see Villa *et al.* 2009). In fact they propose that a DIF frequency of between 7.9 % and 26.5 % is likely for a residential site based on the frequency of DIFs on microliths recovered from their animal targets and arrows (Yaroshevich *et al.* 2010: 379). This is based on the assumption that the remaining pieces would not make it back from a hunt in a hunter's kit or in the animal (also see Bergman & Newcomer 1983: 243).

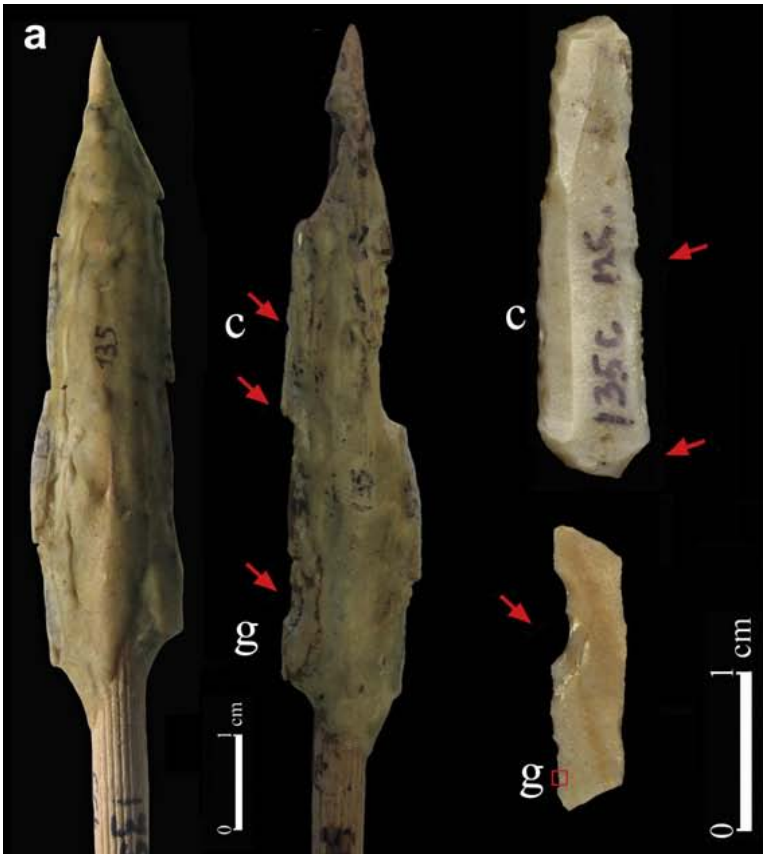


Figure 2.3. Reconstructed lateral hafting positions for bladelets and associated impact damage *(Adapted from Yaroshevich et al. 2010, Fig. 10: 382)*

The individual macrofractures from the Yaroshevich *et al.* (2010) experiments were then studied in terms of hafting position and microlith type. Oblique and perpendicular snap fractures that start at some point on the sharp edge of the

microlith (their fracture type b3) were the most common macrofracture types in their experiments, these fractures occurred most often on barbs (Yaroshevich *et al.* 2010: 383). Next were parallel fractures, such as impact burinations and step terminating fractures (their fracture types a1, a2 and a3), which occurred most frequently on straight points. It appears that single macrofracture types did not occur on only one hafting arrangement. This is based on their sample of trapezes/rectangles (n = 71), which were hafted in all configurations. They did note that certain multiple macrofracture patterns do occur in association with certain haft types. The following are some macrofracture types and associated hafting arrangements observed in their experiments:

1. Obliquely hafted pieces tended to have multiple macrofractures (step terminating, spin-off and snap fractures) that initiate on a sharp edge and remove tips in a blunt angle or by parallel/oblique fractures on both ends of the tool (Yaroshevich *et al.* 2010: 383).
2. Transversally hafted pieces tended to have more fractures (notches) initiating on a cutting edge perpendicular to their long axis (Yaroshevich *et al.* 2010: 383, Fig. 3. b1; also see Nuzhnyi 1990: 117).
3. Microliths hafted as straight points tend to accumulate multiple fractures on the same end of the tool, such as step terminating fractures, impact burinations and bifacial spin-off fractures, which are considered the most diagnostic of macrofracture types (Fischer *et al.* 1984; Nuzhnyi 1990; Lombard 2005a).
4. Lateral blades tended to accumulate oblique invasive fractures (sometimes snap fractures and 'shearing' breaks) and notches, which acted to remove part of the cutting edge and sometimes the tips (also see Caspar & De Bie 1996: 445 for microwear patterns associated with this hafting arrangement).

These are useful predictive patterns that can be applied to archaeological assemblages when addressing questions of possible hafting variations (refer to Section 12.4.5). The results of these experiments were then compared to DIFs on microliths from a Kebaran (n = 311) assemblage at Neve David and a Natufian (n = 299) assemblage from el-Wad Terrace, Israel (Yaroshevich *et al.* 2010). The

DIF frequencies on the Kebaran (5.3 %) samples and Natufian (8.4 %) samples are low and most resemble what Yaroshevich *et al.* (2010) would call a residential site (see Table 2.2). The Kebaran assemblage of trapezes/rectangles and other backed microliths show mainly single parallel fractures, step terminating and burin-like fractures, and invasive fractures on the cutting edge resembling damage on their experimental lateral blades (Yaroshevich *et al.* 1984). Fractures initiating on the microlith cutting edge which split the microlith across its body, characteristic of their experimental barbs, were noted on two backed pieces (Yaroshevich *et al.* 2010: 397). Of their Natufian lunates, 92 % show oblique/perpendicular fractures of the sort seen on oblique and transversally hafted experimental pieces as well as barbs (Yaroshevich *et al*. 2010).



Figure 2.4: Some Middle Eastern sites with macrofracture data
(Map of southern Africa, retrieved and modified on Aug 13, 2010 from www.googlemaps.com)

From these comparisons, Yaroshevich *et al.* (2010) suggest that the shift from bladelet production in the Kebaran to lunate production in the Natufian reflects a possible preference for a more flexible and durable hafting strategy that employed

lunates rather than bladelets (Yaroshevich *et al*. 2010: 386; see Crombe *et al*. 2001 for a similar discussion).

2.4 Archaeological applications of the macrofracture method in Africa

Until quite recently, most macrofracture analyses had been done outside of Africa. Lombard (2005a, 2006) started to examine southern African tools for use-traces in an effort to answer questions relating to the hunting function of post-HP points and HP-backed artefacts. Based on an adapted version of the Fischer *et al.* (1984) method, using only DIFs, Lombard (2005a, 2006) undertook macrofracture analyses on tools from three HP sites, namely Sibudu Cave, Umhlatuzana and Klasies River Cave.

Diagnostic Impact Fractures were noted on 22 % of the Sibudu pieces, 24 % of the Umhlatuzana sample and 21 % of the Klasies River Cave 2 sample (Lombard 2005b, 2006; Wurz & Lombard 2007) (see Table 2.2). Although these percentages are relatively low in comparison to experimental outcomes (refer to Section 2.2) they support the idea that HP segments were hafted and used to tip hunting weapons (Lombard 2005b, 2006, 2007b, 2008; Wurz & Lombard 2007; Lombard & Pargeter 2008).

Macrofracture analysis has also been used in an attempt to reconstruct hunting weaponry during the LSA (Lombard & Parsons 2008). Two late Holocene LSA assemblages, from Jagt Pan 7 and Melkboom 1 in the Northern Cape Province, were examined for macrofractures (see Table 2.2 and Figure 2.2). The Jagt Pan 7 sample (n = 919) belongs to the Swartkop industry because of its age and high numbers of unmodified whole and broken blades and bladelets (Lombard & Parsons 2008). The Melkboom 1 sample (n = 330), a mostly informal quartz based assemblage with fewer blades and bladelets, and more backed artefacts and convergent pieces, is characteristic of the later Doornfontein industry (Lombard & Parsons 2008).

The macrofracture frequencies from Jagt Pan 7 (9 %) and Melkboom 1 samples (12 %) are relatively similar and low in comparison with the HP assemblages mentioned above, but compare well with some European Holocene assemblages (Fischer *et al.* 1984) (see Table 2.2). The high frequency of snap fractures on both assemblages (c. 82.5 %) indicate that other processes such as trampling and knapping may have damaged these tools (cf.McBrearty *et al.* 1998). These fractures are interpreted as the result of a technological approach to weapon insert production involving the snapping of blades/bladelets (Lombard & Parsons 2008).

Accepting that some blades and bladelets were probably hafted and used as projectile inserts, there may also have been other functions for these tools (e.g. cutting, slicing, sawing etc) (refer to Section 5.2.1). Framed within the discourse of reliable hunting technologies, these blade and bladelet components could probably have been hafted as lateral inserts along the sides of projectile weapons in order to increase their penetrative success as weapons (Lombard & Parsons 2008). Multicomponent weapons do increase the damage a hunter is able to exert but are heavier and more difficult to maintain once broken, as opposed to arrows with a single microlith tip (Yaroshevich *et al.* 2010).

Lombard and Parsons (2008) suggest that a shift from the bladelet dominated Swartkop industry to the backed artefacts and convergent pieces of the Doornfontein industry, later in time, reflects less reliance on reliable hunting technologies. The shift is possibly associated with the use of domestic stock by the makers of the Doornfontein industry (Lombard & Parsons 2008: 142). This study shows that macrofracture analysis could provide useful contributions to investigations into the issues of decision-making and risk management in prehistoric communities.

Results of analyses such as those above create an exploratory framework for further experimental and replication studies and are an example of the multi-analytical approaches where macrofracture analyses are most useful (also see Caspar & De Bie 1996).

2.5 Chapter summary

The macrofracture method is largely an experimentally derived method with potential for archaeological application. The method can be used to initiate multi-analytical studies designed to investigate the hunting function of stone artefacts. More recently, this method has been used in conjunction with other analyses, such as microresidues and microwear studies. Experimental studies are contributing to our database of hunting-related fracture types and show which variables are important for the formation of macrofractures and which are not. New World and Old World assemblages have been examined using the macrofracture method and these analyses have shown that the method is a useful precursor to initiating debates surrounding issues of social and technological change.

CHAPTER 3: BACKGROUND TO MORPHOMETRIC ANALYSES

Morphometric analyses refer to methods that use quantitative data from artefacts to infer, among other things, aspects of their function and production and are especially useful when studying artefact change (Mohapi 2008). Measurements of artefacts are typically the starting point in morphometric analyses. These measurements are then used in various statistics to create categories of artefacts and to help identify patterns in and between artefact assemblages (Thomas 1986; Eerkens & Bettinger 2001). Morphometric techniques are also used to help simplify the amount of data that are generated when artefacts are counted, measured and quantified but have greater descriptive than predictive value (Clark 1982; Deacon, J. 1984). All of the artefacts in this study were measured for their length, breadth and thickness variables. These data are used in various calculations to see if it could help interpret the potential functions of these tools in the past (refer to Chapter 11). This section provides a brief rationale for the use of morphometric methods in studies such as this. The specific morphometric methods employed in this study are outlined in detail in Chapter 8.

The shape and dimension of stone artefacts has long been used to interpret the function of these objects (Goodwin & van Riet Lowe 1929). In order to perform a particular function, an artefact must have a particular shape or possess certain features. For example, to perform as a successful hunting weapon tip, an artefact must have some kind of pointed end and sharp cutting edge/s. It would be difficult for the weapon to penetrate a carcass without these features. Pointed ends and sharp cutting edges can be arranged in a variety of different ways, shapes and sizes on an artefact and hence we do not expect all hunting weapon tips to look exactly the same or to conform to the same design standards (Lombard & Phillipson 2010). Cultural preferences, raw material constraints and skill levels may all have had an effect on the design of stone artefacts in the past. These factors need to be taken into account when assessing morphometric data.

Not every artefact would have been used for only one function, as artefacts are very often multipurpose (Elston & Brantingham 2002; Torrence 2002). Some artefacts may have been manufactured and never used at all. Sometimes a weapon tip, designed to last, is not what is required for the task; instead a fragile, brittle stone tip is preferable (Knecht 1997). This is the case with certain hunting weapon tips that are designed to break inside an animal carcass thereby causing more severe wounds (Lombard & Phillipson 2010). Morphometric methods help in understanding this variability but cannot account for unused or multipurpose artefacts or for artefacts that do not conform to optimal design standards. They provide a useful hypothetical framework from which to begin assessing the potential functions of artefacts in the past (Sisk & Shea 2009; Lombard & Phillipson 2010).

Morphometric studies are also used to measure the amount of standardisation in an artefact assemblage by looking at the degree to which aspects of an artefact vary from one to another (Chase 1989; Wurz 1999; Eerkens & Bettinger 2001; Marks *et al.* 2001; Monnier 2006). Standardised artefacts can be indicators of technological skill and artefact function. Standardisation is particularly important when looking at multicomponent hunting weaponry (Mohapi 2008). Morphologically similar artefacts can easily be replaced in standardised hafts should one component break or become dislodged (Bleed 1986; see Torrence 2002 for an alternative perspective). Tools such as this are flexible, can reduce the probability of loss in a hunting situation are easily repaired and are reliable (Bleed 1986, 2001; Hughes 1998; Bousman 2005; Dewar *et al.* 2006; Lombard & Parsons 2008). The influence of human error, different needs and cultural preferences mean that many artefacts are not standardised, but are still useful.

Morphometric analyses and the data that are generated from them can be widely applied. Measurement data recorded from artefacts can be compared to other artefacts from varying times and places in order to assess the similarities and differences between them (Niekus 2009). This is useful as particular design types are repeatedly found in the archaeological record from different areas. The

morphology of artefacts with known functions can also be compared to data sets where function is still at question.

Morphometric techniques alone cannot predict which artefacts were used for which purposes and are best used in conjunction with other strands of evidence, such as macrofracture and residue data (see Hodder 1978). Two artefacts that appear to be morphologically similar cannot be assumed to derive from the same functional or cultural group unless this is demonstrated using further lines of archaeological evidence (Deacon, J. 1984). When other strands of archaeological data are not available, for example due to lack of preservation, morphometric data provide useful initial avenues to begin addressing issues of function and design in artefacts.

3.1 Chapter summary

Morphometric techniques are based on the study of the physical characteristics of artefacts. A main aim when using these techniques is to identify patterns within archaeological assemblages and to begin to explain why these patterns occur. These techniques are most useful when combined with other use-related data and when used as an initial step, much as with the macrofracture method, towards studying artefact functions.

CHAPTER 4: BACKGROUND TO EXPERIMENTAL ARCHAEOLOGY

4.1 Introduction

Experimental archaeology consists of a set of scientific research methods that help in accessing aspects of the past such as tool functions not directly available from arteafacts (Coles 1997; Dockall 1997; Matieuh 2002; Matieuh & Meyer 1997; Outram 2008). Some aspects of archaeological research, for example stone tool technology, owe much of their interpretive strength to experimental research (cf. Keeley & Newcomer 1977; Johnson 1978; Odell & Odell-Vereecken 1980; Vaughan 1985; Rots 2005; Robertson & Attenbrow 2008).

The goal of actualistic studies is not to suggest singular functions for individual artefacts (Dockall 1997). The goal is rather to create a chain of observable procedures and outcomes from known conditions that can be replicated and used as analogies for understanding archaeological problems and mental processes of the past (Holmes 1894: 121 in Johnson 1978; Coles 1973, 1997; Schiffer 1972, 1978, 1983; Odell 1981; Wylie 1988; Gifford-Gonzaléz 1991; Caspar & De Bie 1996; Bleed 2001; Outram 2005; Bamforth & Bleed 1997; Dominguez-Rodrigo *et al.* 2009; Seetah 2008; Sisk & Shea 2009; van Gijn 2010; Wadley 2010a). These observations create a critical interpretive framework and working hypotheses for researchers wishing to study social and technological aspects of artefact function and human behaviour.

This chapter outlines the theoretical background to actualistic studies in archaeology and focuses on two aspects of archaeological experimentation: trampling experiments and macrofracture formation.

4.2 Theoretical tenets of experimental archaeology

Experiments are an integral part of research in archaeology and are largely modelled on experimental procedures used in the natural sciences (see Bird 1998). In these disciplines, one of the main theories behind experimentation is that of empiricism (Hempel 1950). *Empiricism* is the notion that hypotheses can be evaluated using evidence derived from the sensory exploration of data and, in particular, sensory-based data derived from experimental situations (Rosenberg 2000). Thus data that can be seen, felt, touched, smelt and measured by the senses are recorded as they relate to the behavioural properties of physical materials (Papineau 1997). In archaeology, the physical materials are artefacts, ecofacts and features, and the behavioural properties those of humans.

The empirical basis of experiments in archaeology relates to the observation of cycles of human 'gestures' and meaningful actions when items of material culture are created (Leroi-Gourhan 1993; Geneste & Maury 1997). *Gestures* are chains of repetitive technical actions that are meaningful for the people who enact them (Crabtree 1966; Sheets 1975; Leroi-Gourhan 1993; Sellet 1993; Schlangler 1994; Bleed 2001). Gestures and actions are the invisible aspects of the archaeological record and experimental and technological studies are means of recreating these actions. The goal of experiments in archaeology is to re-situate gesture (both human and natural) and action in studies of ancient cognition and technology by observing the empirical outcomes of simulated scenarios involving, to a large degree, material culture items (Isaac 1981; Barham 1992; Bell 1994). This marks a fundamental divergence in archaeological experiments from those conducted in the natural sciences.

Another main tenet of experimentation in the sciences is that of falsification (Popper 1959, 1963; Hawking 2001). Positivism states that hypotheses can never be proven or shown to be correct due to the context-dependant nature of knowledge (see Kuhn 1970). Instead we should aim to evaluate experimental hypotheses in relation to how well they stand up to being 'falsified' or shown to

be incorrect (Popper 1959; Lakatos 1970). Experiments that have stood up to the process of falsification generate further hypotheses to be tested in future experiments. This dialectic of generating hypotheses, testing them experimentally and generating further workable hypotheses is known as a *hypothetico-deductive* process (Popper 1963; Dominguez-Rodrigo *et al.* 2009; Outram 2008: 1). This process allows for sequences of thematically and methodologically related experiments to develop and to generate explanatory hypotheses for the archaeological record (cf. Wadley 2005; Hodgskiss 2006; Lombard 2008; Lombard & Wadley 2007; Wadley & Lombard 2007; Wadley 2009; Wadley *et al.* 2009 for examples).

4.3 Building analogies along experimental lines

Experiments in archaeology involve the creation of analogies that can be used to help explain and evaluate archaeological data. Despite much historical criticism of analogies (see Wylie 2002:136), they are a significant part of archaeological research (see Ascher 1961; Orme 1973, 1974; Wadley 1989). Analogies function to broaden the potential range of explanations for archaeological data. They provide alternative perspectives and when used to narrow the range of potentials, rather than acting as all-encompassing explanations, can be useful tools for archaeologists (cf. Ucko 1969). Analogies derived from controlled and contextualised experiments that are applied to well-excavated and dated archaeological sites and address specific technological questions are most useful (cf. Sisk & Shea 2009). Analogies and experiments focused on techno-functional questions have the widest applicability in archaeology. The further away experiments are from technically-based reconstructions experiments are based, the less applicable the inferences and analogies that they generate (Hawkes 1954; Clark 1963:355).

Hypothesis creation and evaluation in archaeology requires the use of numerous and diverse strands of evidence and a constant reflection on data, hypotheses and experimentally derived analogies that help explain archaeological data. The combination of these elements, or strands, results in what can be described as a

theoretical ‘cable’. The more detailed the evidence and multistranded the hypotheses and analogies, the stronger the resulting theoretical cable. The cumulative weight of these strands of evidence compensates for single arguments that do not explain the phenomena in question on their own (Bernstein 1983). The value of a cabled perspective of archaeological understanding lies in the dialogue that ensues between these different strands of evidence (Wylie 2002: 161-169). This allows for a closely knit explanatory framework that is united, yet at the same time can be critical of all its component parts.

Movement between data and explanations, in an interpretive cable, is facilitated by a series of vertical, horizontal and diagonal ‘tacks’ (see Geertz 1979 for the anthropological origins of the concept). ‘Tacking’ can be used to imagine how a theoretical cable is held together (Wylie 2002). Tacks are composed of what Wylie calls “source-side knowledge” (2002: 166) derived from sources such as experimental and ethno archaeologies that provide analogies for understanding excavated archaeological data (also see Inizan *et al.* 1999).

4.4 The applicability of experiments in Archaeology

The applicability of experiments in archaeology is sometimes questioned (Andrefsky 1998). This doubt centres on the fact that experiments are conducted in the present, by modern humans, and therefore cannot, by their very nature, completely recreate prehistoric situations (Mathieu 2002). Whilst there is a need to marry and model our experiments on actual prehistoric cases, as closely as possible, this is not entirely possible as not all aspects of the past are known to archaeologists (Coles 1997; Reynolds 1999: 159; Mathieu 2002: 1; Outram 2008). Were it not for this lack of a complete understanding of the past, there would be little need for us to resort to experiments as a heuristic device in archaeology. Rather than *reconstructing* the past, we should focus on modelling experiments around different and specific aspects of the past and realise that no experiment will ever be a complete *reconstruction* of the past (see Hawkes 1954 for a similar discussion relating to the use of analogies in archaeology).

Rather than *replicating* prehistoric situations completely, experiments in archaeology should aim to control as many variables in the experiment as possible when constructing test situations (Odell & Cowan 1986; Reynolds 1999; Mathieu 2002; Shea *et al.* 2001). A complete control over variables that relate to human behaviour, as opposed to physical matter in natural sciences, is not possible. The number of potential variables in experiments dealing with human behaviour is potentially infinite and controlling these is not easy. Archaeologists are therefore forced to compromise by introducing modern materials and protocols, alongside archaeologically relevant materials, into their experiments to eliminate non-relevant variables and to focus on those aspects of the experiment that are the most pertinent. As a result, experiments in archaeology are sometimes devoid of the human variable by various apparatus and machines that help standardise the testing process (see Greiser *et al.* 1979; Shea *et al.* 2001; Lerner *et al.* 2007; Pargeter 2007; Sisk & Shea 2009). The principle of standardisation and control over variables is fundamental to the experimental process borrowed by archaeologists from other scientific disciplines such as chemistry and physics.

Understanding the physical properties of materials under laboratory conditions does not detract from an experiment having archaeological relevance. For example, studies by Wadley *et al.* (2009) focus on the chemical changes that take place when ochre is heated and added to plant gum to form a compound adhesive. Using various scientific methods (such as scanning electron microscopy and Malvern Zetasizer Nano systems for measuring PH changes in the compounds) they come to an understanding of the scientific properties of these materials when combined to form adhesives compounds. These laboratory studies also helped Wadley *et al.* (2009) to understand that the colour symbolism of red ochre (haematite) is a possible by-product of the heating of yellow ochre (goethite) and may be over-stated by archaeologists in certain cases (Sievers & Wadley 2008; Wadley 2009).

With this knowledge, Wadley *et al.* (2009) hafted replicated stone artefacts onto wooden hafts using these adhesive recipes and materials and methods that were available during the MSA in southern Africa. Various tasks were performed with the tools to better understand the performance properties of adhesives in less controlled, and more *reconstructed* situations. The reference samples derived from these experiments are applicable to the archaeological record and have relevance to our understanding of the complex nature of adhesive manufacture and use, particularly during the HP phase in South Africa.

4.5 Referring to the archaeological record

Experiments in archaeology always need to have a referent in the archaeological record (Coles 1997; Andrefsky 1998; Inizan *et al.* 1999). This helps to ensure that experiments are relevant in terms of the hypotheses they set out to assess and that the data and analogies they generate are applicable. Experiments that refer back to the archaeological record help to focus our attention on the technological details of entities, such as artefacts, ecofacts and features, and not only on their broader contexts (Saraydar & Shimada 1973). Ultimately, it is the past that we seek to explain by conducting experiments in archaeology and when experiments lack academic context and relevance they become more about experience and exploration than assessment and inference (Outram 2008). In this situation, it is very difficult to integrate experimental results into archaeological research and therefore to gauge whether the resulting analogies are suitable to help interpret aspects of the past (Amick *et al.* 1988: 9).

The relationship between experiments and the archaeological record should not be a one-way process (Reynolds 1999). The association involved is dynamic whereby experiments are informed by the archaeological record, but can in turn have ramifications for the way we practise archaeology and investigate its record. By gaining a better understanding of the archaeological record, we are more capable of recognising new patterns or trends in the past, which will lead to new

and more detailed experimental programs. The macrofracture method is a good example of an on-going product of this type of dialectical process.

Experiments in archaeology benefit most from archaeological sequences that have fine-grained resolution, detailed technological information and have been studied from a multi-analytical perspective. This enables experiments to be established that are more specific and controlled and address more focused questions of gesture and action in the archaeological record. Detailed archaeological sequences also allow for specific experimental questions to be designed that address aspects of technological behaviour and change in the past. Whilst experiments restrict the range of potentials in the past, detailed archaeological sequences constrain the range of potential and likely results that are generated through experiments (Reynolds 1999).

4.6 A typology of experiments in archaeology

There are many different types of experiments conducted by archaeologists (Coles 1997; Reynolds 1999). These range from the quantitative, for example the use of scanning electron microscopy and EDS elemental analysis to detect residues on experimentally manufactured stone flakes by Jahren *et al.* (1997), to more actualistic and qualitative, for example Jones' (1980) experimental butchery with replicated bifaces. Reynolds (1999: 158-62, also see Outram 2008: 3) has defined five major classes of experiments conducted in archaeology that include construct, process and function, simulation (equifinality/taphonomy), eventuality trials and technological/methodological innovation experiments. All of these classes of experiments can be further sub-divided into qualitative and laboratory-like experiments (quantitative). These are not absolute categories and there is considerable overlap between the different classes of experiments. The trampling and knapping experiments conducted in this work fall mostly into the simulations (taphonomy) and technological/methodological innovation experiment types (refer to Chapter 7). For this reason these two categories are discussed in more detail below and a few examples of each experiment type are given.

A. *Simulation*: These are experimental investigations into the formation processes and post-depositional processes affecting in the archaeological record. They tend to be longer term experiments although their time spans do vary. The experiments focus attention on the potential for different forces creating similar or the same results, a concept known as *equifinality* (Shea & Klenck 1993; Beven & Freer 2001). In archaeology, understanding the specific cultural and non-cultural factors responsible for a certain set of observable outcomes, a "stubbornly complex reality", is difficult (Schiffer 1972: 159). One way to address this absence of direct evidence relating to formation processes is to reconstruct potential formation and alteration situations using experiments. Examples of simulation experiments include trampling (Gifford-Gonzalez *et al.* 1985; Nielsen 1991; Shea & Klenck 1993; McBrearty *et al.* 1998; Blasco *et al.* 2008), vertical dispersal and site formation processes (Villa & Courtin 1983; Gifford-Gonzalez *et al.* 1985; Macphail *et al.* 2003), bone modification (Marean 1991), lithic heat treatment and transformation (Flenniken & Garison 1975; Domanski & Webb 1992; Rowney & White 1997; Mercieca & Hiscock 2008; Brown *et al.* 2009) and food preservation and storage (Henshilwood *et al.* 1994).

B. *Technological/methodological innovation:* In order to maintain the tighter analytical environment required for working hypotheses, methodological reflexivity is crucial. A constant dialogue between archaeological data, analytical methods and experimental studies allows us to refine our methods of study. These experiments introduce new techniques and methods and trial existing methods. Examples of technological innovation experiments include: macrofracture analyses (Fischer *et al.* 1984; Odell & Cowan 1986; Lombard *et al.* 2004; Lombard 2005a; Lombard & Pargeter 2008; Yaroshevich *et al.* 2010), residue analyses (Jahren *et al.* 1997; Wadley *et al.* 2004; Rots *et al.* 2006; Lombard & Wadley 2007; Langejans 2009, 2010), bone cut mark analyses (Dewbury & Russell 2007; Braun *et*

al. 2008; de Juana *et al.* 2010) and microwear analyses (Keeley 1980; Sala 1986; Rots 2005; Lerner *et al.* 2007).

4.7 Chapter summary

Actualistic studies are most useful when used as part of a multidisciplinary research effort. They benefit from well-excavated and detailed archaeological sites that help in the formation of specific and testable hypothesis that can generate relevant and specific experimental data sets. There are many different types of experiments that are conducted in archaeology, but this study is mostly concerned with function, simulation and technological/methodological innovation experiments. These experiments are a part of the necessary methodological reflexivity in archaeology and the continued efforts to tighten and refine the macrofracture method for identifying Stone Age hunting weaponry.

CHAPTER 5: BACKGROUND TO THE FUNCTIONAL STUDY OF BLADELETS, BACKED ARTEFACTS AND CONVERGENT PIECES

5.1 Introduction

Here I describe first the morphology of the three artefact types (bladelets, backed artefacts and convergent pieces) examined in this study. Next I give the reader a background to the archaeological associations of these tool types, the study of their potential functions and their potential uses as components in various hunting weapons. In the last section of this chapter, different prehistoric hunting weapon forms, and the different forms of hunting weaponry relevant to Africa, are outlined and discussed.

5.2 Background to bladelets, backed artefacts and convergent pieces

5.2.1 *Bladelets*

Blades are artefacts with a length twice the breadth, with parallel sided sharp cutting edges and dorsal ridges indicating the ridges on the core, which guide their detachment (Cotterel & Kamminga 1979; Whittaker 1994; Bar-Yosef & Kuhn 1999; Cochrane 2008) (see Figure 5.1). Bladelets, also known as microblades, are narrow, relatively standardised, miniature versions of blades (Hiscock 1994; Bousman 2005). Some researchers use a breadth measurement of < 15 mm to distinguish bladelets from blades (e.g. Bar-Yosef & Kuhn 1999), whilst others use a length measurement of < 15 mm to distinguish between the two (e.g. Henshilwood 2008; Lombard and Parsons 2008). This study uses the breadth variable to distinguish between blades and bladelets. The reason being that length can easily be changed if a bladelet is snapped whereas breadth remains the same.

Bladelet technologies allow for a greater control over the shape and form of the end product and can produce a more standardised product than most other lithic technologies (Chazan 1995; Bar-Yosef & Kuhn 1999). Standardised bladelets have many functions, among which is their use as hafted components in

composite weapons (Costa *et al.* 2005). Morphologically similar bladelets are useful in hafts that are of a standard size as they fit into the same size slots and are therefore interchangeable should one component break or become dislodged (Bleed 1986).



Figure 5.1: A selection of Robberg bladelets from Byneskranskop 1

Blade technologies are present in MSA assemblages in East Africa by at least 285ka and in South Africa by c. 120 ka (Bar-Yosef & Kuhn 1999; McBrearty & Brooks 2000). Blades, or bladelets, are an integral part of HP assemblages in southern Africa, dated to between c. 64 and 59 ka (Jacobs *et al.* 2008). During the HP phase they were sometimes used as pre-forms for backed artefacts (Soriano *et al.* 2007; Cochrane 2008). Blades, and more commonly bladelets, are also found in LSA assemblages and are considered to represent an advanced form of tool technology (Sheets & Muto 1972; but see Bar-Yosef & Kuhn 1999 for an alternative perspective). They are the type fossils of the Robberg industry and are present in the Wilton industry where they are sometimes used as tool blanks (Deacon, J. 1978; Mitchell 1995; Wadley 1996). Other regions of the world, such as the Levant (Bar-Yosef & Kuhn 1999; Yaroshevich *et al.* 2010), Australia (Hiscock 2002), Northern Asia (Elston & Brantingham 2002) and Eastern Europe (Nuzhnyi 1993, 2000) have bladelet-rich assemblages in varying archaeological contexts showing their wide-spread efficacy (Neeley 2002).

Bladelets, like backed artefacts, are presumed to have had multiple functions (Cochrane 2008). Most of these presumptions revolve around the use of bladelets, especially backed bladelets, as hafted pieces (Clark *et al.* 1974: 367, 369; Mitchell

2008; Binneman 1997; Rots *et al*. 2003). Yet, because bladelets commonly lack a pointed end they are not often associated with hunting weaponry (Lombard & Parsons 2008). However, there are numerous studies that suggest their use as laterally hafted armatures in composite low and high-velocity hunting weapons (see Mitchell 1988; Ambrose & Lorenz 1990; Parkington 1998; Nuzhnyi 2000; Elston & Brantingham 2002; Bocquentin & Bar-Yosef 2004; Lombard & Parsons 2008; Yaroshevich *et al.* 2010) (see Figure 5.2).

Binneman's (1997) usewear analysis of 15 Robberg bladelets from Rose Cottage Cave shows various macro- and micro wear traces along one or both lateral edges on these pieces. Vegetal polishes, striations and macroflake removals suggested that these bladelets were hafted in a linear fashion and used to cut, saw, whittle and shave vegetal and hide materials (Binneman 1997; also see Binneman & Mitchell 1997). Other possible functions for bladelets hafted laterally in straight lines include cutting, sickle-use and use as knives (Hiscock 1994; Caspar & De Bie 1996; Nelson 1997; Torrence 2002; Edwards 2007).

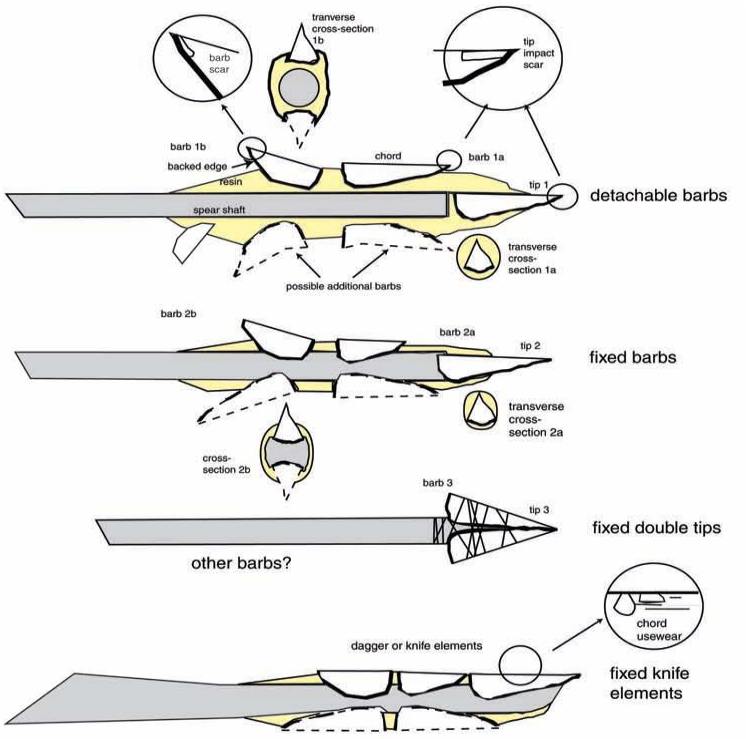


Figure 5.2: Reconstructed hafting arrangements and usewear indicators for bladelets
(From Fullagar et al. 2009, Fig. 10: 267)

5.2.2 *Backed artefacts*

Backed artefacts are formed by the intentional, or natural, blunting of one or both edges of a blade or flake (Schweitzer & Wilson 1982; Hiscock 2002) (see Figure 5.3). They are typically asymmetrical, often geometric and standardised in shape and tend to be relatively small in length ranging between 10 and 50 mm (Ambrose 2002; Robertson & Attenbrow 2008).

The specific morphology of these tools, especially the backing or blunting of the convex edge is probably functional. Backing eases the handling of these tools where they might be hand-held (Gibson *et al.* 2004) or to facilitate the hafting process by creating a broader, rougher surface onto which mastic could adhere (Clark 1970, 1977; Phillipson 1976; Ambrose 1998, 2001; Nuzhnyi 2000; Wadley *et al.* 2004; Lombard 2005b, 2006, 2007a, 2008; Wurz and Lombard 2007; but see Torrence 2002). Hafting of stone tools enhances the efficiency and force with which a tool can be used (Rots *et al.* 2003).



Figure 5.3: A selection of Wilton backed artefacts from Byneskranskop 1

The oldest known backed artefacts come from the sites of Twin Rivers and Kalambo Falls in Zambia, with an associated age of roughly 300 000 years (Barham 2000, 2001, 2002; Clark & Brown 2001; Cornelissen 2002; Barham & Mitchell 2008). Backed artefacts are also the type fossils of the HP industry in southern Africa. The Robberg (c. 18 – 12 ka) and Wilton (c. 8 – 2 ka) LSA industries in southern Africa also have backed artefact components (Deacon, J.

1978; Schweitzer & Wilson 1982; Henshilwood 2008). These LSA backed artefacts are said to be more standardised than the earlier MSA and HP backed tools (Deacon, H. J. 1972; Thackeray 1992, but see Wurz 1999; Delagnes *et al.* 2006; Cochrane 2008) (refer to section 11.4.2 for a discussion of the length/breadth ratios and standardisation of Wilton segments).

The repeated occurrence of backed artefacts in the archaeological record has fuelled interest in their potential functions (McBrearty & Brooks 2000; Ambrose 2002; Barham 2002). Yet because of their unusual morphologies (especially segments), backed artefacts have been often left out of functional studies (e.g. Shea 2006; but see Lombard & Pargeter 2008). In recent years, usewear methodologies have been adapted to accommodate these pieces (see Lombard & Parsons 2008; Wadley & Mohapi 2008; Shea 2009; Villa *et al.* 2010; Yaroshevich *et al.* 2010) (refer to Chapter 2).

Archaeologists have often suggested that MSA backed artefacts were parts of hunting weapons, possibly as arrowheads, spearheads or as barbs on spears (Deacon, H. J. 1989, 1995; Lombard 2005b; Shea 2009). Most assumptions about the uses of backed artefacts are based almost solely on Mesolithic, LSA, Upper Palaeolithic and ethnographic analogies (Clark 1954; Clark & Walton 1962; Parkington & Poggenpoel 1971; Jacobi 1978; Oshibkina 1985). Several of these analogies have focused on the use of backed artefacts as components in hunting weaponry (e.g. Turner 1932; Clark 1959; Fagan 1965; Deacon, H. J. 1972; Klein 1974, 1983, 1989; Parkington *et al.* 1980; Inskeep 1987; Wadley 1987; Noli 1993; Deacon, H. J. & Deacon, J. 1999; Lombard & Pargeter 2008; Mohapi 2008; Niekus 2009; Villa & Soriano 2010).

Direct evidence for the function of backed artefacts also exists. Middle to late Mesolithic microliths embedded in animal bones from the British mainland indicates their possible use as arrowheads (Petch 1924: 29; Noe-Nygaurd 1974; Jacobi 1978). In Denmark, fragments of backed microliths were found embedded in aurorchs at Prejlerup (Van Petersen & Brinch Petersen 1984 in Crombé *et al.*

2001) and Vig (Fischer *et al*. 1984). A bone point with multiple backed tools along its laterals from the Mesolithic in Denmark is documented by Chard (1969). The find of an Australian aboriginal man speared to death by a weapon tipped and barbed with backed artefacts suggests their use in conflict and warfare (McDonald *et al.* 2007 also see Flood 1995; Bocquentin & Bar-Yosef 2004; Fullagar *et al.* 2009).

Backed microlithic inserts, some still in mastic and hafted in pairs, are reported to have tipped historic San arrowheads (Goodwin 1945; Clark 1977; Deacon, J. 1992). Portions of LSA microlithic arrowheads, some of them backed have been noted from Big Elephant Shelter (Wadley 1979), Pomongwe Cave (Cooke 1975), Melkhoutboom (Deacon, H. J. 1976) and De Hangen (Parkington & Poggenpoel 1971). Microlithic artefacts with hafting mastic still on their backed edges are known from BNK 1 and NBC (Inskeep 1987; Schweitzer & Wilson 1982). Extensive examples of the uses of backed artefacts as hunting and cutting weaponry during the time of Ancient Egypt have also been noted (Clark *et al.* 1974).

Microresidue analyses conducted on backed artefacts from the HP layers of Rose Cottage Cave (Gibson *et al.* 2004) and Sibudu Cave (Delagnes *et al.* 2006; Lombard 2005c, 2006, 2008) have yielded direct evidence for the hafting of these tools. Of the 48 pieces analysed by Gibson *et al.* (2004), all have evidence of a high occurrence of ochre/plant residues on their backed edges. These results support hypotheses put forward by researchers, such as Clark (1970) and Phillipson (1976), about the hafting function of backing on artefacts such as segments. Lombard's (2006) analysis of 53 segments from Sibudu Cave also shows a clear concentration of ochre and resin residues on their backed portions that suggests hafting. Replication studies involving backed microliths have provided further information about the potential hunting functions of these backed tool types (refer to Section 2.2 and Section 2.3).

Evidence of the hafting and use of backed artefacts as cutting components to process/harvest plant material has also been noted (Oakley 1958; Kamminga 1980; Binneman 1983; Deacon, J. 1995; Wadley and Binneman 1995; Finlayson & Mithen 1997). The use of Australian backed artefacts as hafted hide-working implements is attested to by Robertson and Attenbrow (2008). Wurz (1999) suggests that the production of HP backed artefacts reflects arbitrary stylistic trends that could also have been used as symbolic/ritual and exchange items in the past (also see White & O'Connell 1982; Ambrose 2002; McDonald *et al.* 2007).

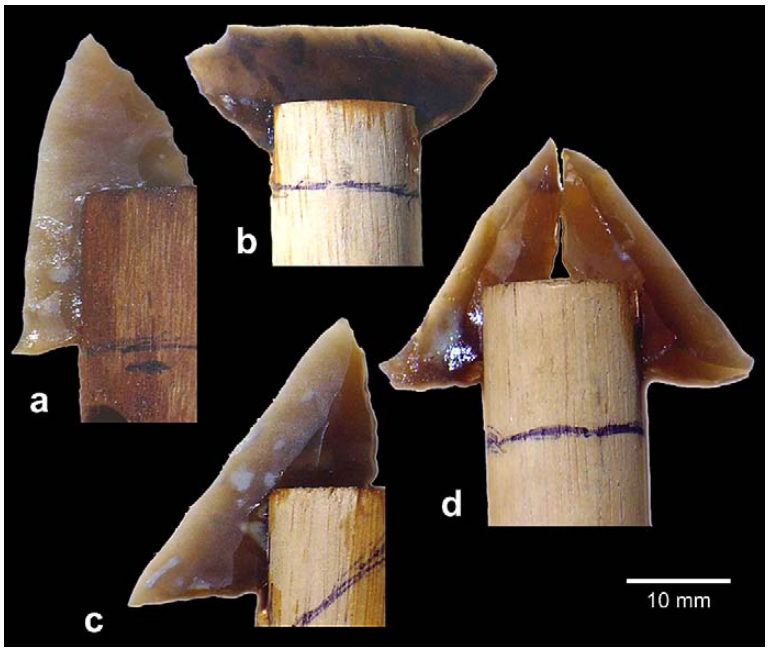


Figure 5.4: Reconstructed hafting positions for segments used in the Pargeter (2007) experiments *(Source: Lombard & Pargeter 2008, Fig. 2: 2525)*

5.2.3 *Convergent pieces*

Convergent pieces are retouched and unretouched artefacts with lateral edges that converge to form a point, or if broken are reconstructed as having a pointed end (see Figure 5.5). These tools are also known as points (Debenath & Dibble 1994). The term *point* is omitted here to avoid typological connotations that associate the concept of a 'point' only with retouched pieces (Debenath & Dibble 1994; Marks 1998).

Convergent pieces are included in this study because their morphology, i.e. their sharp points and sharp convergent edges, make them suitable for use as weapon tips. Some convergent pieces also show basal thinning which is probably related to hafting (McBrearty & Brooks 2000). This is, however, an oversimplification of the range of functions for which convergent pieces could have been used in the past (Shea *et al.* 2001).



Figure 5.5: Selected broken and whole unretouched convergent pieces from the Wilton layers at Nelson Bay Cave

Convergent pieces are the type fossils of the MSA from at least c. 285 ka in Africa and come in many different forms and shapes across the continent (McBrearty 2001, 2007; Tryon & McBrearty 2002). Some researchers attribute these differences to stylistic trends in artefact manufacture (e.g. Wilkins 2010) and others to functional differences (Clark 1988). These variations have been used to differentiate stone tool industries of the African MSA (Brooks *et al.* 2006). Convergent stone tools are either rare or absent in most HP assemblages where they appear to have been replaced by backed tool forms (Lombard 2005c; Soriano *et al.* 2007; Mohapi 2008; Wadley 2008). Based on my observations at NBC, BNK 1 and BBF 4 unretouched convergent pieces are features of the Robberg and Wilton assemblages at these sites.

Functional interpretations of convergent pieces come from the results of residue analyses, experimental archaeology, technological, morphological and faunal studies as well as macro- and microwear analyses. The majority of these reports

conclude that convergent pieces were used as the tips of hunting weaponry, sometimes thrusting and throwing spears, sometimes arrow and dart tips (Shea 1988; Milo 1998; Shea *et al.* 2001; Henshilwood 2004; Lombard *et al.* 2004; Brooks *et al.* 2006; Villa & Lenoir 2006; Lombard 2007a; Phillipson 2007; van Gijn 2010 and references therein) (see Figure 5.6). Direct evidence for the use of pointed stone artefacts as hunting weapon tips comes from South Africa, Syria and other European sites (Noe-Nygaurd 1974; Friis-Hansen 1990; Milo 1998; Boëda *et al*. 1999; Letourneux & Pétillon 2008 and references therein). Milo (1998) documents a stone point embedded in a clean-cut extinct Buffalo cervical vertebrae from Klasies River Mouth. Boëda *et al.* (1999) discuss evidence of a Levallois point lodged in an equid vertebra from Umm el Tlel, Syria. Some of the Umm el Tlel points also have bitumen mastic traces on them, suggesting that they were hafted (Boëda *et al*. 2008).

Other suggested uses of the sharp tips and edges on convergent pieces include cutting, scraping and use in warfare (Shea 1988, 2006; Holdaway 1989; Shea *et al.* 2001; Churchill *et al.* 2009; van Gijn 2010). There is evidence to suggest that Still Bay and early Levantine Mousterian points may have been hafted and used as butcher knives (Shea *et al.* 2001; Lombard 2007a). Wilkins (2010) suggests that the diverse point shapes and sizes during the MSA in Africa may even have functioned as symbolic markers of social relations between individuals. Considerable morphological variability exists within convergent pieces and they could have been used for a number of different tasks and had a variety of meanings.



Figure 5.6: Hafted experimental convergent flake *(Adapted from Lombard & Phillipson 2010, Fig. 1: 3)*

5.2.4 *Summary*

The three artefact types discussed above have morphological qualities indicating that one of their uses may have been as hafted components. Blade technologies, backed artefacts and convergent pieces have their origins in the earlier MSA of Africa. They become more widespread later in time and are common features of some LSA assemblages in southern Africa. It is likely that these qualities would have made them suitable for use as different parts of hafted tools, some on lateral ends (e.g. bladelets and backed artefacts) and others as tips (e.g. convergent pieces and backed artefacts). They could have been used in a variety of other ways too. The repeated occurrence of these artefact types in the archaeological record is likely associated with their functional flexibility.

5.3 Hunting weaponry forms and functions

In the above section bladelets, backed artefacts and convergent pieces and their likely function/s were discussed. One potential use for all three artefact types is as components in hunting weapons. I now wish to discuss the different hunting weapon types relevant to southern Africa and the archaeological evidence associated with these weapons.

5.3.1 *What are hunting weapons?*

Hunting weapons can be low or high velocity weaponry. High velocity weapons are also referred to as 'mechanically projected' (Lombard & Phillipson 2010) or 'technically assisted' (Solecki 1992) weapons. There is considerable variation in hunting weaponry across space and time, and it is difficult to find a system of categorisation and classification to account for all variations in weapon types and uses (Mohapi 2005). The term *hunting weaponry* includes implements such as spears**,** arrows and darts. Only spears and arrows are relevant to this discussion as darts are not believed to have been present in Africa in the past (Villa & Lenoir 2006). I will now discuss two broad categories of hunting weapons: mechanical and non-mechanical hunting weapons.

5.3.2 *Mechanically projected weaponry*

Mechanically projected weapons, such as bows and arrows, are different to low-velocity hunting weapons because they are often lighter and more aerodynamic and as such they can obtain higher velocities (Hughes 1998). They are also propelled using some form of device, such as a bow or spear thrower (Villa & Lenoir 2006). Mechanically projected weaponry allows hunters to inflict wounds from a greater distance, at less risk to the hunter (Hughes 1998; but see Lombard & Phillipson 2010 and references therein). The larger significance of mechanically projected weaponry is that it requires other technologies such as ropes, mastics, planned and cooperative behaviour and is a component in broader subsistence diversification and intensification strategies (see Shea 2009; Lombard & Phillipson 2010; Shea & Sisk 2010).

The bow and arrow is an example of a high-velocity mechanically projected weapon type. Bows are wooden staves, tapering towards the ends and connected by string or animal sinew to form a bent arc (Noli 1993). Arrows are wooden 'wands', pointed at one end and nocked and fletched at the other (Noli 1993: 1). Ethnographic evidence suggests that bow and arrow technologies were sometimes used in conjunction with poisoned tips (Noli 1993 and references therein; Ellis 1997; Hitchcock & Bleed 1997; Mohapi 2005). Bow and arrow technology may only have been a seasonal option for hunters owing to the seasonality of certain poison sources (Wadley 1987; Hitchcock & Bleed 1997; but see Hall & Whitehead 1927). Arrows are often tipped by artefacts smaller than spears, owing to the lighter weight and greater flight velocities of these weapons (Churchill *et al.* 2009; Shea 2009). Segments and other backed microliths are cited as being arrowhead tips (refer to Section 5.2.2) but could also have functioned as small spear tips (Pargeter 2007; Wadley & Mohapi 2008; Lombard & Phillipson 2010). Bladelets may have been used as barbs and laterals on arrows to increase their effectiveness (Nuzhnyi 1990) (refer to Section 5.2.1). Bow and arrow hunting is often associated with small and more diverse animal species than is spear hunting and use in more closed environments (Terashima 1983; Wadley 1987, 1989; Hitchcock & Bleed 1997; Ellis 1997; Nuzhnyi 2000; Mohapi 2005; but see Friis-

Hansen 1990). Shea (2009, also see Shea & Sisk 2010) prefers to see mechanically projected weaponry within a niche broadening framework. Here the emphasis is on the versatility of these weapons and their potential applicability for hunting a broad range of animal types and sizes.

5.3.3 *Non-mechanical hunting weaponry*

Non-mechanical hunting weapons are low-velocity weapons propelled by the arm rather than a bow or spear thrower. An example of this type of weaponry is the spear. There are typically two types of spears: short stabbing spears and longer throwing spears. However, shaft diameter and length alone are not enough to distinguish between thrusting and throwing spears, and it is possible that one type of spear may have served both thrusting and throwing functions (Villa & Lenoir 2006, 2009).

Short stabbing spears, or thrusting spears, are used at short distances to inflict higher impact damage (Frison 1989). These are not projectile weapons as they do not leave the hand. Handheld spears oblige the hunter to come into close quarters with prey, thereby increasing the danger associated with this weapon type (Hitchcock & Bleed 1997; Churchill 2002). Short stabbing spears are likely to have been used in conjunction with other forms of hunting weaponry. Longer throwing spears can be launched at a target from some distance with the arm. These weapons impact with lower velocities than short stabbing spears (Villa & Lenoir 2006). Experiments have been conducted to test the effectiveness and damage patterns of both of these types of spear use (Frison 1989; Shea *et al.* 2001; Lombard *et al.* 2004) (refer to Section 2.3). Spears may have been tipped by larger stone artefacts, such as convergent pieces, and larger backed artefacts (Mohapi 2005; Shea 2006; Villa *et al.* 2009; Wadley & Mohapi 2008; Churchill *et al.* 2009). These weapons are also sometimes associated with the cooperative hunting of large animals (Hitchcock & Bleed 1997; Milo 1998; Wadley 1989, 1998). The effectiveness and reliability of spears can be increased with the addition of barbs and other laterally hafted pieces (e.g. bladelets and backed

artefacts) that cause larger and more gaping wounds (Terashima 1983; Nuzhnyi 2000; Elston & Brantigham 2002; McDonald *et al.* 2007) (see Figure 5.2).

5.3.4 *Summary*

Two broad categories of hunting weapons are applicable to this study: mechanically assisted and non-mechanically assisted weapons. These weapon categories include implements such as thrust and thrown spears and bows and arrows. It is possible that differently sized artefacts were used to tip these different weapons and that they were valuable assets in the broadening and intensification of prehistoric subsistence practices. Spears and bows and arrows have been discussed most often with regards to the southern African prehistoric record. At present, it is assumed that darts and spear throwers were not used in southern Africa during the MSA. In the following section, I discuss the archaeological evidence for spears and bows and arrows.

5.4 Archaeological evidence for mechanical and non-mechanical hunting weapon types

We are not certain which MSA and LSA stone tools in southern Africa were used for which types of weapons. However, recent advances have been made to interpret the functions of African Late Pleistocene MSA and LSA artefacts using context-based data such as: residue analyses, macrofracture analyses, detailed *chaîne opératoire* analyses and morphometric measurements. Because the organic elements of hunting weapons do not often survive, most of these methods apply to the stone components of these weapons.

5.4.1 *The archaeological evidence for bow and arrow use*

Recent research has suggested that bow and arrow technology may be as old as 64 ka in southern Africa (Wadley & Mohapi 2008; Lombard & Phillipson 2010). Shea (2009) suggests that projectile weapons, possibly bows and arrows, may have been present in Africa between 50 and 100 ka and may have played a role in the dispersal of *Homo sapiens* out of Africa after 50 ka (also see Shea & Sisk 2010). Wadley and Mohapi's (2008) use of the modified TCSA calculation (refer

to Section 8.3.2) suggests that the small quartz HP segments from Sibudu Cave were hafted transversally and used as arrowheads (also see Shea 2009). Lombard and Phillipson (2010) use contextual evidence, such as the presence of high tension strings and rope (see Wadley 2010b) as well as residue and usewear data, to argue for bow and arrow technology during the HP industry at c. 64 ka (but see Villa & Soriano 2010). Mohapi (2005) proposes that the small size of points from layer dc at Rose Cottage Cave (< 30 ka) would have made them suitable for use as bow and arrow tips.

The use of hafted geometrics and convergent pieces as components in bow and arrow technologies during the Wilton time period (c. 8 – 2.5 ka) is well described (Deacon, H. J. 1976; Deacon, J. 1978; Mitchell 1999; Wadley 2000). Unfortunately, there is little direct evidence to confirm this. Microgravette points are interpreted as arrowheads, which would make bow and arrow technology in Europe as old as c. 30 ka (Villa & Soriano 2010). Direct evidence for the use of bow and arrow technology in Europe, in the form of preserved arrow shafts, occurs later at c. 10 000 ka at the late Palaeolithic site of Stellmoor, Germany (Weinstock 2000; Villa & Soriano 2010). Organic preservation, such as that at Stellmoor, is rare and probably does not represent the earliest example of bow and arrow technology.

5.4.2 *The archaeological evidence for spear use*

The oldest direct evidence for spear technologies comes from Shöningen in Germany with an associated age of c. 400 – 300 ka (Thieme 1997). The six wooden spears discovered at Shöningen are associated with the remains of at least 19 butchered horses, suggesting that they were probably hunting weapons (Thieme 1997). However, the Shoningen spear tips were of wood, that had been burnt to harden it, and not stone. There is some evidence to suggest that these were thrusting spears, not throwing spears, although they could have served both functions (see Shea 2006). Very little secure direct evidence for spear technologies exists apart from the Shöningen materials (but see Movius 1950). It is commonly assumed that some of the retouched points in the MSA and

Mousterian were hafted and used as spears (Henshilwood 2004; Lombard *et al.* 2004; Mussi & Villa 2008; Shea 2009; Sisk & Shea 2009; Villa *et al.* 2009; but see Plisson & Beyries 1998) (refer to Section 5.2.3). The ability to haft stone artefacts onto wooden shafts and use them as low-velocity weapons (e.g. spears) may, therefore, have been present in Africa, the Middle East and Europe by 200 ka (Wynn 2009).

Some of the HP backed artefacts and Still Bay bifacial points represent early versions of spear tips in southern Africa (Lombard 2007a; Lombard & Pargeter 2008). Wadley and Mohapi (2008) use a modified version of the TCSA calculation (refer to Section 8.3.2) to show that Sibudu Cave HP segments, manufactured from dolerite at c. > 60 ka, fall within the morphometric range of spear tips if they were hafted back-to-back. Mohapi (2005) suggests that the morphology of the thick and broad post-HP points from Rose Cottage Cave (< 50 ka) makes them suitable for use as hunting spear tips (also see Lombard 2005b). Robberg bladelets (c. 18 – 12 ka) may have been used as components in spears (Deacon, H. J. 1983; Mitchell 1988, 2000 but see Wadley 1996). It is possible that bladelets were sometimes hafted along the lateral edges of organic spear shafts to increase the effectiveness and penetrative abilities of these weapons (Nuzhnyi 2000).

5.4.3 *Summary*

Bow and arrow technology may have first appeared in the African late Pleistocene MSA, but the oldest direct evidence for this technology comes from Stellmoor in Europe. The oldest direct evidence for spear use comes from Shoningen in Germany. Currently there is strong evidence to suggest that African MSA artefacts were also used as spear tips. Contextual evidence at present suggests that bladelets, backed artefacts and convergent pieces of the HP, Robberg and Wilton industries were possibly used as the tips of these weapon types.

5.5 Chapter summary

Among other functions, it is possible that bladelets, backed artefacts and convergent pieces may have been used as components in hunting weapons. Exactly which type of weapons is not clear at present. The morphological variability and functional flexibility of these three artefact types would have made them useful components in both mechanically assisted and non-mechanically assisted hunting weaponry. Contextual evidence at present suggests that low- and high-velocity weapons may have been present during the HP, Robberg and Wilton industries in association with both large and small game hunting. The continued macrofracture and morphometric analysis of these artefact types is therefore needed.

CHAPTER 6: BACKGROUND TO ARCHAEOLOGICAL SITES AND SAMPLES

6.1 Introduction

In this Chapter I provide background to three southern Cape coastal sites used in this study: Nelson Bay Cave (NBC), Byneskranskop 1 (BNK 1) and Blombosfontein Nature Reserve site 4 (BBF 4). Stone artefact assemblages from these sites were examined for macrofractures, and the sites are shown in Figure 6.1.

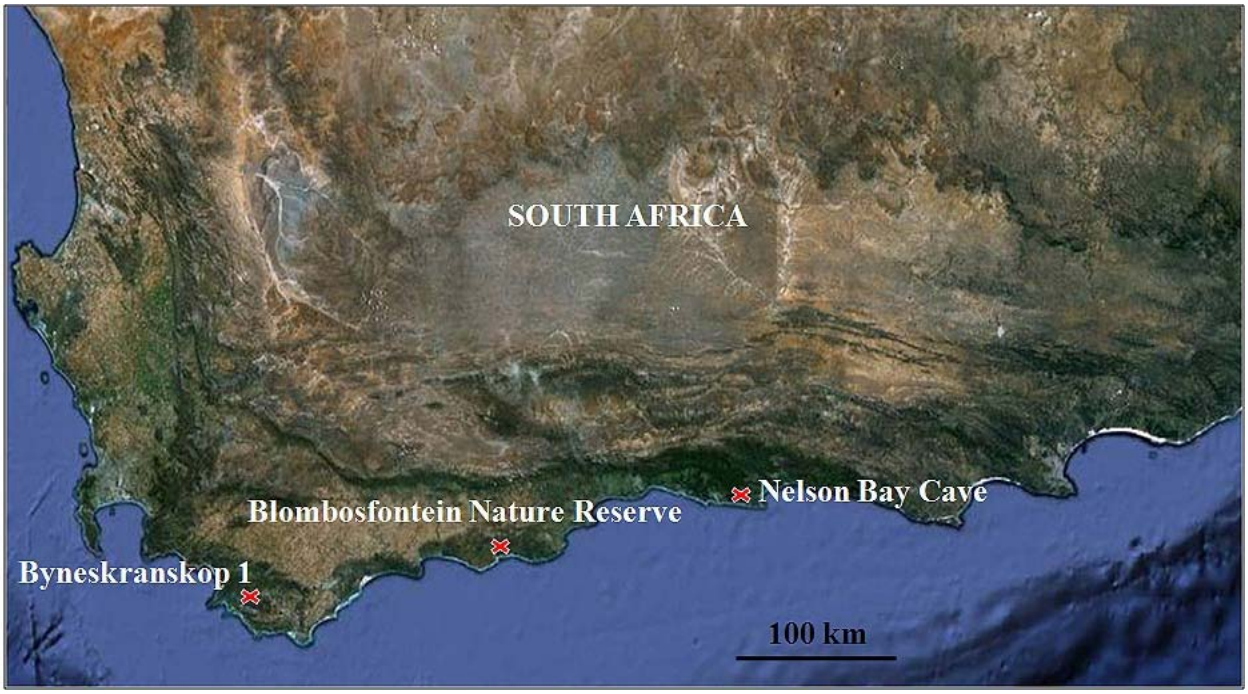


Figure 6.1: Distribution map showing location of Cape coastal sites in this study *(Map of southern Cape coast, retrieved and modified on Aug 13, 2010 from www.googlemaps.com)*

6.2 Background to Nelson Bay Cave

Nelson Bay Cave is situated on the Robberg Peninsula near Plettenberg Bay about 550 km east of Cape Town. It is one of approximately 20 Stone Age occupation sites in the area (Deacon, J. & Brett 1993). The cave is composed mainly of brecciated and quartzitic composite sediments and has a floor roughly 18 – 22 m

wide and 32 – 36 m long (Klein 1972a; Butzer 1973) (see Figure 6.2). The site has an archaeological sequence that contains HP as well as Robberg, Oakhurst and Wilton assemblages. The LSA occupations at the site occur largely after the Last Glacial Maximum, after c. 12 ka (Klein 1983). Sediments with Robberg type artefacts are dated to c. 16 – 18 ka at the site. The concern of this project and the focus of this discussion is that of occupation layers excavated by Richard Klein in 1970/71, dating to between 16 – 18 ka (Robberg) and 5 – 6 ka (Wilton).

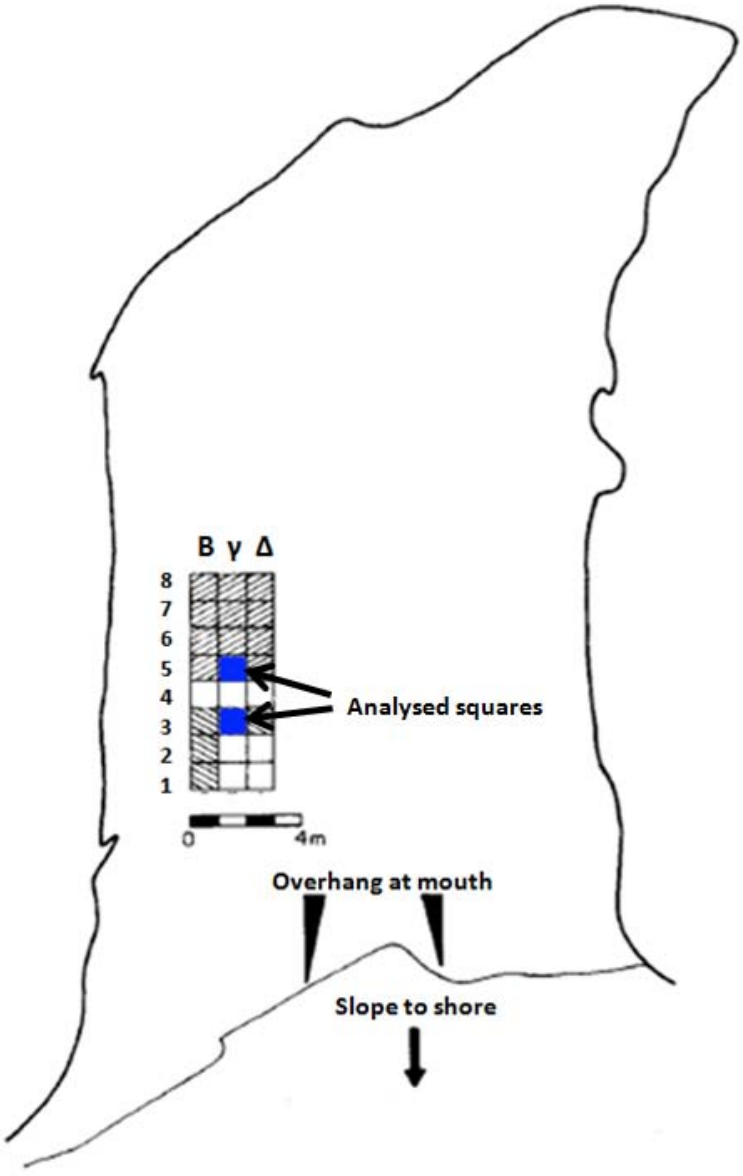


Figure 6.2: Floor plan for Nelson Bay Cave showing excavation grid and analysed squares
(Adapted from Klein 1972a, Fig. 1: 179)

The history of controlled excavation at NBC extends back to 1965, when Ray Inskeep began excavations of the Holocene layers at the site (Inskeep 1965; Deacon, J. 1978). Between 1970 and 1971, Richard Klein conducted penetrating vertical excavations of the earlier layers that were revealed in Inskeep's test excavations (Klein 1972a). Klein's excavations focused on the occupation layers dating to between c. 5 – 125 ka that lay below the surface shell-middens that Inskeep had excavated in 1971 (Klein 1972a). A total area of 30 m^2 was excavated at the site, 1.5 m^2 of which was taken to bedrock. This excavated material was first passed through a 12 mm sieve with 3 mm and 6 mm screens below (Klein 1972a). Klein divided the complex sediments at the site into stratigraphic layers by differentiating strata according to disjunctions in material in the shell-midden strata (layers 1 – 11) and soil colours and textures in the loamy soil strata (layers 12 – 18) (Klein 1972a). These layers were later consolidated into 18 units above the MSA by Janette Deacon (1978).

The LSA deposits relevant to this study can be grouped into the following cultural phases (Deacon, J. 1978) (see Table 6.1):

1. Units IC, BSC and RA (layers 1 – 9) (Wilton): These units represent various middens and brown humic soils that accumulated between c. 5 and 6 ka.
2. Units BSL, YSL and YGL (layers 15 – 18) (Robberg): These represent yellow loamy soils, which contain no shell remains. These units were deposited between c. 10 and 18 ka.

Table 6.1: Overview of Nelson Bay Cave archaeological layers and units relevant to this study *(Source: Vogel 1970; Klein 1972a; Fairhall & Young 1973; Fairhall et al. 1976; Inskeep & Vogel 1985)*

Layer number	Unit	Date	Cultural designation	Dominant rock types used	Deposit type
1 – 3	IC	4.86 ± 6.5 ka	Wilton		
4 – 8	BSC	6.05 ± 80 - 5.82 ± 150 ka	Wilton	Quartzite (cobbles), quartz, chalcedony	Midden deposits
9	RA	6.07 ± 125 ka	Wilton		
15	BSL	10.6 ± 150 ka	Oakhurst (Albany)/Robberg		
16	YSL	16.7 ± 240 ka	Robberg	Silcrete, crystal quartz, chalcedony	Loamy deposits
18	YGL	18.1 ± 550 ka	Robberg		

Layers 1 - 9 (units IC, BSC and RA) were assigned to the Wilton industry based on the presence of microlithic scrapers of varying sizes and backed artefact forms including segments (Deacon, J. 1978). Although small numbers of segments are recorded from Klein's layers 14 (GSL) and 15 (BSL), they only form a significant part of the site's artefact assemblages from layer 8 (BSC), with the highest frequencies occurring in layers 1 - 3 (IC) (Deacon, J. 1978). The diversity of formal tools increases in layer 8 and the layers above (Deacon, J. 1978).

Units 15 - 18 (BSL, YSL and YGL) contained an unrecognisable (at the time) lithic component, which later became the type assemblage for the Robberg industry (Deacon, J. 1978). The frequencies of bladelet cores are highest in these layers reflecting the Robberg's emphasis on bladelet production, yet only three retouched bladelets have been found in the Robberg layers (Deacon, J. 1978). During this study, my searches at Iziko SA Museum through the other lithic bags from the site, revealed many more unretouched bladelet pieces. Layer BSL is considered a transitional Robberg/Albany assemblage, and is included in this analysis.

6.2.1 *Samples selected for the macrofracture analysis*

Bladelets, backed artefacts and convergent pieces from the Gamma 3 and Gamma 5 squares of the Klein 1970/71 excavations were selected for macrofracture analysis (see Table 6.2). These squares were chosen because they are in the same

excavation line in the site grid and have sufficiently large samples. Both squares have section drawings published in Klein (1972a) and both form part of the Deacon, J. (1978) analysis at the site. All pieces, broken and whole were examined for macrofractures and pieces were sourced from all the lithic categories and not just those considered to be retouched (see Lombard 2005a and Odell 1988 for rationale). Artefacts from the site are divided into three main categories: waste, utilised pieces and formal tools (Deacon, J. 1978). All of the above categories were considered when sourcing pieces for this study, not just the formal tools. One reason for this is that at the time of Janette Deacon's (1978) analysis, unretouched bladelet pieces were designated to the waste category, and the published number of bladelets was therefore not a true reflection of the total bladelet assemblage at the site (Schweitzer & Wilson 1982: 133).

Table 6.2: Summary of Nelson Bay Cave materials examined for macrofractures, provenience details and tool types

Layer	Square		Tool Types				
	Gamma 3	Gamma 5	Bladelet	Convergent	Backed	Segment	Blade
1 (IC)	6	0	6	0	0	0	0
2 (IC)	1	0	1	0	0	0	0
3 (IC)	0	49	28	7	5	9	0
4 (BSC)	52	0	11	37	2	0	2
5 (BSC)	0	130	52	62	15	1	0
6 (BSC)	9	0	4	4	1	0	0
7 (BSC)	3	0	0	0	2	0	1
8 (BSC)	32	0	0	0	32	0	0
9 (RA)	13	0	0	0	13	0	0
15 (BSL)	7	0	3	2	2	0	0
16 (YSL)	28	72	63	17	20	0	0
18 (YGL)	116	5	82	14	25	0	0
TOTAL	**267**	**256**	**250**	**143**	**117**	**10**	**3**

6.2.2 *Faunal remains from Nelson Bay Cave*

The faunal assemblage from NBC is quite fragmented and largely anthropogenic in origin. These remains are therefore indicators of human subsistence practices, technologies and gross climate change during the Robberg and Wilton phases at the site.

Klein relates changes in this faunal component to changes in the coastline during the post 18 ka phase (Klein 1972a, b; also see Dingle & Rodgers 1969 and Deacon, J. 1978) (see Figure 6.3). The Wilton layers at the site are composed mainly of smaller bovids and other small terrestrial food packages (Klein 1972a; Klein & Cruz-Uribe 1983). The faunal assemblages from Rose Cottage Cave and Jubilee shelter mirror this trend during the Wilton phase (Wadley 1986, 2000). The emphasis on smaller mammals in the Wilton layers at NBC could be a reflection of environmental changes in the Cape Ecozone and the extinction of Late Pleistocene 'giant' fauna. They could also reflect changes and developments in LSA Wilton hunting technologies and tool kits (Klein 1981; Avery 1982; Deacon, J. & Lancaster 1988) (refer to Section 12.4.2). The post 10 ka (layer BSL) increases in faunal diversity at NBC coincide with the advent of the warmer interglacial Holocene time phase and the beginning of modern climatic regimes in the Cape (Deacon, J. & Lancaster 1988).

Table 6.3: Fauna list for the Robberg and Wilton units at Nelson Bay Cave expressed as minimum number of individuals (MNI). *Faunal data for units RA and RB are published as a combined total and are included here as such even though unit RB lies outside of the scope of this study (Source: Klein 1972a; Deacon, J. 1978, 1984)*

			Units (Layers)					
	Wilton	**Robberg**	**IC (1 – 3)**	**BSC (4 – 8)**	**RA+RB (9,10)**	**BSL (15)**	**YSL (16)**	**YGL (18)**
Blesbok/bontebok *(Damaliscus pygargus/dorcas)*	0	30	0	0	0	5	20	5
Blue antelope *(Hippotragus leucophaeus)*	7	25	2	3	2	9	7	9
Blue duiker *(Philantomba monticola*)	1?	0	1?	0	0	0	0	0
Bushbuck *(Tragelaphus scriptus*)	14	0	4	4	6	0	0	0
Bushpig *(Potamochoerus larvatus*)	8	5	3	3	2	2	2	1
African buffalo *(Syncerus caffer)*	16	20	4	9	3	7	6	7
Cape grey mongoose *(Galerella pulverulenta*)	5	2	1	2	2	0	2	0
Cape hare *(Lepus cf saxatilis*)	0	3	0	0	0	1	1	1
Eland *(Tragelaphus oryx*)	0	14	0	0	0	4	4	6
Cape fur seal *(Arctocephalus pusillus)*	101	1?	38	27	36	0	0	1?
Chacma baboon *(Papio hamadryas*)	17	5	1	3	13	2	2	1
Clawless otter *(Aonyx capensis*)	1	0	0	1	0	0	0	0
Dolphin *(Delphinidae)*	9	1	4	4	1	0	1	0
Egyptian mongoose *(Herpestes ichneumon*)	5	2	0	3	2	0	2	0
Gazelle *(Gazella)*	0	1	0	0	0	0	1	0
Giant alcelphaline	0	2	0	0	0	0	2	0
Giant buffalo *(Pelorovis antiques*)	0	15	0	0	0	5	6	4
Grimm's duiker *(Sylvicapra grimmia*)	3	0	1	1	1	0	0	0
Hare *(Lepus*)	0	2	0	0	0	1	0	1
Hartebeest *(Alcelaphus buselaphus*)	0	4	0	0	0	2	1	1
Mongoose *(Herpestes sp)*	*2*	*0*	2	0	0	0	0	0
Hippopotamus *(Hippopotamus*)	8	0	2	1	5	0	0	0
Honey badger *(Mellivora capensis*)	1?	0	0	0	1?	0	0	0
Jackal *(Canis*)	1	1	0	0	1	0	1	0
Klipspringer *(Oreotragus oreotragus,*)	0	5	0	0	0	0	1	4
Mountain reedbuck *(Redunca fulvorufula*)	2	5	0	1	1	3	2	0
Pangolin *(Manis*)	0	1	0	0	0	0	0	1
Porcupine *(Hystrix africaeaustralis*)	6	0	1	3	2	0	0	0
Quagga *(Equus quagga quagga*)	0	3	0	0	0	0	2	1
Roan *(Hippotragus equinus*)	0	4	0	0	0	3	1	0
Rock hyrax *(Procavia capensis*)	74	44	20	27	27	5	25	14
Sea elephant *(Mirounga leonina*)	3	0	1	1	1	0	0	0
Small carnivore	2	2?	2	0	0	0	1?	1?
Southern reedbuck *(Redunca arundinum*)	0	9	0	0	0	9	0	0
Springbok *(Antidorcas marsupialis*)	0	11	0	0	0	3	7	1
Steenbok/grysbok (Raphicerus campestris/melanotis)	63	11	27	17	19	2	4	5
Vaal rhebok (Pelea capreolus)	6	11	5	1	0	3	7	1
Warthog (Pelea capreolus)	0	2	0	0	0	0	2	0
Water mongoose (Atilax paludinosus)	5	0	2	3	0	0	0	0
Wildebeest (Connochaetes taurinus)	0	9	0	0	0	2	5	2
TOTAL	358	247	120	114	124	68	114	65

During the Robberg phase at NBC, the coast was 80 km south of its current position whereas during the Wilton phase the ocean was considerably closer (Deacon, J. 1978). This is reflected in the absence of shellfish remains and marine mammals in the Robberg deposits and the increase in such resources after c. 8 ka at the site (refer to Section 6.2.3). Overall the number of individual animals being brought back to the site during the Robberg phase is less than during the Wilton (see Table 6.6). The predominance of larger grazers in the Robberg layers indicates the presence of grassland vegetation and cooler conditions in the surrounding area (Deacon, J. 1978). This is a general feature of other late Pleistocene LSA sites (Deacon, H. J. 1976; Wadley 2000). The phase between c. 16 and 10 ka is also known to have been markedly wetter and cooler than the subsequent Holocene phase. This would have induced generally lower sea levels and a more open vegetative regime (Deacon, J. & Lancaster 1988).

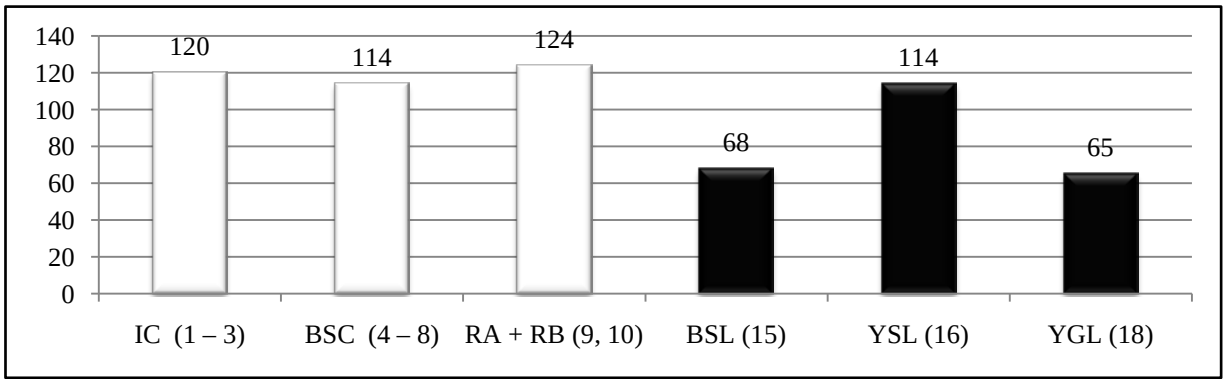


Figure 6.3: Faunal changes in the various Wilton and Robberg layers at Nelson Bay Cave expressed as minimum number of individuals *(Specific layer-by-layer data are not available for NBC as such the data are grouped together into units here. White columns represent Wilton units, black columns indicate Robberg units)*

6.2.3 *Shell remains and marine resources at Nelson Bay Cave*

The aquatic resources from NBC provide some insight into the non-terrestrial subsistence sources that were used by the inhabitants of the cave. This is useful as it provides a window onto the broader food packages available at the time and other potential functions to which stone artefacts could have been put. The shellfish remains from NBC have not yet been analysed on a layer-by-layer basis, this makes anything more than generalised comments and comparisons difficult.

The mid-Holocene layers at NBC reflect a shift in resource exploitation towards a greater variety of marine resources and less terrestrial animals (Inskeep 1987; Henshilwood 2008). As at BNK 1 (refer to Section 6.3.3), the Robberg layers are largely devoid of shellfish remains and other marine resources. These trends in marine resource harvesting are likely to reflect cultural adaptations by the site's inhabitants to climate and sea level changes relative to the site during the warmer interglacial Holocene (Klein 1972b; also see Henshilwood 2008).

A shift from cold water black (*Choromytilus meridionalis*) to warm water brown (*Perna perna*) mussel procurement after 10 ka suggests that gross climate and shoreline changes affected marine resource exploitation after the Robberg phase at NBC (Klein 1972b; Henshilwood 2008). This date is commonly accepted as the interchange between the terminal Pleistocene and early Holocene with generally warmer interglacial temperatures (Klein 1972b). The discovery of possible stone sinkers at the site is further testament to the mid-late Holocene emphasis on marine resources at NBC (Klein 1974).

Janette Deacon (1978) states that the increased use of marine resources on the coast during the Holocene would have supplemented a diet rich in plant resources further inland as a seasonal transhumance pattern emerged. Increased abilities to harvest marine resources during the Holocene could have resulted in an increase in population sizes along the Cape coast reflected in a greater number of archaeological sites at this time (Klein 2001). Nelson Bay Cave may have been occupied between August and October (summer months) during parts of the post 12 ka period (Klein 2001). This is based on the young age profile of the Cape fur seal bones, which occur in high numbers in unit IC (layers 1 – 3), indicating the harvesting of young seals born during the spring months (Klein 1972a).

6.2.4 *Summary*

Nelson Bay Cave contains a long sequence of well-dated and intermittent human occupations that include MSA, Robberg, Oakhurst and Wilton assemblages. The Robberg and Wilton layers are the focus of this work, and in particular the

bladelets, backed artefacts and convergent pieces from these layers. The faunal assemblages from the site reflect shifting climate and sea levels in the area over time and show clear changes between the Robberg and Wilton phases. It remains to be seen if the macrofracture frequencies from the site mirror these changes.

6.3 Background to Byneskranskop 1

Byneskranskop 1 is one of three inland cave sites situated on a limestone ridge between the coastal plain and the Cape Fold Belt Mountains c. 160 km east-south-east of Cape Town. The nearby Uilenkraals River provides a permanent source of water and a useful route between the surrounding mountains and the sea (Schweitzer & Wilson 1982). The site has a long sequence of human activity spanning the terminal Pleistocene into the Holocene. These layers contain Robberg, Oakhurst and Wilton industries. I selected materials from Layers 2 – 9 (Wilton) and 18 and 19 (Robberg) for examination and these layers will be focused on in the following section.

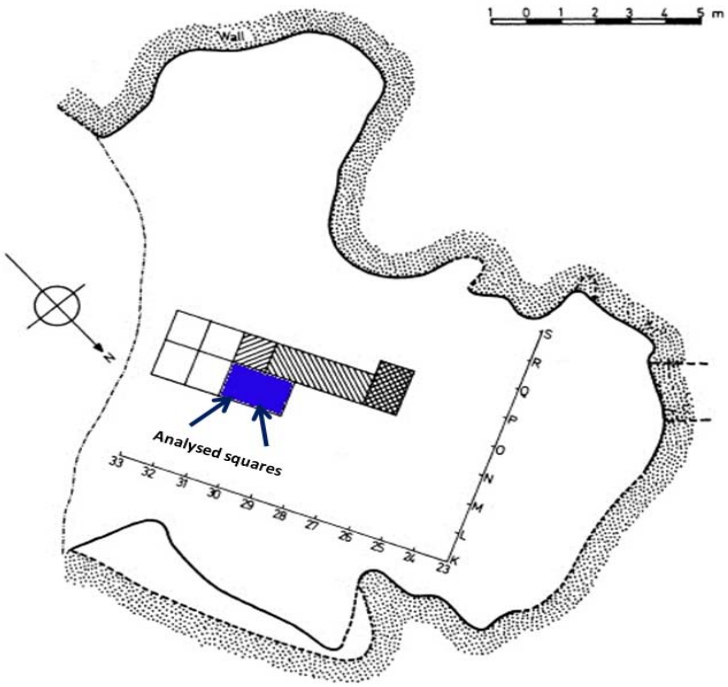


Figure 6.4: Floor plan for Byneskranskop 1 showing excavation grid and squares chosen for analysis *(Adapted from Schweitzer & Wilson 1978, Fig. 2: 138)*

Frank Schweitzer directed excavations at the site between 1973 and 1976. A grid of 1 x 1 m squares was laid out over a portion of the site, from which squares 0 29 and O 30 were chosen for analysis in this study. All excavated material was sieved over 13 mm and 3 mm grid sieves. Although the sediments consisted largely of undifferentiated fine dark grey soil, they revealed a relatively long LSA sequence of 19 layers with materials dated to between c. 13 ka and 250 years ago. Occupations at the site appear to have been more frequent and intensive from layers 12 and younger (c. 7700 ka) (Schweitzer & Wilson 1982). Layers 7 – 9 in the BNK 1 stratigraphy are most comparable, in terms of age, to the Wilton component from NBC excavated by Klein (1972a) and analysed by Janette Deacon (1978).

Human occupation at the site is divided into four phases reflecting changes in artefact frequencies, resources, environmental contexts, raw material frequencies and apparent occupation densities (Schweitzer & Wilson 1978) (see Table 6.4). Artefact changes take place throughout the sequence at BNK 1, with marked differences between artefacts found in the uppermost and lowermost layers and phases (Schweitzer & Wilson 1982). Phases 1 and 3/4 are roughly equated with the Robberg and Wilton and are the focus of this work. Phase 2 corresponds to the Oakhurst industry at the site.

Phase 1 contains unmodified and utilised bladelets and bladelet cores with few backed pieces (Schweitzer & Wilson 1982). Phases 3 and 4 show an increase in the frequency of backed pieces, modified tools and adzes. An increase in adzes over scrapers in these layers could spell a greater role for woodworking, and perhaps the processing and preparation of more hunting weapon shafts during this time (Schweitzer & Wilson 1982). The absence of usewear analysis on these pieces makes it difficult to say for certain whether this was the case. Quartz is overall the most common raw material in both Wilton and Robberg phases, but silcrete is used more commonly for retouched artefacts in both phases (Schweitzer & Wilson 1982).

Table 6.4: Outline of the principle components from the Wilton and Robberg phases at Byneskranskop 1 *(Source: Schweitzer & Wilson 1982)*

	Phase 3/4	**Phase 1**
Ages	6.1 - 0.255 ka	12.7 ± 185 ka
Cultural designation	Wilton	Robberg
Layers	2 - 9	18 - 19
Environmental information	Warmer climate Grassy flats, more barren hills and open/scrub vegetation	Cool climate Extensive scrub and barren hills
Occupation density	High	Medium - high
Rock types	Quartz (layer 4)/Silcrete (layer 3) most common	Quartz most common
Material culture	High frequency of backed and retouched artefacts, especially adzes (layer 4) Higher frequency of unmodified blades (layer 3) Higher frequency of bone and shell ornaments Frequent bone artefacts	Unmodified, utilised bladelets and bladelet cores frequent (more in layer 18 than 19) Higher frequency of artefacts than layers above Fewer backed pieces Very few bone tools

6.3.1 *Samples selected for the macrofracture analysis*

Samples for macrofracture analysis were taken from the Robberg and Wilton layers in squares 029/30 of the 1974/76 excavations (see Table 6.5). These squares were chosen as they were both excavated in the 1976 field season when the stratigraphy of the site was better understood than in 1974 (Schweitzer & Wilson 1982). These two squares were excavated to bedrock, which allowed for a study and comparison of the Wilton and Robberg artefacts. A total of 166 000 stone artefacts were recovered from the 1974/76 excavations. These were sorted into unmodified pieces (waste), which constitute 97, 4 % of the total assemblage, modified pieces (including utilized) constituting 0, 8 %, and formal tools comprising 1, 8 % of the total (Schweitzer & Wilson 1982). All of these categories were considered when sourcing pieces for macrofracture analysis.

The rock types used by the site's inhabitants were mainly quartz and silcrete, but quartzite, limestone and shale are also present. Silcrete is the main raw material used for the manufacture of formal tools in the Wilton and Robberg layers (Schweitzer & Wilson 1982). Prior to this study, the stone artefacts from the site had not been subject to any further study beyond that which was conducted by Schweitzer and Wilson (1982). Numerous backed pieces, retaining traces of mastic, were noted during the analysis, suggesting the presence of hafted backed implements at the site (also see Schweitzer & Wilson 1982: 55). These pieces were not examined for macrofractures aso as to prevent them from contamination and to preserve them for future residue analysis.

Table 6.5: Summary of Byneskranskop 1 materials examined for macrofractures, provenience details and tool types

Layer	Square		Tool Types					
	0 29	**0 30**	**Bladelet**	**Convergent**	**Backed**	**Segment**	**Blade**	**Other**
2	2	2	3	0	0	1	0	0
3	6	1	2	1	1	3	0	0
4	16	11	5	4	7	11	0	0
5	34	20	10	12	12	16	0	4
6	16	22	7	6	4	21	0	0
7	16	16	6	3	4	19	0	0
8	5	13	0	0	7	11	0	0
9	18	15	0	2	5	26	0	0
18	23	7	14	6	10	0	0	0
19	111	211	204	64	49	0	0	5
TOTAL	**247**	**318**	**251**	**98**	**99**	**108**	**0**	**9**

6.3.2 *Faunal remains at Byneskranskop 1*

The BNK 1 faunal assemblage is mostly derived from the refuse of human activities (Schweitzer & Wilson 1982). Almost 75 % of the faunal materials from the site were excavated from layers 1 – 9, but this number is relative to the higher excavated volumes in the upper deposits at the site and is skewed by the large sample from layer 5 (see Table 6.6 and Figure 6.6). Layers 18 and 19 appear to have much smaller faunal components, but this is distorted by a small sample from layer 18 and larger sample from layer 19 (see Figure 6.6). Smaller Juveniles make up roughly 20 % of the faunal assemblage at the site. Smaller animals are represented in the deposits by more complete ranges of skeletal elements and

often identification was only possible to the level of genus or family (Schweitzer & Wilson 1982).

Although the faunal assemblage from BNK 1 is not very large, it does show some interesting shifts through time. In general, the shift from uppermost to lowermost layers is from smaller to larger food packages (Schweitzer & Wilson 1982). This change is not reflected in the Robberg layers where medium - large mammals dominate. In layers 9 and above the trend is towards browsers and mixed feeders, whilst in layers 10 and below the fauna tends to be composed of large grazing ungulate species (Klein & Cruz-Uribe 1983) (see Table 6.6). This is a trend mirrored in other southern Cape sites at roughly the same time and reflects a general change towards warmer climates and more bushveld, forest and scrub type vegetation (Klein & Cruz-Uribe 1983; Henshilwood 2008). In the Wilton layers, smaller mammals are much more common, reaching a peak of 53.5 % in layer 4 (Schweitzer & Wilson 1982) (see Table 6.6). This reflects a general decline in the size of the relative meat packages being brought back to the site during the Wilton time phase.

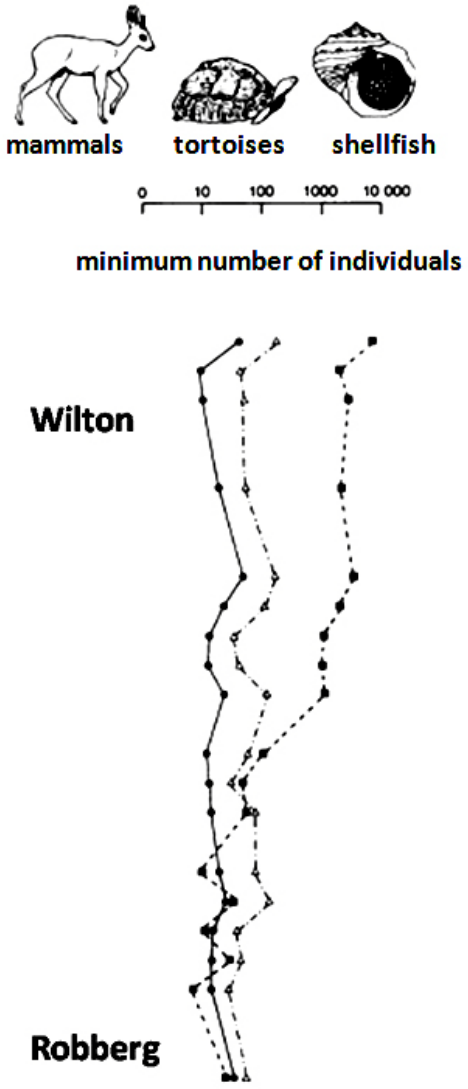


Figure 6.5: Mammalian, tortoise and shellfish changes between the Robberg and Wilton phases at Byneskranskop 1 expressed as minimum number of individuals *(Adapted from Klein & Cruz-Uribe 1983, Fig. 2: 27)*

Analyses of the angulate tortoise distal humeri indicates that the people living at BNK 1 after 6 ka (Wilton) were processing smaller tortoises than the pre-6 ka inhabitants (Klein & Cruz-Uribe 1983). They use this pattern to suggest an increase in human populations on the southern Cape coast during the mid - late Holocene. Increased human populations would have put increased pressure on tortoise populations which in turn would have caused a general reduction in population sizes (Klein & Cruz-Uribe 1983). This conclusion may be supported by a general increase and diversification of mammalian fauna and marine resources consumed during the post 6 ka phase at BNK 1 (see Figure 6.5).

Table 6.6: Mammalian fauna list from the Robberg and Wilton layers at Byneskranskop 1 expressed as minimum number of individuals (MNI) *(Source: Schweitzer & Wilson 1982)*

			Layers									
	Wilton	**Robberg**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**18**	**19**
African buffalo *(Syncerus caffer)*	23	5	1	2	0	4	3	3	3	7	1	4
African bush elephant *(Loxodonta cyclotis*)	2	0	0	0	1	1	0	0	0	0	0	0
Black backed jackal *(Canis mesomelas*)	4	0	0	1	1	1	1	0	0	0	0	0
Bontebok *(Damaliscus dorcas)*	0	1	0	0	0	0	0	0	0	0	0	1
Brown fur seal *(Arctocephalus pusillus*)	6	0	0	0	1	1	2	1	1	0	0	0
Cape dune mole rat (*Bathyergus suillus)*	105	12	6	5	19	49	12	5	4	5	0	12
Cape grey mongoose *(Galerella pulverulenta*)	5	0	0	0	1	2	1	1	0	0	0	0
Cape grysbok *(Raphicerus malanotis*)	26	0	2	0	3	16	4	1	0	0	0	0
Caracal *(Caracal caracal*)	4	0	0	0	1	1	1	0	0	1	0	0
Chacma baboon *(Papio hamadryas*)	5	0	0	0	1	1	1	1	0	1	0	0
Clawless otter *(Aonyx capensis*)	1	0	0	0	0	1	0	0	0	0	0	0
Egyptian mongoose *(Herpestes ichneumon*)	2	0	0	0	1	1	0	0	0	0	0	0
Extinct Cape zebra	0	1	0	0	0	0	0	0	0	0	0	1
Grey rhebok *(Pelea capreolus*)	3	0	0	0	1	0	1	0	1	0	0	0
Grysbok/steenbok *(Raphicerus sp)*	66	2	4	4	8	25	9	6	5	5	0	2
Hartebeest *(Alcelaphus buselaphus*)	5	6	1	0	0	2	0	1		1	2	4
Klipspringer *(Oreotragus oreotragus*)	4	2	0	0	0	3	0	0	0	1	0	2
Large bovids	27	7	1	2	2	4	3	5	3	7	1	6
Large medium bovids	13	12	1	1	1	4	2	1	1	2	2	10
Oryx *(Oryx gazelle*)	2	2	0	0	0	0	0	2	0	0	0	2
Quagga *(Equus quagga quagga*)	1	2	0	0	0	0	0	0	0	1	0	2
Rabbit/hare *(Leporidae spp*)	4	2	1	0	0	0	0	0	1	2	1	1
Rhinoceros *(Ceratotherium)*	4	1	0	0	1	1	1	1	0	0	0	1
Roan, bluebuck, sable *(Hippotragus spp)*	5	4	0	0	1	2	0	0	1	1	0	4
Rock hyrax *(Procavia capensis*)	6	3	0	0	1	1	1	1	1	1	1	2
Small bovids	71	5	4	4	9	28	9	6	5	6	1	4
Small medium bovids	9	2	1	1	1	1	1	1	1	2	0	2
Southern reedbuck *(Redunca arundinum*)	1	1	0	0	0	0	1	0	0	0	0	1
Steenbok *(Raphicerus campestris*)	4	0	0	0	1	2	1	0	0	0	0	0
Striped polecat *(Ictonyx striatus*)	1	0	0	0	0	1	0	0	0	0	0	0
Wildcat *(Felis silvestris*)	4	0	1	0	1	1	1	0	0	0	0	0
TOTAL	**413**	**70**	**23**	**20**	**56**	**153**	**55**	**36**	**27**	**43**	**9**	**61**

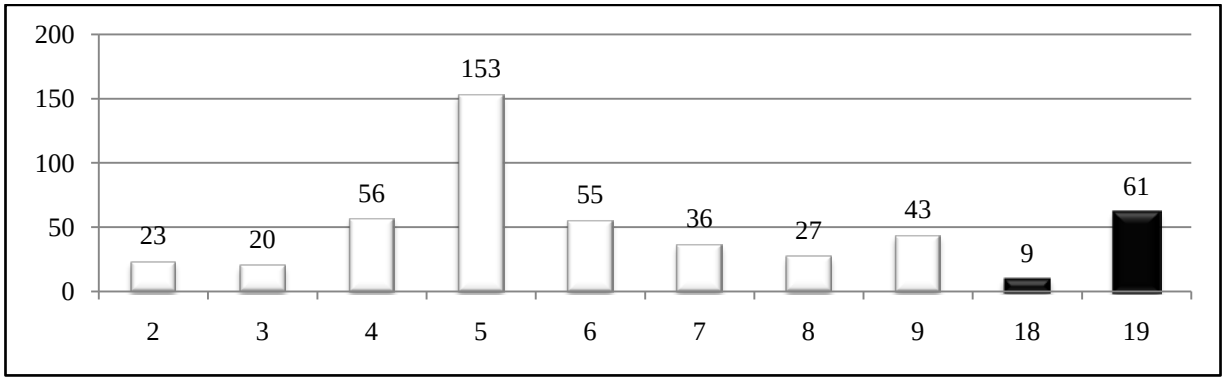


Figure 6.6: Faunal changes in the Wilton and Robberg layers at Byneskranskop 1 expressed as minimum number of individuals. (*White columns represent Wilton layers, black columns indicate Robberg layers)*

6.3.3 *Shellfish and fish remains at Byneskranskop 1*

Similar shifts in frequencies observed in the mammal remains from BNK 1 are seen in the shellfish and fish remains from the site. Layer 3 (a shell midden) has the highest frequencies of shellfish and layers 1 – 9 in general contain 98.6 % of the site total, whilst layers 10 – 19 contain only 1.3 % of the total shellfish and fish remains from the site (see Table 6.7) (Schweitzer & Wilson 1982). This increase in the site's shellfish and fish quantities (at c. 6000 ka) coincides with decreases in the mammalian meat masses being brought back to the site. The shellfish species collected in the lower layers of the site consist mainly of surf clams (*Donax serra*) as opposed to South African turban and pink-lipped top shell (*Turbo sarmaticus* and *Diloma sinensis*) in the upper layers (Schweitzer & Wilson 1978: 137, 1982; Klein & Cruz-Uribe 1983).

Table 6.7: Shellfish and fish remains as per layer and cultural phase at Byneskranskop 1 represented as minimum number of individuals (MNI). (AD: average density/m^3).

			Layer									
	Wilton	**Robberg**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**18**	**19**
Shell Total	16703	25	2101	3030	2288	3563	2146	1243	1137	1195	6	19
AD/m^3	3552	13.5	3686	12120	2514	2873	2555	1535	1960	1172	9	19
Fish Total	242	1	11	7	22	105	48	21	12	16	0	1
AD/m^3	34	0.5	19	28	24	85	57	26	20	16	0	1

6.3.4 *Summary*

Byneskranskop 1 is a well-excavated and relatively long-sequence archaeological site on the Cape coast. The presence of both Robberg and Wilton assemblages, comparable to those at NBC, make it a useful site for studying changes in human subsistence strategies over time. The faunal assemblage, although somewhat smaller than that of NBC, shows shifts through time that also appear to be reflected in the shellfish and fish remains. Similar changes are seen at other Cape coastal sites at roughly the same time intervals.

6.4 Background to Blombosfontein Nature Reserve site 4

The BBF 4 site was excavated as part of a large-scale project to investigate coastal midden sites initiated by Christopher Henshilwood between 1992/3 (Henshilwood 1995, 2008) as part of his doctoral research. This site is within an area previously known as the Garcia State Forest (GSF), now known as the Blombosfontein Nature Reserve (BBF) (see Figure 6.7).

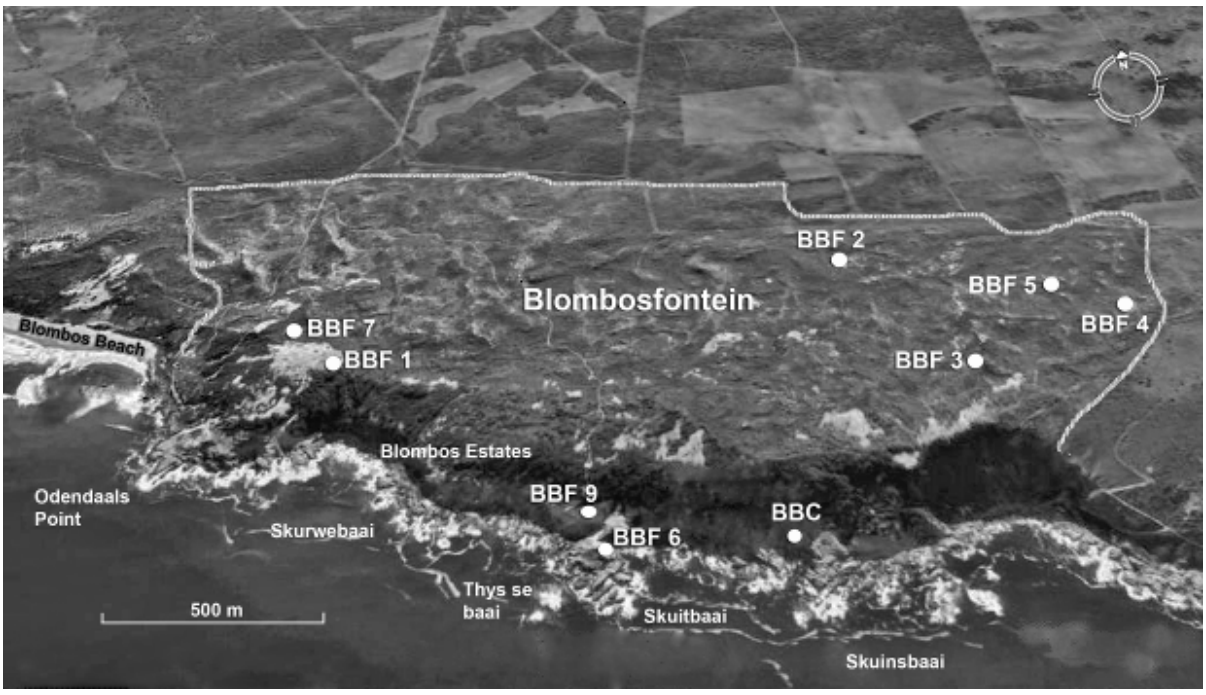


Figure 6.7: Map of the Blombosfontein Nature Reserve with excavated sites and Blombosfontein reserve site 4 at top right *(Source: Henshilwood 2008, Fig. 5.2: 62)*

The site is in a different archaeological context compared to the other two sites investigated in this study (NBC and BNK 1). Located approximately 800 m from the sea, it is potentially a single occupation (aggregation), mid-Holocene, open-air coastal midden site as opposed to the long-sequence cave sites at BNK 1 and NBC (Henshilwood 2008). The added emphasis on backed tools, especially segments and backed scrapers, at the site and the single date of c. 5.68 ka make it comparable to the earlier Wilton layers at BNK 1 and NBC. The excavations at BBF 4 focused on a 50 m^2 area within a larger 250 m^2 grid laid across the site, composed of 1 x 1 m quadrants (Henshilwood 2008). Of the 50 m^2 area, 38 m^2 in an ashy central area of the site was considered to be *in situ* (squares BD 2 – 10). The *in situ* nature of the inner deposit at the site was determined from soil sample comparisons between squares BD 51 (*in situ*) and BD 7 (talus slope). The *in situ* area showed a marked staining of quartz particles derived from their ashy organic matrix, but this staining was absent on the talus slope material (Henshilwood 2008). The remaining areas were excavated on the outer (squares EA 1 - 5 and AE 51 - 91) and inner areas of the talus slope (squares BD1 - 91) and were mainly shell dump areas (Henshilwood 2008).

The site has a relatively simple stratigraphic context, with two clearly distinguishable layers, a 5 - 10 cm thick layer containing *in situ* materials underlain by grey-black humic soils without cultural materials (Henshilwood 2008). The rest of the area around the excavation is typical white-aeolian sand dune. Recovered material was sieved through a 1.5 mm fine mesh ensuring that even small debris was recovered. The main components at the site are marine shell and stone artefacts manufactured mostly from silcrete (91 %) and quartzite.

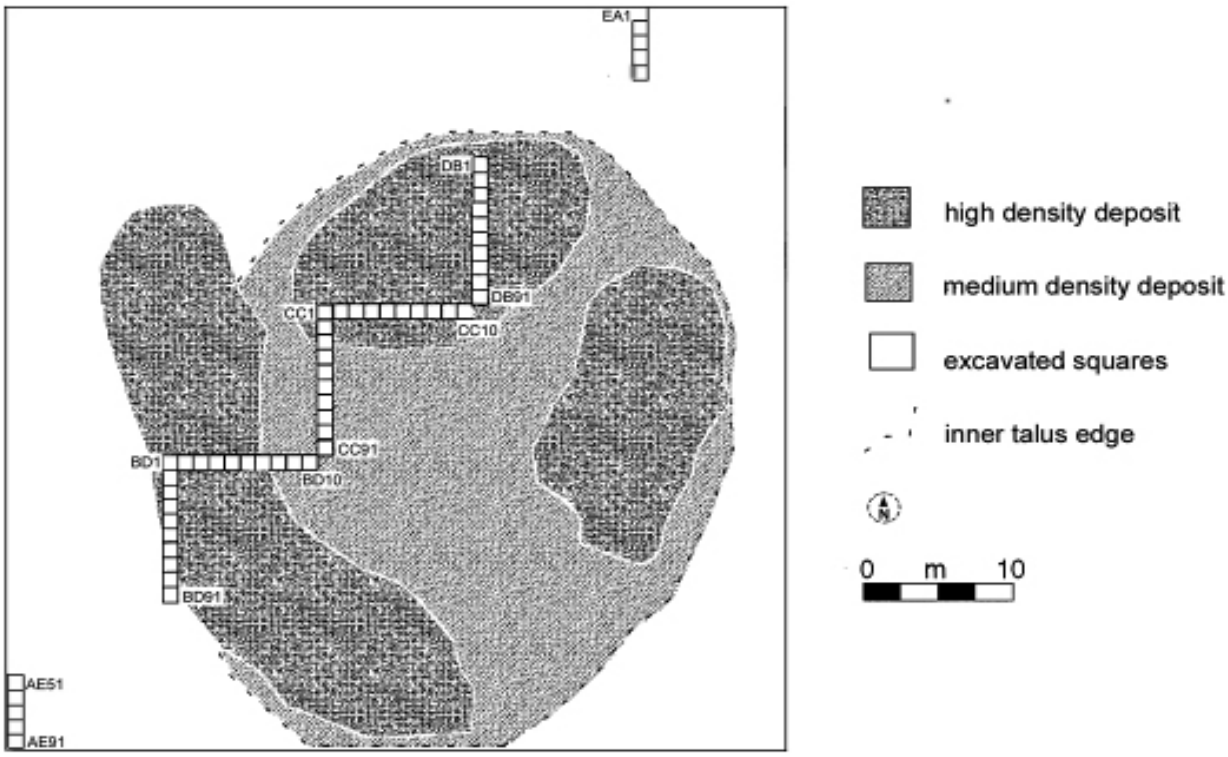


Figure 6.8: Site map and excavation grid for Blombosfontein reserve site 4
(Source: Henshilwood 2008, Fig. 5.10:72)

A single shell date from the site returned an uncalibrated C^{14} age of 5.68 ± 70 ka (Henshilwood 2008). This date makes the site broadly comparable to layer 9 (RA) at NBC (c. 6.07 ± 125 ka) and layer 9 at BNK 1 (c. 6.1 ± 140 ka). The age and numerous backed artefacts, scrapers and segments from the site make it a classic Wilton assemblage (Henshilwood 2008). Henshilwood (2008) interprets the site as a single occupation event. The overall artefact assemblage from BBF 4 is small in comparison to NBC and BNK 1. Retouched stone artefacts were divided into two distinct subclasses, namely those that show evidence of deliberate backing and those without backing. The former subclass includes scrapers, segments, flakes, bladelets and points, whilst scrapers, adzes, borers and miscellaneous retouched pieces fall in the latter group (Henshilwood 2008). The high frequency of backed artefacts, mainly backed scrapers, which account for 76 % of the retouched artefact category at BBF 4, could indicate habitual hafting of stone tools at the site (Henshilwood 2008) (refer to Section 5.2.2). However, backed blades and bladelets form only a small percentage of the BBF 4 backed

class (2.8 %) and are all in silcrete. The high number of scrapers suggests that hide working may have been a principle activity for the occupants of the site (Henshilwood 2008). These tools could also have had other functions possibly related to the processing of shellfish at the site.

6.4.1 *Samples selected for macrofracture analysis*

All of the backed artefact, bladelet and convergent pieces from the site were studied because of the small size of the BBF 4 artefact assemblage. The published formal tool component from the site could not be examined as it had been removed from the Iziko SA museum and was missing at the time of the analysis. The remaining bladelets, backed and convergent pieces were analysed for macrofractures (see Table 6.8). This sample is therefore biased towards the bladelet and convergent categories, as many of the backed pieces and segments had already been removed.

Table 6.8: Summary of Blombosfontein reserve site 4 materials examined for macrofractures, provenience details and tool types

Squares		**Tool Types**			
	Layer totals	**Bladelet**	**Convergent**	**Backed**	**Other**
CC 1 – 10	55	46	1	8	0
CC 11 – 91	41	39	0	2	0
BD 1 – 10	61	52	0	9	0
BD 11 – 91	18	14	0	3	1
DB 21 – 91	31	26	0	5	0
EA 1	5	5	0	0	0
EA 21	1	1	0	0	0
AE 71 – 91	3	3	0	0	0
TOTAL	**215**	**186**	**1**	**27**	**1**

6.4.2 *Faunal remains at Blombosfontein Nature Reserve site 4*

There is a distinct lack of well-preserved faunal material at BBF 4. Bone fragments were found scattered throughout the deposit, but none of these fragments were viable for recovery or study (Henshilwood 2008). Thus, there was likely to have been a non-marine component to the diets of the site's inhabitants, but unfortunately it is only the marine subsistence activities that can be reconstructed at the moment.

6.4.3 *Shellfish and fish remains at Blombosfontein Nature Reserve site 4*

Marine resources are the best preserved of all food remains at the BBF sites, BBF 4 is no exception in this regard (Henshilwood 2008). The shellfish component at BBF 4 is similar to other pre-2 ka sites excavated in the BBF area, with higher frequencies of South African turban shells (*Turbo sarmaticus*) relative to pink-lipped top shells (*Diloma sinensis*) (Henshilwood 2008).

The small quantities of South African turban and pink-lipped top shell at NBC hint at a difference in shellfish exploitation strategies between the two sites (Henshilwood 2008). Whereas at BNK 1, South African turban shells are also of the most common shellfish found (32 % of total shellfish) in the upper layers at the site (Schweitzer & Wilson 1982; Henshilwood 2008).

Seven South African turban shells were selected for oxygen isotopic analysis from the BBF 4 assemblage (Henshilwood 2008, but see Brune 2006 for complications with this method). The results showed that the shells most likely lived in cold, winter sea temperatures indicating that BBF 4 was likely occupied between May and October (Henshilwood 2008).

6.4.4 *Summary*

The BBF 4 site is different to both NBC and BNK 1. The large backed artefact and bladelet assemblage, as well as the silcrete emphasis, make it a potentially use-specific occupation site. The stone artefact collection from the site shows a very high number of unretouched and retouched bladelets and some backed pieces. The single date of 5.68 ± 70 ka for the site makes it comparable to the early - mid Wilton layers from BNK 1 and NBC, although these two sites are in different contexts to that of BBF 4. The site does not contain any identifiable faunal materials, but the shellfish remains are potential indicators of the seasonal occupation of BBF.

6.5 Chapter summary

In this chapter I presented the three archaeological sites and their assemblages used in this study. All three sites have Wilton assemblages whilst only NBC and BNK 1 have Robberg assemblages. The Wilton components from the three sites are comparable in time, whilst the two Robberg components have some temporal overlap although the NBC Robberg assemblage starts considerably earlier than at BNK 1. Bladelet, backed artefact and convergent pieces were selected for macrofracture analysis from the Wilton and Robberg layers in certain excavated squares at NBC and BNK 1. Both NBC and BNK 1 have large faunal components, which show similar trends in composition through time as faunal diversity and frequency increases into the Holocene. This trend is also reflected in the marine resource component of the Wilton layers from the two sites. The BBF 4 faunal component is too fragmented for analysis and comparison here. The site is most useful used as a single occupation open-air comparison to the relatively long-sequence cave sites at NBC and BNK

CHAPTER 7: EXPERIMENTAL METHODS

7.1 Introduction and aims

The primary aim of the set of experiments I present in this chapter was to assess whether macrofractures, DIFs in particular, form on unretouched stone flakes made from dolerite, milky quartz and quartzite (a.) when they are trampled by cattle or humans or (b.) during hard hammer direct percussion knapping.

The questions addressed in these experiments were as follows:

1. Do macrofractures (DIFs in particular) occur on unretouched stone flakes when trampled by humans or cattle?
2. Do DIFs form on hard hammer direct percussion knapping debris?
3. Do these fractures occur on parts of flakes that analysts would associate with hunting activities, such as tips? Would an archaeologist be able to tell that a particular flake was not a hunting weapon, but rather a flake trampled by a cow or other large mammal, or a human?
4. Do semi-circular notches form on flakes when trodden on by cattle and humans? If so, can these be distinguished from notches found on ancient and replicated hunting weapon components?
5. Is there a set of macrofractures that can be used to detect cattle or human trampling in the archaeological record?

The initial hypothesis that I aimed to address in these experiments is whether during trampling and knapping tools would be subject to different forces than those experienced during hunting situations (refer to Chapter 2). If so, would the flakes therefore not accumulate DIFs? If DIFs did occur during these experiments, then is this an example of equifinality or of the same longitudinal forces being produced during trampling as are experienced during the impact forces of hunting (see Shea & Klenck 1993: 176)? These aims and questions were evaluated in a series of cattle and human trampling experiments. The experiments were divided into two sets, one cattle and one human trampling per set, in order to compare the

results of the two sets. The knapping debris, from manufacturing the experimental flakes, were also examined for macrofractures (see Table 7.1).

7.2 Background to the trampling experiments

Previous research has shown that DIFs seldom occur through processes such as rocks rolling or being dropped on flakes/blades or during human trampling on these pieces (Fischer *et al.* 1984). Unfortunately, the exact details of these experiments were not published. To assess these claims, I introduced human and cattle trampling and knapping experiments in this project to evaluate the boundaries of macrofracture formation.

Previous human and animal trampling studies and experiments have focused on the role of trampling in: artefact displacement (Stockton 1973; Gifford-Gonzalez & Behrensmeyer 1977; Hughes & Lampert 1977; Siiriäinen 1977; Gifford-Gonzalez 1978; Wilk & Schiffer 1979; Villa 1982; Villa & Courtin 1983; Gifford-Gonzalez *et al.* 1985; Nielsen 1991; Eren *et al.* 2010), lithic modification (Bordes & Bourgon 1951: 17 in McBrearty *et al.* 1998; Bordes 1961; Tringham *et al.* 1974; Shea & Klenck 1993; McBrearty *et al*. 1998; Lopinot & Ray 2007), bone modification (Fiorillo 1984; Behrensmeyer *et al.* 1986; Olsen & Shipman 1988; Blasco *et al.* 2008; Domínguez-Rodrigo *et al.* 2009; Gaudzinski-Windheuser *et al.* 2010) and its effects on soils and vegetation (Liddle 1975; Weaver & Dale 1978).

Some of these studies have shown that human trampling can obliterate previous usewear on artefacts (Shea & Klenck 1993), can produce pseudo tools and usewear (Bordes 1961; Shea and Klenck 1993; McBrearty *et al*. 1998) and can also produce random scar patterns (Tringham *et al* 1974; Keeley 1980). Human and animal trampling has also been shown to mimic ‘cut marks’ on bone (Fiorillo 1984; Behrensmeyer *et al.* 1986; Haynes 1986; Olsen & Shipman 1988) and can create pseudo bone tools (Brain 1967; Myers *et al.* 1980). All of these studies focus on the role of either human or large mammal trampling as taphonomic

agents at archaeological and paleontological sites, but not as agents of macrofracture formation.

The human and cattle trampling experiments conducted in this work moved beyond previous trampling studies in a number of ways:

1. Including cattle (as analogies for large mammals) as agents of fracture formation on stone artefacts.
2. Directly comparing the macrofracture results of trampling by two different agents (cattle and humans).
3. Investigating the formation of a very specific set of fractures (i.e. macrofractures and DIFs) under both human and cattle trampling conditions.
4. The formation of the fractures was tested on locally available rock types relevant to the southern African archaeological record (i.e. dolerite, milky quartz and quartzite).
5. Participants in these experiments wore only socks to protect their feet and not rubber or other synthetic soled shoes. Most previous human trampling experiments were conducted with participants wearing soft-soled or rubber-soled shoes (e.g. Flenniken & Haggerty 1979; Villa & Courtin 1983: 273; Gifford-Gonzalez *et al.* 1985; Behrensmeyer *et al.* 1986; Nielsen 1991; Shea & Klenck 1993; McBrearty *et al.* 1998). This is a potential variable in fracture formation and so in this set of experiments participants wore only soft socks.

7.3 Experimental materials

Most of the choices with regards to designing the experiments and choosing apparatus were made with the goal of standardisation in mind as no single experiment can test all archaeologically relevant variables (refer to Section 4.4). The most productive and useful experiments are those that have clearly defined, controlled and standardised variables that are being tested (e.g. Shea *et al.* 2001). Thus, the specific materials used in these experiments were chosen in order to control as many variables as possible (see Table 7.1).

Table 7.1: Replication and experimental protocol, samples and apparatus

Experiment type	No. of experiments /analyses	Number of pieces	Depth of placement	No. of individuals	Apparatus	Duration	Protocol
Cattle trampling	2	50 milky quartz; 50 dolerite; 50 quartzite (second trampling only)	50 at 10cm; 50 on the surface (75 at 10cm; 75 at surface in second trial)	40	Trowels, sieves and plastic bags, hand lens, digital camera.	27 days	McBrearty *et al.* 1998; Gifford-Gonzalez *et al.* 1985
Human trampling	2	50 milky quartz; 50 dolerite; 50 quartzite	All on surface	6	Individuals wore socks. Trowels, sieves, plastic bags, plastic beacons, stop watch, hand lens.	1 hour	McBrearty *et al.* 1998
Knapping debris analyses	1	Random grab samples of each raw material	N/a	1	Hand lens for the macrofracture analysis.	N/a	Fischer *et al* 1984*;* Lombard 2005a

7.3.1 *Flakes*

Flakes used in the first human and cattle trampling experiments were manufactured from milky quartz and dolerite. The knapping technique employed was direct hard hammer percussion with a dolerite cobble. Quartzite was sourced fairly late into the experiments and was therefore used only for the last cattle trampling experiment as well as the knapping debris analyses. These rock types were chosen for experimentation as only one previous experiment has dealt with macrofracture formation on local southern African rock types (hornfels, chert, quartzite and mudstone) (Lombard *et al*. 2004) (refer to Section 2.3). Dolerite, milky quartz and quartzite are rock types that were used during the Wilton, Robberg and HP time phases and are therefore relevant to southern African archaeology and this project (Wadley 1986; Orton 2004; Delagnes *et al*. 2006; Wadley & Jacobs 2006; Henshilwood 2008; Wadley & Mohapi 2008). The rock types used in these experiments were sourced from regions in the south and north of Malawi (Figure 7.1). Dolerite was sourced from the Chisombezi River where it

occurs in rounded cobbles from an exposed dolerite dyke in the area. Milky Quartz was sourced from the town of Bangwe where it occurs in large chunks and quartzite cobbles came from the Karonga district in northern Malawi.



Figure 7.1: Map of Malawi showing sources of the three rock types used in these experiments
(Map accessed on 10 August 2010 from www.wikimedia.org)

None of the flakes were retouched prior to being trampled. This was done in order to follow existing experimental protocol (e.g. Lombard *et al.* 2004), to avoid influencing the formation of macrofractures (see Plison & Beyries 1998 in Lombard *et al.* 2004: 162) and because macrofracture formation is meant to be independent of artefact shape (refer to Chapter 2). The flakes selected for use in the experiments were of varying sizes and shapes, although a preference for larger flakes was made in the cattle trampling experiments as these were easier to recover after the experiments. Fifty flakes of each raw material are used in each of the trampling experiments.

7.3.2 *Trampling agents*

The main differences between the two trampling experiments were the trampling agents. A herd of 40 cattle were used for the two cattle trampling experiments. Domesticated cattle in Africa are large enough to be comparable to ungulates living during the Pleistocene and Holocene in Africa, such as zebra (*Equus burchelli*) and wildebeest (*Cannonochaetes taurinus*). The herd used in these experiments also included smaller, younger individuals (n = 10) that are comparable in size to smaller bovids such as impala (*Aepyceros melampus*) known to have been present during the Wilton, Robberg and HP phases (Turner 1986; Plug & Engela 1992; Clark & Plug 2008). The effects of these cattle on the stone artefacts are comparable to a herd of wild bovids trampling a lithic assemblage in an open-air environment.

The human trampling experiments were conducted with six individuals of varying weight, height and sex for a period of one hour per experiment. This experiment was comparable in length to previous trampling experiments (Bordes & Bourgon 1951:17 in McBrearty *et al.* 1998; Tringham *et al.* 1974; Gifford-Gonzalez *et al.* 1985). Whilst the number of participants in this experiment was lower than the 30 people in an average old world forager group (cf. Marlowe 2005) it was comparable to Dobe dry season camp sizes in the Kalahari Desert, which can be as low as five or six individuals (Yellen & Harpending 1972). I designed the human trampling experiment to simulate the movement of a group of people within a rock shelter or other confined area. Plastic beacons were used to demarcate the trampling boundaries, a stop watch was used to time each trampling session and a hand lens was used for identifying macrofractures after experimentation (see Table 7.1). Trowels and hoes were used to prepare the cattle trampling area and plastic bags were used for the storage of trampled artefacts.

7.4 Experimental Methods

7.4.1 *Knapping*

Manufacturing of the experimental flakes took place in Malawi. A black tarp was laid on the ground to capture the knapping debris. This debris, if larger than 1 cm, was used for the knapping debris macrofracture analyses. An observation from the knapping sessions, especially the milky quartz knapping, is the high number of small bladelet-like and convergent pieces that were found in the knapping debris. These unintended by-products look like unretouched bladelets, but are an accidental by-product of the knapping process (refer to Section 12.4.7 for a further discussion of this issue).

After knapping, the flakes were measured for length, width and thickness prior to trampling (see Figure 7.2). Thickness was measured at the maximum point in the profile of the flake, length was the maximum dimension from the bulb of percussion (if discernable) and width was the maximum dimension perpendicular to the length measurement. A table of the experimental flake morphometrics is supplied in appendix 1 on the cd at the back of this dissertation.

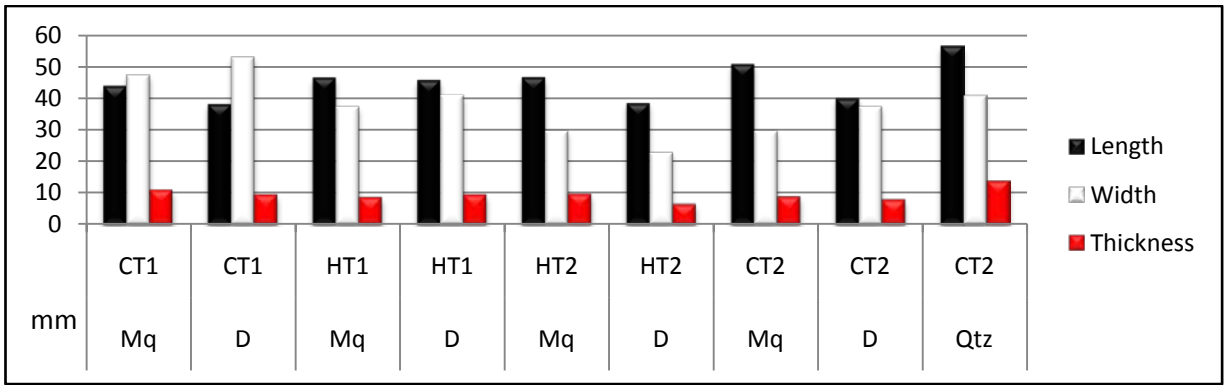


Figure 7.2: Morphometric measurements on experimental flakes
(CT: cattle trampling; HT: human trampling; Mq: milky quartz; D: dolerite; Qtz: quartzite)

The flakes were numbered on their ventral surfaces, making sure not to cover any distinguishing knapping features, such as platforms or bulbs of percussion (see Figure 7.3). These knapping features were important for distinguishing between DIFs and non-DIFs. An X was marked on the dorsal surfaces of all the flakes (in paint) prior to trampling (see Figure 7.3). This enabled broken flakes to be re-

assembled after experimentation. The flakes were then photographed for later comparative work. These photographs act as a form of control sample against which the trampled flakes could be compared after experimentation.

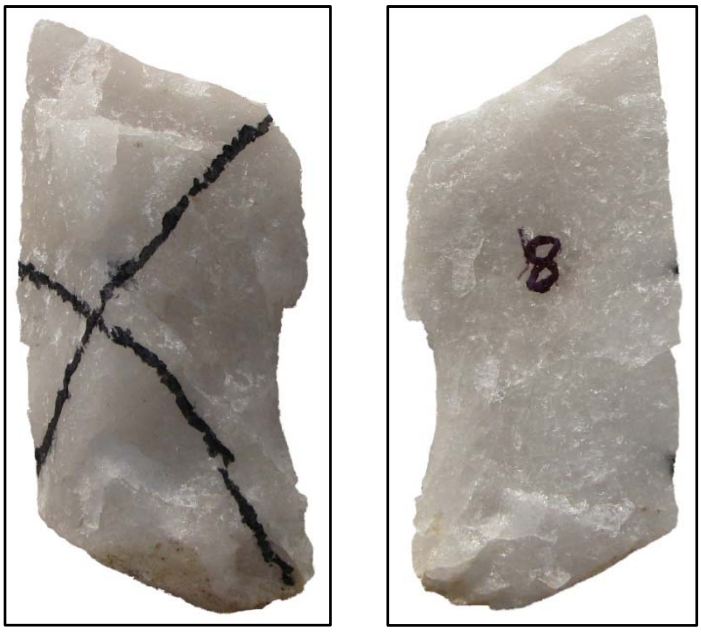


Figure 7.3: Dorsal and ventral view of experimental flake (milky quartz) from the first cattle trampling experiment

7.4.2 *Cattle trampling*

The experiments were conducted at a cattle kraal in Malawi. This kraal has an entrance that is approximately 1.3 m wide and acts to control the movement of cattle into the kraal. The area selected for the trampling experiments was located just before this entrance (see Figure 7.4). The dominant substrate here is a sandy clay soil with some larger rock and sand inclusions. The same area and substrate were used in both experiments (cattle and human) as previous tests have shown soil type to be a variable in trampling experiments (see Villa & Courtin 1983; Gifford-Gonzalez *et al.* 1985; McBrearty *et al.* 1998).



Figure 7.4: Trampling area in front of cattle kraal entrance

A rectangular area of approximately 3 x 2 m was excavated outside of the kraal entrance. This was a large enough area to allow for the distribution of the 100 stone flakes (150 for the second cattle trampling experiment). In this area, a pit was excavated to a depth of 12 cm (see Figure 7.5). The last two centimetres were covered with soil to prevent the bottom most flakes from sitting on a harder substratum, which could cause them to break more easily (e.g. Gifford-Gonzalez *et al.* 1985; Nielsen 1991; McBrearty *et al.* 1998). Half of each raw material sample (25 pieces) was placed at a depth of 10cm, and the other half just below the surface. Here, I aimed to assess whether or not the formation of macrofractures was affected by the depth at which they were placed.



Figure 7.5: Cattle trampling pit lower 10cm layer *(left)* **and upper layer** *(right)*

The flakes were then left in the soil for 27 days before being excavated. This number ensured that the assemblages were subject to ample treading. The cattle left and entered the kraal once a day, and trampled the surface above the flakes/blades for a total of 54 times over the 27 days (see Figure 7.6).



Figure 7.6: Cattle entering kraal over experimental trampling pit

7.4.3 *Human trampling*

A square area of approx 5 x 5 m was demarcated in the same area as the cattle trampling experiments, but was not excavated. As in the cattle trampling experiments, 50 flakes of each raw material were used (see Table 7.1). Using the same number of flakes and substrate type as in the cattle trampling experiments meant that the two data sets were comparable, with the exception that half of the human trampling sample was not placed at a depth of 10 cm as this was a shorter-term experiment than the cattle trampling. The six individuals were divided into teams of three and walked across the trampling area for 30 minutes per group, a total of 60 minutes in each experiment (Figure 7.7). Photographic and notary recordings of any displacement of the flakes or any other interesting observations were taken during the day.



Figure 7.7: Human trampling within demarcated area

7.4.4 *Knapping debris*

A random sample of debris, consisting of approximately 100 pieces, was taken from one milky quartz, dolerite and quartzite knapping session. Pieces larger than 1 cm were then selected from these random samples and were examined for

macrofractures. Debris smaller than 1 cm are difficult to examine using only a hand lens and are often too small to contain macrofractures that are diagnostic.

7.5 Macrofracture analysis

After knapping and trampling, all the samples were subjected to inspection for macrofractures. The aim of these visual observations was to see if macrofractures occur as a result of human and cattle trampling and knapping and if they were the same as those commonly described as DIFs. When conducting the macrofracture analyses, the method developed by Fischer *et al.* (1984) and adapted by Lombard (2005a) was used for identifying Stone Age hunting weapons (refer to Chapter 2 and Section 8.2). This ensured consistency with existing protocols, and that my experimental results were directly comparable to the existing database of macrofracture results (refer to Chapter 2 and see Table 2.2).

7.6 Chapter summary

In order to evaluate the possible limitations of the macrofracture method, I designed and conducted four experiments (two human and two cattle) to assess whether DIFs occur in ways other than longitudinal impact. These experiments dealt with the relationship between trampling (both human and cattle) and macrofracture formation. Three locally available and archaeologically relevant rock types, dolerite, milky quartz and quartzite, were used to manufacture 450 unretouched stone flakes that were then subject to human and cattle trampling. The knapping debris from these experiments were also examined for macrofractures.

CHAPTER 8: MACROFRACTURE AND MORPHOMETRIC METHODS

8.1 Introduction

In this chapter I outline the macrofracture and morphometric methodologies that were employed for the purpose of this study. All of the experimental and archaeological samples in this study were examined for macrofractures (refer to Chapter 9 and Chapter 10). Statistical tests for independence were done to assess the macrofracture method by comparing the macrofracture results from the knapping and trampling to previous hunting macrofracture experiments (refer to Section 12.2). Macrofracture results from the archaeological assemblages in this study were also statistically compared to these experimental results to assess similarities and differences (refer to Section 12.4.1). Morphometric calculations and statistical tests for independence were done on the archaeological materials with DIFs (refer to Chapter 11). Background information to the macrofracture and morphometric methods in this Chapter is given in Chapters 2 and 3.

8.2 Application of the macrofracture method

All complete and broken artefacts in an assemblage were examined for DIFs regardless of size. This was done to account for all possible hunting weapons in an assemblage, which would include broken pieces, and because it is not always possible to establish which tools broken pieces were originally a part of.

During the analysis, attention was given to where macrofractures occur on the tools. This is important as macrofractures can form as a result of the application of a variety of forces (e.g. knapping) and in a variety of positions on artefacts (e.g. laterals and proximal ends). When macrofractures were found in association with knapping features, such as platforms and bulbs of percussion, they were not included in the final fracture counts. Fractures with negative bulbs of percussion were also excluded from the analysis. Only fractures found in association with distal ends (i.e. tips) or areas likely to have functioned for penetration, were

considered diagnostic. However, it must be noted that macrofractures can occur on the proximal ends of tools as a result of impact, thus caution should be exercised when analysing proximal tool ends for macrofractures (Odell & Cowan 1986; Villa *et al.* 2009) (refer to Section 2.1).

Paying attention to the morphology of pieces during macrofracture analysis helped to eliminate pieces that accumulate macrofractures in ways other than hunting. Tools that did not fit the standard concept of projectile weapons, for example bladelets and other backed artefacts, needed to be assessed in relation to how they could have been hafted, used and fractured. To be consistent when recording fracture locations, pieces were orientated in specific ways (see Figure 8.1). For backed pieces (e.g. segments) the backed edge was always placed facing left and for non-backed artefacts the recording was done with the dorsal side up and the ventral side facing down. The pieces were then divided into six portions for segments and eight portions for regular flakes and fracture provenience recording refers to these portions (Figure 8.1).

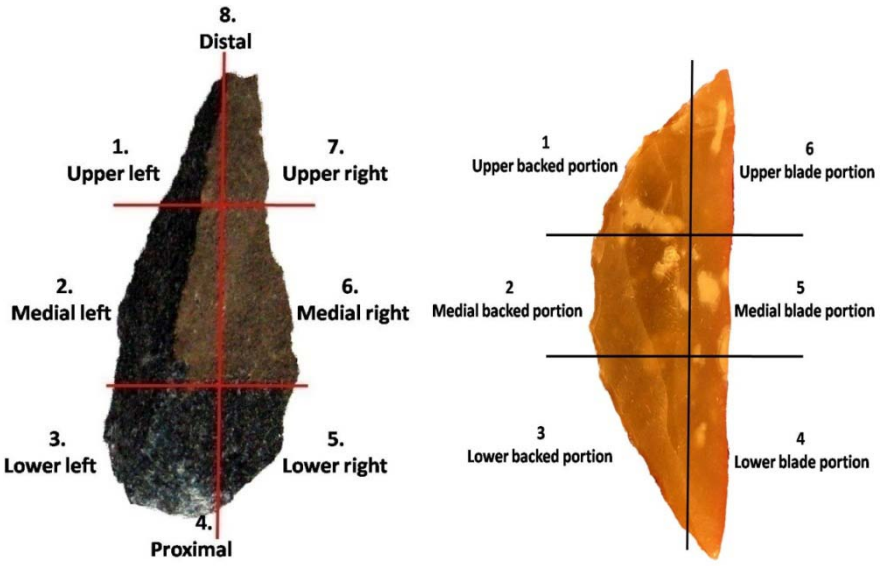


Figure 8.1: Analytical division of stone artefacts during macrofracture analysis

Macrofracture inspection requires a hand lens or magnifying glass and lamp for identifying the fractures and a digital camera with a macrofeature to photographically record the details on the tools. A low-power microscope can be

useful when detecting and photographing some of the smaller fracture types, but is not necessary.

8.3 Morphometric and statistical methods employed in this study

Coefficient of variation (CV), tip cross-sectional area (TCSA) and cross-sectional perimeter calculations were done on the length, breadth and thickness measurements from the Wilton and Robberg stone artefacts with DIFs. Two statistical measures for independence were used on the experimental and archaeological results in this study: Fischer's exact test and a Student's t-test. These methods are outlined in more detail below.

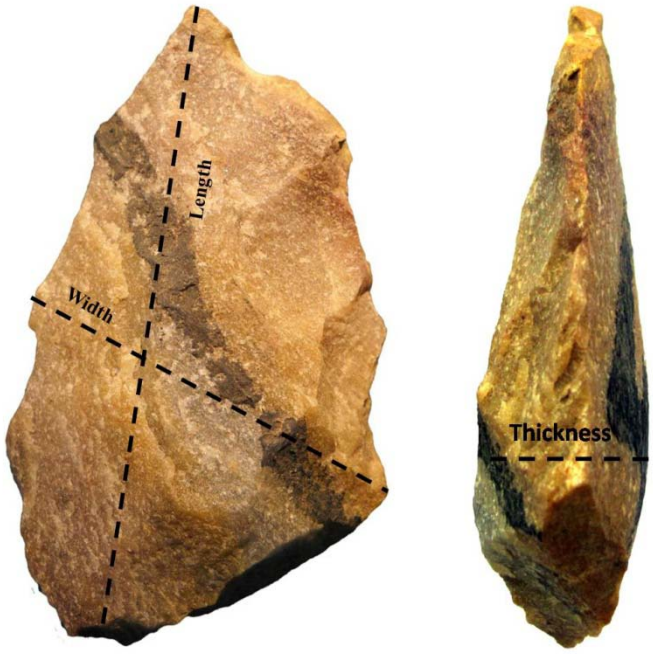


Figure 8.2: Illustration of how length, breadth and thickness measurements are taken

8.3.1 *Coefficient of variation calculations*

The CV is one way of measuring standardisation in stone artefacts (Eerkens & Bettinger 2001). The CV formula is given as SD/mean x 100, SD being the standard deviation (e.g. Wurz 1999; Wadley & Mohapi 2008). A high CV value indicates a variable assemblage and a low CV indicates a more standardised artefact assemblage. Tools are standardised when their SD is low and their overall CV is low. A higher SD indicates that measurements vary considerably from the

mean and will result in a higher CV value when means are small. Different CV values are given to approximate a standardised artefact assemblage. Wadley and Mohapi (2008) use a value of 10, whilst Fisher (2006) uses a value of 20. Both of these measurements are essentially arbitrary cut off points. Eerkens and Bettinger (2001) state that CV values of 1.5 and 57.7 represent the absolute standardisation and random patterning respectively. In this study I followed Wadley and Mohapi (2008) in using a value of 10 as a relative mark of standardisation. This value was chosen so that comparisons between these bladelets and HP segments could be made, some of which are likely to have been used as hunting weapon tips and barbs (refer to Section 5.2.1 and 5.2.2). In this scheme, values of 10 and lower indicate standardisation.

8.3.2 *Tip cross-sectional area calculations*

Hughes (1998) and Shea (2006) studied the morphometric properties of a variety of archaeological, ethnographic and experimental weapons to assess their morphological qualities. From these data, they propose that TCSA values are a useful means of hypothetically differentiating between optimal modes of weapon delivery (but also see Lombard & Phillipson 2010 and Sisk & Shea 2009). Two versions of the TCSA calculation were employed in this study. The TCSA 1 calculation follows a regular formula which is (0.5 x maximum breadth) x maximum thickness. The TCSA 2 calculation follows Wadley and Mohapi (2008) in replacing breadth with length to reflect the potential use of segments as transverse hafted pieces. Here the length measurement becomes an estimation of the shoulder breadth of the projectile tip (Wadley & Mohapi 2008). The TCSA values have been calculated for ethnographic, archaeological and experimental arrowheads, darts and thrusting spears from North America (Shott 1997; Shea 2006). These values are useful for comparisons only in that they are meant to represent ideal types of weapons. It must be noted that, because these comparative pieces are all of North American or ethnographic origin, they are not representative of all weapon types at all times, and the method cannot conclusively determine function (Lombard & Phillipson 2010).

There are no absolute high or low TCSA measurements that can be used to distinguish between different weapon delivery systems, such as the bow, spear thrower, dart or hand thrown or thrust spears. Instead the TCSA values are compared to existing ethnographic, archaeological and experimental weapon types to assess their similarities and differences. Average TCSA values falling outside of those for the ethnographic and archaeological comparative types are thought to be less likely hunting weaponry tips (Shea 2006). The conclusions drawn from these comparisons are most useful when used in conjunction with other strands of archaeological data to investigate the types of weaponry employed at a particular site and time (Wadley 2008; Sisk & Shea 2009; Lombard & Phillipson 2010).

8.3.3 *Cross-sectional perimeter calculations*

The cross-sectional perimeter equation measures the potential penetrative abilities of pointed artefacts (Hughes 1998; Sisk & Shea 2009). The idea behind the use of this equation is that penetration depth is related to tip cross-section size and perimeter (Hughes 1998). Tips with smaller perimeters and breadths are able to create deeper penetrations and to penetrate tougher surfaces, such as animal hide and bone (Hughes 1998; Sisk & Shea 2009). Large and thick tips need greater force and energy to make the same kinds of penetrations through animal hide and bone. Attaining an appropriate tip size is therefore especially important for low-velocity hunting weapons such as hand cast spears (Hughes 1998). The original cross-sectional perimeter calculation was designed to evaluate the penetrative abilities of bifacially worked convergent pieces and is given by Hughes (1998) as:

$$perimeter = 4\sqrt{s}; \quad s = \left(\frac{1}{2}width\right)^2 + \left(\frac{1}{2}thickness\right)^2$$

Equation 8.1: Cross-sectional perimeter calculation for bifacially worked convergent pieces *(Source Hughes 1998: 354)*

This calculation was later modified (Sisk & Shea 2009: 2043):

$$perimeter = width + 2 \times \sqrt{\left(\frac{1}{2}width\right)^2 + thickness^2)}$$

Equation 8.2: Cross-sectional perimeter calculation for simple unifacial convergent pieces *(Source Sisk & Shea 2009: 2043)*

This modified calculation accommodates for simple, unifacial convergent pieces. The modified version of this calculation is applied here as the convergent pieces in this study are simple, unretouched and unifacial. The modified version of the cross-sectional perimeter equation has been used to assess small experimental Levallois arrowheads shot into simulated animal carcasses (Sisk & Shea 2009). The tip perimeter areas and corresponding penetration depths from this experiment are presented in Table 11.11 and Table 11.12 (refer to Section 11.6). Tips with lower cross-sectional perimeter values tended to produce deeper penetrations, but did not necessarily last longer (Sisk & Shea 2009; but also see Lombard & Phillipson 2010). In fact, the smallest three points in their assemblage were among the most successful in terms of penetration depths. If we look at the maximum and minimum values for the tips that caused the deepest penetrations, there is some amount of variation. Yet, when the SD values for the same samples are considered, only a few pieces show high variability, and in general successful tips conform to a specific range of perimeter values.

8.3.4 *Student's t-test for independence*

A common approach to comparing the means of two samples is a Student's t-test (Drennan 1996). Student's t-test evaluates the differences in means between one or two samples with respect to their combined standard deviations (Drennan 1996). The test probability value generated in a Student's t-test (*p*-value) is compared to a hypothetical alpha value to determine whether or not there are grounds for a null hypothesis to be rejected or accepted (Drennan 1996; Hopkins 2000). The Student's t-test in this study used an alpha value of 0.05. The alpha value of 0.05 is a number indicating the confidence level for the statistical probability or *p*-value not being random. An alpha of 0.05 or a 95 % confidence

interval is a standard *p*-value used in Student's t-tests (Drennan 1996; Hopkins 2000). A *p*-value greater than alpha ($p > 0.05$) indicates the difference between the samples is not significant enough for the null hypothesis to be rejected. A *p*-value less than alpha ($p < 0.05$) indicates the difference between the samples is significant enough for the null hypothesis to be rejected. The alternative hypothesis is then accepted. A *p*-value equal to or greater than alpha ($p \geq 0.05$) indicates that there is no discernable difference between the two samples (Drennan 1996).

A two-sample Student's t-test assumes that both the samples have normal distribution profiles and roughly the same data distributions (Fischer 1958). The bladelet samples in this study conformed to both assumptions for this particular test. As such, an unpaired two-sample Student's t-test was conducted on the Wilton and Robberg bladelet morphometric data in this study (refer to Section 11.3).

8.3.5 *Fisher's exact test for independence*

The Fisher's exact test of independence is most useful when data sets are small; when any of the numbers in the cells in a test are < 5 and when there is large variance between the cells in a 2 x 2 table test (Upton 1992). This was the case with some of the knapping and trampling samples in this study, where some cells contained samples < 5 making a Chi-Square test inappropriate. Fisher's exact test was used to test for independence between the experimental trampling and knapping results and archaeological results in this study and previous hunting macrofracture results (refer to Section 12.2). The Fisher's exact test works to test whether two variables are independent of each other and begins with the establishment of a null hypothesis much the same way as in a Student's t-test. With the Fisher's exact test using the PAST statistics program a Monte Carlo *p*-value is also generated (Besag & Clifford 1991). This value reflects the repeated random sampling of the variables being tested, and provides greater *p*-value accuracy when testing for differences between two samples. Low *p*-values ($p < 0.05$) allow for the rejection of the null hypothesis, high *p*-values ($p > 0.05$) call for an acceptance of the null hypothesis. In this case, the null hypothesis is that

there is no difference between the DIF frequencies on artefacts and the experimental knapping and trampling flakes. The test results for a 2 x 2 table show no degrees of freedom as this value is always ‘1’ in such a test.

8.4 Chapter summary

The methodologies in this study are divided into three main components: experimental archaeology, macrofracture and morphometric analyses (analysis). In this chapter I outlined the macrofracture and morphometric methodology components. Macrofracture analyses were conducted on all of the experimental and archaeological materials in this study. Morphometric and statistical methods were used on the artefact measurements and the results of the macrofracture analysis. The results of the analyses based on these methods are presented in Chapters 9, 10 and 11 and are discussed in Chapter 12.

CHAPTER 9: RESULTS OF MACROFRACTURE ANALYSIS ON THE EXPERIMENTAL MATERIALS

9.1 Introduction

In this chapter I present the results of the macrofracture analyses on the experimental trampling and knapping assemblages carried out in this study (refer to Chapter 7). The focus of these results is on the different DIFs from the trampled pieces, and the general macrofracture types encountered in these experiments. I first provide the cumulative results for the different experiments and then break the data down as per deposition depths and raw material types.

9.2 Macrofracture results on the trampling and knapping experimental flakes

9.2.1 *Human trampling 1 (n = 100)*

Snap, hinge/feather terminating fractures and notches were the only macrofractures found on the flakes in this experiment (Figure 9.1). Snap fractures were the most common fracture category, occurring on 56 % (n = 56) of the flakes, notches occurred on 6 % (n = 6) and hinge/feather terminating fractures on 4 % (n = 4) of the flakes. Notches are at present not considered DIFs and are therefore not included in the ‘tools with DIFs’ statistics in the data tables from this chapter. No DIFs were present on this trampled assemblage.

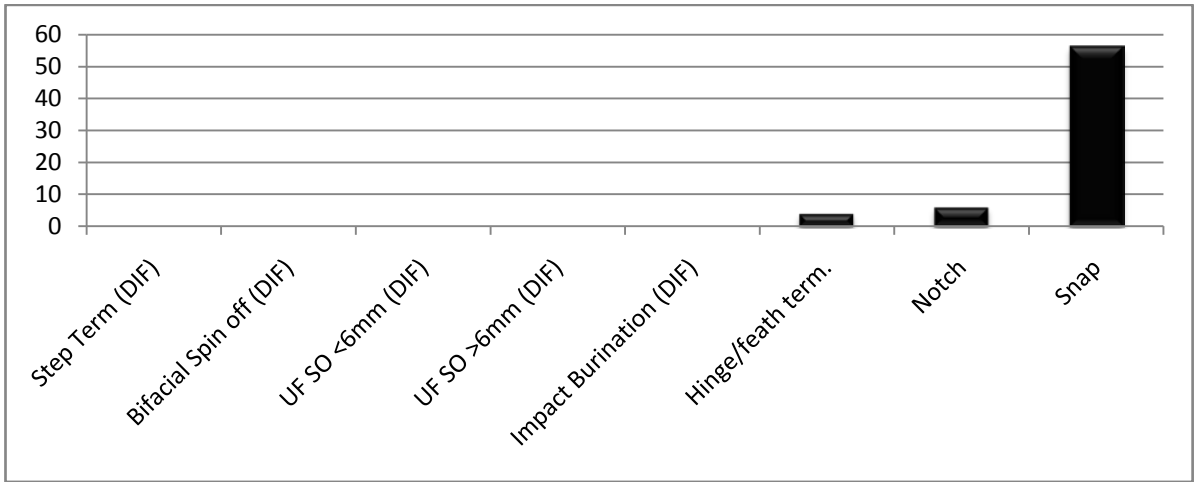


Figure 9.1: Macrofracture frequencies from the first human trampling experiment.
(UF SO: Unifacial spin-off fracture; DIF: diagnostic impact fracture)

9.2.2 *Human trampling 2 (n = 100)*

As with the first human trampling experiment, snap fractures were the most frequent fracture type occurring on 56 % (n = 56) of the flakes. Hinge/feather terminating fractures occurred on 9 % (n = 9) of the flakes and notches were slightly less frequent on only 4 % (n = 4) of the flakes (see Figure 9.2). Two step terminating fractures (4 %) and one impact burination (2 %) were the only DIFs present in this assemblage (see Figure 9.3). The overall DIF frequency in this trampling experiment was 3 % (n = 3).

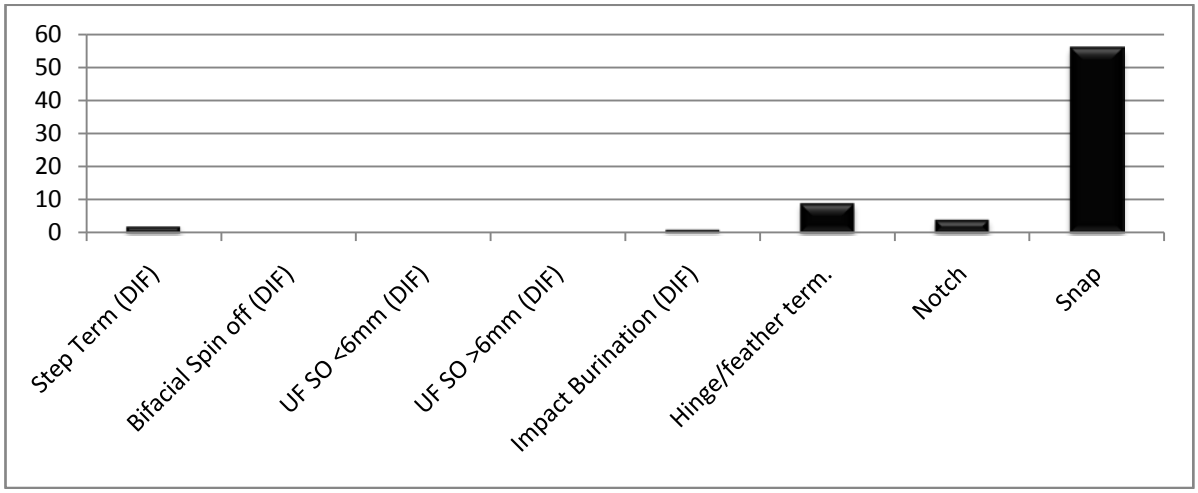


Figure 9.2: Macrofracture frequencies from the second human trampling experiment.
(UF SO: Unifacial spin-off fracture; DIF: diagnostic impact fracture)

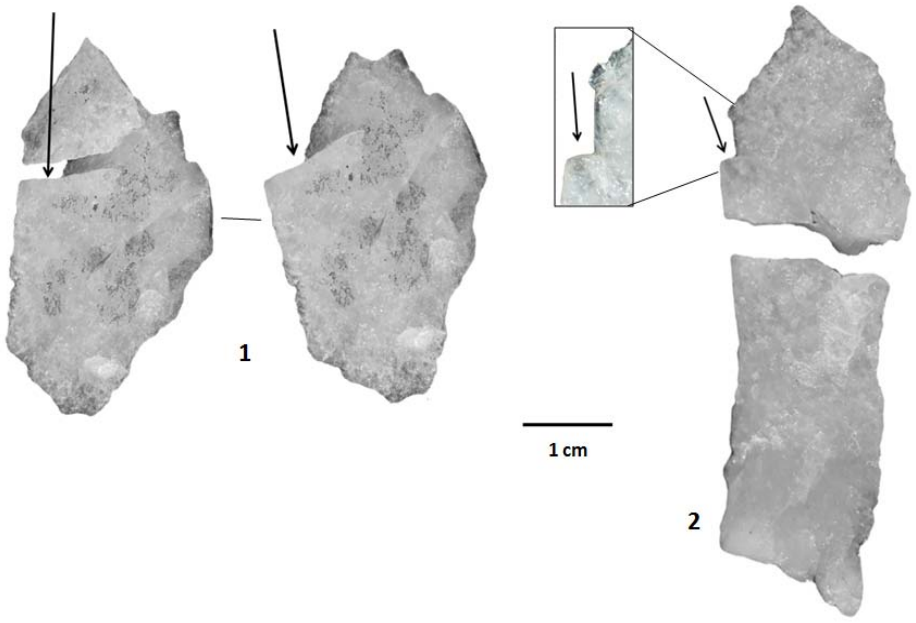


Figure 9.3: Diagnostic impact fractures on milky quartz flakes from the second human trampling experiment. *(1: Step fracture and 2: Impact burination)*

9.2.3 *Cattle trampling 1 (n = 100)*

Although these flakes were left in the ground for a longer amount of time than in the human trampling experiments, my observations during the experiments indicate that most fracturing occurred within the first few days of trampling. Thereafter some of the flakes tended to become covered by deposit, if they were not at the bottom to start, and were protected from further fracturing.

The first cattle trampling experiment showed a lower number of snap fractures (n = 45; 45 %) than the human trampling assemblages (see Figure 9.4). Notches occurred more frequently in this trampled assemblage, at 19 % (n = 19) of the pieces, whilst hinge/feather terminating fractures occurred on only 2 % (n = 2) of the flakes. Two step terminating fractures and one impact burination were found on these trampled pieces. The overall DIF frequency from the first cattle trampling experiment was 3 % (n = 3) (see Figure 9.5).

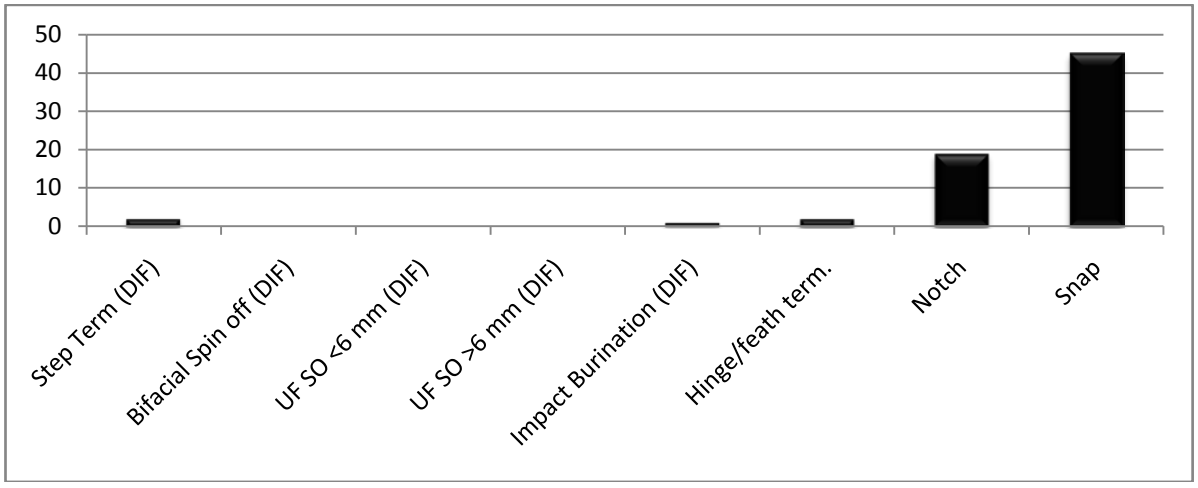


Figure 9.4: Macrofracture frequencies from first cattle trampling experiment. *(UF SO: Unifacial spin-off fracture; DIF: diagnostic impact fracture)*

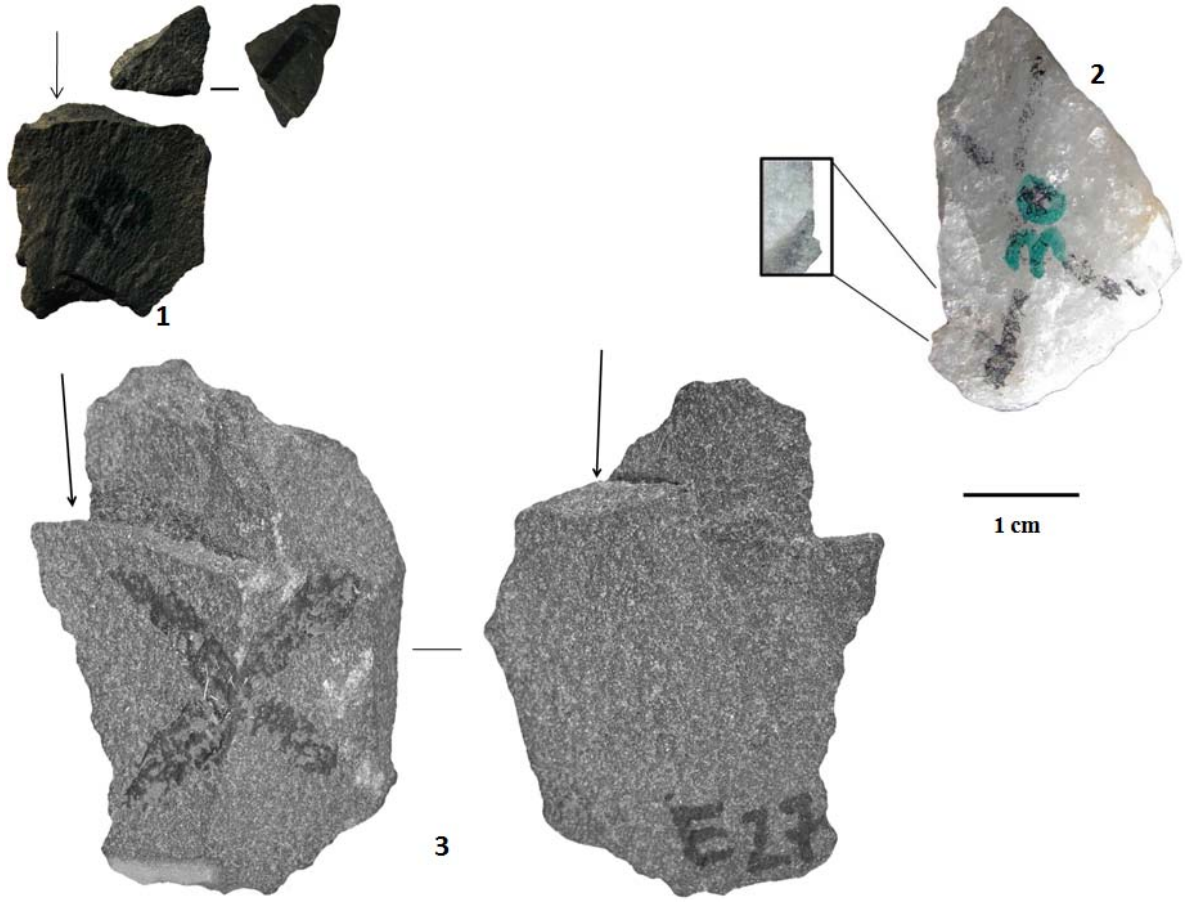


Figure 9.5: Diagnostic impact fractures from the first cattle trampling experiment.
(1: Step fracture and broken tip; 2: Impact burination on milky quartz flake; 3: Step termination on dolerite flake)

9.2.4 *Cattle trampling 2 (n = 150)*

The second cattle trampling assemblage had similar macrofracture frequencies to those discussed above. Snap fractures were the most frequent fractures at 39.3 % (n = 59) of the flakes, followed by hinge/feather terminating fractures (n = 17; 11.3 %) and notches (n = 6; 4.7 %) (see Figure 9.6). This trampled assemblage had the highest hinge/feather terminating fracture frequency of all the experimental assemblages. Three impact burinations were the only DIFs on these trampled pieces, making the overall DIF frequency from the second cattle trampling experiment 2 % (n = 3) (see Figure 9.7).

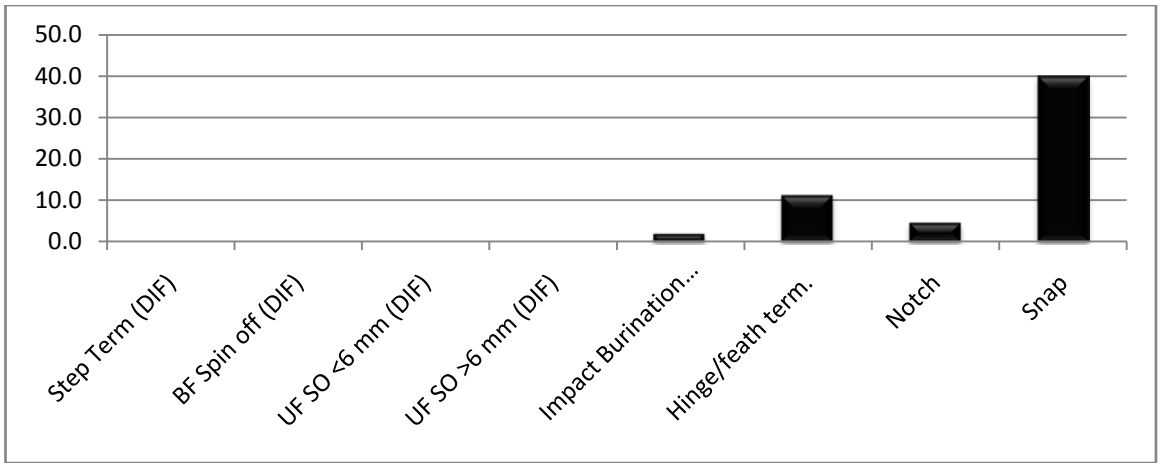


Figure 9.6: Macrofracture frequencies from second cattle trampling experiment.
(UF SO: Unifacial spin-off fracture; DIF: diagnostic impact fracture)

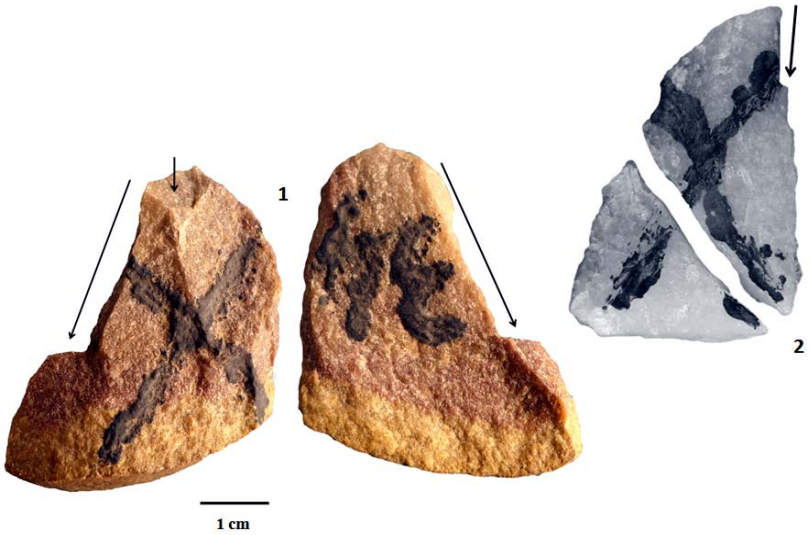


Figure 9.7: Diagnostic impact fractures from the second cattle trampling experiment.
(1: Impact burination on quartzite flake and 2: Impact burination on milky quartz flake)

9.2.5 *Knapping debris (n = 327)*

Macrofractures occurred less frequently from knapping than cattle or human trampling in this study. Snap fractures account for 25.7 % (n = 84) of the debris with fractures. Hinge/feather terminating fractures occurred on 9.2 % (n = 30) of the debris (see Figure 9.8). No notches were present on the knapping debris. In the trampling experiments more of the fragile acute-angled edges were subject to downward forces than during knapping. Trampling notches were often found in association with these acute-angled edges and are therefore not found in the knapping debris.

The knapping DIFs consisted of three impact burinations (0.9 %), two step terminating fractures (0.6 %) and a single unifacial spin-off fracture > 6 mm (0.003 %). This was the only spin-off fracture noted from all of the experimental assemblages (see Figure 9.9). A few burination and step fractures were noted in association with platforms as a result of knapping. These were excluded from the analysis as they would be in the macrofracture analysis of an archaeological assemblage (see Lombard 2005a).

The knapping debris showed the highest number of DIFs, but the overall sample is also larger (n = 327). The likelihood of a DIF forming during knapping, at 1.8 % (n = 6), is less than during cattle trampling (n = 6; 2.4 %), but more than during human trampling (n = 3; 1.5 %).

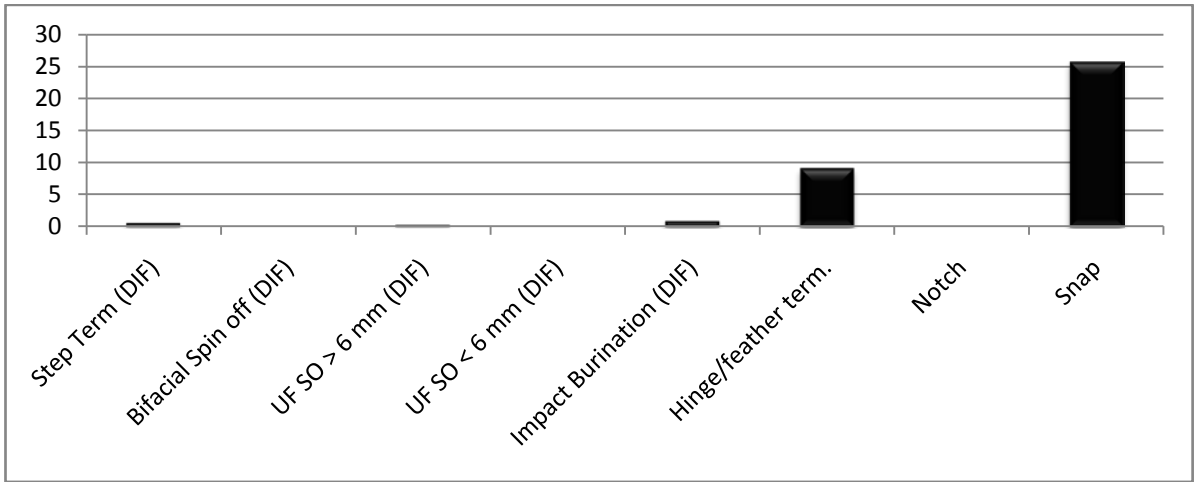


Figure 9.8: Macrofracture frequencies from the knapping debris. *(UF SO: Unifacial spin-off fracture; DIF: diagnostic impact fracture)*

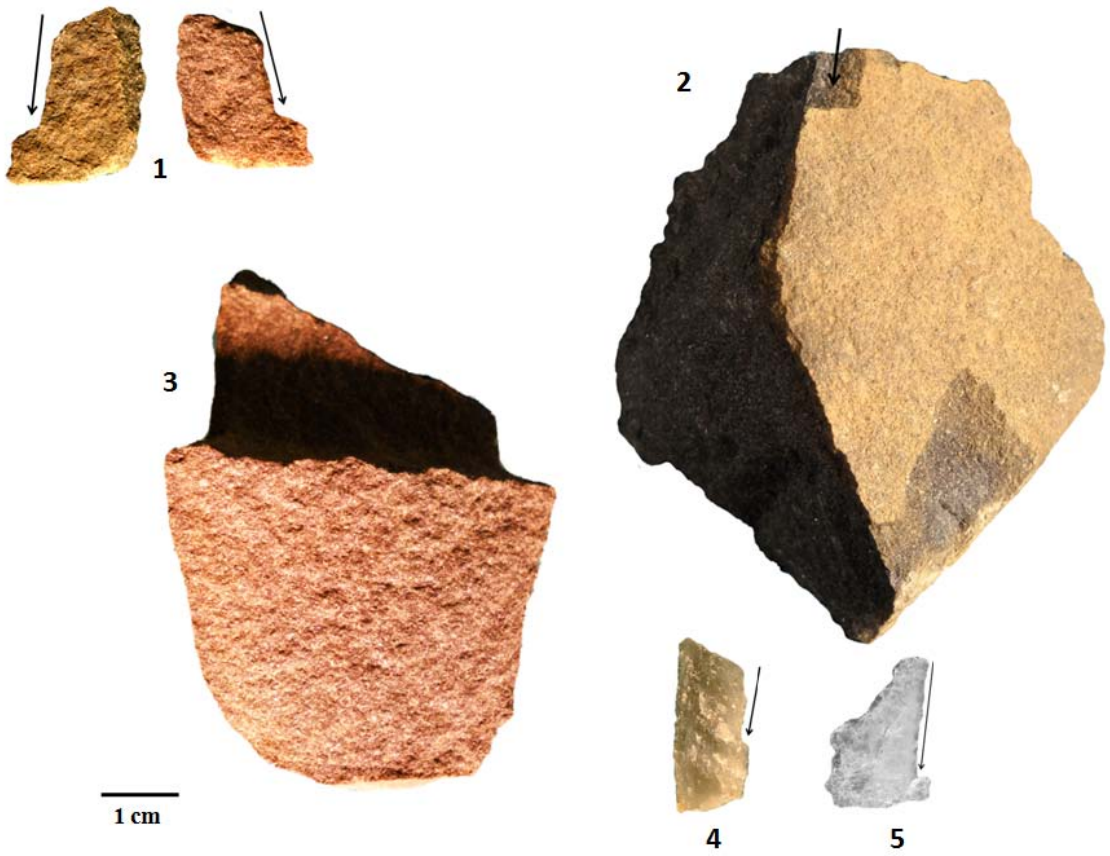


Figure 9.9: Diagnostic impact fractures from the knapping debris *(1: Impact burination on dolerite flake; 2: Unifacial spin-off fracture > 6 mm on dolerite flake; 3: Step terminating fracture on dolerite flake; 4: Impact burination on quartzite flake and 5: Impact burination on milky quartz flake)*

9.3 Results as per depositional depth

Half of each of the cattle trampling samples (n = 50 and n = 75) were buried at a depth of 10 cm below the surface prior to trampling to test whether depositional depth affects fracture formation. Macrofractures (excluding DIFs) are roughly twice as likely to form on surface flakes (n = 77; 30.8 %) than flakes at 10 cm (n = 38; 15.2 %) (see Figure 9.10). Diagnostic impact fractures were also more likely to form on the surface (n = 4; 1.6 %) as opposed to a depth of 10 cm (n = 2; 0.8 %) (see Figure 9.10). Flakes placed 10 cm below the ground did fracture to some degree. This is likely due to the fact that, after the experiment was set up and the area excavated, the deposit was fairly soft and penetrable. The first few days of cattle trampling are the likely cause of these few fractures at depths of 10 cm. After a few days the deposit hardened and less fracturing of the lower pieces, or pieces that had by now migrated downwards, was possible. These results show that depth of deposit does affect fracture formation.

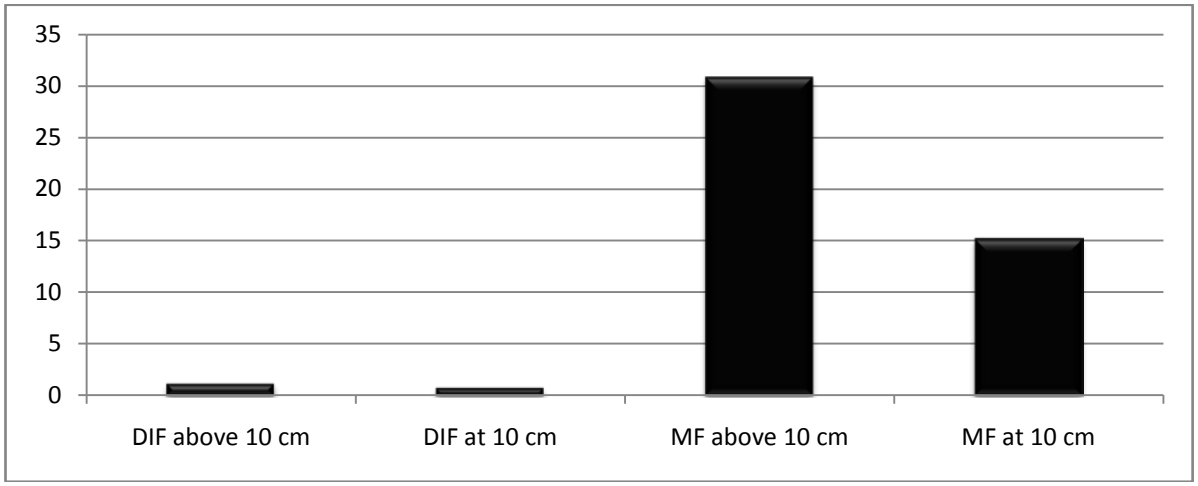


Figure 9.10: Macrofracture (MF) and diagnostic impact fracture (DIF) frequencies as per depth in the cattle trampling experiments. *(The MF statistic excludes pieces with DIFs and is the number of fractured pieces divided by the total number of pieces in the sample)*

9.4 Results as per rock type

Macrofracture frequencies on the different rock types tested in these experiments were fairly irregular (see Table 9.1). However, there are some trends especially with regards to the differences in fracture frequencies between the less brittle

dolerite and more brittle milky quartz and quartzite flakes. These differences are discussed in more detail below.

Table 9.1: Overall macrofracture frequencies on the different raw material types in the trampling and knapping experiments

	Dolerite		**Milky Quartz**		**Quartzite**	
	n = 222		**n = 222**		**n = 133**	
	n	**%**	**n**	**%**	**n**	**%**
Step terminating	3	1.4	3	1.4	0	0
BF Spin-off	0	0	0	0	0	0
UF Spin-off < 6 mm	0	0	0	0	0	0
UF Spin-off > 6 mm	1	0.5	0	0	0	0
Impact Burination	1	0.5	4	1.8	2	1.5
Hinge/feather terminating	20	9	18	8.1	24	18
Notch	16	7.2	17	7.6	2	1.5
Snap	102	45.9	144	64.9	55	41.4
Tools with DIFs	**5**	**2.3**	**7**	**3.2**	**2**	**1.5**
Total macrofractures	**143**	**64.4**	**186**	**83.8**	**83**	**62.4**

9.4.1 *Dolerite (n = 222)*

Dolerite is a relatively hard and less brittle rock type than milky quartz or quartzite (between 5 and 6.5 on Moh's scale) (Holmes 1966; Kleyn & Bergh 2008; Wadley & Mohapi 2008). In these experiments, dolerite fractured less (64.4 %) than the hard and brittle milky quartz (83.8 %; 7 on Moh's scale of hardness) and similarly to the hard and slightly less brittle quartzite (62.4 %; 7 on Moh's scale of hardness) (Howard 2005) (see Table 9.1). Notches (n = 16; 7.2 %) and snap fractures (n = 102; 45.9 %) were more common on dolerite flakes than on quartzite flakes (n = 2; 1.5 % and n = 55; 41.4 %). Hinge/feather terminating fractures occurred at relatively the same frequencies as on milky quartz flakes, but less than half as on the quartzite pieces. Five DIFs were noted on the dolerite assemblage (2.3 % of the total pieces), the same frequency as quartzite, but slightly lower than milky quartz (n = 7; 3.2 %). Three step fractures (1.4 %), one spin-off fracture > 6 mm (0.5 %) from the knapping debris and one impact burination (0.5 %) occurred on the dolerite assemblage.

9.4.2 *Milky quartz (n = 222)*

Snap fractures occurred more frequently on milky quartz flakes, at 64.9 % (n = 144), as opposed to the other two rock types (see Table 9.1). This is likely due to the brittle nature of milky quartz and its susceptibility to shattering and snapping. Notches occurred at the same frequency (n = 17, 7.6 %) as hinge/feather terminating fractures (n = 18, 8.1 %). Four impact burinations (1.8 %) and three step terminating fractures (1.4 %) were found on the milky quartz flakes. The milky quartz sample had a marginally higher DIF frequency (n = 7; 3.2 %) than the other two rock types.

9.4.3 *Quartzite (n = 133)*

Only the second cattle trampling and the knapping assemblages contained quartzite components. The quartzite pieces fractured less frequently than the other two rock types (see Table 9.1). Snap fractures (n = 55; 41.4 %) and hinge/feather terminations (n = 24; 18 %) are the most frequent fracture types in the quartzite assemblage. Two impact burinations (1.5 %) were present on the quartzite flakes.

9.5 Discussion of the trampling and knapping macrofracture results

9.5.1 *Introducing a hypothetical margin of error in macrofracture analyses*

The overall frequency of DIFs observed on any of the broad experimental categories (i.e. human trampling, cattle trampling and knapping) never exceeded 3 % of an assemblage (see Table 9.2 and Figure 9.11). Based on this result, I suggest that the figure of 3 % may be used as an approximation of the margin of error in macrofracture analyses. This means that the first 3 % in any macrofracture analyses may be considered to reflect a hypothetical margin of error accounting for alternative fracture formation processes.

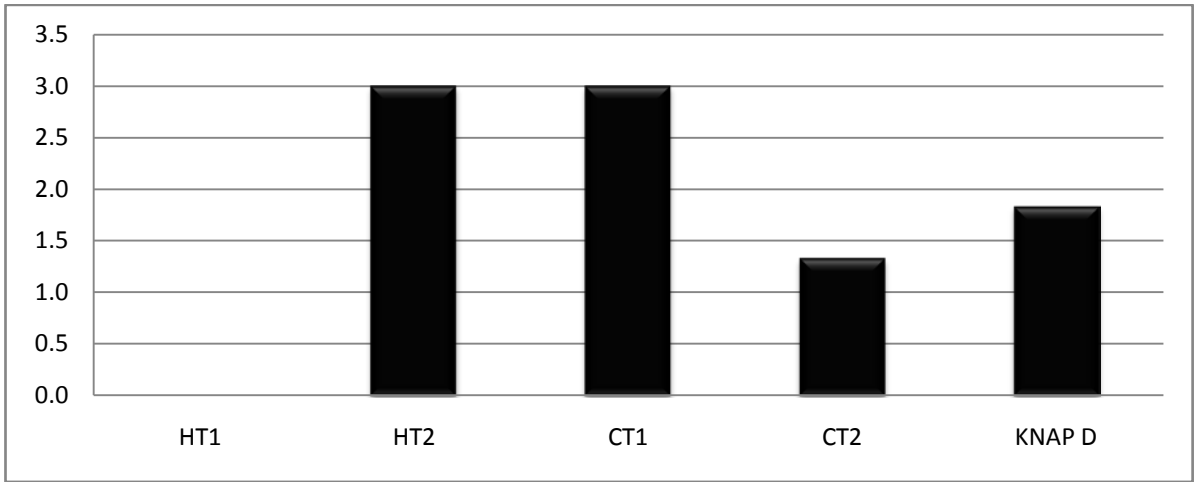


Figure 9.11: Overall diagnostic impact fracture frequencies from the five experimental assemblages. *(HT: Human trampling; CT: Cattle trampling; Knap D: Knapping debris)*

9.5.2 *Differences between cattle and human trampling*

Little distinction is seen in the overall fracture types and frequencies produced by cattle and human trampling. Although cattle trampling did produce slightly more DIFs than human trampling (see Table 9.2). No DIFs were present in the first human trampling experiments, which brings the overall DIF frequency in this experimental group down. The differences between the human and cattle trampling could also be a product of the greater amount of time that the flakes were left in the ground in the cattle trampling experiment. Judging by the similarity of the other fracture categories across the trampling experiments, and my own experimental observations, I suggest that most fracturing takes place within the first few hours of trampling. Afterwards, the tools were generally covered with deposit and were often prevented from further fracturing. The only exception to this were the two cattle trampling assemblages, half of which (n = 125) were buried at a depth of 10 cm before being trampled. The burial depth did have an effect on the fracture formation process, as almost half the number of macrofractures occurred on flakes at a depth of 10 cm as opposed to those on the surface.

Table 9.2: Detailed macrofracture frequencies from the trampling and knapping assemblages. *(CT: cattle trampling; HT: human trampling. D: dolerite; Mq: milky quartz; Qtz: quartzite; BF: bifacial; UF: unifacial ; DIF: diagnostic impact fracture. Note that one tool may have more than one fracture on it)*

	CT1			CT2		HT1		HT2		KNAP D		
	D	**Mq**	**Qtz**	**D**	**Mq**	**D**	**Mq**	**D**	**Mq**	**D**	**Mq**	**Qtz**
Number of pieces	50	50	50	50	50	50	50	50	50	122	122	83
Step terminating	4	0	0	0	0	0	0	0	4	1	1	0
BF Spin-off	0	0	0	0	0	0	0	0	0	0	0	0
UF Spin-off < 6 mm	0	0	0	0	0	0	0	0	0	0	0	0
UF Spin-off > 6 mm	0	0	0	0	0	0	0	0	0	1	0	0
Impact burination	0	2	2	0	2	0	0	0	2	1	1	1
Hinge/feather term.	2	2	30	2	2	6	2	10	8	8	9	11
Notch	14	24	4	4	4	10	2	4	4	0	0	0
Snap	44	46	51	18	52	56	56	40	72	19	26	35
% of tools with DIFs	**4**	**2**	**2**	**0**	**2**	**0**	**0**	**0**	**3**	**2.5**	**2**	**1**

9.5.3 *Differences between the rock types*

Dolerite is less brittle but roughly as hard as milky quartz and quartzite. In these experiments dolerite fractured less often (n = 143; 64.4 %) than milky quartz (n = 186; 83.8 %). Quartzite (n = 84; 62.4 %) and dolerite had relatively similar fracture rates even though quartzite is more brittle, but as hard as dolerite. It appears as if the hardness of a rock type was not as important for its rate of fracturing as its brittleness.

The highest frequencies of DIFs were found on the milky quartz flakes, but all three rock types show some number of DIFs. No step terminations were found on the quartzite pieces, the only spin-off fracture > 6 mm occurred on a dolerite piece from the knapping experiment. The formation of these fracture types may be related to the properties of these rock types. Impact burinations occurred on all rock types with the lowest frequencies occurring in the dolerite assemblage.

9.5.4 *Correlation between flake thickness and macrofracture formation*

This section discusses the relationship between flake thickness and macrofracture formation. Thicker flakes would be expected to be more robust and therefore to fracture less often than thinner flakes. The correlation between fracture formation and flake thickness was calculated in order to assess this claim and to see whether

the formation of macrofractures is independent of flake morphology (refer to Section 2.1).

This analysis examined the thickness and fracture correlations for the second cattle and human trampling experiments. One larger milky quartz flake (thickness = 64 mm) was removed from the analysis as it was a far outlier. Figure 9.12 depicts the correlation between flake thickness and the presence/absence of macrofractures. No significant correlation between flake thickness and the macrofracture formation was present (n = 249; p = -0.0725) (see Figure 9.12). More macrofractures were found on thicker quartzite flakes than either milky quartz or dolerite. However, the quartzite flakes were thicker than milky quartz and dolerite flakes on avergae (see Figure 7.2). Milky quartz and dolerite flakes tended have even numbers of flakes with and without macrofractures within certain thickness ranges.

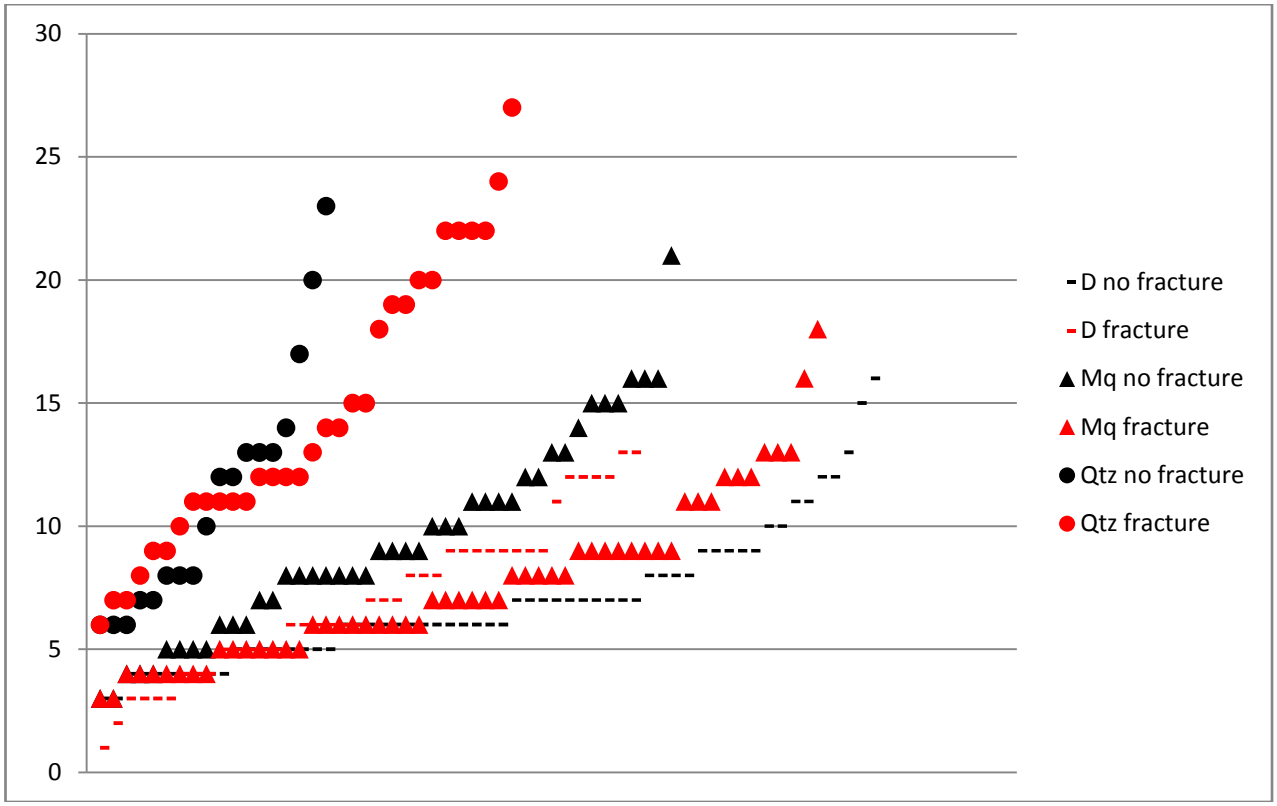


Figure 9.12: Flake thickness values and macrofracture information for the three raw material types from the second cattle and human trampling experiments. *(D: dolerite; Mq: milky quartz; Qtz: quartzite. Note that this chart depicts flakes with any macrofracture type on them, not only DIFs).*

One possible explanation for this lack of correlation is that while thickness is measured at the maximum point in the profile of a flake, fractures form on the flake edges, which may still be relatively thin and brittle. The brittleness of a flake's edge is therefore a more important variable in macrofracture formation (see Section 9.5.3) than flake thickness.

9.6 Chapter summary

Step terminating fractures and impact burinations were the most common DIF types in these experiments and need to be used with some caution when they are found in small frequencies≤(3 %) in future macrofracture analyses. Spin-off fractures > 6 mm appear to be the most diagnostic of the impact fracture types as only one was found in these experiments. No bifacial spin-off fractures were present. Notches occurred on the human and cattle trampling assemblages and should not be used alone as indicators of the hunting function of stone artefacts, nor should they be considered a DIF type.

The greatest distinction in DIF frequencies between the three experiments in this study (human trampling, cattle trampling and knapping) was between the trampling and knapping experiments. The trampling experiments produced a generally higher number of DIFs compared with the knapping experiments. Differences between human and cattle trampling were slight although the cattle trampling experiments did produce marginally higher DIF frequencies. Snap and hinge/feather fractures were the most frequent non-diagnostic macrofractures in all the experiments.

The properties of the three rock types used in these experiments did seem to affect the rate at which macrofractures form. This is related to the brittleness, and not the hardness, or thickness of the different rock types. Brittle rock types, such as milky quartz and quartzite have edges that tend to fracture more often than less brittle rock types, such as dolerite. There also appears to be a non-significant correlation between flake thickness and macrofracture formation as these fractures often form

on flake edges and not at the mid-point where thickness is measured. The depth below the surface at which an artefact was placed also affected the rate at which macrofractures form. The reasons behind this are obvious as more soil cover protects the flakes from fracturing. However, the initial placement of the flakes did not determine where they were eventually found, as soil is a dynamic medium and artefacts do shift up and down during trampling. The DIFs noted on the trampling and knapping experimental assemblages never exceeded 3 % of the total number of flakes or debris. I therefore suggest that this frequency (≤ 3 %) be considered a margin of error for macrofracture analyses in the future. The significance of these results for the macrofracture method in general will be discussed in more detail in Section 12.2.

CHAPTER 10: RESULTS OF MACROFRACTURE ANALYSIS ON ARCHAEOLOGICAL MATERIALS

10.1 Introduction

This chapter is the first of two in which I present the results of analyses on the Wilton and Robberg assemblages from NBC, BNK 1 and the Wilton assemblage from BBF. Here the results of the macrofracture analyses are presented and discussed.

10.2 Nelson Bay Cave macrofracture results

A total of 523 pieces were examined for macrofractures from NBC (refer to Section 6.2.1). The sample is fairly evenly divided between the Wilton (n = 295; 57 %) and Robberg (n = 228; 43 %) layers (see Table 10.1). The Wilton sample in general showed a higher DIF frequency (n = 52; 17.6 %) than the Robberg sample (n = 35; 15.4 %) (see Table 10.1). However, the Wilton assemblage from square G3 had a similar DIF frequency (n = 17; 14.7 %) to the Robberg assemblages from squares G3 and G5 (n = 23; 15.2 % and n = 12; 16.9 %) (see Table 10.2). The G5 Wilton assemblage stands out as having a higher DIF frequency (n = 35; 19.6 %) than the Robberg samples.

Table 10.1: Macrofracture results from the selected Wilton and Robberg assemblages at Nelson Bay Cave (NBC) *(Note that one tool can have more than one macrofracture BF: bifacial; UF: unifacial; DIF: diagnostic impact fracture)*

	NBC Wilton n = 295		NBC Robberg n = 228	
	n	**%**	**n**	**%**
Step terminating	31	10.5	24	10.5
BF Spin-off	0	0.0	0	0.0
UF Spin-off < 6 mm	1	0.3	1	0.4
UF Spin-off > 6 mm	1	0.3	0	0.0
Impact Burination	27	9.2	15	6.6
Hinge/feather terminating	17	5.8	8	3.5
Notch	20	6.8	16	7.0
Snap	108	36.6	88	38.6
Tools with DIFs	**52**	**17.6**	**35**	**15.4**
Tools with multiple DIFs	**5**	**1.7**	**4**	**1.8**

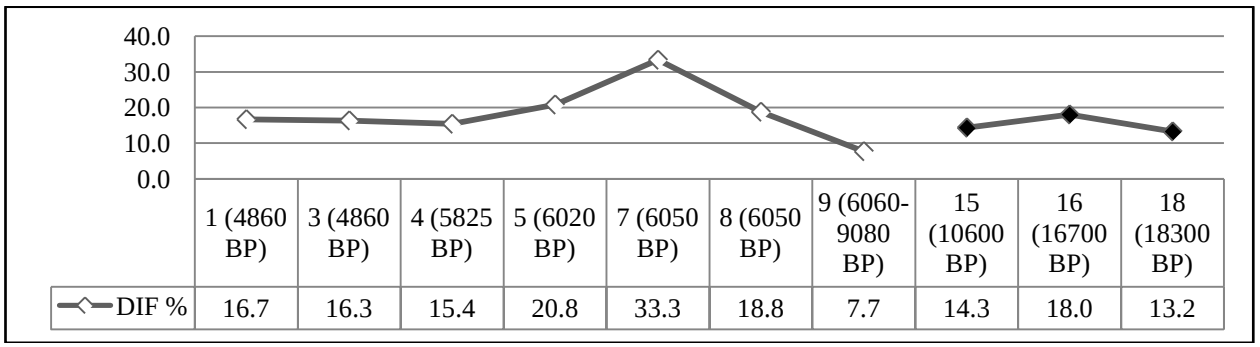
Table 10.2: Wilton and Robberg diagnostic impact fracture (DIF) frequencies from the square G3 and G5 assemblages at Nelson Bay Cave (NBC)

Source	Total Pieces	Tools with DIFs	DIF %
G3 Wilton	116	17	14.7
G5 Wilton	179	35	19.6
NBC Wilton	**295**	**52**	**17.6**
G5 Robberg	77	12	16.9
G3 Robberg	151	23	15.2
NBC Robberg	**228**	**35**	**15.4**

Here I present the DIF frequencies from NBC layer by layer (see Figure 10.1). The aim is to assess whether chronological changes in DIF frequencies can be seen within the Wilton and Robberg layers at NBC. The highest DIF frequencies in the NBC sample came from layers 5 (n = 130; 20.8 %), 7 (n = 3; 33.3 %) and 8 (n = 32; 18.8 %). These are Wilton layers with an associated age range of c. 6020 – 6050 B P. The sample size from layer 7 is low in comparison to layers 5 and 8 and it is therefore better to combine these layers and their DIF frequencies. The combined DIF frequency of these three layers was 20 % (n = 165). Layer 9 had the lowest DIF frequency at 7.7 % (n = 16). Layers 1 (n = 6; 16.7 %), 3 (n = 49; 16.3 %) and 4 (n = 52; 15.4 %) had a combined DIF frequency of 16.1 %. This is lower than the combined DIF frequency from layers 5, 7 and 8. It appears as if the

DIF frequency changes are more marked in the early - mid Wilton layers (5 – 9) than in the later Wilton layers (1 – 4).

The highest DIF frequency in the Robberg assemblage came from layer 16 (n = 100; 17 %). Layers 15 (n = 7) and 18 (n = 121) showed uniformly low DIF frequencies (14.3 % and 14.7 %). The combined DIF frequency for layers 15 and 18 (n = 128) is 14.5 %. This similarity in DIF frequencies is interesting as nearly 8000 radiocarbon years separate layers 15 and 18. The DIF frequency from layer 16 is comparable to the DIF frequencies from the Wilton layers 1, 3 and 4 (16.1 %). This suggests that at NBC, across artefact types, there is more variation in DIF frequencies within the Wilton and Robberg layers than between them, but that the DIF frequency fluctuations are slight.



	1 (4860 BP)	3 (4860 BP)	4 (5825 BP)	5 (6020 BP)	7 (6050 BP)	8 (6050 BP)	9 (6060-9080 BP)	15 (10600 BP)	16 (16700 BP)	18 (18300 BP)
DIF %	16.7	16.3	15.4	20.8	33.3	18.8	7.7	14.3	18.0	13.2

Figure 10.1: Diagnostic impact fracture (DIF) frequencies as per layer at Nelson Bay Cave. Only those layers with DIFs are shown *(White diamonds indicate Wilton layers, black diamonds indicate Robberg layer. DIF: diagnostic impact fracture; BP: before present)*

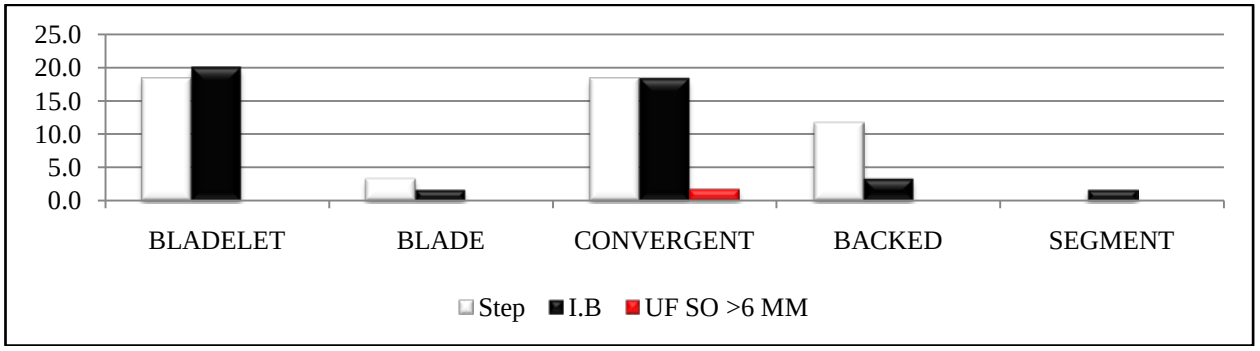


Figure 10.2: Tool types and diagnostic impact fracture (DIF) frequencies from the Wilton layers at Nelson Bay Cave. Frequencies are of total NBC Wilton DIFs *(Note that one tool can have more than one macrofracture. I.B: impact burination; UF SO: unifacial spin-off fracture)*

This section describes the results of the macrofracture analysis with regard to specific tool types and their DIF frequencies. Figure 10.2 shows that DIFs on the Wilton assemblage occurred equally on convergent pieces (n = 23; 38.3 %) and bladelets (n = 23; 38.3 %). Backed artefacts (n = 9; 15 %) and a segment (1.7 %) have smaller DIF frequencies, but the sample sizes are relatively small and therefore the results are probably skewed. Step terminating fractures and impact burinations are the most common DIF types on these tools.

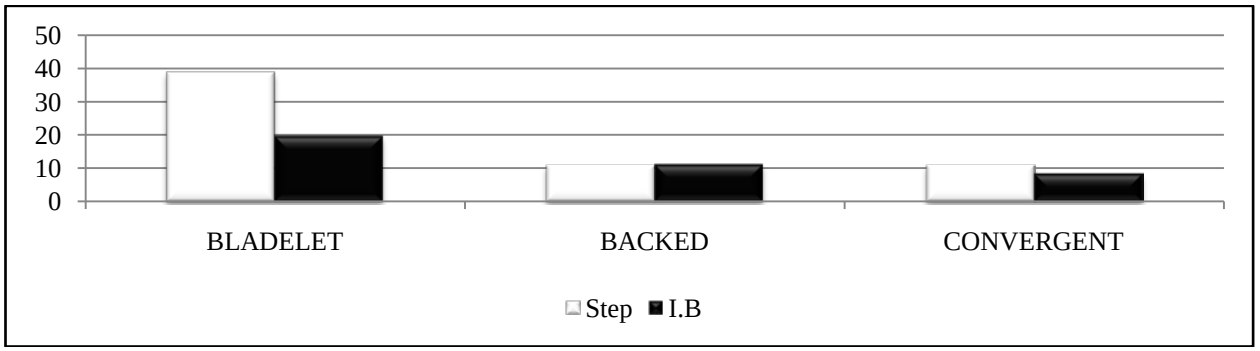


Figure 10.3: Tool types and diagnostic impact fracture (DIF) frequencies from the Robberg layers at Nelson Bay Cave. Frequencies are of total NBC Robberg DIFs *(Note that one tool can have more than one macrofracture. I.B: impact burination)*

Diagnostic impact fractures on the Robberg assemblage occurred mainly on bladelets (n = 21; 58.3 %) with almost even frequencies occurring on the backed (n = 8; 22.2 %) and convergent pieces (n = 7; 19 %) (see Figure 10.3). This was expected as the Robberg is a bladelet dominated industry; the analysed assemblage was dominated by bladelets (n = 148) and previous suggestions have been that bladelets could have been used as hafted armatures (refer to Section

5.2.1). The DIFs on this sample include step terminating fractures (n = 24; 10.5 %) and impact burinations (n = 15; 6.6 %) (see Figure 10.4).

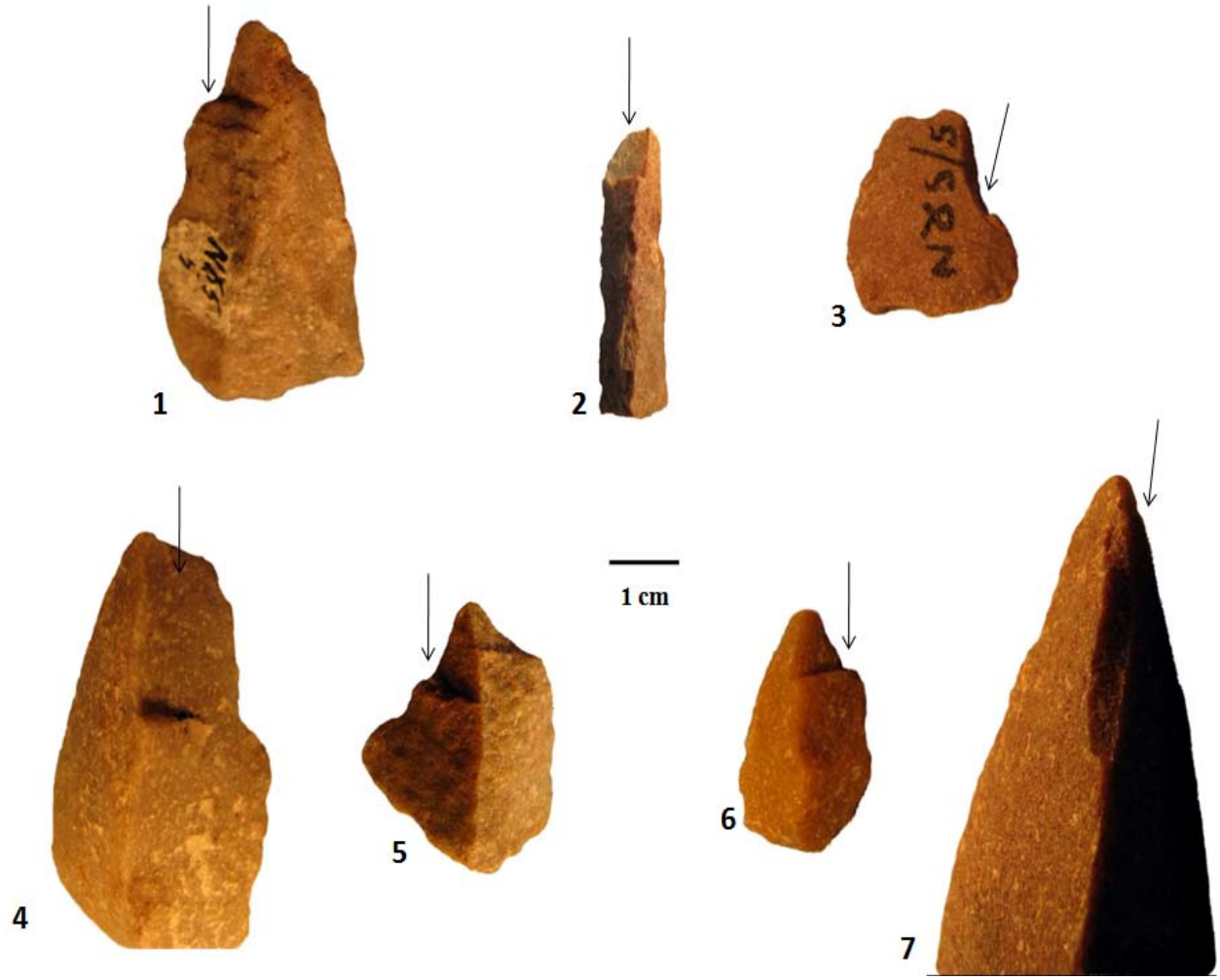


Figure 10.4: Diagnostic impact fractures on the Wilton pieces from Nelson Bay Cave *(1, 2, 4, 5, and 6: Step terminating fractures; 3 and 7: Impact burinations. 1, 3, 4, 5, 6 and 7: Convergent pieces (or fragments thereof). 2: Bladelet. All pieces are of quartzite)*

The most common tool types in both the Wilton and Robberg samples are also the tools with the highest DIF frequencies. Bladelets and convergent pieces had the most DIFs in the Wilton sample as do bladelets in the Robberg sample. Step terminating fractures and impact burinations were the most frequent DIF types on all of the NBC pieces (see Figure 10.5).

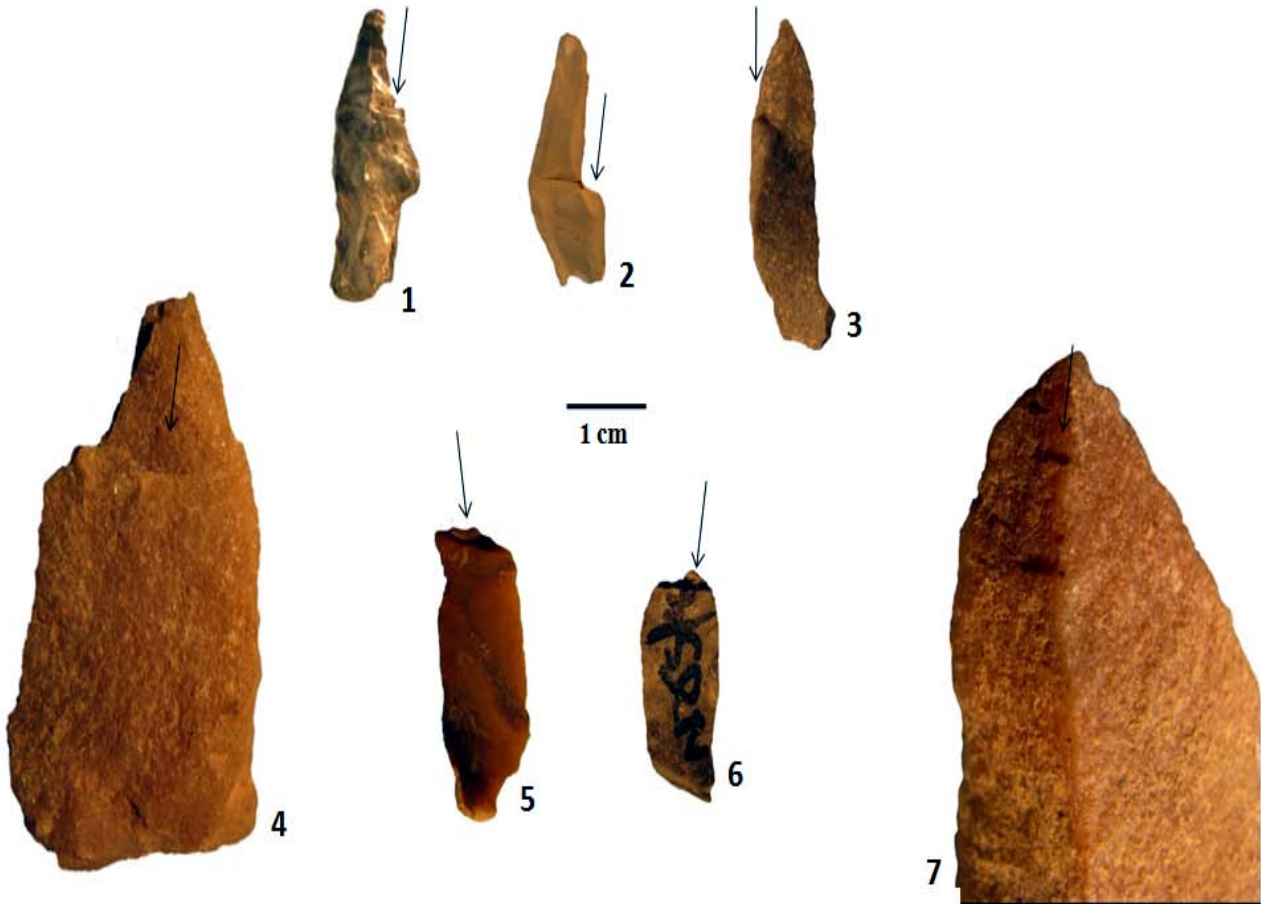


Figure 10.5: Diagnostic impact fractures on Robberg pieces from Nelson Bay Cave *(All are step terminating fractures. 1, 2 and 3: Bladelets; 4 and 5: convergent pieces. 1: crystal quartz; 2: Milky quartz; 3, 4 and 5: quartzite)*

This section presents the macrofracture results as per the different raw material types analysed from NBC (see Table 10.3). The purpose here is to discuss trends in fracture formation on the different raw material types.

Table 10.3: Diagnostic impact fracture frequencies on Nelson Bay Cave (NBC) Wilton tool types as per rock types (*Qtz: quartzite; Mq: milky quartz; S: silcrete; Cq: crystal quartz)*

	NBC Wilton (n = 295)							
	Qtz		Mq		Cq		S	
	n	%	n	%	n	%	n	%
Bladelet	73	24.7	11	3.7	6	2.0	12	4.1
Convergent	99	33.6	3	1.0	4	1.4	4	1.4
Backed	60	20.3	4	1.4	2	0.7	4	1.4
Segment	0	0.0	2	0.7	5	1.7	3	1.0
Blade	3	1.0	0	0.0	0	0.0	0	0.0

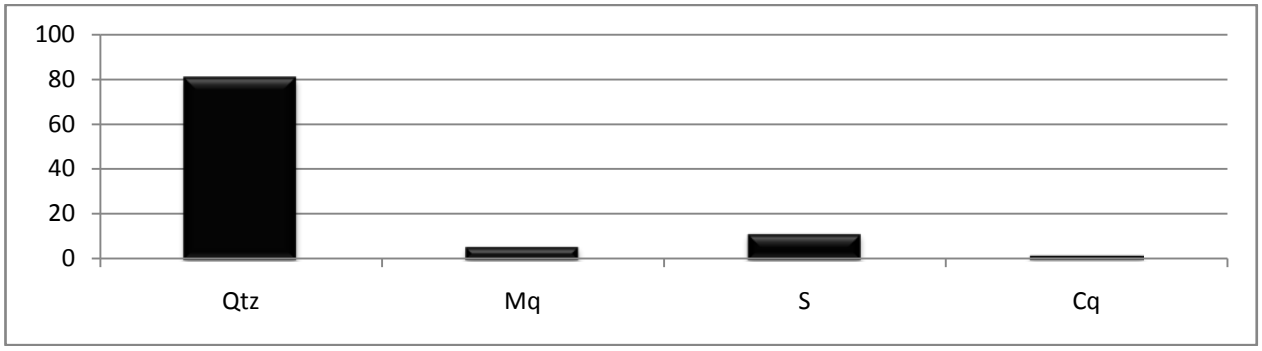


Figure 10.6: Diagnostic impact fracture frequencies on Nelson Bay Cave Wilton artefacts according to rock type type *(Qtz: quartzite; Mq: milky quartz; S: silcrete; Cq: crystal quartz)*

Quartzite was the rock type with the highest DIF frequencies in both the Wilton (n = 42; 81 %) and Robberg samples (n = 14; 40 %) (see Figure 10.6 and Figure 10.7). This pattern was expected for the Robberg assemblage, as quartz and quartzite are the dominant rock types in these layers at NBC (52.41 % and 35.42 %). Quartzite is the most common raw material in the Wilton assemblage at NBC (82.27 %). Silcrete pieces had less frequent DIFs in the Wilton assemblage (n = 6; 12 %) than in the Robberg (n = 7; 20 %) at NBC (see Figure 10.6). Milky quartz pieces had fewer DIFs in the Wilton (n = 3; 6 %) than in the Robberg assemblages (n = 7; 20 %). In both the Wilton and Robberg assemblages crystal quartz pieces had the least DIFs (n = 1; 1.8 % and n = 3; 9 %).

Table 10.4: Nelson Bay Cave (NBC) Robberg tool types broken down according to rock types (*Qtz: quartzite; Mq: milky quartz; S: silcrete; Cq: crystal quartz)*

	NBC Robberg (n = 228)							
	Qtz		Mq		Cq		S	
	n	%	n	%	n	%	n	%
Bladelet	42	18.4	60	26.3	12	5.3	34	14.9
Convergent	25	11.0	2	0.9	1	0.4	5	2.2
Backed	23	10.1	21	9.2	1	0.4	2	0.9

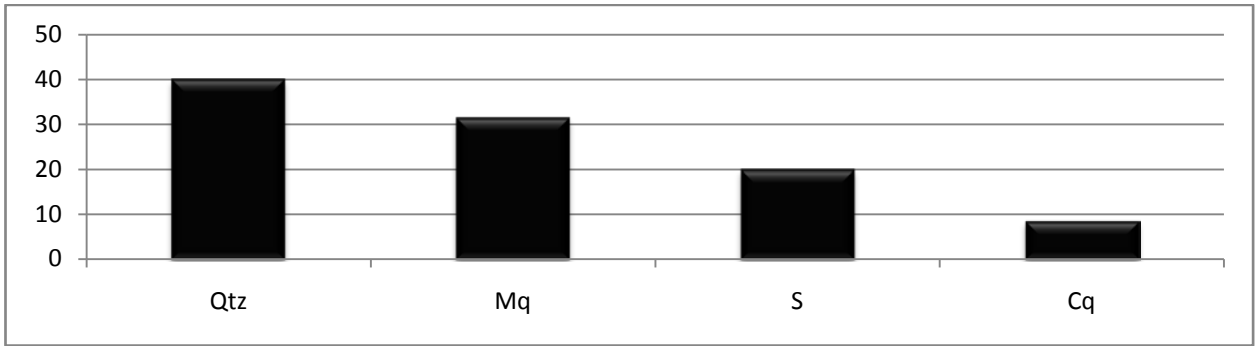


Figure 10.7: Diagnostic impact fracture frequencies on Nelson Bay Cave Robberg artefacts according to rock type *(Qtz: quartzite; Mq: milky quartz; S: silcrete; Cq: crystal quartz)*

The DIF patterns, when viewed as per raw material conformed in most respects to the frequencies of the different rock types in the Wilton and Robberg layers. Silcrete accounted for 8.76 % of the overall rock types in the NBC Robberg layers (Deacon, J. 1978). The high frequency of DIFs on silcrete in the NBC Robberg assemblages suggests that this raw material was chosen specifically for the manufacture of artefacts, especially bladelets, used as parts of impact weapons (see Figure 10.7 and Table 10.4). It is difficult to compare the milky quartz frequencies to the original NBC publications as no distinction was then made between milky quartz and crystal quartz. This is an important distinction as the two rock types have different knapping qualities.

10.2.1 *Summary*

The general macrofracture pattern in this NBC sample was for higher DIF frequencies in the Wilton as opposed to the Robberg. The highest DIF frequencies came from the mid-Wilton layers, but in general there appeared to be more variation, across tool types and layers, within the Wilton and Robberg than between them. Quartzite bladelets and convergent pieces have the most DIFs in the Wilton as do quartzite bladelets in the Robberg. Step fractures and impact burinations were the most frequent DIF types in both assemblages.

10.3 Byneskranskop macrofracture results

The BNK 1 sample consisted of 565 pieces. A majority of these pieces came from the Robberg layers at the site (n = 352, 62.5 %). The Wilton layers had a higher DIF frequency (n = 44; 22.1 %) than the Robberg layers (n = 66; 18.8 %) (see Table 10.5). However the Wilton and Robberg samples from square O 29 had a generally higher DIF frequency (n = 27; 29.1 % and n = 33; 24.6 %) than those from square 0 30 (n = 17; 15.5 % and n = 33; 15.1 %) (see Table 10.6). These frequencies were skewed by the high frequency of segments with DIFs in the O 29 Wilton sample (see Figure 10.9).

Table 10.5: Macrofracture results from the selected Wilton and Robberg assemblages at Byneskranskop 1 (BNK 1). (*BF: bifacial; UF: unifacial; DIF: diagnostic impact fracture)*

	BNK 1 Wilton n = 213		**BNK 1 Robberg n = 352**	
	n	**%**	**n**	**%**
Step terminating	26	12.2	48	13.6
BF Spin-off	0	0.0	0	0
UF Spin-off < 6 mm	6	2.8	2	0.6
UF Spin-off > 6 mm	3	1.4	1	0.3
Impact Burination	20	9.4	23	6.5
Hinge/feather terminating	17	8.0	20	5.7
Notch	33	15.5	43	12.2
Snap	71	33.3	141	40.1
Tools with DIFs	**47**	**22.1**	**66**	**18.8**
Tools with multiple DIFs	**3**	**1.4**	**2**	**0.6**

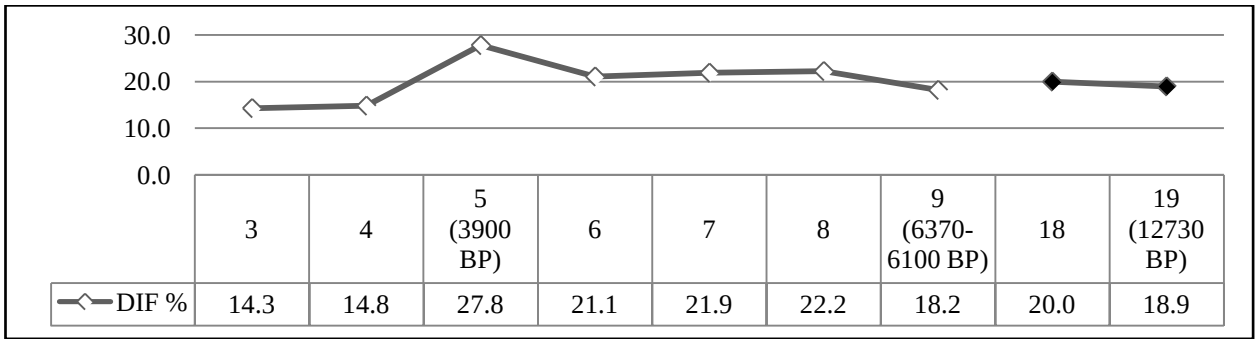
Table 10.6: Macrofracture (MF) and diagnostic impact fracture (DIF) frequencies from the Wilton and Robberg assemblages from squares O 29 and O 30 at Byneskranskop 1 (BNK 1)

Squares	**Total MF**	**Total Pieces**	**Tools with DIFs**	**DIF %**
0 30 Wilton	63	110	17	15.5
0 29 Wilton	76	103	30	29.1
BNK 1 Wilton	**139**	**213**	**47**	**22.1**
0 30 Robberg	130	218	33	15.1
0 29 Robberg	129	134	33	24.6
BNK1 Robberg	**259**	**352**	**66**	**18.8**

The layer by layer DIF data from BNK 1 showed that the lowest DIF frequencies occur in layers 3 and 4 (n = 7; 14.3 and n = 27; 14.8 %) (see Figure 10.8). The sample size from layer 3 is, however, small. The highest average DIF frequencies

came from the Wilton layers 5 – 8. The DIF differences between the layers from layer 5 (n = 54; 27.8 %) until layer 8 (n = 38; 22.2 %) were only slight. These layers are therefore combined in the rest of this section. The average DIF frequency from the Wilton layers 5 – 8 was 21.8 % (n = 31).

The two Robberg layers, 18 (n = 30) and 19 (n = 322), had a combined DIF frequency of 19 %. It is between these two groupings (5 - 8 and 18 - 19) that the greatest similarities existed. When compared to the combined DIF frequency of layers 3 and 4 (14.6 %), the DIF frequency of the Robberg layers appeared much higher, as did the DIF frequency of Wilton layers 5 to 8 (21.8 %). However, the sample size from layers 3 and 4 (n = 34) is somewhat smaller than in the other layers containing tools with DIFs and this may be skewing the results. Larger sample sizes from the later Wilton layers are needed for more conclusive results. With this in mind, changes in the DIF frequencies at the site appear more pronounced within the last 3000 years of occupation.



	3	4	5 (3900 BP)	6	7	8	9 (6370-6100 BP)	18	19 (12730 BP)
DIF %	14.3	14.8	27.8	21.1	21.9	22.2	18.2	20.0	18.9

Figure 10.8: Diagnostic impact fracture frequencies as per layer at Byneskranskop 1 *(Only those layers containing tools with DIFs are shown. White diamonds indicate Wilton layers, black diamonds indicate Robberg layers. DIF: diagnostic impact fracture; BP: before present)*

The Wilton assemblage showed the highest DIF frequency on segments (n = 23; 57.8 %) and convergent pieces (n = 9; 22.2 %) (see Figure 10.9). Backed artefacts (n = 8; 20 %) and bladelets (n = 7; 15.6 %) had the next highest DIF frequencies. This was expected because the Wilton industry at BNK 1 has a high number of backed artefacts and segments, some of which could have been used as hafted armatures (refer to Section 5.2.2). The three unifacial spin-off fractures > 6 mm (1.4 %) and six unifacial spin-off fractures < 6 mm (2.8 %) were the highest

frequencies of these fracture types in all these archaeological samples (Figure 10.10). However, only unifacial spin-off fractures > 6 mm were considered as DIFs (refer to Section 2.1). Step terminating fractures (n = 26; 12.2 %) and impact burinations (n = 20; 9.4 %) were the most frequent DIF types (see Table 10.5).

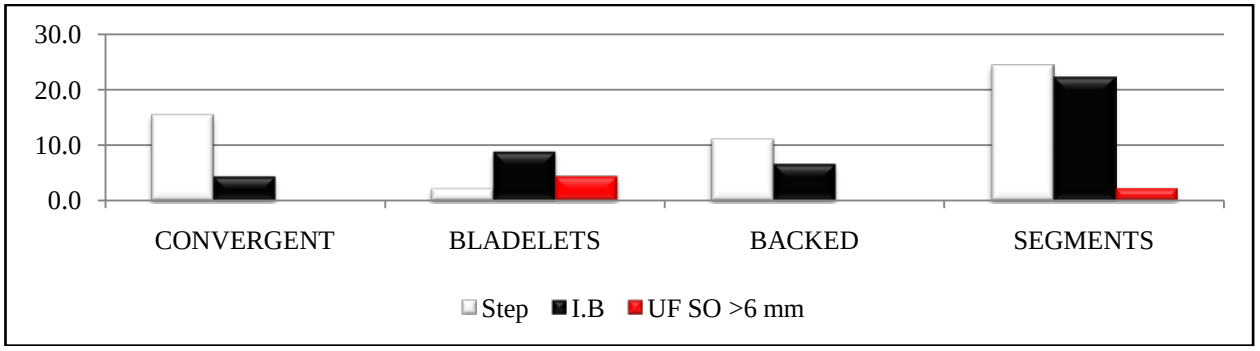


Figure 10.9: Tool types and diagnostic impact fracture (DIF) frequencies from the Wilton layers at Byneskranskop 1 *(Frequencies are of total BNK 1 Wilton DIFs. Note that one tool can have more than one macrofracture. I.B: impact burination; UF SO: unifacial spin-off fracture)*

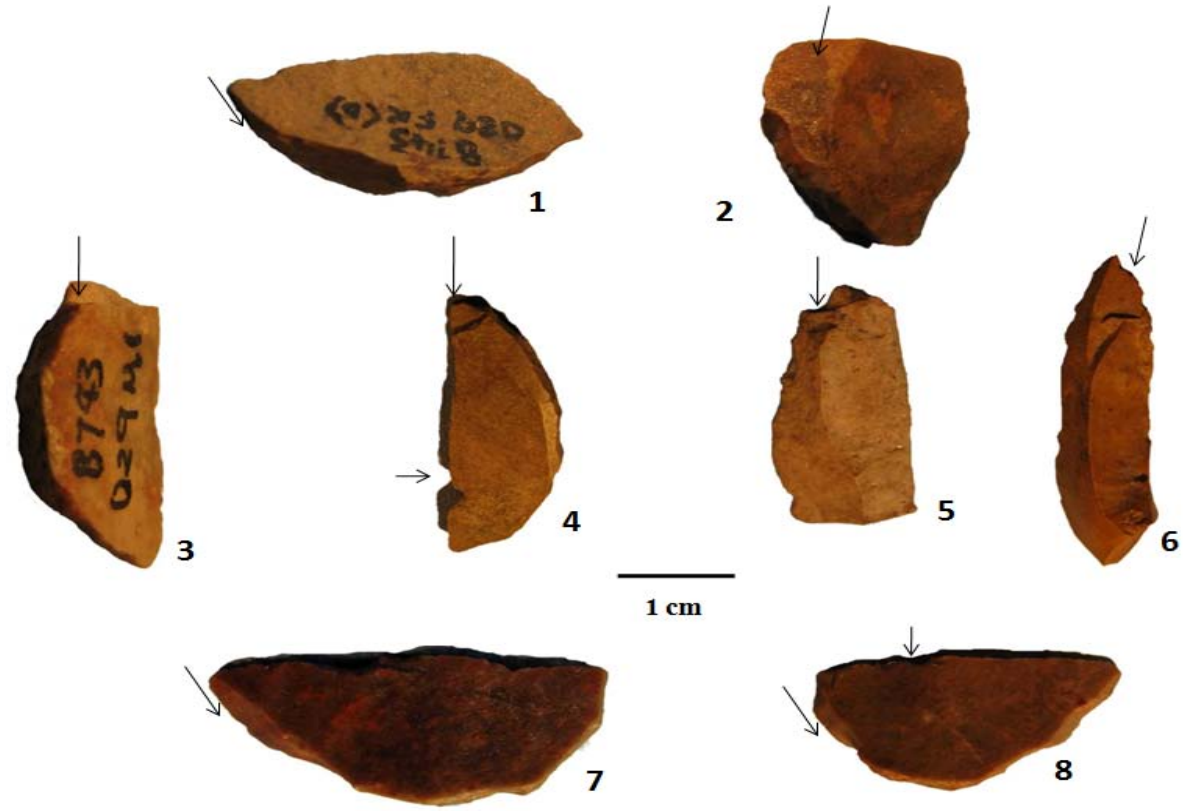


Figure 10.10: Diagnostic impact fractures on the Wilton pieces from Byneskranskop 1 *(1, 7 and 8: Impact burinations; 2: spin-off fracture > 6 mm; 3, 4, 5 and 6: step terminating fractures. 1, 2, 3, 4, 7 and 8: segments; 5 and 6: bladelets. Note: Number 4 has a notch possibly associated with a hafting medium; 7 has ochre staining on the dorsal surface; 8 has a notch on the cutting edge possibly associated with transverse hafting and use. All these pieces are from silcrete). Tools are positioned as in relation to how they may have been hafted and how the macrofractures may have formed.*

Bladelets had the highest DIF frequencies in the BNK 1 Robberg assemblage (n = 45; 63.4 %) followed by convergent (n = 20; 28.2 %) and backed pieces (n = 6; 8.5 %). This was expected due to the dominance of bladelets in the Robberg sample at this site. Step terminating fractures (n = 48; 13.6 %) and impact burinations (n = 23; 6.5 %) were the most common fracture types on these pieces (see Figure 10.12). One unifacial spin-off fracture > 6 mm (1.4 %) was noted on a convergent piece in this sample.

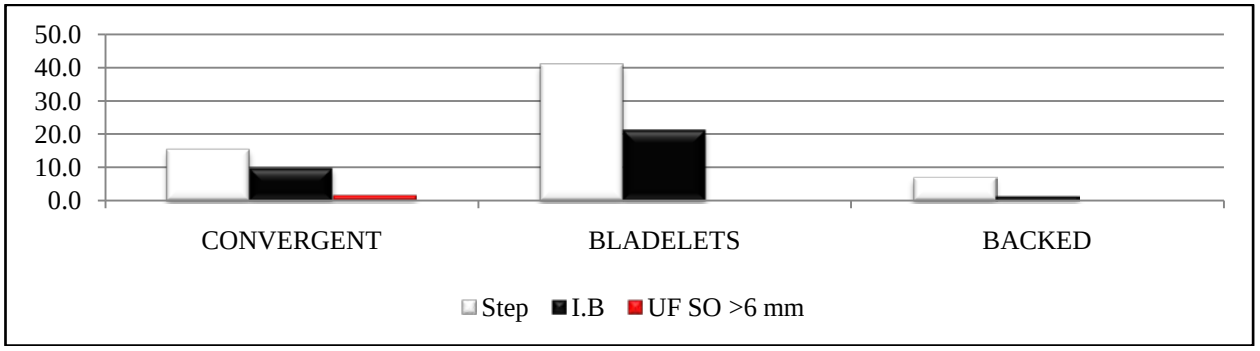


Figure 10.11: Tool types and macrofracture frequencies from the Robberg layers at Byneskranskop 1 *(Frequencies are of total BNK 1Robberg DIFs. Note that one tool can have more than one macrofracture. I.B: impact burination; UF SO: unifacial spin-off fracture)*

The high frequency of DIFs on segments in the BNK 1 Wilton sample was expected, as segments are a common feature of Wilton assemblages in southern Africa and they are possible hafted armatures (refer to Section 5.2.2). The dominance of bladelets with DIFs in the NBC Robberg sample was also expected for the same reasons. Step terminating fractures and impact burinations were the most frequent DIFs in both of these assemblages.

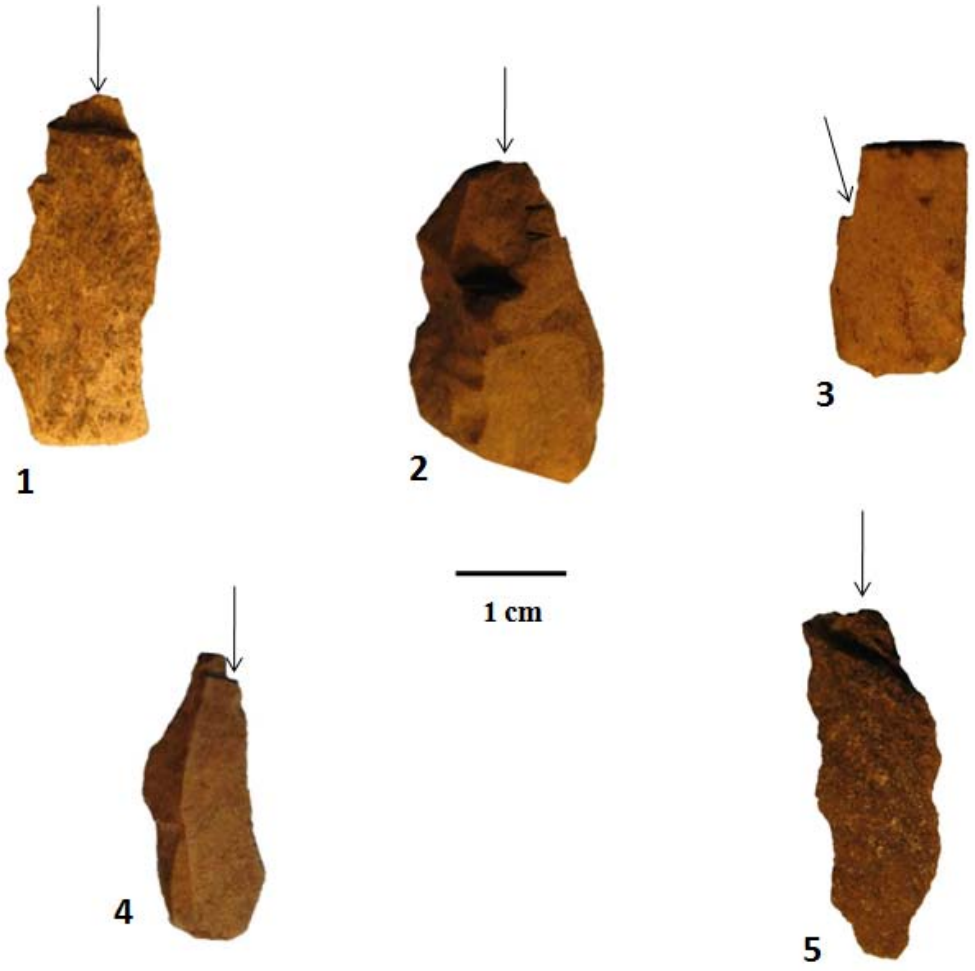


Figure 10.12: Diagnostic impact fractures on Robberg pieces from Byneskranskop 1 *(1, 2, 4 and 5: step terminating fractures; 3: impact burination. All the pieces are bladelets. 1: limestone; 2 and 3: silcrete; 4 and 5: quartzite)*

Silcrete was the raw material with the highest DIF frequencies in the Wilton assemblage at BNK 1 (n = 39; 88.6 %) (see Figure 10.13). This is explained by the fact that the majority of retouched artefacts from the Wilton layers at BNK 1 were made from silcrete (83.68 %) (refer to Section 6.3). Yet silcrete was not the most common raw material in this Wilton sample (see Table 10.7). Diagnostic impact fractures were also found on the quartzite (n = 4; 10 %) and crystal quartz (n = 1; 2.3 %) assemblages from BNK 1.

Table 10.7: Byneskranskop 1 (BNK 1) Wilton tool types broken down according to raw material types (*Qtz: quartzite; Mq: milky quartz; S: silcrete; Cq: crystal quartz)*

	BNK 1 Wilton (n = 213)							
	Qtz		Mq		Cq		S	
	n	%	n	%	n	%	n	%
Bladelet	73	24.7	11	3.7	6	2.0	12	4.1
Convergent	99	33.6	3	1.0	4	1.4	4	1.4
Backed	60	20.3	4	1.4	2	0.7	4	1.4
Segment	0	0.0	2	0.7	5	1.7	3	1.0
Blade	3	1.0	0	0.0	0	0.0	0	0.0
Other	0	0.0	0	0.0	0	0.0	4	1.4

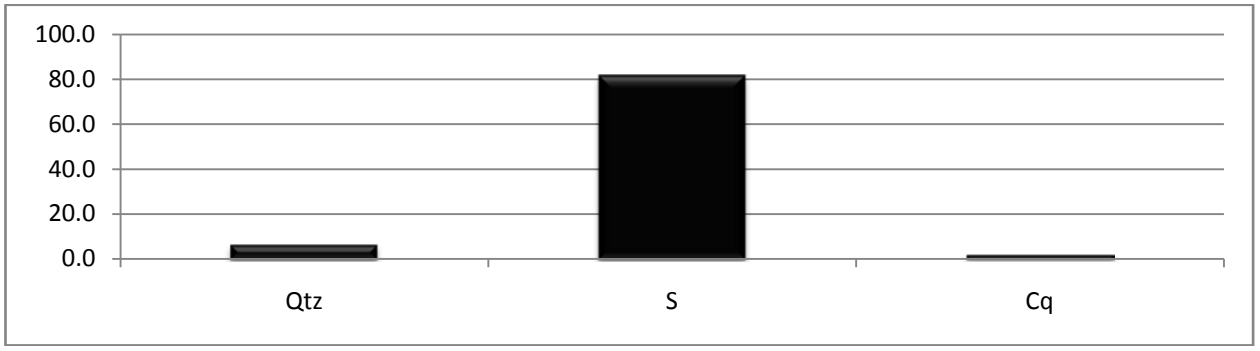


Figure 10.13: Diagnostic impact fracture frequencies on Byneskranskop 1 Wilton artefacts according to rock type *(Qtz: quartzite; S: Silcrete; Cq: crystal quartz)*

The Robberg DIFs occurred mainly on silcrete pieces (n = 29; 43.9 %) (see Figure 10.14). Although quartzite was the most frequent raw material in the Robberg layers at BNK 1 (26 %), silcrete was the most common raw material for retouched pieces (56.8 %) (refer to Section 6.3). This frequency was therefore expected. Quartzite (n = 16; 24.2 %), milky quartz (n = 12; 18.2 %), limestone (n = 6; 9.1 %) and crystal quartz (n = 2; 3 %) also had DIFs. Limestone is a raw material not seen in the Wilton assemblage, but derived from the limestone hill on which BNK 1 is situated.

Table 10.8: Byneskranskop 1 (BNK1) Robberg tool types broken down as per raw material types (*Qtz: quartzite; Mq: milky quartz; S: silcrete; Cq: crystal quartz)*

	BNK 1 Robberg (n = 352)									
	Qtz		Mq		Cq		S		L	
	n	%	n	%	n	%	n	%	n	%
Bladelet	38	17.7	55	25.6	16	7.4	102	47.4	7	3.3
Convergent	33	15.3	12	5.6	3	1.4	14	6.5	8	3.7
Backed	25	11.6	13	6.0	4	1.9	15	7.0	2	0.9

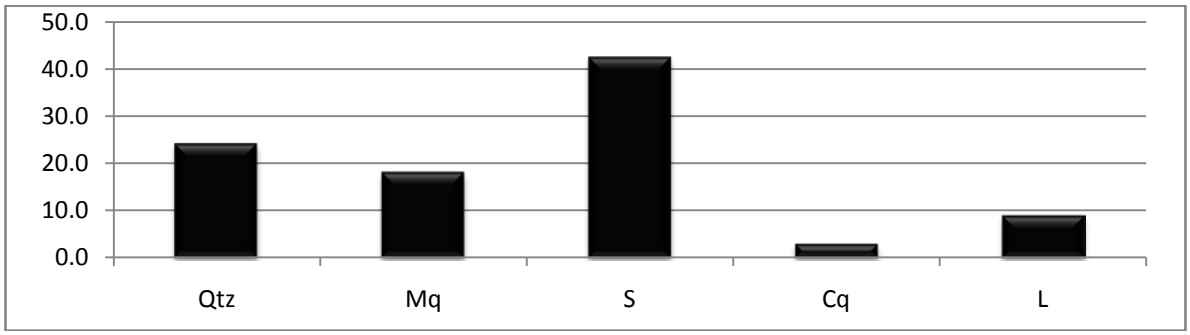


Figure 10.14: Diagnostic impact fracture frequencies on Byneskranskop 1 Robberg artefacts according to rock type type *(Qtz: quartzite; Mq: milky quartz; S: silcrete; Cq: crystal quartz; L: limestone)*

10.3.1 *Summary*

The macrofracture results from BNK 1 showed a slightly higher DIF frequency in the Wilton than in the Robberg sample. The changes in DIF frequencies appear more pronounced in the last 3000 years of occupation at the site, but the samples from layers 3 and 4 are at present too small to be conclusive about this. The tool types with DIFs were expected, and show a greater number of segments with DIFs in the Wilton and bladelets with DIFs in the Robberg. The most common raw material in both samples was silcrete, which was also the most common raw material for retouched and utilised artefacts at BNK 1.

10.4 Blombosfontein Reserve Site 4 macrofracture results

The BBF 4 site contains a classic Wilton assemblage (refer to Section 6.4). The sample consisted of 215 silcrete pieces of which 45 showed some form of DIFs (20.9 %). These are mainly step terminating fractures (n = 43; 20 %) and impact burinations (n = 20; 9.3 %) as is the case with the NBC and BNK 1 assemblages

(see Table 10.9). Only one unifacial spin-off fracture > 6 mm (0.5 %) was present.

Table 10.9: Macrofracture results from the Wilton assemblage at Blombosfontein Reserve Site 4 (BBF 4). (*BF: bifacial; UF: unifacial; DIF: diagnostic impact fracture)*

	BBF 4 Wilton n = 215	
	n	**%**
Step terminating	43	20.0
BF Spin-off	0	0.0
UF Spin-off < 6 mm	0	0.0
UF Spin-off > 6 mm	1	0.5
Impact Burination	20	9.3
Hinge/feather terminating	5	2.3
Notch	35	16.3
Snap	113	52.6
Tools with DIFs	**45**	**20.9**
Tools with multiple DIFs	**2**	**0.9**

In this section, the DIFs from BBF 4 were broken down according to the squares in which the tools were found as the BBF 4 site has only one occupation layer (see Table 10.10). The excavated materials from the site come from high and low density deposits of an inner *in situ* and outer talus slope area (refer to Section 6.4). The DIF frequencies were plotted onto the BBF 4 excavation map (see Figure 10.15) to see if there is a correlation between deposit density and DIF frequencies.

Table 10.10: Diagnostic impact fracture frequencies from Blombosfontein Reserve Site 4 according to square

Square	Total Pieces	DIF Pieces	DIF %
CC	96	19	19.8
BD	79	22	27.8
DB	31	3	10.3
EA	6	0	0.0
AE	3	1	33.3
TOTAL	**215**	**45**	**20.9**

The highest DIF frequencies (n = 3; 33 %) came from the outer talus slope area of squares AE 51 - 91 (see Table 10.10). This was a low density and a secondary context deposit (see Figure 10.15). However, the sample size from this area was small, consisting of only three pieces with one DIF. The sample from the EA

squares, also from the outer talus area, was likewise a small sample (n = 6; 0 %). The focus of this discussion is therefore on the squares with larger data samples at BBF 4.

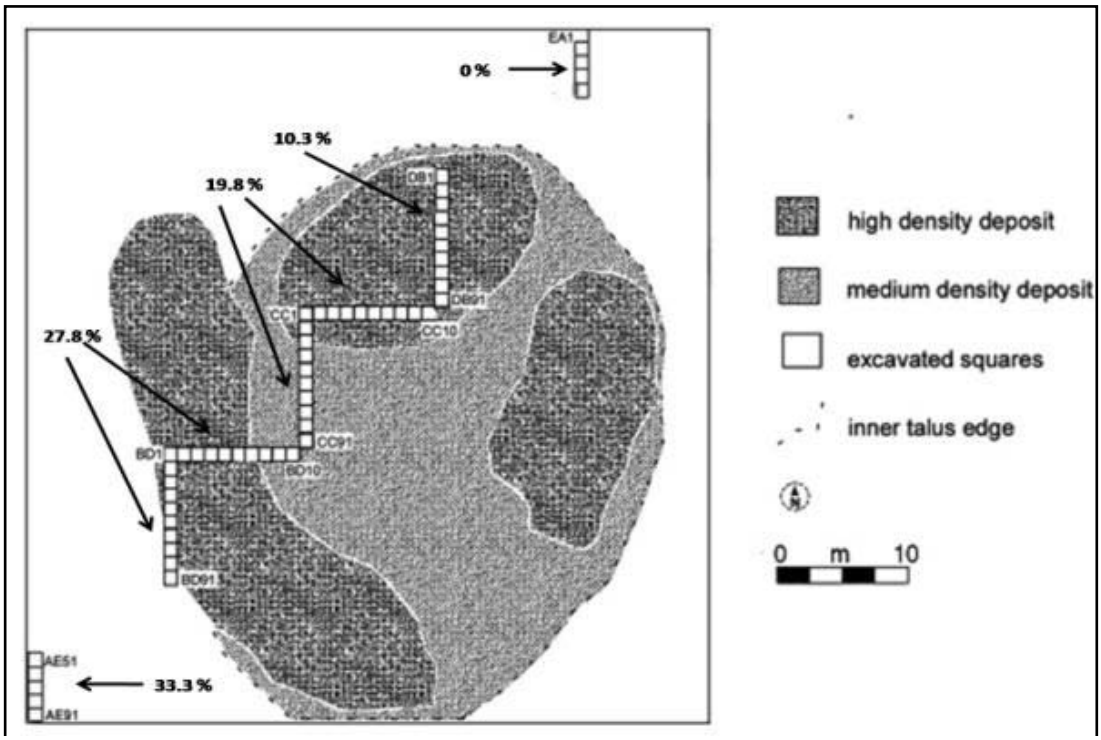


Figure 10.15: Blombosfontein Reserve Site 4 excavation plan and diagnostic impact fracture frequencies according to excavated squares

The samples from squares BD 1 - 10 and 11 - 91 (n = 79), a high density deposit, had the second highest DIF frequencies (27.8 %). The sample from the CC squares (n = 19) had a DIF frequency of 19.8 %. This sample had slightly more tools with DIFs from the squares CC 1 - 10 (n = 10), which was a high density deposit, as opposed to squares CC 11 - 91 (n = 9), a medium density deposit. The second lowest DIF frequencies (n = 31; 10.3 %) came from the DB squares which was in a high density deposit area.

The AE and DB squares had the only samples that did not conform to the pattern of a high density deposit and higher DIF frequencies. They were also the squares with the smallest samples and were therefore not weighted the same as the other larger data samples. In general, the highest DIF frequencies obtained at BBF 4

came from the *in situ* high density deposits. One interpretation of this pattern was that these areas may have been high activity areas, for retooling, hafting or knapping at the site in the past.

Bladelets were the most fractured pieces in the BBF 4 assemblage (n = 46; 97.9 %) (see Figure 10.16). These consist mainly of step terminating fractures (n = 27; 57. 4 %), impact burinations (n = 18; 38. 3 %) and a unifacial spin-off fracture > 6 mm (n = 1; 2.1 %) (see Figure 10.17). A single step terminating fracture was the only DIF on the backed artefacts (2.1 %). These figures were distorted in favour of bladelets as I was unable to analyse and include other backed and retouched artefacts from the site (refer to Section 6.4).

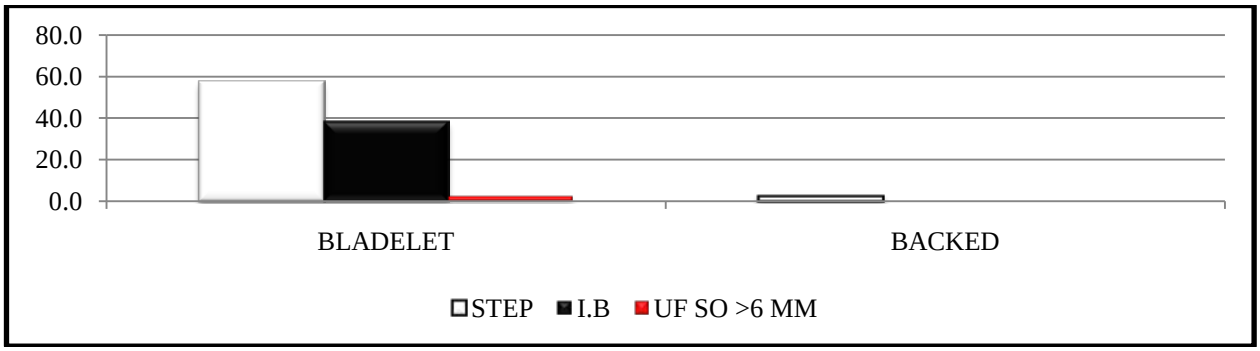


Figure 10.16: Tool types and macrofracture frequencies from Blombosfontein Reserve Site 4
(Frequencies are of total BBF 4 Wilton DIFs. Note that one tool can have more than one macrofracture. I.B: impact burination; UF SO: unifacial spin off fracture)

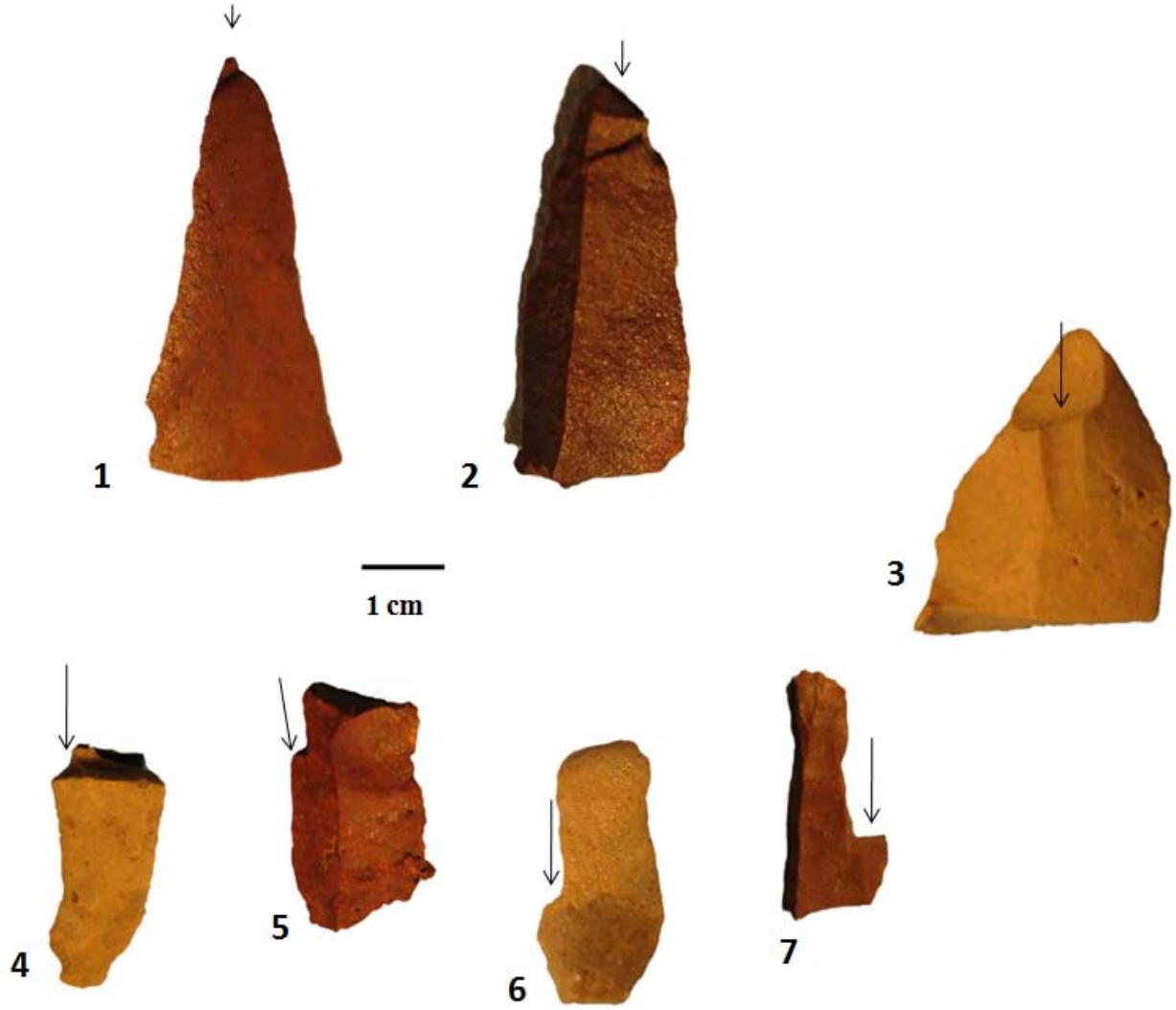


Figure 10.17: Diagnostic impact fractures on the Wilton pieces from Blombosfontein Reserve Site 4 *(1, 2 and 4: step terminating fractures; 3: spin-off fracture > 6 mm; 5, 6 and 7: impact burinations. 1, 2 and 3: convergent pieces; 4, 5, 6 and 7: bladelets. 2 and 6: quartzite; 1, 3, 4, 5, 7: silcrete)*

10.4.1 *Summary*

The macrofracture results from BBF 4 showed DIF frequencies comparable to the Wilton sample from BNK 1. The highest DIF frequencies came from medium - high density deposits at the site. These may have been areas where specific activities, such as fixing hafted implements or knapping took place in the past. Bladelets were the tool types with the highest DIFs and these were mainly step terminating fractures and impact burinations.

10.5 Chapter summary

In this chapter, I presented the results of the macrofracture analyses of the three Wilton and two Robberg assemblages. The Wilton assemblages had a generally higher mean DIF frequency than the Robberg assemblages. There were exceptions to this general pattern as is shown in the gamma 3 Wilton sample from NBC. Most of the DIFs were made up of step terminating fractures and impact burinations with very few spin-off fractures noted. Patterns in the DIF data were most notable when the DIF frequencies were viewed layer by layer at each site. When viewed this way, the mean DIF frequencies were greater within each industry than between the two industries.

CHAPTER 11: RESULTS OF MORPHOMETRIC ANALYSES ON ARCHAEOLOGICAL ASSEMBLAGES

11.1 Introduction

This is the second of two archaeological results chapters. This chapter contains the results of calculations based on length, breadth and thickness measurements from the NBC, BNK 1 and BBF 4 samples (refer to Chapter 6). The morphometric measurements for the Wilton and Robberg bladelets are from complete bladelets. The length/breadth ratios are for bladelets with DIFs as this measurement takes into account the variation caused by different sized bladelets. The remaining pieces presented in this chapter were found with some form of DIF on them. A complete collection of data tables containing the results of all the measurements and calculations contained in this chapter are provided in Appendix 2 on the cd at the back of this dissertation.

The aims of this chapter are threefold. Firstly, I aim to assess whether temporal and typological patterns can be identified and added to the macrofracture data already reported for these pieces (refer to Chapter 10). I then aim to investigate what weapon types may be represented by the backed artefacts and bladelets from BNK 1 and NBC during the Wilton and Robberg phases, as macrofracture data are only considered a starting point for this type of investigation. Lastly, I aim to assess whether the convergent pieces from BNK 1 and NBC could have performed as the tips of successful hunting weapons.

Cross-sectional perimeter, co-efficient of variation (CV), length/breadth ratios and tip cross-sectional area (TCSA) calculations on the Wilton and Robberg segments, broken and whole bladelets and convergent pieces are presented and discussed. Comparisons of these measurements with other archaeological assemblages are given and the results of the Student's t-tests for difference between the Wilton and Robberg whole bladelets are presented.

11.2 Wilton and Robberg whole bladelet morphometric comparisons

One of the technological assumptions about the bladelet components of the Wilton and Robberg industries is that they represent a standardised form of stone tool technology (Deacon, J. 1984) (refer to Section 5.2.1). Standardised bladelets can be used as components in hafted weaponry and can replace one another because of their morphological similarities. Morphologically similar tools can be used in hafts that are of a standard size as they all fit into the same size slots.

11.2.1 *Results of co-efficient of variation (CV) calculations*

The CV calculation is one way of measuring standardisation in stone artefacts (Eerkens & Bettinger 2001) (refer to Section 8.3.1). Coefficient of variation values were calculated for the Wilton and Robberg whole bladelets to see if either assemblage is standardised, and if this changes over time between the Wilton and Robberg industries (see Table 11.1 and Table 11.2). Measurements used in the equation are: length, breadth and thickness.

Table 11.1: Results of CV calculations on the Blombosfontein Reserve Site 4 (BBF 4), Byneskranskop 1 (BNK 1) and Nelson Bay Cave (NBC) Wilton whole bladelets *(L: length; B: breadth; T: thickness; SD: standard deviation; CV: coefficient of variation. Measurements are in millimetres)*

	BBF 4 Wilton Bladelets n = 51			**BNK 1 Wilton Bladelets n = 16**			**NBC Wilton Bladelets n = 41**			**Wilton Bladelets overall n = 108**		
	L	B	T	L	B	T	L	B	T	L	B	T
Mean	17.7	8.0	3.4	24.1	12.3	4.7	18.2	8.6	3.5	18.81	8.83	3.60
SD	5.7	2.4	1.6	9.7	3.6	1.6	4.9	2.1	1.1	6.49	2.87	1.51
CV	**32.1**	**29.9**	**48.9**	**40.3**	**28.9**	**33.4**	**27.0**	**24.5**	**32.3**	**34.52**	**32.49**	**42.03**

Table 11.2: Results of CV calculations on the Byneskranskop 1 (BNK 1) and Nelson Bay Cave (NBC) Robberg whole bladelets *(L: length; B: breadth; T: thickness; SD: standard deviation; CV: coefficient of variation. Measurements are in millimetres)*

	BNK 1 Robberg Bladelets n = 49			**NBC Robberg Bladelets n = 61**			**Robberg Bladelets overall n = 110**		
	L	B	T	L	B	T	L	B	T
Mean	14.9	7.5	3.2	17.9	8.1	3.5	16.55	7.86	3.38
SD	4.2	2.9	1.6	4.6	2.4	1.2	4.65	2.67	1.37
CV	**27.9**	**39.2**	**49.1**	**26.0**	**29.7**	**33.4**	**28.12**	**34.02**	**40.54**

Compared to Wadley and Mohapi's (2008) mark for standardisation (CV≤ 10) , the CVs for bladelet length in the Wilton are less standardised (CV = 34.52) than in the Robberg (CV = 28.12 mm). The CV for bladelet breadth in the Robberg (CV = 34.02 mm) is greater than the same variable for the Wilton bladelets (CV = 32.49 mm). The Robberg bladelet thicknesses are slightly more standardised (CV = 40.54 mm) than in the Wilton (CV = 42.03 mm). None of these values is close to Wadley and Mohapi's mark for standardisation. The variables that come closest to Wadley and Mohapi's mark are the NBC Wilton bladelet breadths (CV = 24.5 mm) and lengths (CV = 27 mm) (n = 41) and NBC Robberg bladelet lengths (CV = 26 mm) (n = 61). The rest of the CVs are also relatively unstandardised (see Figure 11.1).

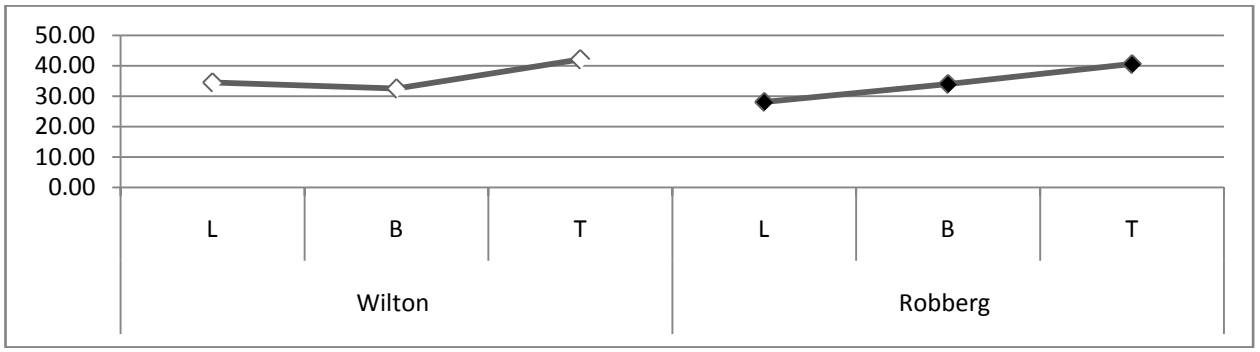


Figure 11.1: Results of coefficient of variation calculations on Wilton and Robberg whole bladelets from Nelson Bay Cave, Byneskranskop 1 and Blombosfontein reserve site 4 *(White diamonds indicate Wilton measurements, black diamonds indicate Robberg measurements. L: length, B: breadth, T: thickness. Measurements are in millimetres)*

Table 11.3 presents the results of measurements and CV calculations on the Howieson's Poort segments from Sibudu Cave (Wadley & Mohapi 2008). The three segment populations presented in this table are thought to represent the tips of different hunting weapon types (Wadley & Mohapi 2008: 2599). Hornfels and dolerite segments have relatively high TCSA values (refer to Section 11.4) and are interpreted as possible spear tips. The quartz segments from Sibudu Cave have smaller mean TCSA values (refer to Section 11.4) that makes them comparable to North American arrowheads, assuming they were hafted transversely.

Table 11.3: Coefficient of variation values for the Sibudu Cave Howieson's Poort segments as per rock type *(Source: Wadley & Mohapi 2008: 2599, SD: standard deviation; CV: coefficient of variation. Measurements are in millimetres)*

Rock Type	Statistic	Length	Breadth	Thickness
Hornfels segments	Mean	28.1	11.7	3.8
	SD	10.2	3.3	1.2
	CV	36.3	28.4	31.4
	n	43	53	53
Dolerite segments	Mean	36.2	14.2	5.0
	SD	11.1	3.4	1.4
	CV	30.7	24.1	28.0
	n	23	29	29
Quartz segments	Mean	17.0	9.7	3.8
	SD	4.0	2.7	1.4
	CV	23.5	27.8	35.9
	n	13	14	14

I now wish to briefly compare the CV measurements for the Sibudu HP segments to the CVs for the Wilton and Robberg whole bladelets in this study. Although these are not the same tool types, they are both hypothesised to have been hafted and potentially used as components in hunting weapons (refer to Section 5.2). It is therefore useful to compare their morphological aspects. The lengths of the Wilton (mean = 18.81 mm) and Robberg bladelets (mean = 16.55 mm) are comparable to the lengths of the Sibudu small quartz segments (mean = 17 mm). In terms of length, the bladelets in this study are less standardised then the Sibudu HP segments. The Wilton (CV = 32.49 mm) and Robberg (CV = 34.02 mm) breadths are larger than the breadth CVs for the Sibudu segments (CVs = 28.4; 24.1; 27.8 mm). I interpret this to mean that the breadths of the bladelets in this study are less standardised, especially those of the Robberg, in comparison to the segments from Sibudu. The Wilton (CV = 42.03 mm) and Robberg (CV = 40.54 mm) CVs for thickness are considerably larger than any CVs for thickness of the Sibudu segment samples. Bladelet thickness and breadth are therefore the least similar variables between the two data sets, whilst length is the most similar only to the Sibudu small quartz segments.

Taken as a whole, it appears as if the greatest similarity in mean length, breadth and thickness values exists between the Wilton and Robberg whole bladelets and the small quartz segments from Sibudu. All of the whole bladelet samples in this analysis were unstandardised in comparison with the Sibudu HP segments.

11.2.2 *Results of length/breadth ratio calculations on broken bladelets*

Length/breadth ratios provide a means of assessing the overall shape and elongation of artefacts (Wadley & Mohapi 2008). Here this measurement is used as a means of assessing the morphological similarities and differences between Wilton and Robberg broken bladelets.

Table 11.4: Length/breadth ratios for the Wilton and Robberg broken bladelets from Byneskranskop 1 (BNK 1), Nelson Bay Cave (NBC) and Blombosfontein reserve site 4 (BBF 4). *(SD: standard deviation; CV: coefficient of variation. Measurements are in millimetres)*

	BNK 1 Robberg	**NBC Robberg**	**BNK 1 Wilton**	**NBC Wilton**	**BBF 4 Wilton**
Mean	2.2	2.1	1.8	2.1	2.2
SD	0.6	0.4	0.3	0.4	0.6
CV	28.5	20	15.4	21.6	28.2
n	43	20	6	21	45

Table 11.4 presents the overall results of the Wilton and Robberg broken bladelet length/breadth calculations. The length/breadth ratios for these broken bladelets show that both bladelet populations are very similar in shape and are similarily elongated. The NBC Robberg, BNK 1 Wilton and NBC Wilton bladelets are most standardised in this ratio (CVs = 20; 15.4; 21.6), while the BNK 1 Robberg and BBF 4 Wilton bladelets are similarily less standardised in this ratio (CVs = 28.5; 28.2). Table 11.5 summarises the results of a Student's t-test on these values. The results show that the Wilton and Robberg broken bladelets are not significantly different in terms of their length/breadth ratios. This is likely a reflection of the generally similar morphometric attributes of the bladelets from these two industries (see Table 11.1 andTable 11.2). The BNK 1 Wilton bladelets have the lowest length/breadth ratio (1.8) although this sample is relatively small (n = 6).

Table 11.5: Student's t-test results on the Wilton and Robberg bladelet length/breadth ratios
(Df: degrees of freedom; t. statistic: test statistic; p: two-tailed test probability)

Variable description	n	Mean	Df	t. statistic	p
L/B ratio of Wilton bladelets	72	2.17	133	0.08	> 0.05
L/B ratio of Robberg bladelets	63	2.17			

11.2.3 *Summary of the Wilton and Robberg bladelet morphometric comparisons*

From these values it appears as if both Wilton and Robberg bladelet samples tended to be most standardised in terms of length (CVs = 34.52 mm and 28.12 mm), relative to their other morphological characteristics. The length/breadth ratios show that the bladelets from both of these industries are similar, although not standardised in terms of shape and elongation.

The CVs for length (34.52 mm and 28.12 mm) vary the most between the two samples, whilst the CVs for breadth (32.49 mm and 34.01 mm) and thickness (42.03 mm and 40.54 mm) are the most similar between the two samples. These values lay well above Wadley and Mohapi's (2008) mark for standardisation (CV ≤ 10). The greatest similarity in CV values exists between the whole bladelets and the HP small quartz segments from Sibudu Cave. The mean length, breadth and thickness measurements are also most similar between the Wilton and Robberg bladelets and Sibudu small quartz segments.

11.3 Tests for difference on the Wilton and Robberg whole bladelet measurements

The data sets in this section do not differ significantly from normal distributions profiles. As such, an unpaired two-tailed Student's t-test for unequal variances was conducted on the Wilton and Robberg bladelet measurements (L, B, and T) (refer to Section 8.3.4). This was done to see if the differences and similarities identified in Section 11.2 are significant (see Table 11.6). The null hypothesis used in these tests is that there is no difference between the two tested dimension and the two bladelet measurements are therefore equal. The alternative hypothesis is that there is a significant difference between the two tested dimensions and that the two bladelet measurements are therefore different.

Table 11.6: Student's t-test results on the Wilton and Robberg whole bladelet measurements
(Df: degrees of freedom; t. statistic: test statistic; p: two-tailed test probability)

Test #	Variable description	n	Mean	df	t. statistic	p
1	Length of Wilton bladelets	108	18.81	194	-2.95	< 0.05
	Length of Robberg bladelets	110	16.54			
2	Breadth of Wilton bladelets	108	8.83	214	-2.58	< 0.05
	Breadth of Robberg bladelets	110	7.86			
3	Thickness of Wilton bladelets	108	3.60	213	-1.14	> 0.05
	Thickness of Robberg bladelets	110	3.38			

The Wilton and Robberg whole bladelet lengths are significantly different (see Table 11.6) indicating a significant difference between the sample means. On average, the Wilton whole bladelets in this sample are longer than Robberg whole bladelets. Wilton and Robberg breadths are significantly different (see Table 11.6) indicating that the Wilton whole bladelets are wider than Robberg whole bladelets on average. Mean thicknesses for the Wilton and Robberg bladelets are not significantly different (see Table 11.6). Thus, these bladelets are most similar with respects to their thickness values.

The results of these tests support observations from the CV calculations (refer to Section 11.2) that Wilton bladelets are significantly different from Robberg bladelets in length (t = -2.95; p = < 0.05) and breadth (t = -2.58*;* p = < 0.05). Bladelet thickness is the measurement most similar (t = -1.14*;* p = > 0.05), but the least standardised (CV = 42.03 and 40.54) between the Wilton and Robberg samples. If Wilton bladelets were consistently different from Robberg bladelets consistently higher *p*-values for comparisons of the length, breadth and thickness variables would be expected between the two samples. Non-significant differences were only for the bladelet thickness comparisons.

11.3.1 *Summary of the Student's t-tests for difference on whole bladelet measurements*

From the above tests, it is clear that the Wilton bladelets sampled in this project are consistently different from the Robberg bladelets in two of the tested dimensions. Breadth and length in the two samples are most different, whilst

thickness is most similar. The similarity in thicknesses between the two samples may be related to potential similarities in the hafting and functions of these bladelets (refer to Section 12.5). However, the fact that both of these bladelet populations are relatively unstandardised in this measurement makes this seem unlikely.

11.4 Tip cross-sectional area and length/breadth calculations on Wilton segments

This section presents the results of two versions of the TCSA calculation on the Wilton segments from BNK 1 and NBC with DIFs (see Table 11.7). For details of the TCSA method refer to Section 8.3.2. The results of length/breadth ratio calculations for these segments are also presented.

11.4.1 *Results of tip cross-sectional area calculations*

One Wilton segment from NBC had a DIF whilst the Wilton assemblage from BNK 1 had 20 segments with DIFs. The two samples were combined for these calculations because both of them are from the Wilton industry, and because the NBC sample had only one piece. The NBC and BNK 1 segments' TCSA values were compared to TCSA values from other archaeological and ethnographic tools. The TCSA values have been calculated for HP quartz, hornfels and dolerite segments from Sibudu Cave (Wadley & Mohapi 2008) (see Table 11.7). Sibudu quartz segments' mean TCSA values are close to those of North American arrowheads, whilst hornfels and dolerite segments have higher mean TCSA values and there is the potential that they were used to tip spears (Wadley & Mohapi 2008). As my tools are also segments, I have used these data for comparative purposes here. Segments hafted back-to-back, from the Pargeter (2007) experiments, are added here for further comparison because their TCSA values fall in between those for North American arrowheads and darts. In the Pargeter (2007) experiments, these weapons most resembled small spears (refer to Section 2.2). The values given in Table 11.7 are mean values, which mask variability within the samples. Given these constraints, the TCSA values are calculated and

compared here to see where my tools fit into an existing hunting weaponry classification scheme.

Table 11.7: Results of tip cross-sectional area (TCSA) calculations on the Byneskranskop 1 (BNK 1) and Nelson Bay Cave (NBC) Wilton segments and comparisons to ethnographic and archaeological samples *(Two versions of the TCSA calculation are presented here. The TCSA 1 calculation follows the regular calculation formula. The TCSA 2 calculation follows Wadley and Mohapi 2008 in replacing breadth with length in the equation to reflect the potential use of segments as transverse hafted pieces. SD: standard deviation. Measurements are in millimetres)*

Sample description	Mean (mm^2)	Max	Min	SD	n
NBC & BNK 1 Wilton segments TCSA 1	15.99	37.25	2.87	8.61	24
NBC & BNK 1 Wilton segments TCSA 2	29.88	83.43	6.91	18.05	24
Sibudu quartz segments TCSA 2	31.5	60	14.7	15.4	13
Sibudu hornfels segments TCSA 2	56.9	151	19	34.6	43
Sibudu dolerite segments TCSA 2	95.7	239	19.7	46	23
North American arrowheads TCSA 1	33	146	8	20	118
North American darts TCSA 1	58	94	20	18	40
Experimental thrusting spears TCSA 1	168	392	50	89	28
Back-to-back hafted segments TCSA 1	71.3	100	27	28.3	6

The BNK 1 and NBC Wilton segments' mean TCSA 1 value (15.99 mm^2) is considerably lower than the TCSA 1 value for North American darts (mean = 58 mm^2) and arrowheads (mean = 33 mm^2) (see Table 11.7). This value is also less than the experimental spears (mean = 168 mm^2) and back-to-back hafted segments (mean = 71.3 mm^2). The maximum TCSA 1 value for this data set (37.25 mm^2) is very similar to the mean value for the Sibudu quartz segments (31.5 mm^2) and North American arrowheads, but the minimum value (2.87 mm^2) is not. Taken as a mean, the TCSA 1 value for these segments has no comparison in this scheme.

The second TCSA calculation assumes that the BNK 1 and NBC Wilton segments were hafted transversally. Here the mean TCSA 2 value (29.88 mm^2) is closer to the mean North American arrowhead and Sibudu quartz segments' values than it is to the darts, thrusting spears or back-to-back hafted segments. The TCSA 2 maximum value (83.43 mm^2) is higher than the North American arrowhead mean TCSA 1 value and is closer to the back-to-back hafted segments mean value, whilst the minimum value (6.91 mm^2) has no parallel. The SD for this TCSA 2

calculation (SD = 18) is higher than the standard deviation for the TCSA 1 calculation (SD = 8.61). This means that the segments in this study are more variable in terms of length than breadth, as this is the variable that is switched in these two calculations.

These average TCSA 2 values suggest that the BNK 1 and NBC segments, hafted transversally, could hypothetically have been used as arrowheads. However, there is considerable variation within these data samples. For instance, the BNK 1 and NBC Wilton segments' TCSA 2 calculation has a maximum value of 83.43 mm² and a minimum value of 6.91 mm². These values suggest that some of these Wilton segments, if hafted transversally, could be considered larger than arrowheads and closer to hypothetical tips of darts or spears. The same is true of the BNK 1 and NBC Wilton segments' TCSA 1 values, which show a maximum of 37.35 mm² (arrowhead) and a minimum of 2.87 mm² (no parallel). These values are therefore most useful when they are considered as an initial means of assessing the hypothetical placement of Wilton segments into broad weapon typological schemes.

11.4.2 *Results of length/breadth ratio calculations*

The results of length/breadth ratio calculations for the BNK 1 and NBC Wilton segments are presented in Table 11.8. In terms of these ratios, the Wilton segments have dimensions that are less blade-like than the Howieson's Poort hornfels or dolerite segments from Sibudu and are more like the short and robust small quartz segments from Sibudu. However, the Wilton segments length/breadth ratios are not as standardised (CV = 18.4) as the small quartz segments from Sibudu (CV = 7). In terms of length/breadth ratio standardisation they are much closer to the dolerite (CV = 18) and hornfels (CV = 22) segments from Sibudu.

Table 11.8: Results of length/breadth ratio calculations on Wilton segments from Byneskranskop 1 (BNK 1) and Nelson Bay Cave (NBC). Comparison is made with hornfels, dolerite and quartz Howieson's Poort segments from Sibudu Cave. ***(Source: Wadley & Mohapi 2008: 2599, SD: standard deviation; CV: coefficient of variation. Measurements are in millimetres)***

	BNK 1, NBC Wilton segments	Hornfels segments	Dolerite segments	Quartz segments
Mean	1.8	2.5	2.5	1.8
SD	0.3	0.5	0.4	0.1
CV	18.4	22	18	7
n	21	43	23	13

11.4.3 *Summary of the Wilton segments TCSA and length/breadth ratio calculations*

The mean TCSA 1 values for Wilton segments in this study are low and have no parallel in this set of comparisons. The mean TCSA 2 values, assuming that segments were hafted transversally, indicate a close similarity between the combined BNK 1 and NBC segments and North American arrowheads. Paying attention only to the mean TCSA values is problematic, as these values mask considerable morphological variation within the segments examined in this study. The length/breadth ratios of the BNK 1 and NBC segments are the same as for the small quartz Howieson's Poort segments from Sibudu. The Wilton segments are not, however, as standardised in this measurement as the small quartz segments from Sibudu.

11.5 Tip cross-sectional area calculations on Wilton and Robberg convergent pieces

In this section, the results of standard TCSA calculations on the Wilton and Robberg convergent pieces from BNK 1 and NBC are presented. Convergent pieces have the right morphology (pointed tip, convergent laterals) to have standard TCSA values calculated for them. They are also similar in this respect to other pointed artefacts that have been called projectile tips (see Shea 2006). For these reasons, I calculated the TCSA values for the Wilton and Robberg convergent pieces in my samples. Only the BNK 1 and NBC convergent pieces had DIFs on them, and they are therefore the only pieces presented in this section.

These values are compared to the TCSA values calculated for the MSA triangular flakes from Klasies River Mouth and the Still Bay points from Blombos Cave (data from Henshilwood *et al.* 2001; Henshilwood & d' Errico 2004; Shea 2006; also see Henshilwood 2005). Some of the Klasies River Mouth pieces are interpreted as being thrusting spear tips, whilst some of the Still Bay points may have been spear tips or butcher knives (Milo 1998; Henshilwood 2004; Shea 2006; Lombard 2006, 2007b). This is an initial step towards comparing the TCSA values for LSA and MSA convergent pieces from southern Africa.

The TCSA values from ethnographic, archaeological and experimental arrowheads, darts and thrusting spears in North America (Thomas 1978; Shott 1997; Shea 2006), and back-to-back hafted segments (Pargeter 2007) are used for further comparisons. The tips of these weapon types are also convergent in morphology. The purpose of this comparison is to begin to understand where these pieces would fit in a hypothetical scheme of weapon types and not to provide firm conclusions about their use as the tips of specific weapon types (also see Lombard & Parsons 2008; Lombard & Phillipson 2010).

A few convergent pieces with exceptionally large TCSA values were noted in the BNK 1 and NBC assemblages. These outliers have been removed from the analysis as they distort the data and the mean TCSA values of the remaining pieces (see Shea 2006). The pieces are: one from the NBC Robberg (TCSA = 366.1); one from the BNK 1 Robberg (TCSA = 460); one from the BNK 1 Wilton (TCSA = 276. 07) and five from the NBC Wilton (TCSAs = 538.1, 446.1, 402.1, 232.4 and 201.7). The remaining convergent pieces' TCSA values are presented in Table 11.9.

Table 11.9: Results of tip cross-sectional area calculations on the Wilton and Robberg convergent pieces from Byneskranskop 1 (BNK 1) and Nelson Bay Cave (NBC) and comparisons to ethnographic and archaeological samples *(SD: standard deviation. Measurements are in millimetres; KRM: Klasies River Mouth)*

Sample description	Mean (mm^2)	Max	Min	SD	n
BNK 1 Wilton convergent pieces	16.14	35.97	5.34	11.88	9
BNK 1 Robberg convergent pieces	78.52	164.32	5.44	56.57	16
NBC Wilton convergent pieces	78.85	166.49	18.02	50.67	20
NBC Robberg convergent pieces	48.91	80.28	14.33	29.53	6
KRM MSA1	160	350	55	60	71
KRM MSA2 Lower	199	1210	50	105	545
KRM MSA2 Upper	170	512	36	79	298
KRM MSA1 pieces < 200 mm^2	138	198	55	37	58
KRM MSA2 Lower pieces < 200 mm^2	139	198	50	36	328
KRM MSA2 Upper pieces < 200 mm^2	131	198	36	39	213
Blombos Cave Still Bay points	143	842	4	109	239
North American arrowheads	33	146	8	20	118
North American darts	58	94	20	18	40
Experimental spearheads	168	392	50	89	28
Back-to-back hafted segments	71.3	100	27	28.3	6

The BNK 1 TCSA values vary between the Wilton and Robberg assemblages (Table 11.9). The BNK 1 Wilton convergent pieces have a mean TCSA value (16.14 mm^2) that is outside of this comparative scheme. The BNK 1 Robberg convergent pieces have a mean TCSA value (78.52 mm^2) closer to the back-to-back hafted segments (mean = 71.3 mm^2) than the experimental thrusting spears (mean = 168 mm^2). There are considerable variations within this sample as can be seen in the BNK 1 Robberg TCSA maximum (164.32 mm^2), minimum (5.44 mm^2) and SD (56.57 mm^2) values. Thus, although the mean TCSA values show a distinction between the BNK 1 Wilton and Robberg pieces, the samples are too variable to make definite statements using these values alone.

The Klasies River Mouth and Blombos TCSA values are relatively high and similar to each other, but are different to the BNK 1 and NBC convergent pieces. The TCSA values for the Klasies River Mouth triangular flakes and Blombos Cave Still Bay points (ranging between 199 mm^2 and 131 mm^2) are closest to the NBC Wilton (mean = 78.52 mm^2) and BNK 1 Robberg (mean = 78.85 mm^2) convergent pieces, but these values are still quite different. There is very little

similarity between the TCSA values for the LSA convergent pieces in this study and these MSA triangular flakes and bifacial points. Their DIF frequencies are also quite different (refer to Section 2.4 and Chapter 10).

The NBC Wilton sample shows different TCSA values to the NBC Robberg. The NBC Wilton convergent pieces have a mean TCSA value (78.85 mm²), which is closest to the TCSA values for the back-to-back hafted segments. The NBC Robberg convergent pieces have a lower mean TCSA value (48.91 mm²), which lies somewhere between the North American arrowheads (mean = 33 mm²) and darts (mean = 58 mm²). When the four samples from BNK 1 and NBC are viewed together, the Wilton values are not consistently different to the Robberg values. A close similarity exists between the mean TCSA values for the NBC Wilton (mean = 78.85 mm²) and the BNK 1 Robberg pieces (mean = 78.52). Both of these means are close to the mean TCSA value for back-to-back hafted segments.

11.5.1 *Summary of the Wilton and Robberg TCSA calculations*

The mean TCSA values for the NBC and BNK 1 samples are most similar between the NBC Wilton and BNK 1 Robberg convergent pieces and back-to-back hafted segments. They are much lower than the same values for Klasies River Mouth MSA 1 and 2 and Blombos Cave Still Bay points. The NBC Robberg convergent pieces have a mean TCSA value in between that of arrowheads and darts. The BNK 1 Wilton sample mean TCSA value has no comparison in this scheme. These four samples have relatively high standard deviations meaning there is a great deal of variation within them.

11.6 Cross-sectional perimeter calculations on Wilton and Robberg convergent pieces

In this section, I aim to evaluate the performance characteristics of the Wilton and Robberg convergent pieces from NBC and BNK 1 using the cross-sectional perimeter calculation (Sisk & Shea 2009) (refer to Section 8.3.3). The cross-sectional perimeter data presented here are meant to supplement the TCSA (refer to Section 11.4 and Section 11.5) and macrofracture data already discussed (refer

to Chapter 10). The data in this section are not meant to be conclusive on their own and are best used in conjunction with other strands of archaeological information (Lombard 2008).

Table 11.10 presents the results of the cross-sectional perimeter calculations on the BNK 1 and NBC Wilton and Robberg convergent pieces. The lowest mean perimeter value is from the BNK 1 Wilton sample (mean = 28.15 mm). The two Robberg samples have similar mean values (44.76 mm and 43.41 mm,) and the highest cross-sectional perimeter value comes from the NBC Wilton sample (mean = 55.85 mm). These mean values mask a considerable amount of variation within these samples though. This is especially true of the BNK 1 Wilton sample, which has a mean value of 28.15 mm and a standard deviation of 23.66 mm.

Table 11.10: Cross-sectional perimeter values for the Byneskranskop 1 (BNK 1) and Nelson Bay Cave (NBC) Wilton and Robberg convergent pieces *(SD: standard deviation. Measurements are in millimetres)*

Sample description	Mean	Max	Min	SD	n
BNK 1 Wilton convergent pieces	28.15	92.57	13.62	23.66	10
BNK 1 Robberg convergent pieces	44.76	99.75	12.13	22.46	17
NBC Wilton convergent pieces	55.85	112.77	22.71	26.78	23
NBC Robberg convergent pieces	43.41	97.52	19.32	26.01	7

The NBC Wilton and Robberg and BNK 1 Robberg mean cross-sectional perimeter values are relatively small and place these pieces outside of the mean values given in Table 11.11. This makes sense as the convergent pieces in this study are not small Levallois points, and were not being compared for this reason. Reflecting on the theory behind this calculation, which is that convergent pieces with smaller cross-sectional perimeter values and thicknesses should have greater penetrative abilities, these values could reflect successful convergent pieces. Considering that there is some amount of variability within the NBC and BNK 1 samples, these conclusions can only be generalised, hypothetical statements at present.

Table 11.11: Cross-sectional perimeter values and penetration depths from trials 1 and 2 in the Sisk and Shea (2009) experiment *(SD: standard deviation. Measurements are in millimetres)*

Penetration depth (Trial 1)	Mean	Max	Min	SD	n
11.5 – 7 cm	91.52	111.93	55.45	16.85	28
6.5 – 2.5 cm	95.94	112.37	72.33	12.28	19
0 cm	95.42	112.86	75.97	18.19	4
Penetration depth (Trial 2)					
5 – 10 cm	89.78	112.37	55.45	15.71	24
2 – 4 cm	97.29	108.84	82.28	3.30	5
0 cm	99.29	112.86	82.19	10.79	18

The NBC Robberg (mean = 43.41 mm) and Wilton (mean = 55.85 mm) and BNK 1 Robberg (mean = 44.76 mm) values are comparable to the three smallest successful Levallois convergent tips presented in Table 11.12. Both of the Robberg samples and the NBC Wilton convergent pieces therefore appear to be more like experimentally successful projectile tips than do the BNK 1 Wilton convergent pieces.

Table 11.12: Cross-sectional perimeter values for the three smallest tips in the Sisk and Shea (2009) experiment and their penetration depths *(Note that the maximum penetration depth for trial 1 is 11.5 cm and for trial 2 is 10 cm)*

Tool number	Cross-sectional perimeter (mm)	Penetration depth (cm) (trial 1)	Penetration depth (cm) (trial 2)
1	62.32	10.00	8.00
10	66.03	8.00	8.00
12	55.45	9.50	10.00

11.6.1 *Initial conclusions from the cross-sectional perimeter calculations*

All of the convergent pieces, with the exception of the BNK 1 Wilton pieces, have mean cross-sectional perimeter values comparable to some of the successful experimental arrowheads in the Sisk and Shea (2009) experiment. When the BNK 1 and NBC results are assessed in relation to their standard deviations and minimum and maximum values, considerable variation within the samples is evident. It must also be kept in mind that these pieces are not small Levallois points and are not typologically comparable to the convergent pieces in the Sisk and Shea (2009) experiment. The cross-sectional perimeter values show no clear trend in time between the Wilton and Robberg samples in this study.

11.7 Chapter summary

Few of the morphological characteristics for the Wilton and Robberg bladelets are standardised, including their length/breadth ratios and no clear difference in standardisation exists between the Wilton and Robberg bladelet samples. Thickness is the most similar attribute between the two samples, but not the most standardised, whilst length and breadth are the least similar attributes. The whole bladelet CV values and mean length, breadth and thickness values are most similar to small quartz segments that are interpreted as arrowheads.

The mean TCSA 2 value for the NBC and BNK 1 Wilton segments hafted transversally suggests a similarity between them and North American arrowheads. The length/breadth ratio for the Wilton segments suggests a similarity between these pieces and the small quartz segments from Sibudu which were possibly used as arrowheads. The mean TCSA 1 values on convergent pieces are similar in the NBC Wilton and BNK 1 Robberg samples, which are most similar to the TCSA values for back-to-back hafted segments. The NBC Robberg convergent pieces' mean TCSA values fall in between hypothetical darts and arrowheads. These TCSA values mask considerable variation within the samples that is apparent when looking at their standard deviations, maximum and minimum values. Cross-sectional perimeter values for the NBC Wilton and Robberg and BNK 1 Robberg convergent pieces are similar to the values for successful small Levallois points used as experimental arrowheads. The BNK 1 Wilton convergent pieces perimeter values have no parallels in these experiments.

CHAPTER 12: DISCUSSION OF RESULTS

12.1 Introduction

In this chapter, I contextualise the experimental and archaeological results from Chapters 8, 9 and 10. I also discuss the importance of the trampling and knapping experiments for assessing the macrofracture method, and other outcomes from the experiments. Finally, I examine the macrofracture and morphometric results and their significance for understanding the subsistence and technological behaviours during the Wilton and Robberg phases.

12.2 Assessing the macrofracture method

A primary aim of this project was to assess the macrofracture method for detecting ancient hunting weaponry. This was done partly by comparing the trampling and knapping experimental results presented in this study to previous hunting macrofracture experiments using a two-tailed Fisher's exact test (see Table 12.1 and refer to Chapter 2 and Chapter 7). The DIF frequencies from two previous hunting experiments (Lombard *et al.* 2004; Pargeter 2007; Lombard & Pargeter 2008) were combined and compared to the DIF frequencies from the trampling and knapping experiments in this study. These hunting experiments were selected as they used the same macrofracture methodology, and because detailed information per tool is available. Therefore, these results were directly comparable. In addition the Fischer *et al.* (1984) experiments were compared to the experimental samples from this study using only DIF means because their original tool data are not available (see Figure 12.1).

Table 12.1: Results of Fisher's exact test on the mean diagnostic impact fracture frequencies from previous hunting experiments and the trampled and knapped assemblages in this study *(Source: Lombard et al. 2004a; Lombard & Pargeter 2008. D: dolerite; Mq: milky quartz; Qtz: quartzite; α: alpha level)*

	Variable 1	Variable 2	*p*-value (Fisher exact)	*p*-value (Monte Carlo)	α value
Test 1	Hunting	Cattle Trampling 1	<0.0001	<0.0001	0.05
Test 2	Hunting	Cattle Trampling 2	<0.0001	<0.0001	
Test 3	Hunting	Human Trampling 1	<0.0001	<0.0001	
Test 4	Hunting	Human Trampling 2	<0.0001	<0.0001	
Test 5	Hunting	Knapping D	<0.0001	<0.0001	
Test 6	Hunting	Knapping Mq	<0.0001	<0.0001	
Test 7	Hunting	Knapping Qtz	<0.0001	<0.0001	

I interpret the results of the exact test to show that trampling and knapping produce DIF frequencies significantly different from hunting experiments ($p < 0.0001$). The trampling and knapping assemblages also appear different to the Fischer *et al.* (1984) hunting experiments when compared on the level of DIF means (see Figure 12.1). Similar longitudinal impact forces are probably responsible for the small number of trampling and knapping DIFs as for the hunting DIFs. The high proportion of step terminating fractures and impact burinations suggests that the experimental tools were also subject to frequent bending forces during trampling and knapping.

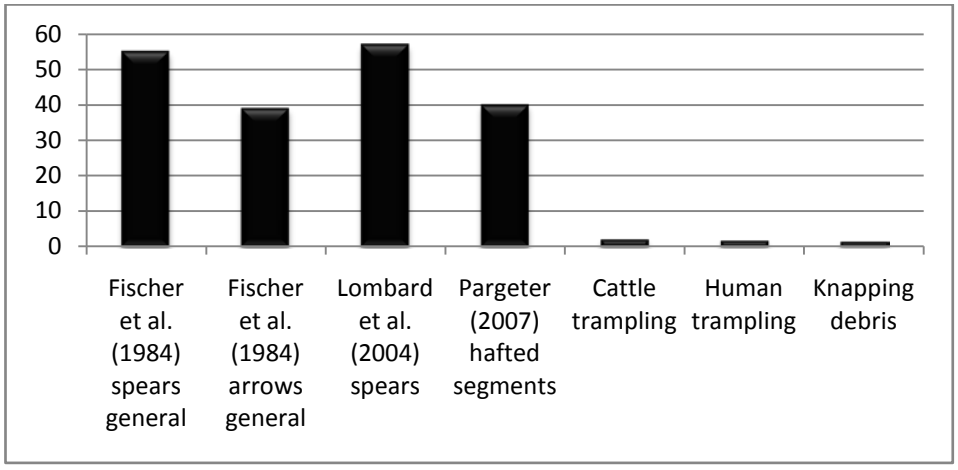


Figure 12.1: Comparison of mean diagnostic impact fracture frequencies from three hunting experiments and the experimental samples in this study *(Source: Fischer et al. 1984; Lombard et al. 2004; Pargeter 2007; Lombard & Pargeter 2008)*

12.2.1 *Notches as a DIF category*

Previous hunting experiments with backed artefacts revealed the presence of smooth semi-circular notches on one transversely hafted segment used as an impact weapon (Pargeter 2007; Lombard & Pargeter 2008) (refer to Chapter 5). The experiments conducted by Yaroshevich *et al.* (2010) also showed this fracture type to occur in association with transversely hafted weapon tips (refer to Chapter 5). These finds raised questions as to whether or not semi-circular notches, also termed *impact notches*, developed as a result of hunting and whether they could be used as a DIF type to help identify transverse hafting. From the Lombard and Pargeter (2008) study it is unclear if alternative forces, such as trampling, could also account for the formation of this fracture type. Smooth semi-circular notches were noted during the macrofracture analysis on all the human and cattle trampling assemblages in this study (n = 35; 7.8 %). The first cattle trampling experiment contained the highest number of these notches (n = 19; 19 %). Milky quartz and quartzite pieces had a much higher frequency of notches (89 %) than dolerite (11 %). Milky quartz and quartzite have brittle edges and notches form more easily on them as opposed to the less brittle dolerite edges. The only assemblages without notches were the knapping debris. Thus, it is unlikely that only raw material properties affect the formation of this fracture type. It appears that the specific forces exerted during trampling cause notches on the edge of flakes.

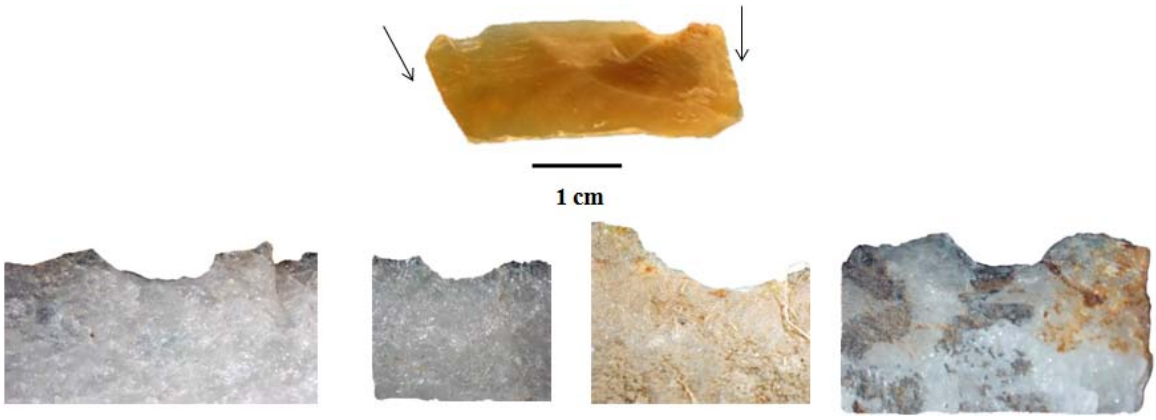


Figure 12.2: Notches from the cattle and human trampling experiments *(bottom)* **compared with two impact notches** *(top)* **from the Pargeter (2007) hunting experiments.** *(Note that the top piece has other macrofractures in association with the notches)*

A majority of the trampling notches (57 %) were found in association with cutting edges and pointed ends of the flakes and might be considered use-related in a regular macrofracture analysis (Figure 12.2). No notches in this study were found in association with other DIF types, and none of these pieces could have been hafted transversally with success. These results suggest that notches cannot be considered a DIF category on their own. Although they occur as a result of human and cattle trampling, they can be useful functional markers when found in association with other DIF types or on tools potentially used as transverse weapon tips (but refer to Section 12.4.5).

12.2.2 *Step terminating fractures as a DIF category*

The simplest of DIFs are step terminating fractures (Fischer *et al.* 1984). For this reason, step terminating fractures have been referred to as one of the primary DIFs to identify the potential use of stone-tipped weaponry (e.g. Lombard 2005a; Lombard & Pargeter 2008; Villa *et al.* 2009) (refer to Chapter 5). Villa *et al.* (2009: 854) even state that, "step terminating scars have never been obtained in trampling experiments hence they are considered diagnostic regardless of size" (for a similar argument see Mussi & Villa 2008; Villa & Soriano 2010). Many of the step terminating fractures in this analysis were not found in association with tips and other diagnostic areas of the flakes. The eight (1.7 %) step terminating fractures in direct association with the tips of trampled pieces suggest that caution be taken when small frequencies of step terminating fractures are noted on archaeological samples. These fractures should only be considered diagnostic when found on pieces that are morphologically potential hunting weapon components. Their formation is associated with bending forces that can be produced by a variety of agents amongst which are human feet, cattle hooves and hard hammer percussion.

12.2.3 *Impact burination as a DIF category*

Impact burinations originate from longitudinal forces running down the side of a tool to remove a burination spall perpendicular to the axis of the piece (Lombard 2005a) (refer to Chapter 5). This fracture type was initially not considered

diagnostic of projectile use in the experiments by Fischer *et al.* (1984), but was noted by Barton and Bergman (1982) and Bergman and Newcomer (1983) and was included as a DIF category by Lombard (2005a). Since then, burinations have been used to identify the impact function of numerous stone artefacts. They are a common fracture type on HP backed artefact assemblages (see Table 12.3) and were the most frequent DIF type in my own hunting experiments (Lombard & Pargeter 2008).



Figure 12.3: Cattle and human trampling of milky quartz *(left)* **and dolerite flakes** *(right)*

Impact burinations were noted on flakes from the knapping debris as well as in the cattle and second human trampling experiments. These fractures can thus also occur when a longitudinal force is applied to the edge of a tool from above, i.e. by the hoof of a cow or a human foot (see Figure 12.3). During the cattle trampling experiments some of the tools were displaced into upright positions (see Figure 12.4). These upright flakes are subject to similar forces as a hunting weapon when the hoof of a cow or a human foot stepped downwards onto their edges. This trampling action and direction is similar to the force of a projected weapon impacting an animal. Eleven (1.4 %) impact burinations are found in association with tips making this the most common DIF type in the experiments. These results suggest that small numbers of burination spalls on archaeological samples should also be viewed with caution in future macrofracture analyses.



Figure 12.4: Upturned flakes (milky quartz) from the first cattle trampling experiment

12.2.4 *Spin-off fractures as a DIF category*

Spin-off fractures are considered to be the most diagnostic of DIFs (Fischer *et al.* 1984: 23). Only one spin-off fracture was noted on the trampling and knapping experimental assemblages. This was a unifacial spin-off fracture > 6 mm on a snapped medial fragment from the dolerite knapping debris (refer to Section 9.2.5). The Fischer *et al.* (1984) human trampling experiments also contained only one spin-off fracture. This one example is not enough to discredit spin-off fractures as a DIF category, but it does suggest that small spin-off fracture frequencies do occur as a result of trampling and knapping. Considering their low occurrence in these experiments spin-off fractures appear to be the most reliable DIF type. This is especially true of bifacial spin-off fractures, which were not noted in any of the experiments.

12.2.5 *A hypothetical margin of error in macrofracture analyses*

The DIFs noted on the trampling and knapping experimental assemblages never exceeded 3 % of the total number of flakes or debris (refer to Section 9.5). The highest DIF frequencies came from cattle trampling (2.1 %), followed by knapping (1.8 %) and then human trampling (1.5 %). These differences are, however, slight. I, therefore, suggest that this frequency (≤ 3 %) be considered a margin of error for macrofracture analyses in the future. This marker provides room for researchers to account for the unexpected and unintended aspects of the past that act to fracture stone artefacts.

12.3 Further observations from the trampling and knapping experiments

12.3.1 *Macrofracture results as per depth*

An attempt was made to track whether flakes placed 10 cm below the surface would fracture more or less than flakes placed on the surface (refer to Section 8.3). The results of this test show that flakes placed further underground fracture less often than the uppermost flakes. After a few hours of trampling the uppermost flakes were generally covered by deposit and were prevented from further fracturing. Some flakes migrated even further down into the deposit. At the end of the cattle trampling experiments, the continuous trampling solidified the deposits and most movement of the flakes stopped. From this set of experiments it is clear that archaeological strata should be considered dynamic, moveable mediums “through which archaeological items float, sink, or glide" (Villa 1982: 287; also see Eren *et al.* 2010). Macrofracture formation is therefore a continuously variable process.

12.3.2 *Differences between the rock types*

When I began this set of experiments, I presumed that dolerite, a relatively hard rock type, would fracture less frequently than milky quartz or quartzite. All three rock types in these experiments showed some number of DIFs, with milky quartz fracturing most often. Quartzite fractured slightly less often than dolerite even though quartzite is a more brittle raw material than dolerite. In general, it appears that the hardness of a rock type is not as important for its rate of fracturing as are the brittleness of its edges.

12.3.3 *Flake thickness and macrofracture formation*

Thicker flakes are assumed to be more robust and are therefore expected to fracture less often than thinner flakes. However, a non-significant correlation between flake thickness and macrofracture formation was noted for the flakes used in the second cattle and human trampling experiments. This is because macrofractures tend to form on the edges of flakes and not on the thicker mid-sections of flakes where thickness measurements are taken.

12.3.4 *Detecting trampling or knapping activities at an archaeological site*

Some macrofractures can indicate trampling or knapping activities at sites. However, the difference between these processes is a matter of frequencies and therefore distinguishing them is sometimes ambiguous. The highest frequencies of non-diagnostic macrofractures present in these experiments were snap and hinge/feather terminating fractures. Snap fractures were present consistently and more often in the two trampling experiments compared to the knapping experiments. Hinge/feather terminating fractures were present slightly more often amongst the knapping debris than in the trampling experiments. Whilst these fracture types are generally common in macrofracture analyses, high frequencies of them along with small numbers (≤ 6 %) of step terminating fractures and impact burinations may indicate trampling and knapping activities at an archaeological site. Another obvious indicator of trampling at an archaeological site is hoof and foot scuff marks on tools (cf. McBrearty *et al*. 1998). Macroscopic scuff marks were present on only one flake from the cattle trampling experiments (see Figure 12.5).

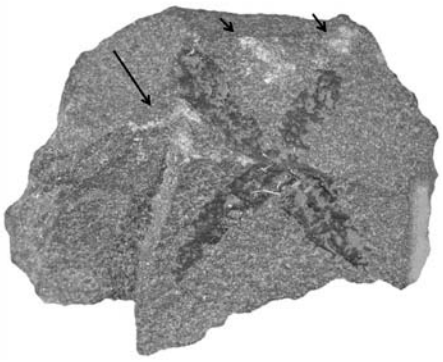


Figure 12.5: Scuff marks on a dolerite cattle trampled flake

12.4 Contextualising the macrofracture results from Nelson Bay Cave, Beyneskranskop 1 and Blombosfontein Reserve Site 4

In general, the Wilton assemblages in this analysis showed higher DIF frequencies than the Robberg assemblages (20 % vs. 17 %). This difference is, however, slight and need not reflect a difference in hunting activities between the two industries.

It may, for example, indicate differential transport of broken tools, or differences in hafting configurations (e.g. Lombard & Parsons 2008). When these DIF frequencies were broken down according to site and assemblage, then the differences appeared less consistent (see Figure 12.6). The only DIF frequency that seemed out of place was from the NBC Wilton sample (18.6 %), which was low, compared to the BNK 1 and BBF 4 Wilton samples (20.7 % and 20.9 %). These results do not indicate that hunting was a significantly more important subsistence activity during the Wilton or Robberg phases, but that similar portions of all of these samples were used as hunting components.

The overall faunal remains from NBC and BNK 1 do show marked changes between the Wilton and Robberg phases (refer to Chapter 5). The trend is generally from a medium – large mammal dominated package, largely devoid of marine resources, in the Robberg to a more diverse broad spectrum subsistence package with considerable amounts of marine resources in the Wilton phase. That the macrofracture frequencies do not clearly reflect these changes shows that the relationship between use-traces and subsistence residues is not a straight forward one.

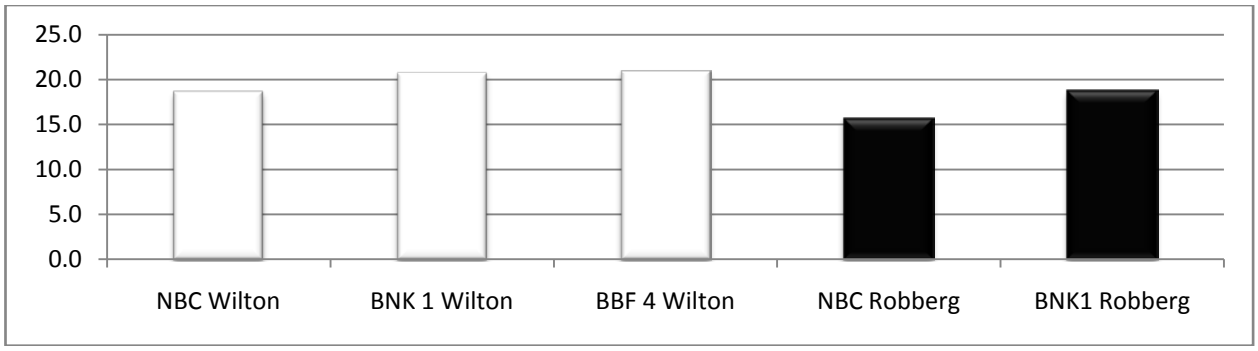


Figure 12.6: Comparison of the mean Wilton and Robberg DIF frequencies from Nelson Bay Cave (NBC), Byneskranskop 1 (BNK 1) and Blombosfontein reserve site 4 (BBF 4). *(White bars indicate Wilton samples, black bars indicate Robberg samples)*

12.4.1 *Statistical comparisons of the trampling, knapping and archaeological DIF frequencies*

The purpose of this section is to determine whether the DIF frequencies from the three archaeological sites differ from trampling and knapping experimental DIF

frequencies in this study (refer to Chapter 9 and Chapter 10). I use the results from this statistical comparison to show that the macrofracture frequencies from the archaeological assemblages are indeed different to the trampling and knapping fractures. A two-tailed Fisher's exact test was conducted on the various samples and the results are presented in Table 12.2. The Fisher's exact test is most useful when data sets are small, and when there is large variance between the cells in a test (Upton 1992) (refer to Section 8.3.5). This was the case with some of the knapping and trampling samples in this study, making a Chi-Square test inappropriate.

Table 12.2: Results of Fisher's exact test on the Wilton, Robberg and trampling and knapping diagnostic impact fracture frequencies *(No degrees of freedom are indicated as the degrees of freedom are always 1 when doing a 2 x 2 table test; BNK 1: Byneskranskop 1; BBF 4: Blombosfontein reserve site 4; NBC: Nelson Bay Cave)*

	Variable 1	**Variable 2**	***p*-value (Fisher exact)**	***p*-value (Monte Carlo)**
Test 1	BNK 1 Wilton	Trampling	<0.0001	<0.0001
Test 2	BNK 1 Wilton	Knapping	<0.0001	<0.0001
Test 3	BNK 1 Robberg	Trampling	<0.0001	<0.0001
Test 4	BNK 1 Robberg	Knapping	<0.0001	<0.0001
Test 5	BNK 1 general	Trampling	<0.0001	<0.0001
Test 6	BBF 4 Wilton	Trampling	<0.0001	<0.0001
Test 7	BBF 4 Wilton	Knapping	<0.0001	<0.0001
Test 8	NBC Wilton	Trampling	<0.0001	<0.0001
Test 9	NBC Wilton	Knapping	<0.0001	<0.0001
Test 10	NBC Robberg	Trampling	<0.0001	<0.0001
Test 11	NBC Robberg	Knapping	<0.0001	<0.0001
Test 12	NBC general	Trampling	<0.0001	<0.0001

There are statistically significant ($p < 0.0001$) differences between the DIF frequencies recorded on artefacts from the three archaeological sites and those recorded on flakes from the trampling and knapping experiments (see Table 12.2). Broken down into Wilton and Robberg components from the three sites, there are consistent differences ($p < 0.0001$) between the experimental and archaeological data sets (see Table 12.2). I interpret these differences to show that it is unlikely the DIF frequencies from NBC, BNK 1 and BBF 4 were produced by taphonomic agents, such as human and cattle trampling or knapping.

12.4.2 *Were there flexible hunting adaptations during the Wilton phase?*

In this section, the DIF results from the NBC and BNK 1 Wilton backed artefact samples are compared to the DIF results from three HP backed artefact samples from Sibudu Cave, Umhlatuzana Rock Shelter and Klasies River Cave (see Table 12.3 and Figure 2.2). This comparison is made for a number of reasons. First, the HP, like the Wilton, contains a significant backed artefact component (refer to Chapter 4). Second, no other LSA backed artefact samples have been analysed for macrofractures and so the HP materials provide the closest macrofracture comparison although they are separated in time from the Wilton by c. 60 000 years. The Wilton backed pieces in this study were shorter and narrower, but were comparable in thickness to the Sibudu and Klasies HP backed pieces (see Wadley & Mohapi 2008; Villa *et al.* 2010) (refer to Chapter 10).

The HP backed artefacts have been said to represent part of a flexible adaptation to resource procurement during the late Pleistocene MSA (Lombard 2008; Wadley & Mohapi 2008). By hafting backed tools onto hunting weapons in a variety of positions (Lombard 2008) and by using various resinous glue recipes to do this (Gibson *et al.* 2004; Wadley 2005; Hodgskiss 2006; Delagnes *et al.* 2006; Lombard 2007b; Wadley *et al.* 2009), different types of animals can be hunted using different techniques. Other contemporary animal procurement techniques, such as trapping and snaring, may also have contributed to resource flexibility during the HP phase (Wadley 2010b). Behavioural and technological flexibility is mirrored in the large amount of variability in the faunal components during the HP phase (Lombard & Clark 2008). This is particularly true of the HP faunal assemblage from Sibudu Cave (Clark & Plug 2008). A similar variety of diet is present during the Wilton and Robberg time periods (refer to Chapter 5), and Mitchell has suggested that Wilton backed artefacts and Robberg bladelets could have functioned as LSA "analogs" (2008: 59) for the flexible HP backed artefacts.

Table 12.3: Summary macrofracture data for the three Howieson's Poort backed artefact assemblages so far examined for macrofractures and the Wilton backed artefacts from Nelson Bay Cave (NBC) and Byneskranskop 1 (BNK 1) *(Source: Lombard 2005b, 2006; Lombard & Pargeter 2008) (refer to Chapter 9)*

	Sibudu Cave		Umhlatuzana Rock Shelter		Klasies River Cave		NBC Wilton		BNK 1 Wilton	
	n = 132		n = 101		n = 85		n = 80		n = 148	
Fracture types	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Step terminating	13	10	15	14	12	14	7	9	15	10
BF Spin-off	6	4.5	0	0	2	2	0	0	0	0
UF Spin-off > 6mm	9	7	0	0	2	2	0	0	4	3
UF Spin-off < 6mm	9	7	1	1	2	2	0	0	2	1
Impact burination	5	4	10	10	3	4	2	3	13	9
Hinge/feather term.	21	16	3	3	3	4	15	19	15	10
Notches	5	4	4	4	No rec.	No rec.	10	13	30	20
Snap	51	39	42	42	24	28	27	34	66	45
Tools with DIFs	**29**	**22**	**24**	**24**	**18**	**21**	**9**	**11**	**32**	**22**

The DIF frequencies in Table 12.3 are most similar between the HP (22 %, 24 % and 21 %) and BNK 1 Wilton assemblages (21.6 %). The NBC backed artefact DIF frequency (11 %) is considerably lower than the HP and BNK 1 Wilton samples. This may have to do with the low number of segments (n = 10, 1 with a DIF) in this sample. The BNK 1 Wilton sample had a higher number of segments (n = 108, 40 with DIFs). The most common DIF type on all the HP samples are step terminating fractures, as was the case with all of the Wilton backed pieces (see Table 12.3). Impact burinations are generally more frequent on the BNK 1 Wilton backed pieces (n = 13; 9 %) and the Umhlatuzana sample (n = 10; 10 %), whilst the NBC sample shares a low frequency of this DIF type (n = 2; 3 %) with Sibudu Cave and Klasies River Cave (n = 5, 4 %; n = 4; 4 %).

As with the HP, the BNK 1 Wilton backed artefacts may have been hafted in a variety of ways (refer to Section 5.2.2 and Section 12.4.5). For now, it is impossible to say if the two backed artefact samples were hafted and used in the same way. However, it appears that they both represent an innovative and flexible approach to the problem of hunting weaponry manufacture. The DIF percentages on all of these backed tools are significantly lower than experimental hunting DIFs (refer to Chapter 2), and there is also a high frequency of small trappable fauna in these LSA Wilton assemblages. Therefore, other resource procurement

strategies, such as traps, nets and snares, may also have played a role in subsistence activities during the Wilton phase (see Wadley 2010b). These strategies would not leave macrofracture traces on stone artefacts and can therefore not be described or discovered using the macrofracture method alone.

From this comparison, it appears as if the HP and BNK 1 Wilton backed artefacts exhibit similar macrofracture frequencies and patterns. When combined with the wide variety of fauna from the Wilton samples in this study, the similarities between the two industries appear stronger (refer to Chapter 5). The NBC Wilton sample DIF frequency is considerably lower, possibly due to its lack of segments, a characteristic tool type of both the HP and Wilton industries, which may have been discarded elsewhere during this phase. It therefore seems likely that during the Wilton phase, people had flexible and reliable hunting technologies, which enabled them to focus more intensely on some food items and more widely on others. This may also have been the case during the HP industry.

12.4.3 *Were there reliable hunting adaptations during the Robberg phase?*

The following discussion focuses on Robberg bladelets and their potential functions. It contains a macrofracture comparison of the Robberg bladelets in this study to a late Holocene bladelet-rich assemblage from the Northern Cape, South Africa (see Table 12.4). Jagt Pan 7 is a late Holocene windbreak or hunter's hide with a bladelet dominated assemblage belonging to the Swartkop industry (Lombard & Parsons 2008) (refer to Chapter 2). The blade and bladelet component from this site was examined for macrofractures by Lombard and Parsons (2008). These results were used to argue, amongst other things, for the use of these pieces as parts of reliable and maintainable multi-component hunting weapons (Lombard & Parsons 2008) (see Table 12.4 and refer to Chapter 2). This is the only macrofracture analysis of a bladelet-based assemblage so far in southern Africa and is therefore the closest comparison for my Robberg bladelets.

Table 12.4: Results of the macrofracture analysis of late Holocene blades and bladelets compared to the Robberg bladelets in this study *(Source: Lombard & Parsons 2008) (Refer to Chapter 2 for background information on Jagt Pan 7; NBC: Nelson Bay Cave; BNK 1: Byneskranskop 1; BF: bifacial; UF: unifacial; DIF: diagnostic impact fracture)*

	Jagt Pan 7 n = 919		**NBC Robberg n = 148**		**BNK 1 Robberg n = 218**	
Fracture types	**n**	**%**	**n**	**%**	**n**	**%**
Step terminating	91	10	29	20	14	6
BF Spin-off	1	0	0	0	0	0
UF Spin-off < 6 mm	7	1	1	1	1	0
UF Spin-off > 6 mm	12	1	0	0	0	0
Impact Burination	63	7	15	10	7	3
Hinge/feather term.	75	8	1	1	8	4
Notches	No Rec.	No Rec.	2	1	1	0
Snap	662	72	14	9	23	11
Tools with DIFs	**111**	**9**	**20**	**14**	**44**	**20**

The average macrofracture frequency from Jagt Pan 7 (9 %) is lower in comparison to the NBC and BNK 1 Robberg samples (14 % and 20 %). The closest parallel is with the NBC Robberg bladelets. Snap fractures are more frequent on the Jagt Pan 7 assemblage (n = 662; 72 %) than on the NBC (n = 14; 9 %) and BNK 1 (n = 23; 11 %) assemblages. These high snap fracture frequencies may result from a technological approach to weapon-insert-production involving the purposeful snapping of blades/bladelets (Lombard & Parsons 2008). High frequencies of snap fractures are also associated with human and cattle trampling activity (refer to Section 12.3.4), which could have occurred at Jagt Pan 7 as it is an open air site. Step terminating fracture frequencies are most similar between Jagt Pan 7 (n = 91; 10 %) and BNK 1 (n = 14; 6 %), whilst impact burinations are most comparable between the Jagt Pan 7 (n = 63; 7 %) and NBC (n = 15; 10 %) samples. There could be a number of possible reasons for these differences including functions other than hunting for some of these bladelets.

The cultural and physical context of the Jagt Pan 7 site differs from NBC and BNK 1, yet there may be similar explanations for the functions of these bladelets. Robberg bladelets used in a variety of ways, as flexible components in composite weapons, could explain the high frequencies of unretouched bladelets in the NBC and BNK 1 assemblages (refer to Section 5.2.1 and Section 12.4.6). Robberg

bladelets show the same potential as Wilton backed artefacts to have been used in different hafting configurations (refer to Section 12.4.6) for use in a variety of purposes (refer to Chapter 4). In addition, many of the Robberg bladelets in this study were unretouched (refer to Section 12.4.7) and could have been made and used *en masse* with less effort than artefacts with elaborate retouch. Framed within the discourse of reliable hunting technologies (sensu Bleed 1986; Bousman 1993, 2005; Elston & Brantigham 2002; Hiscock 2002), these late Pleistocene and Holocene blade and bladelet components were possibly hafted, amongst other things, as lateral inserts along the sides of spears in order to increase their penetrative success and reliability as weapons (Lombard & Parsons 2008). Reliable hunting apparatuses such as these would have assisted people living during the Robberg phase to procure some of the large, and sometimes dangerous, mammals seen in the Robberg layers at NBC and BNK 1 (refer to Chapter 5).

12.4.4 *Are DIF frequencies a reflection of the faunal MNI at a site?*

The DIF data from the Wilton and Robberg assemblages in this study were recorded on a layer by layer basis (refer to Chapter 9). When viewed this way, these frequencies appear more different within each industry than between the two industries. However, the small sample sizes for some of the analysed layers need to be taken into account when assessing these results. Here, I wish to expand this approach by adding layer-by-layer faunal data. The purpose of this comparison is to assess whether changes in the MNI data at these sites are correlated to the frequencies of DIFs seen on the archaeological tools and if this changes through time. A correlation might indicate that the numbers of animals being brought back to these sites is associated with the number of broken tools with hunting fractures. In other words, hunting with composite weapons could be responsible for the accumulation of some of the fauna at these sites. A lack of correlation could indicate that other factors have an effect on the number of animals and hunting fractures in a sample.

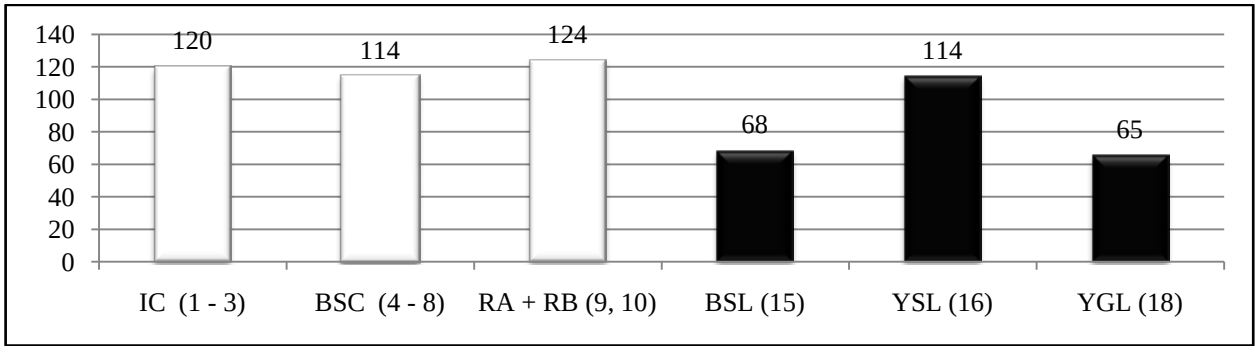


Figure 12.7: Faunal changes in the Wilton and Robberg layers at Nelson Bay Cave (NBC) expressed as minimum number of individuals. *(Specific layer by layer fauna data are not available for NBC and so the layer data are combined into units here. White bars indicate Wilton units, black bars indicate Robberg units. Faunal data for units RA and RB are published as a combined total and are included here even though unit RB lies outside of the scope of this study. Refer to Chapter 5 for the complete faunal table for NBC)*

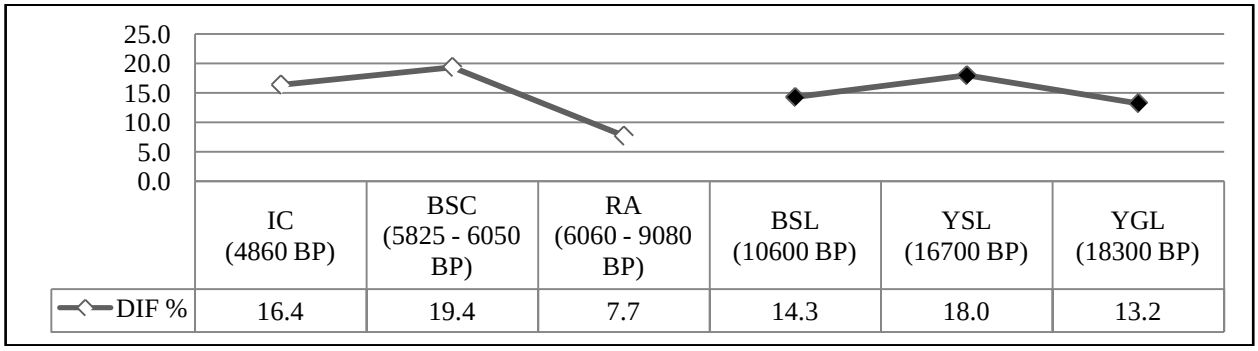


Figure 12.8: Combined diagnostic impact fracture frequencies as per unit at Nelson Bay Cave *(White diamonds indicate Wilton units, black diamonds indicate Robberg units. Unit RB is not examined for macrofractures as it belongs to the Oakhurst industry, which is outside of the focus of this work)*

The unit-by-unit DIF and faunal data from NBC show some interesting parallels (see Figure 12.7 and Figure 12.8). The Wilton DIF and fauna data show less direct parallels, but are still somewhat similar to each other especially in units BSC and IC (see Figure 12.7 and Figure 12.8). These units show relatively high DIF frequencies (16.4 % and 19.4 %) and high faunal signatures (MNI = 120 and 114). However, unit RA has a much lower DIF frequency (7.7 %) as well as the highest faunal signature of all the NBC units (MNI = 124). The comparisons between these data sets are not valid as the faunal MNI data includes both units RA and RB, whilst the DIF data are made up only of tools from unit RA. These differences probably affect the comparison between the two.

The DIFs from the Robberg units match the shifts in the faunal data closer than in the Wilton units. Unit YSL has the highest DIF frequency (18 %) and the highest faunal signature (MNI = 114), whilst BSL (DIF = 14.3 %; MNI = 68) and YGL (DIF = 13.2 %; MNI = 65) rank second and third in both data sets. There may be a correlation between the DIF and MNI frequencies in these layers. Overall, the data seems to suggest that for all the Robberg units at NBC a correlation exists between the DIF frequencies and the faunal MNI data. When DIF frequencies shift, the fauna MNI data also shift. In the Wilton units at NBC the correlation is less clear, but may still be present.

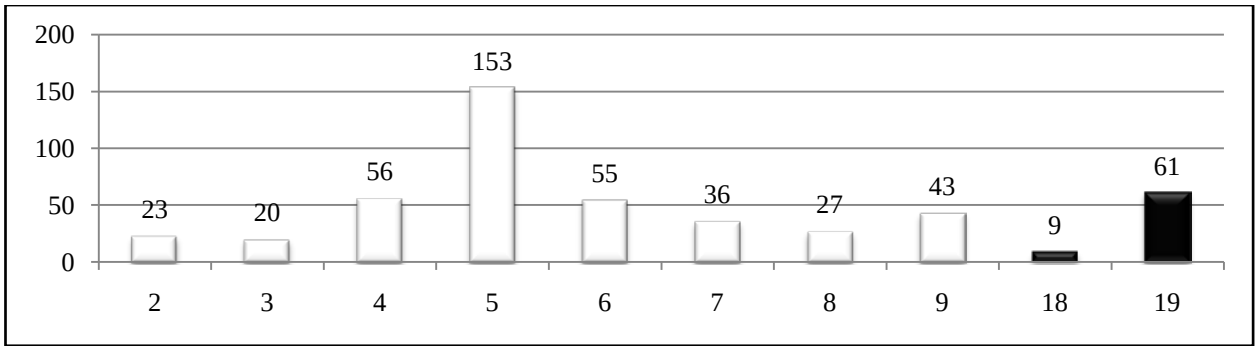
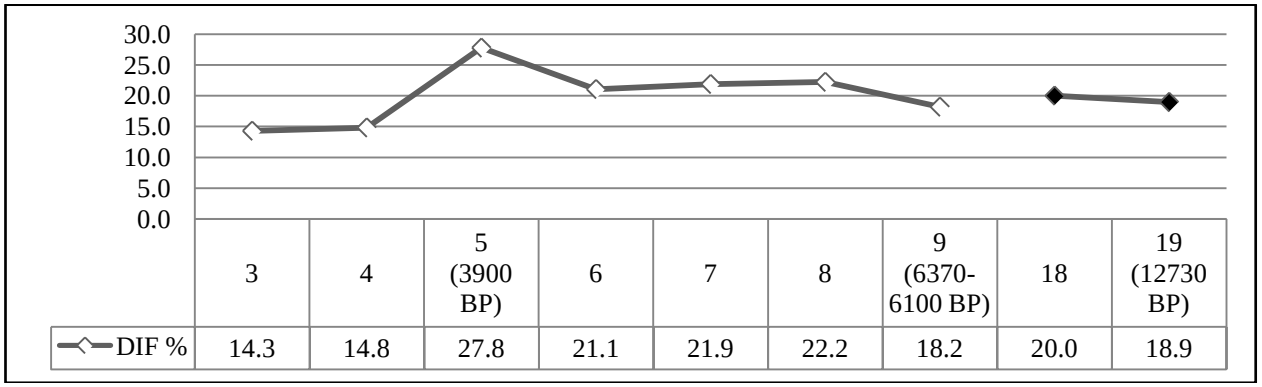


Figure 12.9: Faunal changes in the Wilton and Robberg layers at Byneskranskop 1 expressed as minimum number of individuals *(White columns indicate Wilton layers, black columns indicate Robberg layers)*



	3	4	5 (3900 BP)	6	7	8	9 (6370-6100 BP)	18	19 (12730 BP)
DIF %	14.3	14.8	27.8	21.1	21.9	22.2	18.2	20.0	18.9

Figure 12.10: Diagnostic impact fracture frequencies as per layer at Byneskranskop 1 *(Only those layers containing tools with DIFs are shown. White diamonds indicate Robberg layers, black diamonds indicate Wilton layers; BP: before present)*

The BNK 1 DIF and fauna comparisons are somewhat less clear than at NBC (see Figure 12.9 and Figure 12.10). The closest similarities are between the DIF and faunal data for layer 5 (27.8 %; MNI = 153), both are the highest signatures. This

pattern is not reflected in the layer 8 data, which also has a high DIF percentage (22.2 %), but the third lowest faunal signature (MNI = 27). Layers 3 - 5 show an increase in DIF frequencies as does the faunal data for the same layers. Layers 6 - 9 show the greatest inversion between the two data sets. Layer 18, a Robberg layer, has the lowest MNI signature (n = 9), but the third highest DIF frequency (20 %), whilst layer 19 has relatively high MNI (n = 61) and DIF (18.9 %) signatures. These patterns could be caused by numerous factors, such as the number of broken tools that arrive back at the site after a hunt and the fact that the DIF and faunal sets were not sampled in the same proportions. The faunal data are also likely to include animals that were not hunted with mechanically and non-mechanically projected weaponry. That the DIF data are not for the entire Wilton and Robberg assemblages at NBC and BNK, whilst the faunal data are, makes the comparison at best an approximation at present. Even when these factors are considered, the results suggest that there may be some correlation between DIF frequencies and faunal numbers at NBC and BNK 1.

A look at the composition of the Wilton fauna from NBC and BNK 1 suggests other possibilities for the differences mentioned above. These layers at NBC contain higher numbers of Cape fur seals (*Arctocephalus pusillus)* (MNI = 101), bushpig (*Potamochoerus larvatus*) (MNI = 8), Grimm's duiker (*Sylvicapra grimmia*) (MNI = 3) and grysbok/steenbok (*Raphicerus campestris/melanotis*) (MNI = 63) than in the Robberg layers (refer to Chapter 5). At BNK 1 grysbok (MNI = 66), steenbok (MNI = 26) and other small bovids (MNI = 71) are major components of the Wilton faunal assemblage. Cape fur seals breed in offshore rocky colonies, but also sometimes frequent sandy beaches to breed and give birth during the months of November and December (Payne 1977). During breeding and for the nine months proceeding, young seals are easily procured with clubs, harpoons and bows and arrows (Lyman 1989). Young seals are the predominant individuals found in the Wilton layers at NBC (Klein 1972a, 1974; Klein & Cruz-Uribe 1996). The occasional drift carcass may have also provided further access to seal carcasses for the inhabitants of NBC. There are thus a variety of ways to

procure these animals, not all of which would leave macrofracture traces on stone artefacts.

It is also possible that alternative procurement strategies, such as snaring, trapping and netting, existed during the Wilton phase. Certain animals are more likely, although not exclusively, to be caught using snares and traps than others. These include bushpig, duiker, steenbok and grysbok (Turner 1986, Wadley 2010b and references therein). The high frequency of these relatively small animals in the Wilton layers at NBC and BNK 1 may indicate the presence of alternative hunting strategies, such as trapping and snaring (Oswalt 1976; Wadley 2010b). Traps and snares would not leave macrofracture traces, except if the animals were finished off with stone tipped weapons. It is therefore not possible to detect these hunting techniques using macrofracture data alone. Shifts in the DIF frequencies from layers 3 – 6 at BNK 1 and all the units except RA at NBC are correlated with shifts in the faunal MNI data. Thus it might be possible that at least part of the fauna was brought into the site by hunters using composite hunting weapons. Other hunting methods, such as trapping and snaring, may also have been present, especially during the Wilton phase. Future macrofracture analyses could aim to record DIF and fauna data according to level or layer and square so as to attempt these kinds of interpretations.

12.4.5 *How could Wilton segments have been hafted?*

Macrofractures do not provide unambiguous evidence for the possible hafting positions that bladelets, backed artefacts and convergent pieces could have been used in. However, macrofracture patterns can be compared to recent projectile experiments to investigate the possible positions in which bladelets and backed artefacts during the Wilton and Robberg could have been hafted (see Yaroshevich 2010 and refer to Chapter 2). This section takes a closer look at the possible hafting configurations for Wilton segments and Robberg bladelets from NBC and BNK 1 based on their macrofracture patterns. These two tool types were chosen as we currently know less about how they were hafted than convergent pieces (refer to Chapter 4).

It is difficult to tell whether Wilton segments from NBC and BNK 1 were hafted as barbs, or transversally and diagonally as tips. These three hafting arrangements have the potential to produce similar macrofracture patterns on artefacts. This situation is illustrated in Figure 12.11 (also see Lombard & Phillipson 2010; Villa *et al*. 2010: 641).

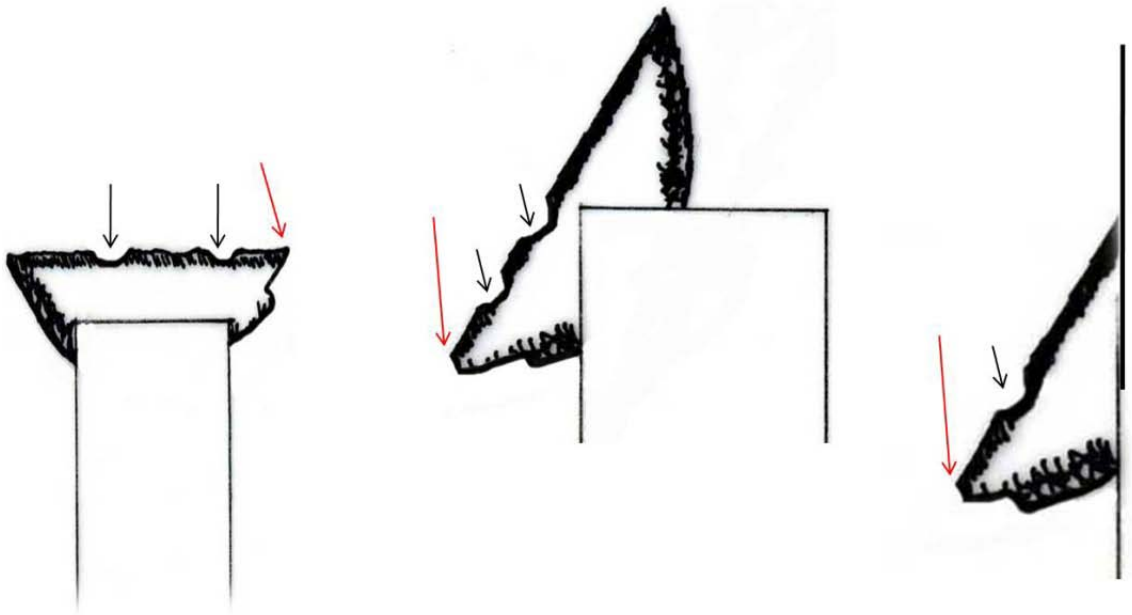


Figure 12.11: Three potential hafting positions for segments *(1: transverse hafting; 2: diagonal hafting; 3: hafting as a barb. Note how all three hafting positions can produce the same macrofracture patterns during experimental hunting [Pargeter 2007]. In this case a transverse step terminating fracture with notches along the cutting edge. Red arrows indicate diagnostic impact fractures; black arrows indicate non-diagnostic macrofractures)*

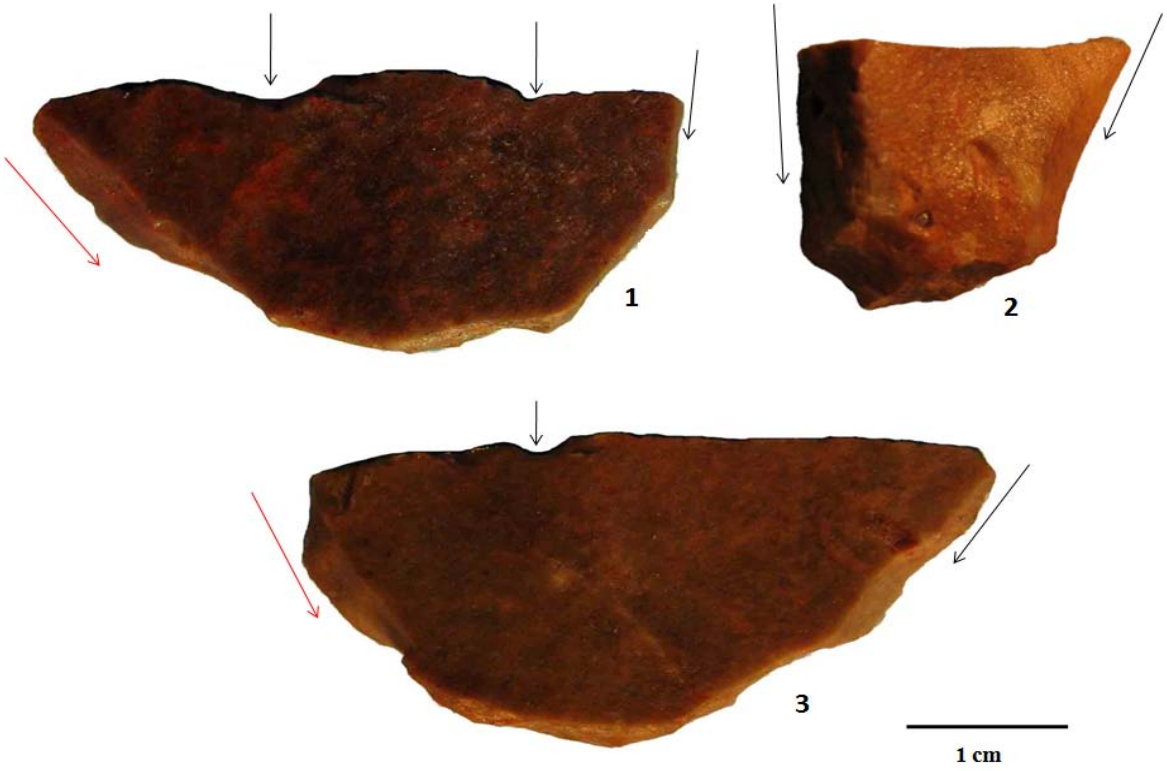


Figure 12.12: Wilton segments from Nelson Bay Cave & Byneskranskop 1 with macrofractures and arrows indicating potential directions of force *(Red arrows indicate DIFs; black arrows indicate non-diagnostic macrofractures)*

Figure 12.12 depicts a selection of Wilton segments from NBC and BNK 1 with macrofractures suggesting that they may have been hafted transversally. The transverse bending fractures and notches on the cutting edges of segments 1 and 3 are similar to these fractures on the transversally hafted piece in Figure 12.11, no. 1. If these pieces were hafted diagonally as tips (see Figure 12.11, no. 2), or barbs (see Figure 12.11, no. 3), they could also have accumulated similar macrofracture types and patterns. Back-to-back hafting of segments would likely produce a mirror effect of the fracture pattern shown in Figure 12.11, no 2. The presence of these fractures on Wilton segments suggests that some of these pieces may have been hafted transversally, but also diagonally or back-to-back (see Pargeter 2007 for hafting configurations).

Some of the Wilton segments from NBC and BNK 1 may also have been hafted vertically. Macrofractures present on the two segments shown in Figure 12.13 are unlikely to have formed from being in any other hafting position. A notch on the

cord of tool no. 2 in Figure 12.13 may have been created by forces from the binding that was used to haft the segment. Microwear analysis of this notch may help clarify this issue.

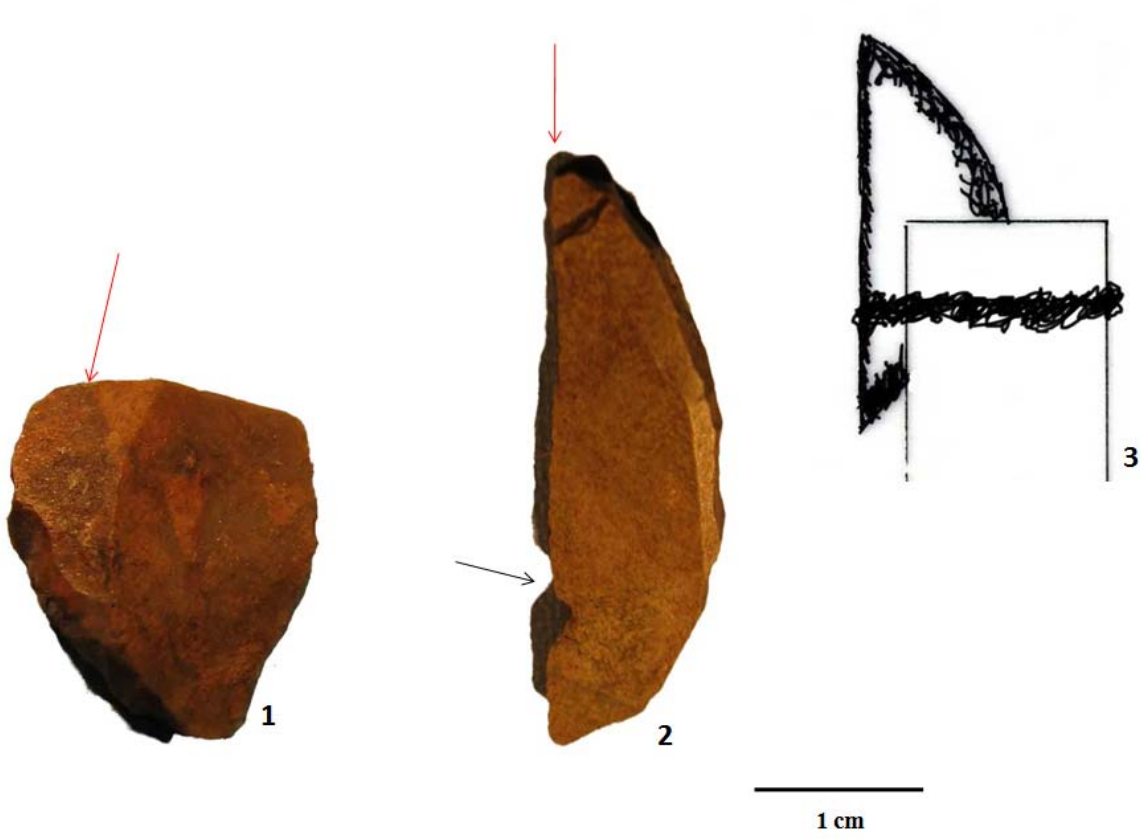


Figure 12.13: Wilton segments from Nelson Bay Cave and Byneskranskop 1 with macrofractures indicative of vertical hafting *(Red arrows indicate DIFs; black arrows indicate non-diagnostic macrofractures. No. 3 is a hypothetical reconstruction of a vertically hafted segment with bindings that could have created the notch on the cutting edge of No. 2)*

12.4.6 *How could Robberg bladelets have been hafted?*

There is much debate about the use and possible hafting of Robberg bladelets (refer to Section 5.2.1 and Section 12.4.3). The Robberg bladelets from NBC and BNK 1 are relatively small (average length: 17 mm; breadth: 8.6 mm; thickness: 3.22 mm) and it appears unlikely that they were used without a haft. This study has shown that at least some of the unretouched and backed bladelets from the Robberg assemblages at NBC and BNK 1 may have been used as inserts in hunting weapons. However, it is unclear how these pieces were attached and used as hunting weapon components. As with the segment question addressed above, the analysis of macrofractures alone cannot provide unequivocal support for one hafting position over another. However, comparing these macrofracture patterns with experimental and hypothetical reconstructions can initiate further investigations into the hafting and use of these tool types.

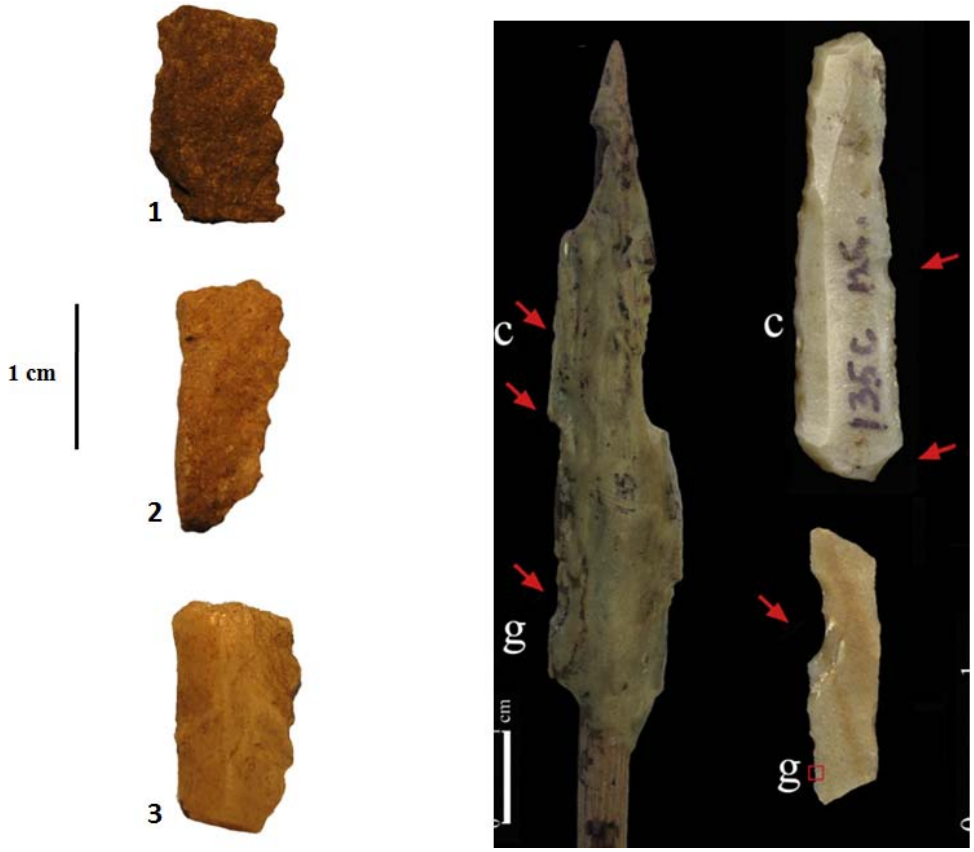


Figure 12.14: Robberg bladelets from Nelson Bay Cave and Byneskranskop 1 shown on the left (No's 1, 2 and 3) and laterally hafted bladelets and associated impact wear from the Yaroshevich *et al.* experiments (2010, Fig. 10: 382) *(Red arrows indicate impact wear from the projectile experiments)*

Bladelets hafted laterally on an arrow shaft develop small denticulations and notches along their cutting edges when projected into an animal carcass (Yaroshevich *et al.* 2010) (see Figure 12.14). These would not be considered DIFs in the Fischer *et al.* (1984) scheme, but are potentially useful indicators of this hafting arrangement. Similar denticulations and small notches were present on some of the Robberg bladelets from NBC and BNK 1 (see Figure 12.14). It is possible that this wear pattern can also be produced in other ways, such as cutting and sawing, with longitudinally hafted bladelets. The microwear analyses of Robberg bladelets from Rose Cottage Cave and Sehonghong, Lesotho, indicate that these bladelets were hafted longitudinally and used for cutting and slicing of mostly vegetal materials (Binneman 1997; Binneman & Mitchell 1997) (refer to Chapter 4). Microwear traces for these actions are mostly in the form of polishes and striations, but three of the Sehonghong pieces showed d-shaped feather, hinge and step terminating fractures on their cutting edges. These wear traces are similar to some of those on the experimentally hafted bladelets in Figure 12.14, used for hunting. Therefore, some of the Robberg bladelets are likely to have been hafted longitudinally, but due to the ambiguous nature of these traces, other causes, besides hunting, for these usewear traces cannot be ruled out at present.

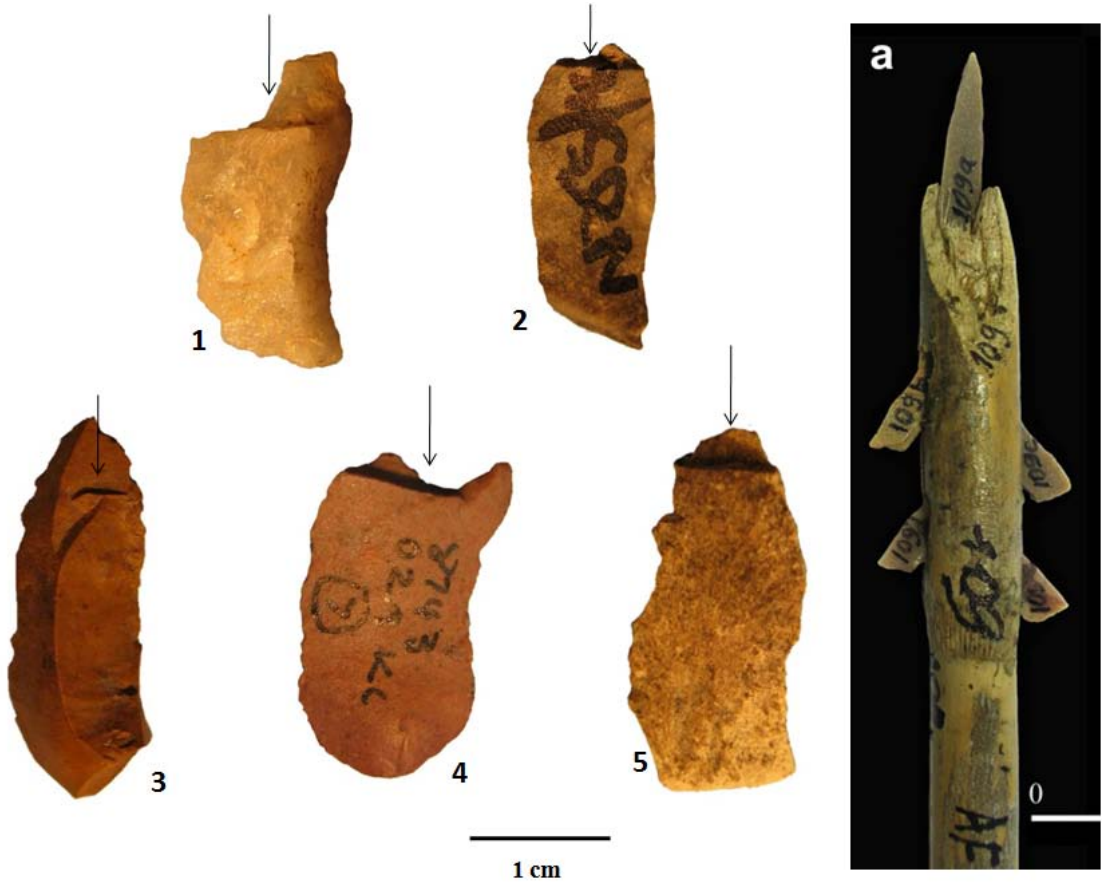


Figure 12.15: Distal step terminating fractures on the Robberg bladelets from Nelson Bay Cave and Byneskranskop 1 indicating their possible use as hunting weapon tips. Comparison is made to an experimental arrow tipped by a convergent bladelet piece *(Source: Yaroshevich 2010, Fig. 7: 397)*

Some of the Robberg bladelets from NBC and BNK 1 may have been hafted as the tips of hunting weapons. Step terminating bending fractures found on the distal ends of some of these bladelets are likely to have been caused by perpendicular/longitudinal impact (see Figure 12.15). At NBC this fracture type and location is found on three of 21 bladelets with DIFs (14 %), whilst at BNK 1 it is noted on 21 of 45 bladelets with DIFs (47 %). This hafting configuration may have been more common at BNK 1 as opposed to NBC. If these pieces were used as the tips of hunting weapons, they must have had some measure of convergence to a pointed tip in order to have been effective at penetrating an animal. Convergences are conceivable for no. 3 and 5 in Figure 12.15, but may have broken off in the remaining pieces. It is therefore likely that some of the Robberg bladelets were hafted as the vertical tips of hunting weapons.

12.4.7 *The use of unretouched pieces for hunting*

During the macrofracture analysis I observed a high number of unretouched artefacts with DIFs, more DIFs than would be expected if trampling was the only factor (refer to Section 12.2.5). During the Wilton and Robberg phases some hunting weapons could thus have been equipped with unretouched pieces. The effectiveness of unretouched stone artefacts as components in hunting weapons is corroborated by experimental and archaeological evidence (refer to Chapter 2). A high number of bladelet-like pieces and convergent flakes were also produced as by-products of the knapping process in the experimental component of this project (refer to Chapter 6). Some of the unretouched pieces with DIFs could therefore have been produced accidentally during knapping. Consequently, the Wilton and Robberg industries may have had low-investment components in which there were no reasons to retouch and shape artefacts into other forms before using them. The predominance of unretouched tool types in these assemblages suggests that archaeologists need to pay more attention to the waste categories of assemblages when doing usewear analyses.

12.5 Assessing the morphometric results

One of the main aims of the morphometric component in this project was to assess the weapon types that may have been present during the Wilton and Robberg phases. The morphometric results showed a range of potential weapon types for the bladelets, backed artefacts and convergent pieces in this study. An overall trend was apparent for a few weapon types: transverse arrowheads and small spear/arrowheads, at the three archaeological sites. The measured pieces with DIFs, on average, have morphological qualities that make them comparable to ethnographic, archaeological and experimental weapon tips. An important point to remember when looking at these results is that they rely largely on the comparisons of means and as such, morphological variability within the samples is masked.

Table 12.5: Summary of the morphometric analyses on the Blombosfontein reserve site 4 (BF 4), Nelson Bay Cave (NBC) and Byneskranskop 1 (BNK 1) artefacts *(CV: coefficient of variation; TCSA: tip cross-sectional area)*

Test/calculation	Samples used	Outcomes
CV	Wilton and Robberg bladelets	–Both sets are generally unstandardised, especially in breadth and thickness. –Length is the most standardised variable. –Wilton bladelets are most comparable in terms of CV to Sibudu small quartz segments.
Length, breadth and thickness t-tests	Wilton and Robberg bladelets	–Thickness is the most similar variable between the two (with a lower mean value than the Klasies River Cave and Jebel Sahaba hafted backed pieces). –Breadth is the least similar between the two.
Length/breadth ratios	Wilton and Robberg bladelets	-Similar length/breadth ratios for both industries. -Length/breadth ratios unstandardised for both industries.
Length/breadth ratios	Wilton segments	-Similar ratios between Wilton segments and Sibudu small quartz segments. -However, this ratio is not as standardised for the Wilton segments as for the Sibudu small quartz segments.
TCSA 1, 2	Wilton segments	–The TCSA 1 mean value has no comparison. –The TCSA 2 mean value is most similar to the Sibudu small quartz segments (hafted transversally as arrowheads).
TCSA 1	Wilton and Robberg convergent pieces	–BNK 1 Wilton has no comparison in the TCSA scheme. –NBC Wilton and BNK 1 Robberg pieces were most similar to back-to-back hafted segments (small spear tips). –NBC Robberg pieces fell between arrowheads and darts; –All these TCSA values are much lower than the MSA 1 and 2 and Blombos Cave Still Bay points' TCSA values.

Cross-sectional perimeter	Wilton and Robberg convergent pieces	–Comparable to successful (in terms of penetration) small experimental Levallois points

The greatest similarity between the Wilton and Robberg industries exists between the BNK 1 and NBC convergent pieces perimeter area values and bladelet thickness CV values. The greatest difference between the two industries exists in the convergent pieces TCSA values and bladelet breadth and length CV values. The similarity in bladelet thicknesses between the Wilton and Robberg samples is interesting as it is the thickness variable that Shea (2009) uses to argue for the use of HP backed artefacts (average thickness = 4.5 mm) from Klasies River Mouth as hafted armatures. Shea (2009) compared the Klasies backed artefact thicknesses to the backed artefact thicknesses from the Jebel Sahaba cemetery in the Sudan (average thickness = 6.43 mm; c. 14 ka) (Wendorf 1968; Shea 2009). At Jebel Sahaba, the backed artefacts were found in a cemetery context in direct association with human skeletons confirming their likely function as hafted armatures (Shea 2009). Shea states that the Klasies backed pieces are not thicker than the Jebel Shaba pieces and therefore may have been hafted pieces. The average thicknesses of the Wilton (3.38 mm; SD: 1.57 mm) and Robberg (3.60 mm; SD: 1.37 mm) bladelets from the three archaeological samples presented here are less than both the Klasies and Jebel Sahaba pieces, but closer to the Klasies backed pieces. This is a possible indication that they too were hafted (cf. Binneman 1997; Binneman & Mitchell 1997). However, there is considerable variation in the thicknesses of the Wilton and Robberg whole bladelets measured in this study. It is therefore difficult to predict whether or not this model would apply to all of these bladelets. More refined functional studies may be able to test this hypothesis (e.g. Lombard 2008).

There is an interesting similarity in the TCSA 2 values and length/breadth ratios for Wilton segments and the Sibudu small quartz segments. The Wilton segments therefore have a length/breadth ratio (1.8) the same as segments interpreted as being arrowheads during the Howieson's Poort industry at Sibudu (Lombard & Phillipson 2010). This is particularly interesting in light of the fact that there are

numerous references alluding to the use of Wilton segments as the tips of arrowheads (refer to section 5.2.2).

The overall picture that emerges from the morphometric analyses is that there is some amount of variation in the weapons types that may have been employed during the Wilton and Robberg phases. On average a congruence between these tool types and and ethnographic, archaeological and experimental spear and arrow tips is present in these results. There is reasonable evidence to suggest that mechanically and non-mechanically projected weaponry was employed, using segments and convergent pieces, during the Wilton period. The exact weapon types present during the Robberg period are, however, not as apparent.

CHAPTER 13: CONCLUSIONS AND SUGGESTIONS FOR FUTURE RESEARCH

13.1 Macrofracture analysis and the trampling/knapping experiments

The macrofracture method has been widely applied to investigate the hunting functions of stone artefacts (refer to Chapter 2). The functional interpretation of numerous stone artefact assemblages currently rests partly on the macrofracture data from these tools. However, the limitations of this method and its applicability in archaeology have been only partially investigated (see Fischer *et al.* 1984; Odell 1988). The primary aim of this study was to assess whether macrofractures found on artefacts are reliable indicators of the prior use of these pieces as weaponry components during the Later Stone Age. My approach was to use experimental archaeology, specifically cattle and human trampling experiments, and stone knapping and to see whether macrofracture frequencies resulting from these processes could be confused with the macrofracture frequencies that might have occurred on stone tools used during hunting.

13.1.1 *Research results*

Step terminating fractures and impact burinations were the most common DIF types that were produced during the trampling experiments, whereas very few unifacial spin-off fractures > 6 mm and no bifacial spin-off fractures occured. I therefore consider spin-off fractures, especially bifacial spin-off fractures, to be the most reliable of the impact fracture types on LSA stone artefacts. Step terminating and impact burination fractures need to be used with some caution when they are found in small frequencies (< 3 %). Notches were present on flakes and blades recovered after trampling by humans and cattle. Similar notches, if present on stone artefacts, should not be used as the sole indicators that these pieces were components of hunting weaponry. These notches can, however, be useful markers of transverse hafting if found in association with other macrofracture types or use-traces. Snap and hinge terminating fractures were the most commonly occurring non-diagnostic macrofracture types in these trampling and knapping experiments. Caution should be exercised when assemblages show

low frequencies (≤ 3 %) of only step terminating fractures and impact burinations and high frequencies of snap and hinge terminating fractures. The additions of micro and macro scuff marks are possible indicators of cattle trampling at archaeological sites. Forces acting upon the tools in these experiments were similar to the impact forces experienced during hunting, except to a lesser degree. In this case the agent of the impact was not a hunting weapon or animal carcass, but a hoof, foot or hammer stone.

The DIFs noted on the trampling and knapping assemblages never exceeded 3 % of the total number of flakes or debris. I therefore suggest that this frequency (≤ 3 %) be considered a margin of error for future macrofracture analyses. When artefact assemblages have DIF frequencies in excess of 3 %, activities besides post-depositional processes, such as trampling, can be considered as contributing to their formation. Until our methods improve to the extent of being able to distinguish between different actions and agents of fracture formation, I suggest this hypothetical margin of error be considered. The first 3 % of DIFs in any macrofracture analysis can be used to represent the unintentional fracturing of stone artefacts in the past through processes that are perhaps not accounted for in other ways.

A few other observations were made during the experiments. Firstly, these experiments showed that rock brittleness, and not hardness, is the most important quality affecting macrofracture formation rates. Brittle rock types, such as milky quartz and quartzite have edges that tend to fracture more often than dolerite, a less brittle raw material. Archaeological assemblages with quartz as a principle component might therefore be expected to have higher macrofracture frequencies as opposed to dolerite dominated assemblages. Second, the burial depth of tools is a variable in post-depositional macrofracture formation. More soil cover protects flakes from fracturing. However, the initial placement of the flakes does not determine where they are eventually found, as soil is a dynamic medium and artefacts can move in it during trampling. In these experiments, I observed how

the formation of macrofractures is a continuous and variable phenomenon affected by the amount of soil cover, the trampling agent and the duration of trampling.

I interpret the results of the statistical tests in this study to show that DIF frequencies from trampling and knapping are significantly different, and lower than those obtained in previous macrofracture hunting experiments. This confirms that macrofracture analysis is a reliable method for detecting Stone Age hunting weaponry. However, the method should not be used uncritically and issues of potential equifinality and artefact morphology should be taken into account when assessing the different fracture types and frequencies found on stone artefacts. In this study the properties of different rock types and the brittleness of their edges have been shown to be potential influences on the formation of macrofractures. The thickness of a flake or blade may influence the likelyhood of it snapping, but is not as important for the formation of macrofractures as the brittleness of its edges.

13.2 Assessing Later Stone Age hunting technologies

There are contentious issues around when and where different hunting weapon types appear in the archaeological record (Lombard & Phillipson 2010; Villa & Soriano 2010). Establishing which artefacts were used for hunting, and which types of hunting weapons were used are also important initial steps towards understanding prehistoric human behaviour and cognitive capacity. At present, we have more contextual evidence for hunting in earlier periods of the archaeological record in southern Africa for example the HP industry, than we do for more recent LSA industries such as the Wilton and Robberg. The secondary aim of this project was to use the macrofracture method and morphometric studies to assess and compare the potential hunting functions of Wilton and Robberg backed artefacts, bladelets and convergent pieces.

13.2.1 *Research results*

Diagnostic impact fracture frequencies on the stone artefacts, which were significantly higher than in the trampling and knapping experiments, were similar in the Robberg and Wilton assemblages. This suggests that similar portions of the Robberg and Wilton stone artefact assemblages were used as impact weapon tips. Although the morphological traits of the Wilton and Robberg tools were not always the same, it is the edge characteristics of the tools that are most important for the formation of macrofractures. It is partly the properties of different rock types that determine the robustness of a flake or blade's edges. This is most apparent in the NBC macrofracture results which show a far higher fracture frequency on flakes and blades made from quartzite and milky quartz which are more brittle raw materials than silcrete (see Figure 10.6 and Figure 10.7). The overall morphometric data suggests, on average, congruence between these LSA tools with impact fractures and experimental, ethnohistoric and ancient spear and arrow tips.

The faunal signatures from the Wilton and Robberg phases appear quite distinct at face value, although there are similarities between them, which was the procurement of medium - large fauna. The greatest distinction between coastal Wilton and Robberg subsistence practices is the high marine component in the Wilton phases at NBC and BNK 1. In spite of these differences, there is not much difference in their DIF frequencies. This indicates that the relationship between subsistence practices and DIF frequencies is a complex one.

At present, it is not possible to tell for sure whether there is a correlation between DIF frequencies and faunal MNI data. The potential for other resource procurement strategies to have been present during the Wilton and Robberg industries, i.e. trapping, snaring, netting, clubbing and organic projectile weapons makes this a difficult pattern to predict. Faunal assemblages also include animals that may have been procured in a variety of different ways, some of these overlap and are difficult to detect and differentiate in the archaeological record. However, if we assume that: (a) the large bovid component at NBC and BNK 1 was hunted;

(b) certain of the small – medium bovids from both NBC and BNK 1 were trapped and snared; and (c) that the seal component at NBC was procured in a variety of ways, then a flexible and varied technological approach, employing both mechanical and non-mechanical weapon types, to resource procurement appears probable at both sites. How this differs between the Wilton and Robberg is not clear yet, but there may have been a greater need for flexible technologies during the Wilton phase and reliable technologies during the Robberg phase, judging by the differences in faunal packages at these times.

When compared to Howieson's Poort backed artefacts and late Holocene bladelet assemblages, both the Wilton and Robberg industries show a potentially flexible, reliable and innovative set of technologies. These are embodied in their versatile stone artefact hafting strategies and variable faunal assemblages. Wilton segments from BNK 1 had DIF patterns suggesting they may have been hafted transversally, diagonally, as barbs or as vertical tips. There is also a consistent morphological similarity between small Howieson's Poort quartz segments interpreted as arrowheads and the Wilton segments from BNK 1 and NBC. The DIF patterns on Robberg bladelets suggest they may have been hafted laterally on mechanically or non-mechanically projected weapons, but could also have been hafted as tips on these weapons. The fact that some of the utilised Robberg bladelets are also unretouched suggests a low-cost, high-output approach to tool manufacture during the Robberg phase.

13.3 Suggestions for future research

An important aspect of the functional analysis of stone artefacts is to understand the relationship between use-wear traces caused by hunting and those caused by post-depositional processes. The experiments in this project are only an initial step towards creating a better understanding of the factors affecting macrofracture formation in post-depositional situations. Future work should examine macrofracture formation as a result of different post-depositional processes such as dropping tools, rolling rocks over them and trampling by other agents.

Macrofractures alone cannot conclusively show which weapon types and hafting positions were adopted in the past and these data would need to be combined with micro-residue and micro-wear data in future analyses in order to provide a clearer picture. The large number of tools with mastic preservation, and careful excavation techniques at sites such as BNK 1 indicates that this would not be a fruitless exercise.

Correlating changes in macrofracture frequencies with faunal changes at archaeological sites is a promising avenue for future research. Future macrofracture analyses, where possible, need to be combined with faunal data sampled at the same level of accuracy in order for meaningful and accurate comparisons to be made.

13.4 Overall conclusions

In this project, experimental archaeology, macrofracture analysis and morphometric techniques have proven to be useful for generating directly comparable data, and for refining understanding about LSA hunting weaponry. The experimental results in this study show that a margin of error exists in macrofracture analysis which accounts for the formation of impact fractures during cattle and human trampling and knapping. These results show that: a) macrofractures occur frequently when stone artefacts are trampled by cattle and humans and in knapping debris; b) DIFs occur on some of the trampled experimental flakes and knapping debris, but are not often associated with tips or pointed ends; c) when they do occur, they could have been produced by forces similar to those experienced during knapping or hunting activities; and e) considering artefact morphology is important during macrofracture analysis.

The Wilton assemblages analysed for macrofractures had a generally higher mean DIF frequency than the Robberg assemblages. These results were also significantly higher than those obtained during the trampling and knapping experiments. Most of the DIFs were made up of step terminating fractures and

impact burinations with very few spin-off fractures noted. Patterns in the DIF data were most notable when the DIF frequencies were viewed layer by layer at each site. When viewed this way, the mean DIF frequencies appeared more different within each industry than between the two industries. Overall it appears as if similar portions of Wilton and Robberg assemblages were employed as hunting weapon components. Based on morphometric similarities, and comparisons with Howieson's Poort small quartz segments, it appears probable that mechanically projected weapons were employed during the Wilton phase. Diagnostic impact fracture patterns suggest that some Robberg bladelets may have been hafted as the tips of weapons, but whether these weapons were mechanically or non-mechanically projected is not clear at present.

Coastal Wilton assemblages contain more diverse, broad-spectrum subsistence packages with considerable amounts of marine resources than are present during the earlier Robberg phase. The Robberg sites analysed in this study contained a more restricted and focused subsistence signature consisting of larger grazing animals and very few marine resources. I interpret the relationship between these faunal signatures and the stone artefacts analysed in this study to indicate a more flexible approach to subsistence procurement during the Wilton contrasted with a greater risk-minimising strategy present during the Robberg.

Macrofracture and morphometric analyses are relatively time and cost efficient and can be used to initiate pilot studies into artefact functions. They are best used as part of a multidisciplinary approach to functional analysis. When appropriate samples are chosen, and thought is given to other strands of information that they can be combined with, these methods become useful interpretive tools for understanding prehistoric behaviours and technologies.

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